Opportunity Re-Evaluation:
How Risk Dimensions Influence Post-Investment Venture Capital Decisions

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ABSTRACT

Why do managers embrace some risks while they reject others that appear to be equally risky? This dissertation examines how risk dimensions influence the decision to hold, reinvest in, or terminate investment in companies within a venture capital portfolio.

I draw on prototype theory to argue that reinvestment is more likely in portfolio companies that "look like" successful VC-backed firms, while investment termination is more likely for firms that "look like" losing portfolio companies. Financial risk is an equivocal signal because it can indicate a problem or recur by design in the VC-backed portfolio company. Different levels of market, technology and management risk are all central characteristics of portfolio winners or losers.

I predict that increasing financial risk will increase the likelihood of both reinvestment and termination compared to holding the investment. However, market, technology and management risk will negatively influence reinvestment. Regarding investment termination, I argue that less controllable risks will be rejected, while firms with more controllable risk will be retained. Therefore, I predict that market risk and technology risk will positively influence termination, while management risk will have no significant effect.

The sample is composed of 542 quarterly observations of 57 companies in an early-stage VC firm's portfolio. The independent variables are the VC's financial, market, technology and management risk assessments. Control variables address fund differences, portfolio company characteristics, cognitive biases, and economic context. The analysis uses multinomial time series logit to compare the likelihood of follow-on investment, investment termination, or profitable sale vs. holding the investment. With the exception of technology risk, the hypotheses are supported.

I contribute to the management and entrepreneurship literatures by examining the under-researched area of risk-based decisions subsequent to an initial commitment. I also use a novel combination of prototype theory and behavioral decision theory to show how risk can be decomposed into multiple dimensions with differing effects on decision-making. Furthermore, my analysis goes beyond binary decisions to incorporate several discrete choices. Finally, this study breaks new ground by analyzing nonpublic, contemporaneous records of actual VC post-investment risk assessments and decisions.

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CHAPTER 1: INTRODUCTION

All managerial decisions entail risk, meaning that their outcomes are uncertain to some degree and they entail some potential for loss. Because risk taking is endemic to business, management and entrepreneurship scholars have endeavored to explain why managers accept or reject risks, and how risk taking can affect subsequent firm performance. While routine corporate decisions may entail minimal uncertainty and loss potential, early stage venture capital is an especially fruitful risk "laboratory," where large bets are placed on small, young companies with undeveloped products and undefined markets. In this dissertation, I will examine why venture capitalists embrace some portfolio company risks while they reject others that appear to be equally risky. Specifically, I will examine the effects of different risk dimensions on the post-investment decision whether to reinvest in a portfolio company, terminate the investment, or continue to hold the company without providing additional capital. My research question is: Why do venture capitalists increase organizational commitment in response to some risks while they end commitment in reaction to others?

Risk is a broad, amorphous concept that is difficult to specify (Baird & Thomas, 1990). The management literature has largely split into two working definitions : 1) the full range – both positive and negative – of past or potential business outcomes, or 2) the expected hazard of downside outcomes (Bromiley, Miller, & Rau, 2001). While statisticians, finance theorists and many strategy researchers may prefer an approach that defines risk as the variance of investment or organizational performance

(Scott, 2003), practicing managers generally think of risk as the potential for loss (March & Shapira, 1987). Because this dissertation examines how managers' risk assessments influence their subsequent actions, I will adopt a risk definition that reflects how managers think: the potential for and magnitude of a possible loss (Shapira, 1995).

Risk taking has a temporal component. In a business context, a risky decision is not analogous to tossing a pair of dice with no control over the results. Instead, managers perceive that an initial risk-based decision launches a process that will unfold over time during which they can intervene to affect the outcome (MacCrimmon & Wehrung, 1986). Most prior risk scholarship, including research on VC investments, examines the initial decision to accept or reject a prospective risk. However, the first decision sets the stage for future risk taking, such as determining whether to continue to commit, or even increase, resources to a specific business strategy. In the case of venture capital, the initial investment enables a young company to continue product and market development, but is probably insufficient to fund large-scale production and distribution. Instead, VCs provide multiple capital infusions staged over several years, each with its own decision process and set of expectations regarding future outcomes (Gompers, 1995). As a result, while the initial investment decision commences the VC's relationship with the portfolio company, its success or failure is also influenced by the VC's actions throughout the

firm's tenure in the portfolio. This dissertation focuses on VC portfolio decisions subsequent to the initial investment.

Post-investment decisions warrant further examination in their own right because their criteria may differ significantly from initial investment rationales and because post-investment actions can materially affect the performance of the VC portfolio. First, as time passes, more information about the portfolio firms capabilities and prospects becomes apparent to the venture capitalist (Moesel, Fiet, & Busenitz, 2001). Second, VCs may be as susceptible as the general population to the cognitive tendency to put a higher value on what they already own vs. what they might acquire (Kahneman, Knetsch, & Thaler, 1991). Finally, institutional and political constraints may force a VC to take actions that suboptimize the return on a specific portfolio company investment (Guler, 2007).

While a follow-on investment entails increased financial commitment, it is an open-ended decision: the VC retains the option to provide additional resources in the future or withdraw support from the firm. On the other hand, investment termination is irreversible: once the VC his withdrawn support and/or sold its interest in the portfolio firm, future gains or losses are impossible. On average, VCs outperform market indices not because they generate profits on each investment, but because achieve a few investment gains that far outweigh other losses within a portfolio (Cochrane, 2005). In fact, initial public offerings and profitable sales of portfolio companies are relatively rare (Zacharakis & Meyer, 2000). Therefore, this dissertation

hypothesizes about investment terminations at a loss for two reasons. First, losing exits are the most common portfolio outcome (Hochberg, Ljungqvist, & Lu, 2007). Second, I want to emphasize the theoretical contrast between follow-on investment (when risk is embraced by increasing a commitment) and investment termination (when risk is rejected by eliminating a commitment).

Risk also can be considered at different levels of analysis: the organizational context, the organization itself, the decision maker(s), and the nature of the "risk problem" itself all may contribute to a propensity for risk taking (Baird & Thomas, 1985). At the lowest level of analysis, a risk problem can be viewed as a prism of multiple risk facets, one of which is how readily the risk can be controlled (Baird & Thomas, 1985; Slovic, Fischhoff, & Lichtenstein, 1985). Like many managers, venture capitalists use functional shorthand to articulate various portfolio investment risk dimensions, such as the qualifications of the management team, the size of the potential market, product differentiation, etc. (Zacharakis & Meyer, 2000). In this dissertation, I examine the effects of four different manager-defined sources of portfolio company risk (financial, market, technology and management) on the VC's "risk problem" of reinvesting, vs. terminating vs. holding.

I invoke categorization theory, specifically the concept of prototypes, to explain how each functional risk dimension signals a portfolio firm's future prospects. I suggest that the category of firms that seek venture capital includes two subordinate categories: winning and losing investments. Financial risk – a common health

indicator of established firms – may indicate either a winning or losing investment because it indicates a current need for cash, but does not necessarily imply poor long-term potential. On the other hand, market, technology and management risks are central prototype characteristics: a "winning" portfolio firm is more likely to be low in these three risk dimensions, while a "losing" portfolio firm probably exhibits higher market, technology and management risk.

Because it is an equivocal signal, financial risk creates urgency because it threatens the survival of a portfolio firm, but it can lead to apparently contradictory VC actions. On the one hand, the VC may make a follow-on investment if the portfolio firm is perceived to be a winning investment in other respects. On the other hand, the VC may respond to increasing financial risk by choosing to terminate investment if it believes the portfolio firm is a likely loser.

In contrast, low market, technology and management risk are central characteristics of winning portfolio investments. As each of these three risks decrease, the VC will be more likely to increase its commitment by making a follow-on investment. However, when a central characteristic's risk level is high, the VC must consider the difficult step of terminating the investment, which is irreversible and can entail the recognition of a capital loss. In this case, the VC considers not only whether a portfolio firm matches the losing prototype, but also whether it has sufficient control over that risk dimension to help the firm look more like a winner. I argue that a venture capitalist will perceive that market risk is largely uncontrollable because

market conditions are outside the VC-portfolio company relationship. Therefore, I predict that increasing market risk will increase the likelihood of investment termination. I also argue that technology risk is less controllable because it is beyond most VCs' expertise and/or is impractical for them to manage directly; therefore increasing technology risk will also positively influence termination. However, control over the composition of the management team is generally a contractually-dictated prerogative of the VC. Therefore, management risk is a more controllable risk that I predict will not influence investment termination.

The hypotheses were tested using a data set of 542 quarterly observations of 57 portfolio companies in two funds of a major venture capital firm over 5 years. The independent variables are the VC's risk assessments in four categories: financial, market, technology and management. Control variables address fund-specific differences, portfolio company characteristics, cognitive biases, and economic context. The analysis uses a multinomial time series logit to compare the likelihood of follow-on investment, investment termination, or profitable exit with the likelihood of holding. (Profitable exit is in the model for statistical reasons, but not reported because it is beyond the scope of this study.)

The results show that financial risk does indeed positively influence both follow-on investment and investment termination. I also find that decreasing market and management risk increase the likelihood of reinvestment. Furthermore, as predicted, market risk positively influences investment termination, but management risk has no

significant effect on termination. Contrary to my predictions, technology risk has no significant effect on either action. Supplemental analyses also were conducted to examine the effects of aggregate risk and risk interactions, and to assess the robustness of the results.

While prior entrepreneurship literature has developed a rich understanding of initial VCs' initial investment criteria, this dissertation breaks new ground in examining post-investment portfolio decisions. It is the first study to get an inside, real-time view of venture capitalist risk assessments and how those perceptions affect a VC's propensity to reinvest or terminate investment. I also extend previous insights on how prototypes influence entrepreneurs' opportunity assessments (Baron & Ensley, 2006; Gregoire, 2005) and VCs' initial investment decisions (Moesel & Fiet, 2001) by examining the role of risk dimensions in VC portfolio decisions. In addition, I integrate prior risk research with prototype theory to suggest that the perceived controllability of central prototype characteristics influences investment termination.

This research also addresses several strategic management research opportunities (Bromiley et al., 2001). First, this is a direct study of actual decisions over time, not a simulation or survey. Second, I analyze the effect of the risk measures that the managers use in their business decisions. Third, this dissertation takes a step toward acknowledging the complexity of managerial decisions by going beyond a yes-no, binary approach to including multiple decision options available to the VC. Finally, while most strategy research on risky decisions uses publically available financial data,

this study includes risk dimensions not available in financial statements, thus helping explain why two portfolio firms that appear to be equally financially risky may be subject to apparently contradictory decisions.

CHAPTER 2: LITERATURE REVIEW

The relationship between risk and managerial action has been a long-term concern of both strategic management and entrepreneurship scholars, and has profound implications for organizational decision making. In this section, I will review previous literature that applies to the questions relevant to this dissertation. What is risk? What type of risk is worth taking? What organizational and psychological factors lead to risk taking? What are attributes of acceptable risks? How do venture capitalists make risk-based decisions? Finally, I will discuss the research opportunities that are addressed by this dissertation.

Definition – What is Risk?

While the importance of risk to organizational decision-making is broadly acknowledged, researchers' varying definitions have produced conflicting predictions and empirical results. An inherent challenge is that the colloquial use of the word is broad and imprecise, resulting in a difficult dilemma for scholars. On the one hand, narrowly specified definitions make it feasible to conduct replicable studies of the antecedents and consequences of risk, but at the expense of being meaningful to many managers. On the other hand, research that employs managers' idiosyncratic risk definitions may not be generalizable beyond the specific decision and population being studied.

The economist Frank Knight suggested that colloquial use of the word "risk" actually applies to two ideas – risk and uncertainty - that should be separated to allow

for more scientific study (Knight, 1921). Knight suggested that risk entails situations where potential outcomes and their probabilities are known, and thus can be measured. For example, gambling on a throw of dice is risk taking because the odds of particular outcomes can be calculated. On the other hand, uncertainty, often referred to as Knightian uncertainty, occurs where outcomes and their probabilities are unknown and therefore unmeasurable. In Knight's view, when entrepreneurs start businesses, they enter the realm of true uncertainty: even in light of sales targets and financial objectives, specific outcomes cannot be predicted with any precision. Knight argued that special insights are required to make decisions in the face of uncertainty and that business profits are payments, in effect, for the exercise of entrepreneurial judgment.

Finance theorists define risk as the variability of returns from an investment (Scott, 2003). In other words, a high risk investment will have high variability of returns over time (higher highs and lower lows), while a low risk investment will produce a more narrow range of returns. Modern portfolio theory states that investors in volatile assets will demand higher average returns in return for accepting the possibility of deeper losses (Rubinstein, 2002). Strategic management researchers have tested the relationship between performance variance and subsequent returns with mixed results. Bowman arrived at the counterintuitive finding that business risk (i.e. variance in profits) and return (mean of profits) are negatively correlated (Bowman, 1980). One possible explanation is that troubled firms are more likely to take risks, meaning that

they seek out higher-variance strategies that often do not work out (Bowman, 1982; Bromiley, 1991).

Bowman's risk-return paradox has been revisited multiple times over the past 25+ years, with conflicting results. One explanation suggested that contextual factors influenced Bowman's result and that the direction of the effect varies by time period (Fiegenbaum & Thomas, 1985). Other research in this stream found that high performers with high variance tend to continue to outperform vs. their industries while low performers with high variance continue to underperform vs. their industries (Fiegenbaum & Thomas, 1988; Jegers, 1991). The relationship between lower variance and high performance may also be the outcome of good management practices: higher strategic responsiveness reduces performance variance and improves average performance (Andersen, Denrell, & Bettis, 2007). It also has been suggested that Bowman's paradox may be a spurious effect of negatively skewed data (Henkel, 2009).

Miller and Bromiley (1990) viewed risk in terms of the variance of different financial measures with relevance to different stakeholders. In other words, income stream uncertainty matters to corporate general managers, while stock returns variance is a primary concern of shareholders, and strategic risk (financial ratios such as capital intensity, debt-to-equity, and R&D intensity) for other external stakeholders. Furthermore, income stream variance, and strategic risk (to a lesser degree) both

negatively affect subsequent performance, while stock price variation has no significant influence on performance (Miller & Bromiley, 1990).

A more intuitive risk definition can be obtained from any dictionary: the possibility of loss or injury (Merriam-Webster, 2003). Downside risk, i.e. a measure of financial performance discrepancy vs. a target, may be closer to how managers actually think and therefore may better explain organizational response to risk (Miller & Reuer, 1996). It appears that the relationship between downside risk and performance is self-correcting: in the face of greater downside risk, managers revise strategies with resulting improved performance. On the other hand, when performance is high, managers are less likely to take downside risks, which dampens future performance (Miller & Leiblein, 1996).

In both the risk-as-variance and downside-risk research streams, risk is defined using financial variables such as accounting profits and/or stock price. However, business risk can also be construed as a complex concept composed of multiple dimensions in multiple domains. Strategic risk decisions - defined as "moves that cause returns to vary, that involve venturing into the unknown, and that may result in corporate ruin" – may be influenced by risk indicators at multiple levels: environmental, industry, organizational, decision-maker, and the "risk problem" itself (Baird & Thomas, 1985). Different considerations drive different risk preferences at each level of analysis, resulting in an apparent hodgepodge of risk indicators. For instance, the health of the economy, competitive rivalry within the industry, incentive

compensation, decision maker self-confidence, and the controllability of the risk positively influence risk taking. On the other hand, government regulation, industry maturity, firm market share, decision-maker age and risk problem complexity negatively affect strategic risk taking (Baird & Thomas, 1985).

A multi-level, multi-domain approach vastly increases the complexity of researching risky organizational decisions, but also reflects the complexity of the decision-making puzzle. One implication is that the managers' definition of risk is nowhere near as precise as many scholars, and that different risk features will be more or less salient depending on the situation. As mentioned earlier, managers appear to define risk in terms of possible loss. However, the issue is not just the potential magnitude of loss, but also the probability of loss (March & Shapira, 1987). Alternatively, managers may specify risk in terms of the magnitude of, chance of and exposure to loss (MacCrimmon & Wehrung, 1986).

Furthermore, managers view risk not as an immutable, exogenous condition (like the odds in a gamble), but as a cluster of organizational and environmental attributes that they can shape and control. Taking a risk is not like throwing a pair of dice, where the result is beyond the control of the gambler. Instead, executing a risky decision initiates a process through which additional managerial actions may affect outcomes over time (MacCrimmon & Wehrung, 1986).

Because they view risk as malleable, managers articulate risk in terms of possible reasons for potential loss, rather than as a single, undifferentiated concept. A potential

for loss due to poor firm management might be called "management risk" while a possible negative outcome due to government action might be referred to as "regulatory risk." Often, managers refer to types of risk in functional terms, i.e. market or management, implying potential organizational levers to mitigate those risks by intervening prior to, during, and subsequent to making a risky decision (Shapira, 1995).

Like other managers, venture capitalists lack a precise risk vocabulary, but prior research has elicited common themes. Consistent with MacCrimmon's and Shapira's findings, VCs focus on the potential for loss and disaggregate risk into possible reasons for loss. Early studies elicited laundry lists of VC risk concerns prior to making an investment. For instance, VCs' venture assessments consider the risk of losing the entire investment, being unable to bail out, failure to implement the venture idea, competitive response, and management/leadership failure (MacMillan, Siegel, & SubbaNarasimha, 1985). A separate study found that VC investment criteria included competitive exposure, inexperience risk, viability risk, and cash-out risk (MacMillan, Zeman, & SubbaNarasimha, 1987). Although the specific order varies by study, VCs' highest concerns tend to focus on the market, product/technology, and management (Baum & Silverman, 2004; Tyebjee & Bruno, 1984; Zacharakis & Meyer, 1998). I will expand on these risk categories later in this literature review.

Prototypes – What Type of Risk is Worth Taking?

The ancient Greek philosopher and naturalist Aristotle's pioneering work on categories fundamentally influenced Western systems of classification for over 2,000 years (Studtmann, 2008). He suggested that all subjects and predicates of a proposition can be placed into one of ten categories, denoting substance, quantity, quality, relation, and others. One of Aristotle's tenets is that categories can be subdivided, but they are also exclusive: an object can be placed in one and only one category at a particular level of abstraction. Therefore, Aristotelian systems of classification, such as Linneaus' taxonomy of living beings (i.e., kingdoms, families, genera and species) attempt to establish clear criteria for inclusion in or exclusion from a category (Fancher, 2000).

Most prior research on VC investment risk taking has implicitly taken an Aristotelian approach. In other words, scholars have attempted to specify the content and boundaries of an investable opportunity. It also has been suggested that formalized, consistent investment criteria would improve venture capital portfolio performance (Shepherd & Zacharakis, 2002; Zacharakis & Meyer, 1998, 2000; Zacharakis & Shepherd, 2005). However, a rules-based prescriptive approach conflicts with the Knightian uncertainty inherent in predicting the performance of young, high-tech firms. Because it entail a "fuzzier" approach to classification, modern categorization theory offers a different prism through which to view the

fundamental question of what makes a risk worth taking. Specifically, I will apply prototype theory to venture capital decisions.

Prototype theory claims that individuals recognize how real-world attributes correlate with each other, and thus create mental categories (or prototypes) that encompass naturally-occurring clusters of characteristics (Rosch, 1973; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Because a prototype is inferred from real-world observations of correlating attributes, people broadly agree about the features and members of a commonly experienced category, such as "bird" or "furniture." However, categorical boundaries are not firm: even concrete categories may be composed of a "fuzzy set" of characteristics. For instance, while most birds can fly, people accept that a penguin is a bird because it has a beak and wings. Instead, prototype theory reflects the philosopher Wittgenstein's concept of "family resemblances," where members of a category have overlapping similarities, but it is possible that no single feature is common to all (Biletzki & Matar, 2008). In other words, mentally placing an object or idea into a category is an exercise in pattern recognition (Reed, 1972).

Attributes serve as cues, i.e., they indicate membership in a category. A prototype is a mental model of the characteristics of the most "typical" member of category. These attributes have high "cue validity," meaning that are most likely to be associated with a specific category (Rosch et al., 1976). For example, a beak and feathers are attributes of birds with high cue validity, while the ability to fly has lower

cue validity because not all birds can fly. In other words, depending on their attributes, not all members of a category are equally representative (Mervis & Rosch, 1981) . In fact, some attributes may be applicable to multiple categories; a specific category is identified by the co-occurrence multiple characteristics. Furthermore, categories can share attributes: both airplanes and mosquitoes can fly. A clear-cut category would be mostly composed of attributes with high cue validity. A category with fuzzy borders would include attributes with lower cue validity that may also be relevant to other categories.

Another insight of prototype theory is that categories are hierarchical. The literature refers, for convenience, to three levels: superordinate (e.g., "animal"), basic (e.g., "bird"), and subordinate (e.g. "robin ")(Rosch et al., 1976). Items in two different subordinate categories may have many different features, but also share sufficient similar attributes that place them in a common basic category. Obviously, there may be more than three levels of nested categories: the key point is that higher-level, more abstract, categories tend to include more dissimilar members than lower-level categories, which are more homogenous (Rosch, 1975).

Categorization is a means of cognitive conservation: when we are confronted with a new object or concept, we can compare it to a mental library of prototypes rather than expend time and energy building a ground-up understanding and determining a response. Management researchers have drawn from this psychological insight to explain organizational decision making. Firms' activities can be distinguished

broadly into two types of activities: organizational routines and nonroutine managerial actions, which require significant effort to diagnose the situation, search for options, select an alternative, and then execute the decision (Bromiley, 2005; Cyert & March, 1992). When discrepancies arise between managerial expectations and organizational performance, managers first categorize a situation as either a problem (i.e., worth resolving) or not. If cue discrepancies are persistent, the problem designation serves as a prelude to taking action (Cowan, 1986). An alternative formulation to the problem construct is "strategic issue," which signifies an external development that requires managerial resolution, but whose pattern of attributes may be recognized as either a threat or an opportunity (Dutton & Jackson, 1987; Jackson & Dutton, 1988).

The entrepreneurship literature recently has begun to consider the implications of prototypes on entrepreneurs' and venture capitalists' decisions. The act of recognizing an entrepreneurial opportunity appears to be a form of pattern recognition, where entrepreneurs compare the characteristics of a potential business opportunity situation to the prototypes that they have developed vicariously and/or through personal experience (Baron & Ensley, 2006). Furthermore, entrepreneurs attempt to match their opportunity prototypes at both a superficial and structural level, seeking to align the features and structure of a new technology with the attributes of the potential market (Gregoire, 2005).

Venture capitalists also compare their own prototypes of winning investments to the characteristics of potential portfolio companies (Kirsch, Goldfarb, & Gera, 2009).

Later in this literature review, I will discuss prior scholars' findings on VC's initial investment criteria which tend to be comprehensive, and were derived from surveys, interviews and protocol analyses, but not on actual decisions. In contrast, Kirsch et al. (2009), who examined actual investment decisions, imply that VCs' effective requirements are limited, primarily to the founding team's entrepreneurial experience.

Over the life of a portfolio, VCs may also perceive that their prototypes are contradicted in some way: discrepant environmental cues may challenge VCs' mental models and trigger a sense-making process that results in portfolio reconfiguration when they decide to invest in new types of portfolio firms and/or terminate some existing investments (Moesel & Fiet, 2001). As a result, VCs' post-investment actions can be as important to ultimate portfolio success as their initial investment selections. However, no one has yet tested empirically the effect of specific, firm-level cue discrepancies and/or confirmations on VC post-investment decisions.

Organizational and Psychological Antecedents to Risk Taking

Earlier in this literature review, when I discussed various definitions of organizational risk, I also alluded to influences on risk taking, because the concepts are empirically intertwined: how researchers define risk shapes their findings regarding the action of risk taking. In this section, I will focus on antecedents to organizational risk taking at the organizational and decision-maker levels.

Managerial risk preferences vary with organizational context: an organization whose survival is threatened or that is performing below its aspirations is more likely

to take risks than one that is meeting or exceeding its aspirations (March & Shapira, 1992). Empirical studies have generally supported the prediction that lower prior performance vs. some reference point increases organizational risk propensity. For instance, risk taking is highest for firms closest to bankruptcy, while it decreases as performance improves relative to aspirations (Miller & Chen, 2004). It also has been shown that prior performance is negatively related to subsequent risk taking in the form of strategic change, innovative product launches, and capital investment (Greve, 1998, 2003a, b). However, such risk taking does not necessarily improve performance. For instance, poor performance may increase the likelihood of organizational risk, which subsequently yields poor returns (Bromiley, 1991). Furthermore, declining organizations are more likely to take unprofitable risks which lead to further decline (Wiseman & Bromiley, 1996).

Individuals vary in how they perceive risks and their propensity to take risks. These individual differences interact with attributes of the situation to influence risk taking (Bromiley & Curley, 1992). Differences in risk perception may derive from the decision maker's history, including inertial forces that drive managers to continue to make the types of choices they made in the past as well as whether prior risky decisions produced successful outcomes (Sitkin & Pablo, 1992; Sitkin & Weingart, 1995). For instance, people more prone to take risks tend to be highly extroverted and open, with relatively lower levels of neuroticism, agreeableness, and conscientiousness (Nicholson, Soane, Fenton-O'Creevy, & Willman, 2005). Risk

propensity may be even be hormonal, where males with higher testosterone levels are both more likely to take risks and to become entrepreneurs (White, Thornhill, & Hampson, 2006).

A decision maker's role, goals and personal circumstances may also be related to risk propensity. For instance, entrepreneurs generally exhibit higher risk propensity than corporate managers, with growth-oriented entrepreneurs more willing to take risks than lifestyle entrepreneurs (Stewart & Roth, 2001, 2004). Furthermore, bankers, less successful managers, and older executives are more risk averse than younger, more successful decision makers in other disciplines (MacCrimmon & Wehrung, 1990).

Also at the individual level, decision-maker heuristics and biases may determine the likelihood of accepting or rejecting a risk. In order to explain why people purchase both insurance and lottery tickets, prospect theory posits that people are risk averse in choices involving sure gains and seek risk in choices involving sure losses (Kahneman & Tversky, 1979). Framing influences risk preferences: when mathematically equivalent choices are presented in terms of potential loss, individuals choose the option that entails uncertainty, possibly because it offers the possibility - no matter how slight - to minimize loss. On the other hand, when equivalent choices are presented positively, people seek to conserve gains through certainty. In other words, in the context of a negative frame, people tend to seek risk/uncertainty, while they avoid risk/uncertainty in the context of a positive frame. Empirically, it appears that

positive framing increases the perception of risk, which makes risk taking less likely (Sitkin & Weingart, 1995).

Prospect theory also suggests that people consider each decision in isolation from the broader context, comparing potential outcomes to some reference point regarding that specific decision (Kahneman & Tversky, 1979). The "isolation effect" is in contrast to expected utility theory, which considers the impact of a decision on net wealth and also assumes that preferences will be linear (i.e. that people are risk-neutral) (Schoemaker, 1982). Some strategy research that invokes prospect theory, however, assumes reference point is actually contextual (such as firm performance), thus implying that the decision maker is making an "unmixed gamble," where potential effects will be different levels of loss or different levels of gain distant from the reference point, not a contrast between loss and gain (Bromiley, 2009a).

When their impacts are considered at the decision level (as opposed to the organizational level), most real business decisions are "mixed gambles," meaning that both positive and negative outcomes are possible. By modeling the parameters of prospect theory to a mixed gamble decision, Bromiley (2009b) found that risk-taking arises from complex interactions among available resources, risk propensity, and reference levels, making it impossible to predict a specific outcome based on just one parameter. One of his key findings is that decision makers are especially loss averse to negative outcomes, and therefore strongly risk averse in mixed gambles (Bromiley, 2009b).

The human tendency to avoid loss underlies status quo bias and confirmation bias. Status quo bias refers to people's tendency to prefer the current state of affairs to some change, because the disadvantages of leaving the current state appear to exceed the advantages of a change (Kahneman et al., 1991) have demonstrated that people disproportionately prefer options that are presented to them as the status quo; also, the status quo becomes increasingly preferable as the number of alternatives increases (Samuelson & Zeckhauser, 1988). This bias is related to people's desire to avoid the regrets that may arise from action and their uncertainty regarding the potential consequences of alternative actions (Anderson, 2003). Individuals also tend to interpret new evidence in ways that confirm the favorableness of actions that maintain the status quo.

Confirmation bias is the tendency to selectively acquire and use evidence that supports a pre-existing perspective (Nickerson, 1998). Therefore, in the face of conflicting evidence, people will tend to notice and remember the information that supports their initial position while discounting information that challenges that position.

Escalation of commitment also has implications for managers' relationship to risk. Both organizational constraints and individual cognitive biases combine to increase the likelihood that managers will persist with an existing course of action, especially as more resources are expended over time (Staw, 1981). This "sunk cost effect" is manifested by managers' increasing tendency to continue an endeavor once an

investment in money, effort and time has been made (Arkes & Blumer, 1985). Such behavior may be due to political pressures to fulfill prior inter- or intra-organizational commitments, or a psychological need to appear not to have wasted all the money that has been spent so far. Managers appear to believe that it is less risky to retain or even to increase commitment to a known course of action vs. redirecting resources and attention to less familiar tactic or strategy – a variant of preferring "the devil you know" to the one not known. The tendency to sustain and/or escalate commitment has been documented in multiple organizational contexts: multiyear capital projects (He & Mittal, 2007; Ross & Staw, 1993; Staw & Ross, 1987), commercial lending (McNamara & Bromiley, 1997, 1999) and venture capital (Guler, 2007).

Observation of the escalation of commitment phenomenon led to the broader threat-rigidity hypothesis, which argues that threatening conditions lead individuals to restrict information processing and constrict control (Staw, Sandelands, & Dutton, 1981). At the organizational level, a threat-rigidity response would lead to continuation of prior policies, especially in the face of bad news. Furthermore, organizational options may be so constricted by decision makers' assumptions, beliefs, and self-interests that little or no strategic change can occur (Ocasio, 1995). Also, the nature of threat may be important to the nature of the response: control-reducing threats (such as increased government regulation) lead to internal actions and falling back on existing strategies, while the prospect of losses leads to riskier, externally oriented organizational actions (Chattopadhyay, Glick, & Huber, 2001). Finally,

organizational resources also come into play: poorly performing firms with greater resources are more likely to expand capacity (i.e. make a strategic shift and take more risk) than resource-constrained poor performers (Audia & Greve, 2006).

Risk Acceptability: The Influence of Controllability

At the level of the risk "problem" itself, multiple dimensions contribute to a manager's determination whether or not a risk is acceptable. Risk acceptability has been studied by both psychology and management scholars, with similar findings. A common theme throughout both the disciplines is that more controllable risks appear to be more acceptable to decision-makers.

MacCrimmon's and Wehrung's (1986) study of over 500 executives in multiple disciplines and industries identified three dimensions of risk. First, there may be a lack of control over the size, likelihood or potential exposure to loss. Second, there may be a lack of information regarding the size, likelihood or potential exposure to loss. Finally, there may a lack of time, meaning that a decision must be made before full knowledge if gained regarding the size, likelihood or potential exposure to loss. These components are viewed by managers not only as potential reasons for loss but also as levers to mitigate the effects of risk. For instance, rather than immediately deciding to accept or reject a risk, a manager may choose to defer action in order to gain information that could then be applied to controlling the potential effect of a risky decision.

Slovic and his colleagues mapped individuals' perceptions regarding 19 risk characteristics of 90 hazards, ranging from jogging to microwave ovens to nuclear power to terrorism. They found that risk attributes cluster in three factors: the number of people exposed to the risk, the degree to which the risk invokes feelings of dread, and the degree to which the effects of the risk are unknown. The most unacceptable risks are those that hurt more people, invoke greater feelings of dread, and may produce effects beyond those that are already known. Within the "dread" factor, a risk's perceived controllability appears to be especially important (Slovic, Fischhoff, & Lichtenstein, 1980).

The importance of the controllability dimension has been broadly validated in behavioral decision theory research. For instance, people accept risks that they feel they can control either by decreasing the likelihood of loss and/or by affecting the level of loss (Klein & Kunda, 1994). Driving a car is an example of a more preferable risk that is perceived to be more controllable while being a passenger in an airplane is an example of a less preferable risk that is perceived to be less controllable. Furthermore, even in uncontrollable situations, such as games of fortune, individuals appear to believe that small acts of control, such as how dice are thrown or personally spinning a wheel of fortune, will improve their odds (Bazerman, 2006). In other words, while perceived control may or may not be realistic, even the illusion of control increases self-confidence and risk taking (Langer, 1975).

Prior management literature also has identified controllability as an important risk consideration. As mentioned earlier, rather than passively accepting a risk, managers attempt to control the risk, thus hoping to increase the odds of a positive outcome. They distinguish between business risk taking and gambling because they believe their actions increase the potential for gain, and decrease the likelihood and level of loss, before, throughout the process of making and implementing a decision (MacCrimmon & Wehrung, 1986; March & Shapira, 1987; Shapira, 1995). Each risk dimension, or potential source of loss/gain, serves as a lever for decision-maker intervention, with managers exhibiting greater preference for domains that are more amenable to their control (MacCrimmon & Wehrung, 1986; Shapira, 1995).

The perception of controllability is closely related to decision-makers' familiarity with a risk. Generally speaking, individuals are more likely to accept risks that are not novel and that they perceive are better understood scientifically (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic et al., 1980, 1985; Yates & Stone, 1992a). Furthermore, people are more willing to take risks about which they feel more knowledgeable (Heath & Tversky, 1991). In business organizations, managers will avoid risks that about which they lack information, but will be more willing to accept risks where they can apply their expertise (MacCrimmon & Wehrung, 1990). For managers, expertise increases the perception of post-decisional control, i.e. the potential to apply knowledge and skills to mitigate risk after a decision has been made (Shapira, 1995).

Venture Capitalists' Initial Investment Opportunity and Risk Considerations

Prior researchers have identified two components of entrepreneurial opportunity recognition. First, the entrepreneur applies superior knowledge or insight to discover or create new means-ends relationships (Casson, 2003; Shane & Venkataraman, 2000) . Second, the entrepreneur must determine if the new insight is sufficiently rewarding – either psychically or financially – to be worth pursuing. In other words, entrepreneurship lies at the "nexus" of the individual and the opportunity (Shane, 2003).

An entrepreneurial opportunity is not necessarily the same as a venture capital investment opportunity for several reasons. First, the VC does not discover or create the means-ends relationship, but rather assesses an opportunity that was identified previously by the management team of firm seeking venture capital. Second, the VC's initial assessment emphasizes financial, not psychic rewards. Third, in assessing the potential return, the VC must balance the potential for gain vs. hazard of losing their investors' money. As a result, for the venture capitalist, opportunity and risk are intertwined considerations.

Whether it is due to temperament or experience, venture capitalists are more willing to take risks than other types of managers, especially bankers (MacCrimmon & Wehrung, 1986). VCs operate in a world of highly subjective risk, meaning that there is uncertainty with potential for loss at the time of their initial investment, but that experience and information can reduce the uncertainty over time (Moesel et al., 2001).

Reduced uncertainty does not necessarily mean better news: the VC also may be forced to acknowledge that a portfolio firm is unlikely to succeed, thus recognizing a loss by terminating the investment. In fact, the likelihood of individual portfolio company success can be significantly worse than the odds of a coin flip. Even though venture capitalists specialize in high-potential businesses, they experience high closure rates of their portfolio companies, ranging from up to 60%, and lose money on the majority of their investments (Zacharakis & Meyer, 2000).

However, even if they are broadly more risk-prone than managers in other disciplines, VCs do make strong distinctions among investment opportunities, investing in only a tiny proportion of the companies they consider. As mentioned earlier, research on VCs' initial investment decision criteria has identified broadly consistent domains of concern in three areas: management, product/technology and market. VCs especially appear to heed the advice of a pioneering venture capitalist who advised preference for a firm with a grade B business idea with grade A management over one with a grade A business idea with grade B management (Bruton, Fried, & Hisrich, 1997). This anecdote has received empirical support: although VCs identify multiple screening criteria, they most heavily weight the quality of management in their initial investment decisions (Baum & Silverman, 2004; Kirsch et al., 2009; MacMillan et al., 1985; Zacharakis & Meyer, 1998; Zacharakis & Shepherd, 2005).

VCs also place the heavy emphasis on market conditions, including the potential market size and competitive landscape (Hall & Hofer, 1993). In fact, VCs place greater emphasis on market criteria than do angel investors, who are relatively more concerned with management risk (Fiet, 1995; Mason & Stark, 2004). U.S.-based VCs also focus more on market factors than do Chinese venture capitalists, which place even greater importance on human capital factors (Zacharakis, McMullen, & Shepherd, 2007).

Technology and product characteristics are also key VC investment criteria. Because VCs generally invest in firms that produce knowledge-intensive, high-technology products, the existence of patents or other intellectual property protection is an especially important initial investment criterion (Baum & Silverman, 2004; Tyebjee & Bruno, 1984) . From the venture capitalist's perspective, technology risk relates to the ability of the potential portfolio company to actually develop and a produce a commercially viable product (Kaplan & Stromberg, 2004).

VCs also have financial concerns, such as the potential profitability of an investment candidate's business model, as well as the options for a profitable exit (Fried & Hisrich, 1994; Mason & Stark, 2004). However, the specific financial risk of a potential investee running out cash is not a VC criterion. In fact, VC investment candidate firms typically need financial capital not only to grow, but to survive; the mix of financing and strategic support is where the VC adds value (Baum & Silverman, 2004; Gorman & Sahlman, 1989). Furthermore, financial risk rises and

falls throughout the VC-portfolio company relationship by design. One way that VCs retain leverage over portfolio firms is by manipulating financial risk over time: after the initial investment, future capital infusions are staged contingent on the achievement of specific business milestones (Gompers, 1995). This often-recurring financial vulnerability prompts the VC to reconsider whether a portfolio firm continues to present a winning investment opportunity.

VCs' Post-Investment Opportunity Re-evaluation

Once a company enters the portfolio, the venture capitalist acquires increased knowledge and new governance powers that may alter the VC's propensity to embrace or reject specific risks. A venture capitalist may try to mitigate post-investment risk by monitoring, advising, and – if possible – intervening in the operations of its portfolio companies (Fried & Hisrich, 1995). Furthermore, they may have contractual mechanisms such as pay-for-performance to company founders, naming rights to a majority of the board of directors, liquidation rights. and rights to prevent dilution of their ownership in the event of later financing (Kaplan & Stromberg, 2004).

Prior entrepreneurship research has explored the shifting dynamics of the ongoing relationship between venture capitalists and the managers of their portfolio companies. For instance, it has been suggested that cooperation arising from relationship-specific investments (such as the VC investing time to better understand the potential of a portfolio firm's technology) and knowledge-sharing routines (such as frequent personal interactions and effective board meetings) can generate relational rents

benefiting both the VC and the portfolio firm (De Clercq & Sapienza, 2001). A high level of communication and commitment increase both the quality and quantity of a VC's value-adding activities, thus leading to higher portfolio company performance (De Clercq & Fried, 2005). On the other hand, VC involvement may also be associated greater conflict with the portfolio company management team and lower performance, possibly because portfolio company was already performing poorly when the VC intervened (Higashide & Birley, 2002). Furthermore, subpar portfolio company performance may provoke greater VC interventions without necessarily achieving positive results. For instance, Guler's study of VC portfolio actions determined that political and institutional factors make VCs increasingly reluctant to terminate unsuccessful portfolio investments; she found that later financing rounds generated declining investment returns (Guler, 2007).

As a result of post-investment information access and intervention mechanisms, it is possible that a risk that was unacceptable at the time of the initial investment becomes acceptable after a firm has entered the portfolio. On the other hand, increased knowledge and/or changing market conditions may call into question whether a portfolio firm continues to present a profitable investment opportunity for the VC. In other words, while prior research has identified initial investment criteria and ongoing risk-mitigation mechanisms, the literature has not addressed if and how a VC's risk criteria change after an initial investment in a portfolio company.

Research Opportunities and Contribution

In their review on risk in strategic management research, Bromiley et al. suggest opportunities for future studies, several of which will be addressed in this dissertation. First, they point out that "we want to understand managerial strategic decisions, but lack research on actual decisions" for many practical reasons (Bromiley et al., 2001). This dissertation examines specific risky decisions by a venture capital firm to reinvest in, hold or divest its strategic assets. A second concern is that many past studies used risk measures that may not reflect the way managers think. This dissertation analyzes the influence of multidimensional risk measures actually used by the managers in the sample. A third opportunity is to better understand "the lag structure of risk return relations," which requires a longitudinal research design. This dissertation uses a longitudinal design that relates prior risk assessments with subsequent managerial actions.

My research also capitalizes on other opportunities emanating from the entrepreneurship literature. First, I apply prototype theory and behavioral decision theory to provide theoretical explanations regarding prior descriptive findings on VC investment criteria. I show that different risk dimensions occupy different positions within the prototype of a firm that seeks venture capital and its two subcategories, winning and losing investments. By distinguishing among these risk dimensions, I offer new insights on how various risk facets differ in their effects on VC decisions.

Second, while most venture capital investment research examines the initial financing decision, I break new ground by determining how risk decision dynamics evolve after the first resource commitment. While an initial investment establishes the starting parameters for the VC-portfolio company relationship, the ultimate success of that investment also depends on the VC's subsequent decisions, especially whether and when to reinvest or terminate investment.

Third, while prior research primarily has emphasized binary risk decisions (to either accept or reject risk), I provide a more comprehensive and realistic view by including the option to hold the investment without either increasing or terminating the financial commitment. This nuanced approach more accurately reflects the practical circumstances of VC portfolios, as well as the psychological reality that doing nothing differs significantly from both positive and negative actions (Anderson, 2003).

In summary, this is the first empirical study to examine the influence of specific risk dimensions on VCs' post-investment portfolio decisions. I advance both management and entrepreneurship research by integrating prototype theory with behavioral decision theory to generate hypotheses that are tested using a rich, longitudinal data set of real-time, risk-based VC decisions.

CHAPTER 3: THEORY AND HYPOTHESES

All nonroutine managerial decisions entail some degree of risk, meaning that they entail uncertainty and potential loss (MacCrimmon & Wehrung, 1986). Risk is especially salient for early stage venture capitalists because they invest in young, usually high-technology businesses that often have incomplete management teams, unproven products and unpredictable markets. As each portfolio firm's story unfolds over time, the VC must decide whether to reinvest in, hold, or terminate its investment. Each of these actions represents a different commitment posture in response to the VCs' assessment of the portfolio firm's current condition and future prospects.

In this chapter, I will address how the dimensions of a VC's risk assessment affect post-investment portfolio decisions. I will begin by considering the nature and implications of the VC's repertoire of post-investment financial actions. I will then relate those actions to the degree to which a portfolio firm matches a venture capitalist's mental image, or prototype, of a winning portfolio firm vs. a losing investment. The balance of this chapter will show how financial risk, market risk, technology risk, and management risk fit into the winner/loser prototypes and offer hypotheses that predict VC post-investment actions in response to each risk dimension.

Post –Investment Financial Alternatives: Hold, Reinvest, Terminate

After the initial investment, the relationship between an early-stage VC and a portfolio company typically last s approximately 5-7 years (Fenn, Liang, & Prowse, 1997), although the duration can range from months to about 10 years . During this

period, the VC may go beyond simply monitoring its investment to playing an active role in a portfolio firm's governance and operations. VC value-added activities may include providing strategic advice, mentoring the CEO, and connecting the portfolio firm to the VC's network of professional contacts (Sapienza & Manigart, 1996). A broader typology of venture capitalists' potential value-added activities includes legitimation, outreach, recruiting, mandating (i.e. setting contractual terms), strategizing, monitoring, consulting, and possibly even operating the portfolio firm (Large & Muegge, 2008). These activities give the venture capitalist a window into the operations of a portfolio firm and its potential market, thus enabling the VC to make an increasingly informed determination of whether or not the venture deserves continued financial support.

Venture capitalists limit their potential losses by providing capital only sufficient to fund a portfolio company's developmental activities for a limited time while retaining the option to invest additional money later, contingent on the achievement of pre-specified milestones (Gompers, 1995). As a result, VCs regularly reassess the composition of their portfolios and reconsider whether to reinvest in a portfolio company, continue to hold it without adding capital, or to terminate the relationship. In this section, I will evaluate each financial action in terms of its cumulative capital cost, required cognitive effort, reversibility, change in commitment level, potential for decision regret, and the VC's implied expectations of the portfolio firm's future.

Holding, which means that cumulative investment in a portfolio firm's is unchanged, is the default financial "action" (or non-action) for multiple reasons. First, the VC avoids depleting a limited capital pool, thus making capital available for other investments. Second, cognitive effort and managerial resources are conserved. To make an affirmative decision to either reinvest or terminate an investment in a portfolio company, a VC must depart from its daily routines in order to make and execute the decision. Nonroutine decisions are expensive because they require effort and time to gather information, determine an action, gain consensus regarding that action, and then execute the decision (Nelson & Winter, 1982). Therefore, due to the time and expense of this search process and subsequent implementation, an active decision that departs from normal routines is relatively rare compared to the status quo (Cyert & March, 1992).

Third, holding is reversible because it generally does not preclude future reinvestment or investment termination.[1] Rather, the VC can continue to monitor the portfolio firm and engage in other nonfinancial value-added activities intended to enhance its value. This approach is consistent with the finding that managers perceive a risk-based decision (in this case, the initial investment decision) to be the beginning of a process during which they can intervene to shape a favorable outcome (MacCrimmon & Wehrung, 1986; March & Shapira, 1987; Shapira, 1995).

[1] Holding may not be an option in some cases. An investment contract may require the VC to "pay to stay," meaning that the VC is required by its coinvestors to either join them in a follow-on investment or terminate its interest in a portfolio firm.

Fourth, holding may also reduce the likelihood of decision regret, or remorse subsequent to making a decision. Behavioral decision theory has shown that people tend to exhibit status quo bias, a preference for the current state of affairs, because the disadvantages of leaving the current state appear to exceed the advantages of a change (Kahneman et al., 1991; Samuelson & Zeckhauser, 1988). This bias toward inaction is related to people's desire to avoid the uncertainty regarding the potential negative consequences of alternative actions (Anderson, 2003).

The implications of holding are ambiguous. While the VC's financial commitment is unchanged, holding does not indicate the degree to which other resources are being expended. For instance, a VC who is the lead investor may be active on the board of directors and participate actively in determining portfolio firm strategy and/or the composition of the management team. On the other hand, a VC with low portfolio firm ownership may play a passive role and devote minimal partner time and effort.

It also is impossible to infer whether the VC is optimistic or pessimistic about a portfolio firm's prospects. Holding simply indicates that the portfolio firm has sufficient cash to persist without VC financial intervention. The firm may be drawing on its capital reserves to successfully develop its capabilities and revenue potential, or it may be experiencing significant problems, but have sufficient capital to survive.

Follow-on investment is the VC's second alternative for financial action. In other words, the venture capitalist has increased its investment in the portfolio firm. An

increase in cumulative capital cost may be by design: a typical early-stage company requires two to four capital infusions after the initial VC investment (Davila, Foster, & Gupta, 2003; Guler, 2007). A follow-on investment requires managerial effort because the initial investment does not guarantee future capital infusions. Instead, the VC must evaluate whether a firm qualifies to receive additional funds based on prior agreements regarding what the portfolio company should have achieved, i.e. completion of a product prototype, submission of a patent, product beta testing, etc.[2]

The VC also must coordinate with co-investors and possibly revise the terms under which the follow-on funding is provided. Follow-on investment is partially reversible: while the money may be gone forever, the VC does have the future option to terminate the portfolio investment. Follow-on investments also keep open the option of future gains from the portfolio company, but at an increased cost. Still decision regret is a possibility, because follow-on investment requires expenditure without certainty of positive outcome.

The additional capital implies that the VC has made a greater commitment to the portfolio company. This commitment may or may not be rational. Follow-on investments may be both the cause and result of the VC's escalation of commitment (Staw, 1981): political and psychological forces may influence the VC to behave

[2] The decision to commit more funds indicates an intention to provide a portfolio company with capital in "tranches." This money may be only partially exhausted if a portfolio firm's performance changes dramatically for either better (e.g. generating unexpected positive cash flow) or worse (e.g. not achieving expected milestones).

consistently with prior actions by making additional capital infusions. In fact, portfolio firms that receive multiple follow-on investments generate lower returns than those that receive fewer late-stage rounds of funding (Guler, 2007). On the other hand, the follow-on investment may be an indication the portfolio firm is doing exactly what it is supposed to do: developing products and operational capabilities, and building customer demand. However, whether or not the sentiment is misguided, a follow-on investment also indicates some level of optimism about the future prospects of a portfolio company.

Termination is the VC's third financial alternative. A VC's exit from a portfolio investment may take several forms: an initial public offering of the company's stock, a "trade sale" of either the business entity and/or assets to a strategic investor, or a write-off when there is no market for the company or it has no saleable assets). According to the National Venture Capital Association, 14% of the firms first funded by VCs in 1991-2000 went public, 33% were acquired, and up to 57% failed (NVCA, 2009). A separate study estimates that about two-thirds of VC investments are total write-offs (Hochberg et al., 2007). In other words, VCs' most common investment termination is to withdraw managerial support from a firm and write off the investment in its accounting records. While initial public offerings generally generate high returns to the VC, trade sales can produce either a significant profit or large loss. The bottom line is that, at the time of terminating its investment, the VC's most common outcome is a negative return.

Investment termination implies that, like holding, the cumulative capital cost is unchanged. However, unlike holding, a termination is irreversible. On the one hand, the VC has no risk of incurring additional costs at a future date, as it would if it held the investment; on the other hand the VC must recognize the final value of the portfolio firm on its books. Furthermore, most portfolio investment terminations incur a loss, which is problematic because individuals and professional investors typically are loss-averse and therefore tend to avoid or delay recognizing losses (Kahneman & Knetsch, 1991; Shefrin & Statman, 1985). Investment termination is a major decision. VCs expend significant managerial resources and cognitive effort to analyze a portfolio firms prospects to determine if the time has arrived to sell and at what price, or whether a complete write-off is required.

Investment termination eliminates the VC's commitment, possibly with a gain but most likely at a loss. Even if the return is positive, terminating an investment is a fundamentally pessimistic act: the VC has determined that the value of its investment will not increase beyond its current value within the lifetime of the limited partnership.

Table 1 summarizes the characteristics of a VC's post-investment financial actions. It shows that reinvesting, holding and terminating are not points on a single continuum, but three distinct alternatives with their own respective characteristics. For instance, reinvesting and terminating investment both require higher cognitive and managerial effort than holding. On the other hand, cumulative capital invested stays the same for holding and terminating, while it is increased by reinvesting. Termination is the

starkest alternative in terms of potential for decision regret and reversibility, while reinvesting is somewhere in the middle and holding is at the lowest level. In yet another configuration, holding implies the minimal or no change in commitment level, which is increased by reinvestment and eliminated by termination. Finally, while reinvestment implies optimism and termination indicates pessimism, it is not possible to infer accurately either expectation from simply continuing to hold a portfolio company. The implication of Table 1 is that termination is not the simple opposite of follow-on investment, nor is holding necessarily the opposite of taking financial action. Instead, the complex, and sometimes conflicting, implications among the alternatives suggest the possibility that the VC will use a different logic to arrive at each outcome.

Table 1: Comparison of VC Post-Investment Alternatives

	Hold	Reinvest	Terminate
Cumulative Capital Invested	Same	Increase	Same
Cognitive Effort	Lower	Higher	Higher
Reversibility	Yes	Partial	No
Change in Commitment Level	Minimal	Higher	Eliminate
Potential for Decision Regret	Lower	Moderate	Higher
Future Expectations	Ambiguous	Optimistic	Pessimistic

In this study, I examine influences on the decision to depart from the default of holding a portfolio investment. I will focus on two options vs. holding: making a follow-on investment and terminating the investment at a loss. I am not focusing on profitable exit because it can be an ambiguous decision. While a few portfolio company exits are highly profitable, clear-cut "wins," others occupy a murky ground above break-even but below an initially aspired-to return on investment. Prior researchers have shown that decision makers' risk preferences shift with their firm's performance relative to aspirations, which adapt to past organizational performance and the performance of comparable firms (March, 1988, 1994; March & Shapira, 1992; Miller & Chen, 2004). However, in the early stage VC setting, post-investment portfolio firm performance is difficult to gauge in the absence of traditional revenue and/or profit measures. Also, new, high-tech companies are unlikely to have directly comparable competitors with publicly available market values.

I have characterized follow-on investment as a consequence of VC optimism while investment termination indicates VC pessimism regarding a portfolio firm's future prospects. At the time of the initial investment, the VC's due diligence process concluded that a venture's characteristics match the pattern of the winning investment prototype. In other words, initially all portfolio firms look like "winners" to the VC. Post-investment, the firm and its environment will continue to evolve and the VC will continue to evaluate its potential. VCs will retain their optimism about firms whose characteristics continue to correspond to the pattern of a winning investment prototype.

Alternatively, VCs will become pessimistic about firms that start to exhibit the pattern of a losing investment prototype. The following section details the prototypical characteristics of firms that seek venture capital, including winning and losing investments.

VC Prototypes of Portfolio Candidates

People use categories to make sense of, and respond to, stimuli. By grouping objects or people or concepts into categories, we conserve cognitive effort in order to react more quickly and efficiently than if we were to painstakingly evaluate each stimulus we encounter. However, it appears to be easier to recognize membership in a category than to articulate a definition for it. The mid-20th century philosopher Wittgenstein famously considered the definition of the category "game," finding that no single feature is common among all games, but that they are connected by a series of overlapping similarities, which he coined "family resemblance" (Biletzki & Matar, 2008). As subsequently determined in psychological research, people determine membership in a category by comparing an object or concept to a mental prototype composed of characteristics induced from prior observations (Rosch, 1973).

In the context of prototype theory, objects and concepts can be grouped into hierarchies of categories, e.g. a robin is a type of bird which is a type of animal (Rosch et al., 1976). A few traits are common among the subordinate, basic and superordinate categorical levels. The difference among the levels is that shared traits become less specific and often more abstract as the categories move to higher levels.

The horizontal relationship among categories is also important, because some characteristics may be unique to particular groups while others can be common to more than one category – e.g. red is the color of many apples and all stop lights. Furthermore, while categories may be based on natural groupings of characteristics, human perception and needs can add distortion. As a result , category membership is not specifically defined, but a fuzzy set composed of a pattern of characteristics, some of which are central and commonly recognized, while others are more peripheral and/or recognized by fewer people (Rosch et al., 1976).

Prototype theory is a useful framework to explain VC initial investment criteria and post-investment decisions. Before addressing what a "good" opportunity is, it is first necessary to consider what type of firm would seek VC funding. Companies that pursue capital from venture capitalists typically have the following central characteristics: high growth goals, proprietary intellectual property and/or capabilities, and high capital needs in the tens of millions of dollars (Timmons & Spinelli, 2003; Timmons, Spinelli, & Zacharakis, 2004b; Ueda, 2004).

High capital requirements and lack of significant revenue make financial risk endemic to early-stage firms both before and after VC investment. Recurrent financial risk is a hallmark of the post-funding VC-venture relationship. VCs stage their capital infusions over multiple years contingent on achievement of future milestones such as product development, testing, market launch and, ultimately, market expansion (Gompers, 1995). High financial risk, meaning that a firm lacks sufficient capital to

survive and/or pursue its growth plans, exists when a firm seeks venture capital, then recedes and recurs with each funding round until a VC-backed firm generates sufficient revenue to be self-sustaining. In other words, financial risk is a recurrent characteristic of the prototype of firms that seek venture capital, not necessarily of a winning or losing portfolio investment.

Venture capital research generally agrees on the pattern of characteristics of a winning portfolio investment opportunity. While there is no single, definitive list of early stage company risk factors, the categories common in new venture business plans have become largely standardized and can be used as indicators of venture capitalists' concerns. The typical business plan includes sections on the market, the product/service and its underlying technology, the economics of the business, and the management team (Sahlman, 2008; SCORE, ; Timmons, Spinelli, & Zacharakis, 2004a). These functional categories are addressed in business plans because they provide a comprehensive view of the business that allows potential investors to determine whether to invest in a new venture based on its potential risks and return.

Through the lens of prototype theory, lists of VC funding criteria constitute the "fuzzy set" of characteristics of a good portfolio investment. The criteria may include market attractiveness, product differentiation, managerial capabilities, environmental threat resistance (i.e. the firm's ability to withstand competitive threats or economic changes), and cash-out (or harvest) potential (Tyebjee & Bruno, 1984). A widely-used textbook's list includes industry and market, economics, harvest issues, competitive

advantage issues, management team and strategic differentiation (Timmons & Spinelli, 2003).

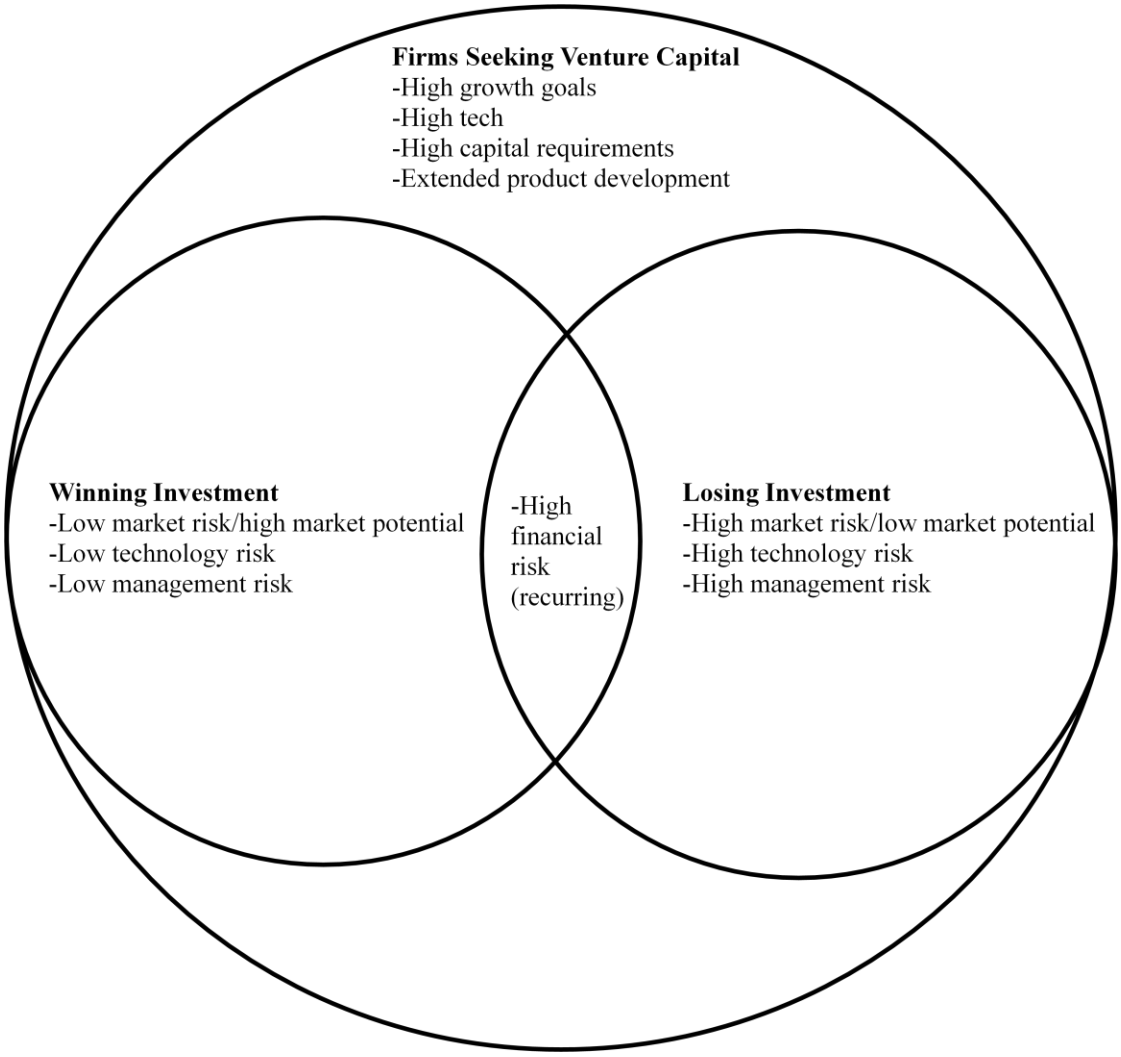
Prototype theory explains that fuzzy sets do not contain equally representative characteristics. A subset of attributes exhibit higher "cue validity," meaning that they accurately associate an object with the correct category with greater frequency (Rosch et al., 1976). Cue validity can help explain the apparent contradiction between venture capitalists' comprehensive lists of characteristics of good investments vs. the relatively short list of attributes they actually consider when screening portfolio candidates. It has been argued that less-comprehensive screening degrades the quality of VC investment decisions (Shepherd, 1999b; Shepherd & Zacharakis, 2002; Zacharakis & Shepherd, 2005). However, categorization theory suggests that it is more efficient for VCs to use characteristics with high cue validity during their initial screening, with the option to broaden their inquiry later during due diligence. This approach conserves cognitive and managerial resources at the possible expense of a type 2 error – a great portfolio candidate that lacks central characteristics typical of other good investment opportunities.

In practice, early-stage venture capitalists emphasize a few characteristics to screen portfolio candidates. George Doriot, a prominent venture capital pioneer, was quoted as saying, "Always consider investing in a grade A man [sic] with a grade B idea. Never consider investing in a grade B man with a grade A idea'" (Bruton et al., 1997). A heavy emphasis on features of the founder and/or leadership team has been

empirically supported in multiple venture capital studies (Baum & Silverman, 2004; Feeney, Haines Jr., & Riding, 1999; Fiet, 1995; Shepherd, 1999a; Shepherd, Ettenson, & Crouch, 2000). Other studies have acknowledged the importance of management, but placed greater emphasis on attributes associated with the market or the product/technology or the market (Fiet, 1995; Hall & Hofer, 1993; Mason & Stark, 2004).

In summary, while there may be some disagreement on their relative importance, strong management (i.e., low management risk), attractive technology (i.e., low technology risk), and high market potential (i.e., low market risk) and can be inferred to be central characteristics of a winning portfolio investment. Conversely, high management, technology and market risk are characteristics of a losing portfolio investment. I will expand on each of these risks later during hypothesis development. Figure 1 depicts a diagram of the prototype of firms that typically seek venture capital, as well as the winning investment and losing investment subcategories.

Figure 1: VC Prototypes of Portfolio Candidates



This section has drawn on prior findings of VC ex ante investment criteria to argue that high financial risk is characteristic of the broader category of firms that seek venture capital, and that low market, technology and management risk are central characteristics of the prototype of a winning portfolio investment. Since financial risk

may be a symptom of either impending success or possible failure, it follows that "aggregate" risk is not necessarily a meaningful predictor of VC action. Instead, managers' risk assessments are noncompensatory: a low risk dimension does not necessarily offset a high risk characteristic because managers resist consolidating different risk dimensions into a single measure (Shapira, 1995).

The following hypotheses will consider the separate effects of financial, market, technology and management risk. While categorization theory provides a helpful framework to attach meaning to each risk dimension, the simple location of a risk characteristic within a prototype may or may not predict VC action. When the news is good, i.e. when a portfolio firm looks like a winning investment, then the VC will be more likely choose to increase commitment by making a follow-on investment. However, because investment termination is not the obverse of reinvestment, it does not follow that a VC will necessarily withdraw support from a portfolio company that "looks like" a loser. While termination implies pessimism (an expectation that a firm's prospects cannot be improved), risk severity is changeable and may be amenable to VC intervention. If a portfolio firm's risk characteristics fall into the losing investment category, then the VC may seek to reduce risk severity through strategic intervention and/or venture management changes (Kaplan & Stromberg, 2004; Tyebjee & Bruno, 1984). However, not all risks are equally amenable to mitigation. In addition to prototypes, the hypotheses regarding investment termination

will also take into account the degree to which risk dimensions are controllable and familiar to the VC.

Financial Risk

Financial risk refers to whether a venture's current financial condition and/or future financial prospects jeopardize whether it will achieve the VC's initially expected return. "Cash runway," i.e. the length of time a firm can persist without a capital infusion, can indicate financial risk. Other indicators may include the amount of capital and length of time required until the business is self-sustaining. Finally, financial risk may also be signaled by the ability of a portfolio firm to attract additional capital from sources beyond the VC.

As discussed earlier, waxing and waning financial risk is endemic to early stage VC-backed companies. Young companies with high capital needs are inherently financially risky at the time of the initial investment because they need money to develop their products and organizational capabilities. If the portfolio candidate does not have high financial risk, it probably would use other sources of capital, such as self-funding or a bank loan, which are higher in the entrepreneur's "pecking order" because they do not require sharing ownership or decision rights with new outsiders (Myers, 1984). Once a firm has entered the VC portfolio, its financial risk may increase by design. Venture capitalists typically "stage" their investments, investing only enough capital to get the portfolio company to its next milestone, thus retaining higher leverage over management, limiting the capital at risk, and retaining the option

to terminate (Gompers, 1995). Future periodic capital infusions are contingent not only on achievement of milestones but the VC's perspective on the long-term value of the portfolio company.

As mentioned earlier, high portfolio company financial risk is an ambiguous cue. On the one hand, a portfolio company may have consumed cash appropriately for product development, production and distribution, and/or sales growth, thus positioning it well for future success. On the other hand, financial risk may be a symptom of underlying problems, such as overspending on development or anemic sales due to lack of market acceptance. In other words, financial risk is characteristics of both investment losers and winners: it can pose either a threat or an opportunity to the VC investor.

Managers typically perceive threats as environmental cues that are negative, uncontrollable and have the potential for loss, while they view opportunities as positive, controllable and have potential for gain (Dutton & Jackson, 1987). However, the two categories also have overlapping qualities including high priority, pressure for quick action, and the potential for significant loss or gain (Jackson & Dutton, 1988). High financial risk appears to straddle the threat and opportunity categories. It is high priority because VC funds' relatively small size (typically only 20-30 investments at any one time) implies that each portfolio firm's performance has material impact on the VC's return (Jääskeläinen, Maula, & Sepp, 2006; Kaiser & Rainer, 2007). High financial risk also requires quick action because – by definition - the portfolio firm

does not have sufficient cash reserves to persist or sufficient revenues to be self-sustaining. Finally, because financial risk is not an indicator of portfolio firm health, addressing it can lead to either potential gain or loss.

Increasing financial risk may lead to follow-on investment for several reasons. First, the portfolio company may have successfully met the objectives to which it agreed with its investors and now requires additional capital because product development, market launch and/or sales growth are projected to consume its remaining cash. When this expected development occurs, the VC is likely to help the young company obtain additional financing (Gorman & Sahlman, 1989), including making its own follow-on investment. Such progress may be dramatic even before the venture has generated sales revenue or positive cash flow. Second, the VC may feel forced to participate in a new round of financing initiated by other investors in order prevent dilution of its ownership position, despite misgivings about a portfolio company (Guler, 2007). However, even in this case, the portfolio company must have sufficient prospects that the members of the investment syndicate perceive it is worth receiving additional capital. Third, financial risk may also induce a venture capital firm to "double down" on its investment in order to avoid recognizing a loss. Simply holding the investment may not be seen as an option: if the VC does not make the follow-on investment, it is effectively dooming a portfolio company in need of capital.

In summary, increasing financial risk may prompt greater financial commitment by the venture capital firm. The follow-on investment may be an

indication of portfolio company success, or it may be a way for the VC to buy time while attempting to address the portfolio firm's problems.

H1a: The likelihood of follow-on investment is positively associated with financial risk.

On the other hand, a venture capitalist may instead choose to abandon its investment in a portfolio company that exhibits high financial risk. Termination may take place even if the VC is forced to recognize a loss on its investment. In this situation, the VC has determined that the prospects of portfolio firm cannot be salvaged, and that it would be better to redirect managerial and financial resources to more promising portfolio companies. In other words, the VC's response to poor performance and poor prospects is to depart from the prior strategy and search for an alternative course of action (Bromiley, 2005; Cyert & March, 1992).

While all investors may be reluctant to recognize losses (Shefrin & Statman, 1985), venture capitalists do accept the fact that the majority of portfolio investments will be terminated at a capital loss (Zacharakis & Meyer, 1998). Increasing financial risk increasingly requires some kind of VC action, and if the VC believes that a financially risky portfolio firm's prospects will not improve, then the investment will be terminated.

H1b: The likelihood of investment termination is positively associated with financial risk.

In summary, because recurring financial risk is a characteristic of both winning and losing portfolio companies, it positively influences the likelihood of both follow-on investment and investment termination vs. holding. Increasing financial risk creates urgency for action: the VC must either reinvest or terminate investment. Other risks provide less ambiguous signals regarding whether a portfolio firm is likely to be a winner or loser. However, the category alone does not necessarily determine whether action will occur. I will now address the role of risk controllability in influencing a venture capitalist's response to market, technology and management risk.

Market Risk

Prototype characteristics are superficial because they illustrate how attributes of objects can cluster together into natural categories, but do not explain why some traits co-occur while others do not (Mervis & Rosch, 1981). However, when considering more abstract categories such as winning and losing portfolio investments, it is necessarily to consider not just surface attributes, but also the underlying meaning of those attributes to the VC. The underlying nature of a portfolio firm's risk dimensions – specifically their level of controllability - helps to explain the VC response. Managers perceive risk taking as an activity where they can exercise judgment, exert control and use their skills to manage the outcome (March & Shapira, 1987; Shapira, 1995). This is not to imply that they believe that all risks are equally controllable and acceptable. Rather, managers distinguish among risks, accepting those they perceive

are more amenable to their control and rejecting those that are not (Mone, McKinley, & Barker III, 1998).

In the venture capital context, domains of controllability can be inferred from previous research on the contractual relationship between VCs and their portfolio companies. The contractual terms attempt to solve the principal-agent problem of financial contracting, where the VC plays the role of principal and the portfolio company's management team plays the role of agent (Kaplan & Strömberg, 2001; Sahlman, 1990). While the ideal may be for the VC and management team to collaborate and cooperate, a contractual relationship is established to enforce alignment of the VC's and management team's interests. This alignment is achieved through the "sticks" of direct means of control such as voting rights, board seats, and access to additional capital, as well as the "carrots" of performance incentives such as contingent management ownership and financial compensation (Fenn et al., 1997).

The VC's greatest contractual control is over the portfolio company's management and financing terms. Voting and board rights, as well as various contractual provisions usually give the VC the power to determine the compensation and composition of the top management team, as well as the vesting of management stock and whether or not the managers can leave the company to join or found a competitor (Kaplan & Strömberg, 2003). Furthermore, the VC retains control over the financing of the portfolio company by staging investments so that each round of reinvestment is contingent on current and projected performance (Kaplan & Strömberg, 2003;

Sahlman, 1990). On the other hand, investment in the portfolio company also entails external and executional risks over which the VC does not have contractual control (Kaplan & Stromberg, 2004). External factors include attributes of the portfolio company's potential market and competition, while executional considerations include the feasibility and progress of product/technology development and production.

Market risk refers to "the degree of uncertainty associated with gaining a competitive advantage due to environmental factors" (Fiet, 1995). VCs are attracted to portfolio companies that operate in market environments characterized in the following ways: high-growth market (MacMillan et al., 1985); long-term industry growth and profitability (Hall & Hofer, 1993); market size, growth and customer access (Tyebjee & Bruno, 1984); and stability of industry key success factors and lack of predatory competitive rivalry (Shepherd, 1999b). In other words, while the specifics vary, low market risk (or high market potential) is a well-established central characteristic of a winning portfolio investment, while high market risk (or low market potential) is a central characteristic of a losing investment.

Since customers are external to the portfolio company, the market is beyond contractual control by the venture capitalist (Kaplan & Strömberg, 2001). Furthermore, while a VC board member may help modify a portfolio firm's marketing strategy on the margin, drastic changes in firms' target markets are difficult to achieve because they may require new (and possibly prohibitively expensive) technologies, routines and/or resources (Hannan & Freeman, 1984). As a result, the VC acts like a

"scout," selecting new portfolio companies that are already targeting high-potential technologies in attractive markets rather than expecting to redirect fundamental market strategy at a later date (Baum & Silverman, 2004).

The logic that influences VCs to invest initially with high market potential (i.e. low market risk) also applies to follow-on investments. While the VC cannot significantly affect the market itself, the VC can provide the wherewithal for the portfolio firm to develop products and capabilities that make it possible to generate profitable sales, and, by extension, a higher return on investment. Therefore, just as a venture capitalist prefers to invest initially in a company with an attractive market, follow-on investment will be more likely when market risk is low and less likely when market risk is high.

H2a: The likelihood of follow-on investment is negatively influenced by market risk.

When an early-stage VC invests initially in a young firm, it is operating on the expectation that a large, relatively uncompetitive market either exists or will develop for the portfolio company's products. However, high-technology markets tend to be turbulent, changing rapidly and unpredictably (Bourgeois & Eisenhardt, 1988). As a result, a portfolio firm's market prospects may degrade due to conditions outside of the control of the VC and even portfolio firm management. As a portfolio firm's market risk increases, its prospects for success decrease, possibly to the point where

the VC would not make an initial investment in the company if it were to be evaluated today.

Retaining a firm in a portfolio with diminishing market prospects creates opportunity costs for the venture capitalist. The VC's managerial resources stay engaged with the investee rather than being redirected to either identifying new investments or enhancing the performance of more promising firms in the portfolio. Also, retaining a firm in the portfolio signals to the investors that there is an expectation of an attractive return. The VC adage "lemons ripen before plums" reflects investor expectation that companies with poor prospects will be shed more quickly from the portfolio while those with stronger potential will be nurtured over time (V_C_Experts, 2009). Since market conditions are less controllable by the VC, it is less likely that the VC would take the time to attempt to mitigate market risk. Therefore, increasing market risk will increase the pressure on the VC to terminate investment in a portfolio firm.

H2b: The likelihood of investment termination is positively influenced by market risk.

Technology Risk

Technology risk refers to the degree to which product/technology characteristics may enhance or undermine a portfolio firm's prospects. In other words, the VC will consider with the technology will work as intended, that it can be produced in sufficient volume, and that it cannot be imitated by competitors. Measures of

technology risk may include the level of intellectual property protection, the presence of technical hurdles obstructing product development and/or production, and the degree to which the technology has already achieved customer acceptance.

The emergence and growth of the venture capital and high technology industries are tightly intertwined; they are both rooted in the recognition by pioneering investors that the private equity model could be applied to the commercialization of emerging technologies (Hambrecht, 1984). While early-stage venture capitalists historically have specialized in portfolio companies that more conservative investors would believe have unacceptably high product/technology risk, from the VC's perspective, there is technology risk variation among portfolio company candidates. Within a higher technology risk population, a VC is likely to seek a firm with relatively lower technology risk, meaning that the product/technology is differentiated from competitors and has strong intellectual property protection (Baum & Silverman, 2004; Tyebjee & Bruno, 1984) .

At the time an early stage venture enters a VC portfolio, its technology probably has not yet been developed into a saleable product that can be produced on a mass scale. The VC's staged investments typically fund the commercialization of the technology in steps: idea, patent, prototype, customer beta test, production and market launch. In other words, the portfolio firm's goal is for its technology to become better understood, better protected legally, and more reliable over time. Throughout this relationship, the VC observes the firm's progress, providing additional capital

contingent on the achievement of milestones, including the progressive reduction of technology risk. However, if the portfolio firm's technology does not progress as expected, technology risk increases and the VC will be less likely to reinvest.

H3a: The likelihood of follow-on investment is negatively influenced by technology risk.

While the VC may play a role in helping set portfolio firm strategy, it does not have direct control over technology risk for two reasons. First, the role of a venture capital firm is to be a conduit of investment funding, which entails to portfolio candidate screening, monitoring and occasional strategic intervention, but not hands-on product development. Second, an emerging technology is likely to require specialized expertise that the VC is unlikely to have within its organization, where partners may have sufficient technical backgrounds to assess an emerging technology, but not to manage its development. In other words, if technology risk increases, the VC is unlikely to be able to reduce that risk because mitigation requires managerial resources and expertise it probably does not possess. As a result, when increasing technology risk creates a cue discrepancy with the prototype of a winning portfolio firm, the VC will be increasingly likely to terminate investment.

H3b: The likelihood of investment termination is positively influenced by technology risk.

Management Risk

Management risk refers to the degree to which the management team may cause the portfolio firm to fail to achieve the expected return on the VC's investment. The management team's leadership skills, industry expertise, and/or technical knowledge have been recognized as key criteria for a VC's investment decisions in multiple studies (MacMillan et al., 1985; Shepherd, 1999a, b). One venture capitalist claimed, "Our business is people and we always bet on people. We do not care as much about the product or the industry as we do about the quality and talent of the entrepreneur" (Kryzanowski & Giraldeau, 1977). While a couple of studies have concluded that market potential is the primary VC concern, there is general consensus that portfolio company management is important to the VC's initial investment decision (Fiet, 1995; Hall & Hofer, 1993).

Paradoxically, while management characteristics are among the most important ex ante investment criteria, they are subject to significant post-investment VC control. Venture capital lore implies that VCs invest more in people than they do in business ideas (Bruton et al., 1997). However, it is also true that the compensation, strategic priorities, and composition of the management team typically are subject to VC control rights incorporated into the VC-portfolio company contract (Kaplan & Stromberg, 2004). For instance, the CEO and top managers may be required to sign employment contracts that stipulate the conditions under which a contract can be terminated (Fiet, 1995; Gompers, 1995). Furthermore, venture capital investors

typically require the inclusion of at least one VC representative on the board of directors who can participate not only in strategy formulation but also in the selection, evaluation and (if necessary) the replacement of the CEO and key executives (Kaplan & Strömberg, 2003). Furthermore, VCs are known to exercise their control rights by firing a portfolio firm CEO if they are dissatisfied with the venture's performance (Bruton et al., 1997; Bruton, Fried, & Hisrich, 2000; Lerner, 1995), or if the CEO does not have the competencies or inclination to lead the professionalization and growth of the venture (Hellmann & Puri, 2002).

Why would early stage VCs worry so much about a potential investee's management if they have the contractual right to replace the leadership team after the firm has entered the portfolio? One reason may be that prior to investment, the quality of the management team is a proxy for the quality of the venture's technology and business concept. While due diligence reduces information asymmetry to a large extent, the VC still is less likely to be as deeply knowledgeable about the technology and potential market than the founding team. Furthermore, replacing members of a management team can interrupt the momentum of a business. First, significant VC time and effort must be spent searching and recruiting new personnel. Second, the new management team must learn the business when a young firm still lacks codified knowledge and routines. Therefore it is not surprising that management turnover can be associated with lower portfolio firm performance (Bains, 2007; Busenitz, Fiet, & Moesel, 2004).

The logic that would lead an early-stage VC to invest initially in a young firm with strong management also applies to reinvestment. If management risk is high, a VC will avoid providing capital in a firm when there is little confidence that the money will be spent productively. On the other hand, if confidence in management is high (i.e. management risk is low), then it follows that the VC would be more likely to reinvest with the expectation that the portfolio firm will make fruitful use of the additional money.

H4a: The likelihood of follow-on investment is negatively associated with management risk.

While low management risk is an important initial investment criterion, it is not necessarily predictive of ultimate portfolio company success. Strong human capital (i.e. low management risk) increases the likelihood of VC financing, but it may have little effect on subsequent portfolio company performance (Baum & Silverman, 2004). There may be several reasons for the apparent disconnect between a VC's beliefs in the importance of management at the time of the initial investment vs. the portfolio company's performance. First, the heavy emphasis on portfolio company management's effect on performance may reflect a fundamental attribution error, i.e. the human tendency to overemphasize the effect of other people's characteristics and motivations while underemphasizing situational explanations (Baum & Silverman, 2004; Ross, 1977). This bias may exist not only at the time of initial investment, but also in explaining a portfolio firm's ongoing results. For instance, VCs

retrospectively point to senior management as the most important contributing factor to the underperformance of a troubled portfolio company underperformance, even as they also acknowledge situational factors like lack of market development or competition (Gorman & Sahlman, 1989). In fact, dismissal of a high-tech CEO in the face of an economic downturn appears to be more associated with the CEO's organizational power than with his or her specific performance (Forbes, Manrakhan, & Banerjee, 2004).

A second reason that management risk may not predict portfolio company performance is that VC and other board members' skills can compensate for management team inadequacies. Board members of venture capital-backed firms can be deeply involved in formulating venture strategy (Fried, Bruton, & Hisrich, 1998). VCs also may play operational roles by providing portfolio companies with introductions that may lead to new managerial hires, vendors and/or customers (Sapienza & Clercq, 2000). Further, if there are agency concerns regarding goal incongruence and/or the CEO's new venture inexperience, then the VC will have increased interaction with the portfolio company CEO (Sapienza & Gupta, 1994). As a result of these value-added activities, venture capitalists help to improve the performance of their portfolio companies (Sapienza, 1992).

Finally, a third reason that VCs may not link management risk to subsequent performance is that the composition of the management team is likely to change in response to VC concerns. If a portfolio firm is not achieving its planned milestones,

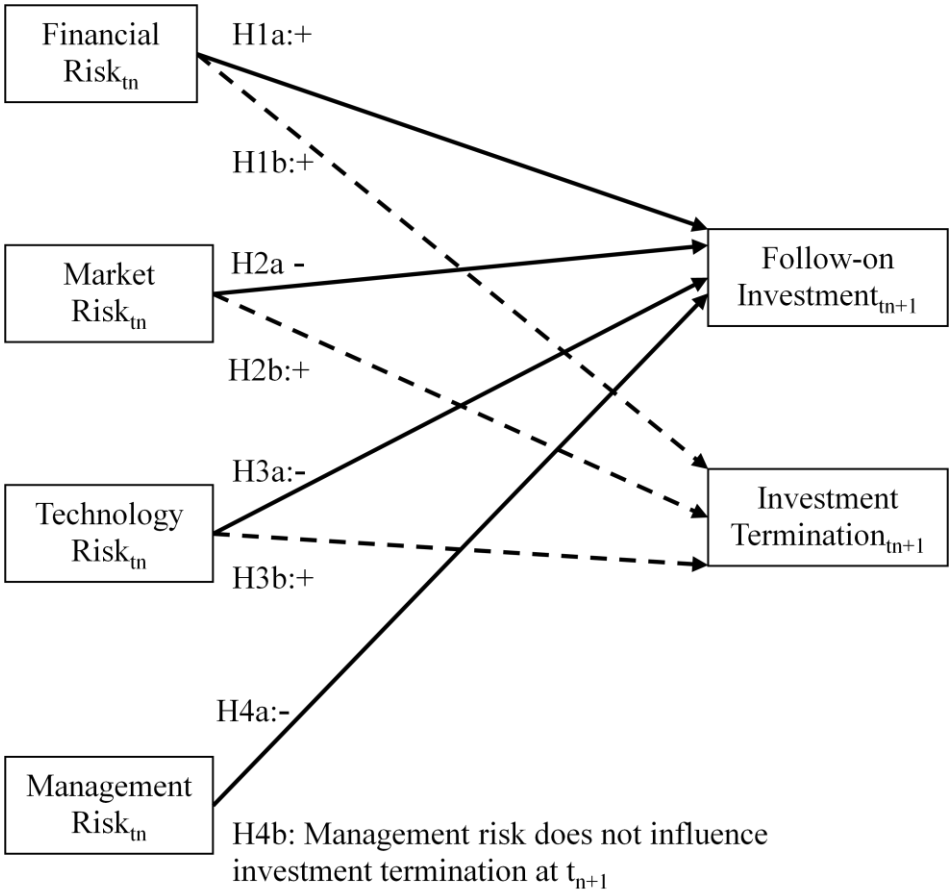
board members (who are likely to include VC investors) will monitor the firm's initiatives more closely in order to determine the cause of underperformance (Sapienza, Korsgaard, Goulet, & Hoogendam, 2000). If the VC becomes dissatisfied with the CEO's abilities or strategic choices, dismissal is likely (Bruton et al., 1997; Bruton et al., 2000).

In summary, VCs can mitigate the effects of management risk through their own strategic and tactical interventions, or reduce management risk by replacing members of the management team. In the face of a more controllable risk, it is not necessary for the VC to make the irreversible decision to terminate investment, thus leading to a null hypothesis:

H4b: The likelihood of investment termination is not influenced by portfolio company management risk.

This chapter has delineated the differences among VC post-investment alternatives and hypothesized how they are influenced by each of four risk dimensions. Figure 2 below depicts the hypothesized model. Note that the model assumes that VCs do not take action in the same time period in which they assess risk. Instead, some period of time is allowed for VC reflection, decision-making, consensus (both among the venture capital firm's partners and with external co-investors), and implementation. The following chapter describes how the hypotheses were tested, including the sample, variables, and analytic approach.

Figure 2: Hypothesized Model



CHAPTER 4: METHOD

This dissertation analyzes nonpublic information from a major venture capital firm as well as public market data to relate the VC's quarterly risk assessments of each of its investment holdings to its subsequent portfolio decisions. I include control variables to account for fund-level differences, industry characteristics, the economic context, portfolio company characteristics, and cognitive biases. The analysis uses time series multinomial logistic regression to test the effects of financial risk, market risk, technology risk, and management risk on the likelihood of a follow-on investment, investment termination, or profitable sale of the portfolio company vs. holding the investment without taking financial action.[3]

Data

The research population is composed of quarterly observations of the portfolio companies in two of a venture capital firm's funds during the five years spanning 01/01/02 through 12/31/06. In order to obtain access to this firm's internal records and investor reports, I signed a nondisclosure agreement that prevents me from identifying it or publishing proprietary information, such as fund and individual portfolio company financial performance. The following description adheres to the

[3] Profitable sales are outside the scope of this study and so are not reported in this dissertation. However, they are included in the analysis for two reasons. First, the power of the analysis is improved because all the observations prior to the profitable sales are included in the data set. Secondly multinomial logit requires the complete set of possible outcomes to be meaningful.

terms of the nondisclosure agreement, while providing sufficient information to indicate the degree to which the firms' activities are reflective of general VC practices.

The focal venture capital firm is based in California's Silicon Valley and specializes in early stage, high-technology companies. This firm was established in the early-mid 1990s by partners with significant prior venture capital experience. With about $1 billion under management in multiple funds, the firm has significantly larger holdings than the U.S. venture capital firm average of $347 million (Thomson_Financial, 2008). The firm operates in the mainstream of the VC industry: it consistently co-invests – often as the lead investor - with top-tier VC firms, while its principals are frequent speakers and panel members at industry events.

The observations in my data set encompass all the companies present between 2002 and 2006 in two of the VC firm's funds, with a combined total of about $750 million in invested assets. Following standard practices for the venture capital industry, both funds are structured as private equity limited partnerships (Fenn et al., 1997). The limited partners are institutional investors (e.g. pension funds) while the VC firm plays the role of general partner, allocating and managing the funds' investments in the portfolio companies. Fund 1, initiated in 1998, received approximately $250 million in invested capital while Fund 2, initiated in 1999, raised about $500 million under management. As is common among venture capital limited partnerships, the two funds were both structured to be liquidated after 10 years, with

the potential for extensions to allow for orderly liquidation of the remaining portfolio holdings.

The VC firm in this study follows industry convention by providing quarterly financial reports, as well as an audited annual report, to its limited partners. The quarterly reports include the VC's current valuation of each portfolio company, as well as the history of all financial transactions. In addition, the VC uses the quarterly report to communicate qualitatively with its investors regarding specific portfolio firms. The quarterly report includes the responsible partner's commentary about each portfolio company's progress and prospects, as well as an assessment of each company's risk level in four categories: financial, market, technology, and management.

The analysis incorporates data from the National Association of Securities Dealers Automated Quotations (NASDAQ) and nonpublic quarterly reports to limited partners. The NASDAQ index is a proxy for the economic context both at the time of the initial investment in a portfolio company, as well as at the time of each company-specific financial action. The bulk of the analysis utilizes data from the quarterly reports, including details on financial transactions and summary information on the VC's assessment of each portfolio company's level of market, technology, management and financial risk. The interpretation and discussion are informed by discussions with VC principals and internal archival information that includes details explaining how the risk assessments were determined.

While the two funds began investing two to three years earlier, this study's observation period begins in January 2002. The starting point corresponds with when the VC firm began reporting its risk assessments to its limited partners. The observation period ends in December 2006, which is the date of the last report provided to me by the venture capital firm.

The research population is composed of 60 companies observed quarterly over the five-year observation period. As can be seen in Table 2, the portfolios were dynamic: entries and exits took place throughout the observation period, creating an unbalanced panel with 26 to 38 companies included in any one quarter. Out of the 60 investments, 33 companies received a total of 127 follow-on investments. Furthermore, 32 investments were exited during the study period: 18 portfolio companies and/or their assets were acquired by strategic investors at prices below the VC's total investment, 12 companies were written down to $0 or $1 in the quarterly financial reports, and 2 companies were sold for a profit.

The risk data is lagged by one quarter because interviews with VC firm partners indicated that they took one to three months to consider each firm's risk assessment, make a decision, gain consensus from co-investors (if necessary), and take action. Lagging the risk data resulted in dropping three portfolio firms and 66 observations, including two investments that were terminated for a capital loss and one company that received a follow-on investment. The final sample is composed of 57 companies observed 542 times over the five-year period.

Table 2: Panel Entries and Exits

			Quarter																		
Freq.	Percent	Cum.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8	13.33	13.33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	8.33	21.67	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.
4	6.67	28.33	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	6.67	35.00	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	5.00	40.00	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1
3	5.00	45.00	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1
3	5.00	50.00	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	3.33	53.33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
2	3.33	56.67	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1
2	3.33	60.00	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1
2	3.33	63.33	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	3.33	66.67	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	3.33	70.00	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	3.33	73.33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.
1	1.67	75.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
1	1.67	76.67	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1	1.67	78.33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1
1	1.67	80.00	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1.67	81.67	.	.	.	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.
1	1.67	83.33	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	1.67	85.00	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1.67	86.67	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	1.67	88.33	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	1.67	90.00	1	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.
1	1.67	91.67	1	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.
1	1.67	93.33	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.
1	1.67	95.00	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.	.
1	1.67	96.67	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.	.	.
1	1.67	98.33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.	.
1	1.67	100.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	.	.	.	.
Companies Per Quarter:			38	36	36	36	37	35	32	29	27	26	26	27	27	28	28	27	27	29	30	29

1= Company was present in the population at the end of the quarter
. = Company was not present in the population at the end of the quarter

Dependent Variables

The analysis considers four mutually exclusive discrete choices for each portfolio company in each quarter: holding, follow-on investment, investment termination at a loss, and sale of the firm at a profit. Holding, or taking no financial action, is the default against which the other options are compared. In other words, the analysis

compares the greater or lesser likelihoods of three financial actions vs. inaction for each portfolio company in each quarter.

Follow-on investment is defined as a transfer of funds from the VC to the portfolio firm. This is not the equivalent of a financing "round." As mentioned earlier, venture capitalists limit their potential losses and maintain leverage over portfolio company management by restricting their initial investment to the capital needed for a portfolio firm to achieve a specific milestone (e.g. a product prototype or a market test), thus requiring the firm to seek additional funding to develop further (Gompers, 1995). Each round of funding (Series A, B, C, etc.) entails a contractual agreement between the portfolio firm and the syndicate of VCs that provides for future capital infusions when a) the portfolio firm needs additional cash and b) the investors are comfortable that the firm is making acceptable progress. In other words, the approval of a formal round of financing indicates the intent, but not an obligation, to provide future capital. This characterization of VC follow-on practices was confirmed with a venture capitalist not associated with the firm in this study (Smaby, 2006).

On the other hand, regularly recurring financial transactions are not necessarily separate decisions subject to VC review. For instance, a portfolio company may receive a fixed amount of money on a fixed day of each month for several months, or multiple capital inflows in a single week (Gompers & Lerner, 2000). As a result, it is necessary to distinguish automatic financial transfers from reinvestments that arise from affirmative decisions. This dissertation consolidates financial transfers that are

obviously pre-programmed and defines follow-on investments as financial transfers that occur at least 60 days apart.

An investment termination occurs when a portfolio firm's final valuation is less than the VC's total cumulative investment. The analysis also includes the option of a profitable sale, which is when the final valuation exceeds the cumulative investment. I included the two profitable sales in the analysis so that observations of the holding and reinvestment decisions regarding those two companies could be included in the sample, but the results for this specific option are not reported because they are outside the score of this study and they are not meaningful.

Independent Variables

Formal risk assessments were the venture capital firm's response to the dramatic stock market decline – especially for technology firms - that occurred in 2001/2002 (Sohl, 2003a, b). These risk assessments were developed for two purposes: to function as an internal decision aid for the VC's general partners, and as a communication tool to increase limited partners' confidence in the VC's risk management skills. Initially, the firm addressed the market crisis by re-evaluating its entire portfolio, using its internally-created risk assessments to determine which companies to retain and which to jettison. The VC also reported on portfolio company risk assessments to its limited partners in order to demonstrate that it was aggressively, yet prudently, addressing the market crisis. When the market began to recover, the

VC continued to use the risk assessments as input to its principals' post-investment decisions and in the quarterly reports as a signal transparency and risk-awareness.

Quarterly risk assessments were conducted by the VC principal with the responsibility to monitor, direct and advise a portfolio firm. The standard procedure was for the general partner responsible for overseeing a portfolio company investment to assess risk in four areas (financial, market, technology and management) using a standardized set of six items for each risk category. The principals used common definitions to rate the portfolio company as high-medium-low risk for each of the six items, which would then be averaged to determine the risk for that functional area. Appendix A shows the full list of risk items and severity criteria as they were defined at the end of 2006.

Financial risk is defined by the VC as "the risk associated with the portfolio company's financing needs and cash flow projections" (Anonymous, 2002), i.e. the degree to which the current and/or prospective financial condition may threaten overall firm viability. The six underlying elements for financial risk are cash runway (i.e. how long the portfolio firm can survive on its current cash reserves), debt plus equity to breakeven (i.e. how much capital will be required until the firm is self-sufficient), business model risk (i.e. how long it will take until the firm is self-sufficient), how much control the VC firm has over the portfolio company, resource availability and investor eagerness. For example, the cash runway item is anchored with the following risk levels: a low-risk company has more than 12 months of cash, a

medium-risk company 6-12 months of cash, and a high risk company has less than 6 months of cash.

Market risk is defined by the VC as "the risk associated with the company's market characteristics and customer traction" (Anonymous, 2002). In other words, market risk is a proxy for the hazard that the portfolio company will not generate the revenue expected at the time of the initial investment. The six elements that inform this risk are market timing, market size, competitive position in the market, market traction, revenue track record and revenue growth. For example, the market size item considers the addressable market for the company's products: low risk is over $500 million, medium risk is between $250 and $500 million, and high risk is under $250 million.

Technology risk is defined as "the risk associated with the company's product development and product release progress"(Anonymous, 2002). The specific items for this risk dimensions differed depending on the portfolio company's industry sector, but each version was summed and reported to limited partners as a single score in the technology risk category without differentiating among the underlying questions. The components version had the following six items for technology risk: product feasibility, proof of intellectual property, product acceptance, development/delivery track record, core technical team, and product development continuity. For example, the proof of intellectual property item has three levels: low risk is a defensible patent(s), medium risk is that the patents have been filed, and high risk is that the patents have not yet been defined.

Management risk is defined by the VC as "the risk associated with the company's management and operational team" (Anonymous, 2002), i.e. the degree to which the characteristics and/or behavior of the management team may undermine portfolio firm performance. The six areas that contribute to this risk assessment are the management team's completeness, leadership, experience, dynamics and execution track record, as well as the quality of the board of directors. For instance, the management completeness item is scored as follows: low risk is no more than one interim or missing VP from the top management team, medium risk is no more than two interim or missing VPs, and high risk is more than two missing or interim VPs.

The independent variables are lagged by one calendar quarter in order to allow for sufficient time between assessment and its effect on an observable action. Each risk assessment reflects the responsible partner's current perception of the potential hazard of a portfolio firm not achieving its expected return. Because the partner is not the sole decision maker regarding post-investment actions, consultation is required, both inside and outside the VC firm before a significant decision can be agreed to and implemented. Like many of its competitors, the focal VC firm in my study made portfolio decisions during regularly scheduled, usually weekly, partner meetings. If a decision was made to either reinvest or terminate investment, additional time was required to gain consensus with co-investing VCs and to execute the decision. However, the deliberation period was not open ended. The periodic nature of the quarterly reports appeared to dictate the pace of the VC's portfolio actions – the act of

highlighting either good or bad news (i.e. low or high risk) in one quarterly report generated the tacit expectation of action that could be reported in the next quarterly report.

Control Variables

Like many managerial actions, VC portfolio decisions take place in a complex context. In addition to considering portfolio company risk, VC partners must also contend with the effects of decisions that they made previously, the current economic and industry environment, and their own biases. Therefore, the analysis will controls for fund-level differences, industry characteristics, the economic context, portfolio company characteristics, and cognitive biases.

The fund is controlled for, with Fund 1 dummy-coded as 1 and Fund 2 dummy coded as 0. The two funds exhibited different initial investing styles even though they shared the same VC principals and analytic staff, had overlapping limited partners, and were managed day-to-day as a common portfolio. Fund 1, which began investing in 1999, rapidly populated the portfolio, with all initial investments completed prior to the observation period of this study. Fund 2, which started investing in 2000, added companies more slowly, continuing to make initial investments throughout the observation period. Fund 1 also had invested in a number of companies from which it exited prior to the observation period. During the observation period, 18 companies were in fund 1 and 39 firms were in fund 2.

A portfolio firm's industry is another potential contextual influence. The VC firm focused primarily on early-stage companies that develop high-tech products and/or provide technology-based services. This dissertation adopts the industry segments used by the VC in this study. The VC assigned its investments to four sectors: software, components, systems, and services. The software portfolio companies provide business-oriented applications primarily in the telecommunications industry. The components portfolio firms provide hardware components primarily for communications networks. The systems firms provide software primarily for large network applications. Finally, the services firms provide either business-to-business wireless services or technical/design services to high-tech manufacturers. While there were sufficient degrees of freedom to include all multiple industries in the control model (which will be discussed below), the analysis would not resolve when I included the full set of variables. In the control model, only the software sector was significant, and dropping the other industry variables did not affect overall model significance. I then ran the full model with each industry sector individually, again finding that only the software sector was significant. Therefore, in the interest of parsimony (Hensher, Rose, & Greene, 2005), I only included the software sector as a control variable in the analysis.

I controlled for the economic environment by including variables that reflect market conditions at two points in time: the date of the initial investment and the current calendar quarter. Past research has shown that prevailing stock market

conditions for technology companies, as proxied by the National Association of Securities Dealers Automated Quotation System (NASDAQ), affect venture capital firms' ability to raise funds and their initial investment levels (Gompers, Kovner, Lerner, & Scharfstein, 2008). Also, during the life of the VC portfolio, current stock market conditions may expand or limit the VC's exit options (Lowry, 2003). During the lifetime of both funds, the NASDAQ composite index was volatile, with a peak of 5,049 on March 10, 2000, a trough at about 1,114 on October 9, 2002, and a partial recovery to 2,416 by December 31, 2006. The Initial NASDAQ is the level of the NASDAQ composite index on the date of the initial investment. The Current NASDAQ is the level of the NASDAQ index on the last day of the observed quarter.

Venture capitalists must operate within the constraints set by the legal structure of their limited partnerships. A VC fund has a defined lifespan, typically 10 years, by the end of which (barring short extensions) all investments must be liquidated, with the proceeds distributed to the limited partners. In other words, the VC has limited time to help a company succeed (or not) and then exit from the investment. This fund-level deadline may cause a VC's patience to diminish the fund liquidation deadline approaches. On the other hand, it also has been argued that losses are more acceptable during the earlier years of a fund because limited partners expect a VC fund's return to take the shape of a "J-curve," i.e. an initial decline in fund value (because management fees are not offset by realized gains) followed by a dramatic increase (Fraser-Sampson,

2004). Time to fund termination counts the number of quarters until the fund is expected to be terminated.

The analysis controls for whether or not a portfolio company is late stage at the time of each quarterly observation. A late stage company is dummy-coded as 1 if it has launched a product in the open market, and 0 if the product is still under development or being beta-tested by a few potential customers. This control variable addresses apparently contradictory forces operating on the VC. On the one hand, the VC may wait to act until the principals perceive that they have sufficient knowledge about a portfolio company's prospects to determine whether or not to exit from the company. The portfolio company's revenue and profit potential can be determined with greater confidence once potential customers have had the opportunity assess and purchase the product. On the other hand, VC folklore suggests that "lemons ripen before the plums," implying that VCs are more likely to withdraw support from an underperforming company if it does not meet developmental milestones shortly after the initial investment (LeBaron & Vaitilingam, 1999).

The analysis also includes controls for emotional, political and institutional influences that combine to increase the likelihood of escalation of commitment (Staw, 1981). Prior research has demonstrated that both VCs and other professional investors may suboptimally retain and reinvest in their portfolio investments as time passes (Bergemann & Hege, 1998; Guler, 2007; Shefrin & Statman, 1985). This analysis uses several variables to address the possible effects of escalation of commitment.

The VC's level of ownership (measured as a percentage) may be positively related to reinvestment for two reasons. First, greater ownership may instill a higher level of emotional commitment by the VC principals, who must personally advocate for each investment and may be reluctant to acknowledge an error in judgment. Second, a greater level of ownership may require the VC to play a leadership role in the investment syndicate, with a greater focus on sustaining its relationships with co-investing VCs than on the specific return of the portfolio company (De Clercq, Sapienza, & Zaheer, 2008; Guler, 2007). Second, investment duration may imply emotional investment as well as a need on the part of the VC to continue to behave in a way that is consistent with its past actions (Beauvois, Joule, & Brunetti, 1993). Finally, the number of formal previous rounds of investment indicates the frequency with which the VC has had to make a public commitment to the portfolio company after its initial investment, increasing pressure on the VC to behave consistently with prior commitments.

Finally, the human tendency to pay selective attention to contradictory signals also may affect the VC portfolio decision. Confirmation bias is our tendency to pick and choose among information, giving credence to and acting on the items that reflect our preferred perspective (Nickerson, 1998). Furthermore, we tend be more hesitant to make an irreversible decision, especially one that may entail a loss if information is contradictory. In the context of this dissertation, the VC has scored each portfolio company's risk in four different functional areas, with the possibility that each form of

risk could be scored very differently from the next one. For instance, a firm with strong management, a large potential market and well-protected technology may have low management, market and technology risk while it has high financial risk because it is running out of cash. Alternatively, a portfolio firm with a good cash position and strong technology may also have an inadequate management team and one or two strong competitors, resulting in an assessment of low financial and technology risk, high management risk and medium market risk. Therefore, the analysis controls for risk variance, which is measured as the variance among the four risk scores for each portfolio company in each quarter, as a proxy for the degree to which the risk assessments are contradictory. Since the four risk scores constitute all the risk information for that particular company-quarter, this variable is calculated as the population (not sample) variance. The calculation is as follows:

$$\sigma^2 = \sum_{k=1}^{k=4} \frac{(x_k - \mu)^2}{4}$$

In summary, the analysis tests hypotheses regarding the effects of financial, market, technology and management risk on the likelihood of follow-on investment vs. holding and investment termination vs. holding. Ten control variables are included to address other influences on the VC's decision. The following sections discuss a) the validity of the sample, b) the validity and reliability of the measures, and c) the analytic approach.

Validity and Reliability

The hypotheses are tested using a limited population and data that was developed for business management, not research, purposes. Therefore it is especially important to place the focal VC firm and its risk assessments in a broader empirical context. While the VC firm was founded prior to the observation period and continues to operate today, the following discussion is limited the observation period spanning 2002-2006.

The focal VC firm operates in the mainstream of its industry, both in terms of its competitive position and its business practices. During the observation period, it was a significant, but not dominant, player in the venture capital industry. At $1 billion in assets, it is in the tier just below the very top firms, which average over $2.5 billion of assets under management, but significantly more than the VC firm average of $347 million (Keller, 2001; Thomson_Financial, 2008). Specific investment performance and the identity coinvesting VCs cannot be discussed due to the nondisclosure agreement discussed earlier. However, it can be established that the focal firm did not operate in a vacuum: it coinvested with other venture capital firms in almost all of the companies in the portfolio, about half of the time as the lead investor. Coinvestment, a standard industry practice, entails more than simply investing in the same company with another investor. In fact, coinvesting is a form of networking that can enhance fund performance through sharing information with other VCs regarding potential investments, reciprocity regarding access to new deals and as well as additional

financing, and increased access to nonfinancial services/resources of value to portfolio firms (Lockett & Wright, 2001; Manigart et al., 2006; Schonfeld 2009). The focal VC's coinvestors include, but are not limited to, the 100 most networked venture capital firms based in the U.S. (Schonfeld 2009).

While the firm was unusual in the degree to which it formalized its risk assessment and reporting, the four risk domains are articulated similarly to the risks identified by prior researchers regarding VCs' initial investment decision criteria (MacMillan et al., 1985; Tyebjee & Bruno, 1984; Zacharakis & Meyer, 1998). While I am not aware of any studies of VC post-investment risk perceptions, it has been established that managers articulate risks in terms that are meaningful to their industries and/or functional areas (Shapira, 1995).

While the risk dimensions appear to resemble scales of reflective indicators often used in psychometrically-based research, I concluded that they are composite constructs composed of formative indicators. I did test to see if the underlying indicators behave like a psychometric scale. Out of the 608 total observations, the VC retained 472 internal worksheets in which the general partners assessed each portfolio firm, but not necessarily on all six items for each risk dimension. The items do not meet the standard threshold for a reflective scale and also do not produce consistent Chronbach's alphas quarter by quarter. Principal factor analysis also does not split out the items into the expected six factors. Tables B-1 and B-2 in Appendix B provide details.

The VC principals and staff confirmed that they perceived each categorical risk is a composite of the items in the worksheet (Anonymous, 2005). A composite variable has several characteristics: a) the direction of the causality is from the items to the construct, b) the items are not interchangeable and adding/dropping an item would change the construct's meaning, c) the items do not necessarily covary but do share a directional relationship, and d) the items do not necessarily share common antecedents and consequences (Coltman, Devinney, Midgley, & Venaik, 2008; Jarvis, Mackenzie, Podsakoff, Mick, & Bearden, 2003). Literature on constructs with formative indicators suggests that they should be developed conceptually (i.e. being clear on the construct's content and using sufficient variables to cover the full domain of the construct), with a couple of empirical guidelines such as limiting item collinearity, and testing external validity by incorporating the formative constructs in a structural equation model that includes reflective indicators as well (Diamantopoulos & Winklhofer, 2001). In the case of this analysis, the individual items do conceptually address different aspects of each risk dimension. However, empirical tests were not feasible: power was low because the internal records were incomplete, collinearity varied a great deal by quarter, and no reflective indicators were used by the VC.

It also must be remembered that the VC firm used the risk assessments as a management and reporting tool, not as a research instrument. As a result, the risk checklists received minor revisions over the five year period, while the summary risk dimensions continued to be reported to limited partners without specifying these

changes. The greatest changes took place in the technology dimension, where somewhat different risk items evolved for each industry sector. Furthermore, the principals did not always bother to score all the items within each category, but would instead sometimes check off a few items and then manually input an overall risk dimension score. Finally, due to clerical turnover, only about two-thirds of the internal risk checklists were retained by the VC firm, although 100% of the quarterly reports contained risk dimensions scores for each firm in the portfolio. (For the internal records that were available, all the risk scores were identical to those that were reported to the limited partners.)

In conclusion, it is both theoretically and empirically appropriate to analyze the effects of the four composite risk dimensions because they were the most salient to the VC decision makers and were consistently reported. Risk dimension composite scores were routinely shared among the firms' principals at regular meetings concerning portfolio company decisions. The scores were also a standard element of each portfolio company review in the quarterly reports to limited partners. Therefore, because the composite risk dimension assessments provided salient input into portfolio decisions, my analysis utilizes the four risk dimensions that were consistently included in the quarterly reports, rather than the items in the internal worksheets.

While all the data for each company were obtained from a common document (the limited partner quarterly reports) with information primarily provided by one source (the VC principal responsible for that company), concerns regarding common

method bias are addressed by the research design (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). First, the model uses a temporal lag of one calendar quarter between when the VC principal assesses risk and when the firm takes action: there is no opportunity for retrospective knowledge about the outcome to affect the VC's risk assessment. Second, while the independent variables are subjective, the dependent variables and most of the control variables are objective. Third, the specificity of the risk item check lists helped to limit each rater's discretion and standardize responses across the different raters.

It is possible that there may be a "halo effect" among the risk assessments, where a strong positive (or negative) assessment in one area may influence a strong positive (or negative) perception in another area (Thorndike, 1920). Since most of my hypotheses examine the differential influence of risk dimensions, the halo effect would tend to reduce the independent variables' effect size thus making the analysis more conservative. While there is significant correlation among the risks, it varies among risks and among quarters. As shown in Table B-3 risk rating correlations broken out by quarter do vary from time period to time period. For instance, market and financing risk Pearson correlations vary from about .06 to about .68, depending on the quarter in which they are observed. Furthermore, as shown in Table B-4, risk severity levels do shift from quarter to quarter. In other words, the VC does appear to differentiate among risk types within a specific quarter and revise its risk assessments between quarters.

Left and right censoring are also a concern with this data set. The two funds were both established prior to the observation period, and one of them had already made its initial investments (as well as several investment terminations) by 2002. At the end of the observation period, both funds still contained portfolio companies. Regarding left censoring, the model controls for economic conditions that existed prior to the observation period by including the level of the NASDAQ index. Furthermore, while the VC made reinvestment and termination decisions earlier, the formal risk assessments – i.e., the independent variables – did not exist until the beginning of the observation period. Right censoring is a greater concern. It is possible that the VC's criteria for reinvestment and termination might change if a requirement to liquidate the fund was impending.

Analysis

The hypotheses were tested on an unbalanced panel using time series multinomial logistic regression. The software is NLOGIT, an extension of LIMDEP, which was developed to analyze panel data with limited dependent variables (Greene, 2007). The time variable is the calendar quarter, with a total of 20 quarters in the observation period. The panel variable is the company id. The panel is unbalanced, with companies entering and exiting the population throughout the observation period.

The model uses maximum likelihood estimation to compute the likelihood that the VC will decide upon choice (j) about an individual company (i) in each time period (t):

$P_{ijt} = \sum^{J}_{j=0} \exp(\beta_j' x_{it})$

Choice j refers to holding, follow-on investment, investment termination, or a premium sale. I report two-tailed hypothesis test results. The significance of each model was determined using a likelihood ratio test. Because the dependent variables are discrete rather than continuous, the p-value significance of the control and independent variables is determined using a Wald statistic, rather than a t test, calculated as follows and compared to the critical Wald value of 1.96:

$Wald = \beta_i / \text{standard error}_i$

The control model includes the 10 control variables discussed earlier in this chapter, with risk variance lagged by one quarter:

$Decision_{ijt} = \beta_0 + \beta_1 Fund_i + \beta_2 Sofware_i + \beta_3 Initial\ NASDAQ_i + \beta_4 Current\ NASDAQ_{it} + \beta_5 Time\ To\ Fund\ Termination_{it} + \beta_6 Late\ Stage\ Company_{it} + \beta_7 Ownership\ Level_{it} + \beta_8 Investment\ Duration_{it} + \beta_9 Cumulative\ Follow\text{-}ons_{it} + \beta_{10} Risk\ Variance_{it-}$

The full model also includes terms for the four risk dimensions, each lagged by one period:

$Decision_{ijt} = \beta_0 + \beta_1 Fund_i + \beta_2 Sofware_i + \beta_3 Initial\ NASDAQ_i + \beta_4 Current\ NASDAQ_{it} + \beta_5 Time\ To\ Fund\ Termination_{it} + \beta_6 Late\ Stage\ Company_{it} + \beta_7 Ownership\ Level_{it} + \beta_8 Investment\ Duration_{it} + \beta_9 Cumulative\ Follow\text{-}ons_{it} + + \beta_{10} Risk\ Variance_{it-1} + \beta_{11} Financial\ Risk_{it-1} + \beta_{12} Market\ Risk_{it-1} + \beta_{13} TechnologyRisk_{it-1} + \beta_{14} ManagementRisk_{it-1}$

Multinomial logit assumes that the error terms are independently and identically distributed (IID) which implies independence of irrelevant alternatives (IIA). In other words, MNL requires that either the full range of alternatives is observed (as is the case in this analysis), or that any additional alternative would not affect the probability of an alternative already in the choice set (Henscher, Rose, & Greene, 2005). This is an area of controversy among statisticians. It has been asserted that in applied settings, the MNL assumption is not particularly restrictive (Dow & Endersby, 2004). Furthermore, the Hausman and other tests may be misleading, because Monte Carlo simulations have shown that they produce both false positives and false negatives , and that the MNL assumptions are generally appropriate in applied settings (Cheng & Long, 2007). The analysis assumes independence of irrelevant alternatives because the model follows Henscher et al.'s (2005)advice to reduce the likelihood that the error term would influence the prediction by including the full choice set, incorporating a rich set of control variables, and measuring the attributes in the way that is meaningful to the decision maker.

I also conducted several supplemental analyses. First, I tested whether or not aggregate risk (calculated as the sum of the four risk dimensions) would affect the VC decision. Second, I considered the possibility that financial risk and the other risks may combine to affect the VC decision: I tested interactions between financial risk and each of the other three risks, and I also examined what would happen if I split the sample between higher and lower risk groups. Finally, I also ran the analysis relaxing

the IIA assumption in two ways: using a common, latent effect as well as separate, freely correlated effects on each utility function (Greene, 2007). The following chapter discusses the descriptive statistics as well as the results of the hypothesis tests and the supplementary analyses.

CHAPTER 5: RESULTS

In this section, I will first discuss the descriptive statistics, with special attention to the characteristics of subsamples by decisions type. I will then address the hypothesis tests and supplemental analyses.

Descriptive Statistics

The summary statistics show the mean, standard deviation, minimum and maximum of each variable, as shown in Table 3 below. Note that lagging the risk dimensions resulted in dropping 66 observations. Just over ¼ of the sample is in Fund 1, with the balance in Fund 2. Software portfolio companies account for 24% of the sample (not shown in the table: components account for 32%, system software accounts for 17%, services account for 8%, miscellaneous for the balance). During the 2002-2006 observation period, the NASDAQ stock index ranged dramatically, from just over 1,000 to as much as 5,000. Approximately 60% of the observations were of late stage companies. Portfolio company ownership average about 17%, but reached as high as 45%. The typical investment duration was 12 quarters, but could range as high as 31 quarters, while cumulative post-investment formal rounds average less than 1, but went as high as 3. Risk variance ranged from 0 to 1, averaging .26.

Turning to the four independent variables, the four risk dimensions all range between the lowest (score of 1) and highest (score of 3) assessments, but with different means. The average financial risk assessment is 2.2, market risk averages at 2.3, technology risk at 2.1 and management risk much lower at 1.75.

Table 3: Summary Statistics

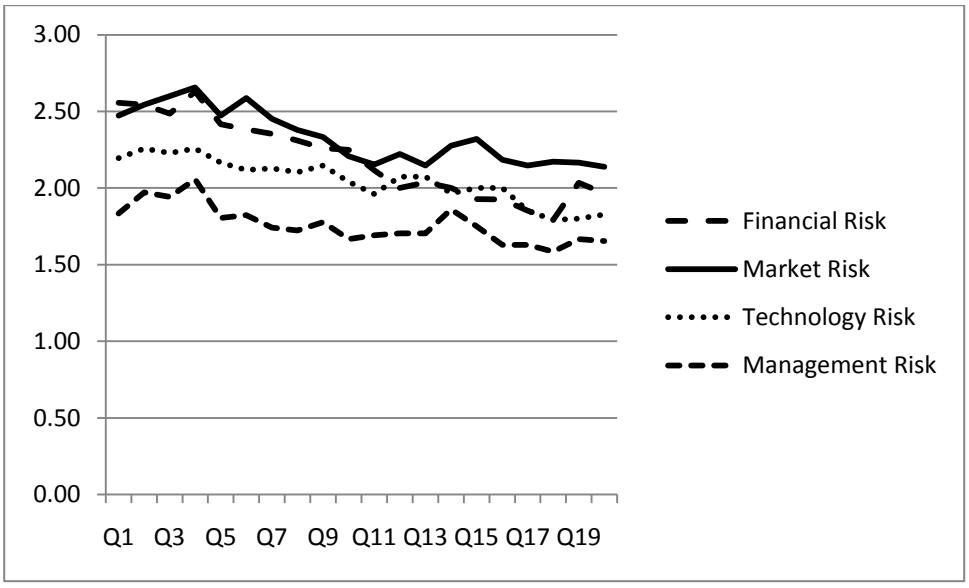
Variable	Mean	Std.Dev.	Minimum	Maximum	Cases	Missing
Fund 1	.292763	.455405	.000000	1.00000	608	0
SOFTWR	.240132	.427515	.000000	1.00000	608	0
Initial NASDQ	2757.89	1106.62	1320.91	4914.79	608	0
Curr. NASDAQ	1897.31	361.736	1139.90	2415.29	608	0
Qs to FundEnd	21.8947	5.64158	9.00000	32.0000	608	0
Late Stage	.590461	.492154	.000000	1.00000	608	0
Ownership	.169013	.092653	.005400	.450000	608	0
Duration	12.3240	6.61100	1.00000	31.0000	608	0
Cum. Rounds	.736842	.761399	.000000	3.00000	608	0
Risk Var.	.261185	.220237	.000000	1.00000	542	66
Fin. Risk	2.19557	.794237	1.00000	3.00000	542	66
Market Risk	2.34133	.716655	1.00000	3.00000	542	66
Tech Risk	2.06089	.705131	1.00000	3.00000	542	66
Mgmt Risk	1.75830	.695028	1.00000	3.00000	542	66

It is interesting to consider how the summary statistics vary by decision type. As shown in Table B-5 in Appendix B, there are noticeable differences among the firms that are held with no portfolio action, those that receive follow-on investment, and those whose investment is terminated. The proportion of portfolio firms that are late stage companies is highest for terminated investments and lowest for the holding decision. The VC's ownership of a portfolio firm is higher for both follow-on investments and terminated investments than for holding. The average risk levels of terminated investments are highest for all four risk dimensions. Among follow-on investments, the average level of management risk is noticeably lower than the other two decision categories, while market and technology risk are just slightly lower than the hold decision type. Finally, financial risk is higher for firms receiving follow-on investments than those that are held.

It is also interesting to consider how the mean risk levels change over time. The relative levels among the risk dimensions stayed the same through the observation

period, with market risk ranking highest, then financial risk, then technology risk, then management risk. Average quarterly risk levels trended downward somewhat during the observation period, as shown in Figure 3.

Figure 3: Risk Dimension Means Over Time



Because the sample is composed of an unbalanced panel, Pearson correlations can be misleading because they do not take into adjust for the numbers of times a firm appears in the overall sample. Correlations by time period are meaningful because each firm appears only once in each quarter. While Table 4 shows the correlations across all the observations, it does not lend itself to interpretation because firms can appear in the sample anywhere from 1 to 20 times. As a result, variables may be

correlated significantly not because of a meaningful relationship but because they are associated with firms that persist in the population longer than others.

It is more instructive to consider the correlations on a quarterly basis. Focusing on the independent variables, specific company/quarter risk dimension correlations vary a great deal, as shown in Table B-3 in Appendix B. For instance, the lowest relationship between two risk dimensions occurs in Quarter 2, when the correlation between market risk and financial risk in the second quarter is .10. The highest correlation takes place in the 16th quarter, when the correlation between technology risk and market risk is .71

.

Table 4: Overall Correlations

	Fund 1	Soft-ware	Initial NASDAQ	Current NASDAQ	Time to Term	Late Stage	Owner-ship	Inv. Duration	Cum. Rounds	Risk Variance	Financial Risk	Market Risk	Tech. Risk	Mgmt. Risk
Fund 1	1.00													
p														
Software	**-0.08**	1.00												
p	**0.04**													
Init. NASDAQ	**0.25**	0.04	1.00											
p	**0.00**	0.32												
Curr. NASDAQ	**-0.28**	**0.14**	**-0.26**	1.00										
p	**0.00**	**0.00**	**0.00**											
Time to Term	0.00	**-0.14**	**0.22**	**-0.81**	1.00									
p	0.99	**0.00**	**0.00**	**0.00**										
Late Stage	**0.12**	**0.26**	**0.20**	**0.17**	**-0.22**	1.00								
p	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**									
Ownership	**-0.09**	**0.08**	**0.09**	**0.11**	**-0.11**	**-0.10**	1.00							
p	**0.03**	**0.05**	**0.02**	**0.01**	**0.01**	**0.01**								
Inv. Duration	**0.47**	-0.06	**0.38**	**0.19**	**-0.39**	**0.28**	-0.04	1.00						
p	**0.00**	0.12	**0.00**	**0.00**	**0.00**	**0.00**	0.38							
Cum. Rounds	**0.25**	**-0.08**	**0.26**	-0.02	-0.06	**0.21**	**0.15**	**0.42**	1.00					
p	**0.00**	**0.05**	**0.00**	0.63	0.12	**0.00**	**0.00**	**0.00**						
Risk Variance	**0.26**	0.06	0.07	**-0.16**	**0.09**	**-0.11**	**0.16**	-0.01	-0.06	1.00				
p	**0.00**	0.14	0.12	**0.00**	**0.05**	**0.01**	**0.00**	0.73	0.19					
Financial Risk	**0.13**	-0.16	**0.11**	**-0.30**	**0.29**	**-0.22**	**0.09**	**0.10**	0.01	**0.23**	1.00			
p	**0.00**	0.00	**0.01**	**0.00**	**0.00**	**0.00**	**0.03**	**0.02**	0.79	**0.00**				
Market Risk	**-0.12**	-0.07	**0.07**	**-0.21**	**0.26**	**-0.34**	**0.15**	**-0.21**	-0.03	**0.24**	**0.48**	1.00		
p	**0.01**	0.12	**0.10**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.46	**0.00**	**0.00**			
Tech. Risk	**-0.14**	**-0.29**	-0.01	**-0.19**	**0.25**	**-0.51**	**0.10**	**-0.17**	**-0.13**	**-0.10**	**0.38**	**0.46**	1.00	
p	**0.00**	**0.00**	0.77	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**		
Mgmt. Risk	-0.04	**-0.24**	-0.03	**-0.16**	**0.17**	**-0.28**	-0.03	0.00	**-0.08**	**-0.23**	**0.47**	**0.47**	**0.52**	1.00
p	0.32	**0.00**	0.42	**0.00**	**0.00**	**0.00**	0.42	0.95	**0.07**	**0.00**	**0.00**	**0.00**	**0.00**	

I also examined trends among the risk correlations, as shown in Figure B-1 in Appendix B. As the graphs show, the correlations fit a quadratic curvilinear trend. The correlations between financial risk and the other risks trends upward until the middle of the observation period, then declines (trend lines' R^2: .66 for market risk, .32 for tech risk, .37 for management risk). The quadratic trend is especially strong for market risk (trend lines' R^2: .66 for financial risk, .60 for tech risk, .69 for management risk). The curvilinear pattern also holds for technology risk and management risk.

Hypothesis Tests

The hypothesized model was estimated using multinomial logit. See Table 5 for a summary of findings and Table 6 for the detailed model estimation. The full model has a pseudo-R^2 of .246 while the control model's pseudo-R^2 is .164. While a traditional R^2 is appropriate to determine the amount of variation explained for a single continuous variable, pseudo-R^2 can indicate fit goodness of fit for a discrete choice model (Hensher et al., 2005). It is calculated by comparing the log-likelihood of a hypothesized model with the intercept model (Statistical-Consulting-Group, 2009):

$$R^2 = 1 - \frac{\ln \hat{L}(M_{Full})}{\ln \hat{L}(M_{Intercept})}$$

In addition the likelihood ratio test shows that the full model is significant above and beyond the control model with a p-value of 0.000.

H1a predicted that financial risk would positively influence follow-on investment. The hypothesis is strongly supported (p=.000). H1b predicted that financial risk would also positively influence investment termination. H1b is also strongly supported (p=.000).

H2a predicted that market risk would negatively influence follow-on investment, while H2b predicted that market risk would positively influence investment termination. H2a is moderately supported (p=.54), as is H2b (p=.60).

H3a predicted that technology risk would negatively influence the likelihood of follow-on investment while H3b predicted that technology risk would positively influence the likelihood of investment termination. Neither hypothesis is supported.

H4a predicted that management risk will negatively influence the likelihood of follow-on investment. H4a is supported (p=.049). Finally, H4b is a null hypothesis, predicting no significant relationship between management risk and investment termination. Management risk is not significantly associated with investment termination, supporting H4b (p=.834).

Table 5: Summary of Findings

	Dimension	Prediction	Finding
H1a	Financial Risk	Positively influences follow-on	Strong Support (p=.000)
H1b	Financial Risk	Positively influences termination	Strong Support (p=.001)
H2a	Market Risk	Negatively influences follow-on	Marginal Support (p=.054)
H2b	Market Risk	Positively influences termination	Marginal Support (p=.060)
H3a	Technology Risk	Negatively influences follow-on	No support (p=.355)
H3b	Technology Risk	Positively influences termination	No support (p=.379)
H4a	Management Risk	Negatively influences follow-on	Support (p=.049)
H4b	Management Risk	No influence on termination	Support (p=.834)

Effects of Control Variables

The model includes10 control variables, many of which significantly influence follow-on investment, investment termination, or both. The VC is significantly more likely to terminate a Fund 1 investment, but fund has no significant effect on follow-on. Whether or not the portfolio firm is in the software sector positively influences the likelihood of follow-on investment, but has no significant influence on investment termination. The level of the NASDAQ index at the time of initial investment significantly and negatively influences subsequent follow-on investment, but has no significant effect on investment termination after the risk variables are added to the control model. The current level of the NASDAQ at the time of the portfolio decision

has no effect on either reinvestment or investment termination. Whether or not the portfolio company is late-stage has no effect on follow-on investment or but does positively influence investment termination in the control model influence termination when the risk variables are included.

The three "escalation of commitment" variables (ownership level, investment duration, and cumulative number of prior follow-on investments) all significantly and positively influence follow-on investment. In the full model, ownership is positively and significantly associated with investment termination, but investment duration and cumulative investment rounds are not significant. . Finally, in the control model, risk variance has no significant effect, but in the full model, it significantly and negatively influences investment termination.

Table 6: Model Estimation – Multinomial Logit

	Control Model		Full Model			Control Model		Full Model	
Follow-On	Std Coeff	p	Std Coeff	p	Investment Termination	Std Coeff	p	Std Coeff	p
Constant	-3.425	0.000	-3.354	0.001	Constant	-2.976	0.003	-4.113	0.000
Fund 1	-1.504	0.133	-1.751	0.080	Fund 1	1.426	0.154	3.162	0.002
Software Sector	3.235	0.001	3.302	0.001	Software Sector	-0.545	0.584	-1.030	0.303
Initial NASDAQ	-2.309	0.021	-2.048	0.041	Initial NASDAQ	0.114	0.910	1.473	0.141
Current NASDAQ	1.196	0.232	1.440	0.150	Current NASDAQ	1.084	0.279	1.559	0.119
Time to Fund Term	2.608	0.009	2.046	0.041	Time to Fund Term	2.289	0.024	0.903	0.366
Late Stage Company	0.406	0.685	0.460	0.646	Late Stage Company	1.258	0.208	2.551	0.011
Ownership Level	6.282	0.000	5.480	0.000	Ownership Level	1.263	0.207	1.902	0.057
Investment Duration	3.088	0.004	1.877	0.061	Investment Duration	1.991	0.046	0.318	0.751
Cumulative Rounds	2.931	0.003	3.654	0.000	Cumulative Rounds	0.871	0.384	0.397	0.692
Risk Dimension Variance	0.825	0.410	-0.704	0.481	Risk Dimension Variance	1.04	0.300	-5.075	0.000
Financial Risk			4.731	0.000	Financial Risk			3.353	0.001
Market Risk			-1.923	0.054	Market Risk			1.880	0.060
Technology Risk			0.925	0.355	Technology Risk			0.880	0.379
Management Risk			-2.811	0.049	Management Risk			-0.209	0.834

Info Statistics:	Control	Full
Log Likelihood	-361.264	-325.079
AIC	1.301	1.217
BIC	1.533	1.544
HQIC	1.387	1.344
Pseudo R-Squared	0.164	0.246
Chi Squared	141.633 (p=0.000)	212.272 (p=0.000)

Note: Shaded/bold-faced boxes indicate significance of p=.10 or stronger.

Supplemental Analyses

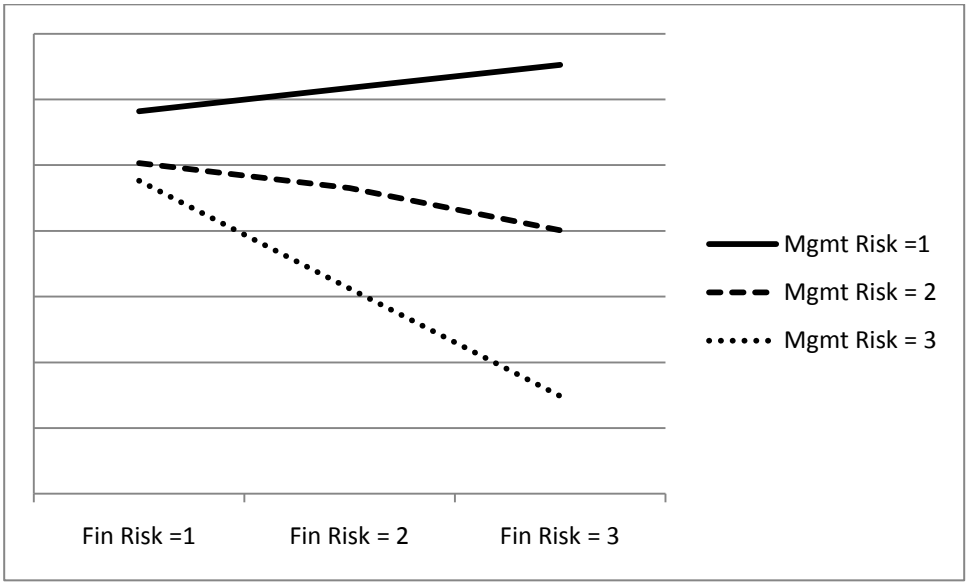
I conducted supplemental analyses to examine the possible effects of aggregate risk and interactions between financial risk and the other three risks. I also considered the effects of an unmeasured, heterogeneous, time-invariant characteristic among the portfolio firms that would lead to a common latent effect among the dependent variables and also freely correlated effects on each utility function (Greene, 2007).

I explored the effect of aggregate risk because a single measure is used so often in management research and because manager vernacular refers to "high risk" or "low risk" companies. For the purpose of this analysis, the aggregate measure is the sum of the four risk dimensions, then lagged by one period. A single risk measure implies that variance among risk components either does not exist or is not known. However, since this study does have a measure for risk variance, I tested the effect of aggregate risk with and without risk variance in the model. When risk variance is omitted, there is no significant effect of aggregate risk. When risk variance is included, aggregate risk does not influence follow-on investment, but significantly and positively affects investment termination. The results are shown in Appendix B in Table B-7

I also examined whether financial risk interacts with market, technology and/or management risk. The results are shown in Appendix B in Table B-8. The addition of the interaction terms is not a significant improvement in log-likelihood over the main effects model. Furthermore, most of the independent variables lose significance, with the exception of the positive effect of financial risk on follow-on investment. There is

also one significant interaction, where management risk negatively influences the effect of financial risk on follow-on investment. As Figure 4 shows, when management risk is low, financial risk positively influences follow-on investment; however, when management risk is medium or high, financial risk negatively influences follow-on investment.

Figure 4: Interaction of Financial Risk With Management Risk



I also considered the possibility that – rather than a multiplicative interaction – the effect of financial risk would be conditional on the presence of different levels of the other risk dimensions. I first attempted to test this condition by splitting the financial risk variable into multiple variables (that would all add up to the total effect of financial risk) in the presence of high vs. low/medium market and management risk,

thus creating four financial risk variables: financial risk in the presence of high market and high management risk, financial risk in the presence of high market and low/medium management risk, financial risk in the presence of low/medium market and high management risk, and financial risk when both market and management risks are low/medium. (I did not include technology risk because it was not significant in the main hypothesis tests and because three additional variables already added complexity.) However, the analysis could not be conducted because there were too few observations in some of the cells. Table B-9 in Appendix B shows the number of observations for each iteration of financial risk

I also tried splitting the sample between observations of high vs. medium/low risk dimensions. In other words, I separately estimated the model with the sample split between high vs. medium low market risk, high vs. medium/low technology risk, and high vs. medium/low management risk. The full results are depicted in Table B-10 in Appendix B; Table 7 below summarizes the results. While the significance of financial risk varies, the main finding is that splitting the sample between different categories of high vs. medium /low risk almost always causes the direction of the influence of financial risk to switch. In the presence of high management risk, financial risk significantly and negatively influences follow-on investment, but in the presence of medium/low management risk, financial risk significantly and positively influences follow-on investment. In the presence of high market risk as well as high technology risk, financial risk significantly and positively influences investment

termination. However, in the presence of medium/low market risk as well as medium/ low technology risk, financial risk significantly and negatively influences investment termination.

Table 7: Summary of Sample Splits Between High vs. Medium/Low Risks

Conditions:	High Mkt Risk		Med-Lo Mkt Risk		High Tech Risk		Med-Lo Tech		High Mgmt Risk		Med-Lo Mgmt	
Follow-On	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p
Market Risk	NA	NA	NA	NA	-0.32	0.75	-0.31	0.76	-0.60	0.55	-0.60	0.55
Tech Risk	1.10	0.28	1.09	0.28	NA	NA	NA	NA	0.908	0.36	0.91	0.36
Mgmt Risk	-1.62	0.11	-1.62	0.11	-1.15	0.25	-1.11	0.27	NA	NA	NA	NA
Financial Risk	-0.94	0.35	0.95	0.34	0.01	0.99	0.18	0.86	-2.22	0.03	2.23	0.03
Termination												
Market Risk	NA	NA	NA	NA	2.41	0.02	2.414	0.02	2.62	0.01	2.62	0.01
TechRisk	2.11	0.04	2.11	0.04	NA	NA	NA	NA	1.77	0.08	1.77	0.08
Mgmt Risk	0.90	0.37	0.90	0.37	0.45	0.65	0.53	0.60	NA	NA	NA	NA
Financial Risk	2.66	0.01	-2.65	0.01	2.41	0.02	-2.36	0.02	0.17	0.86	-0.17	0.87

Because Independence of Irrelevant Alternatives is a strong assumption, I also tested the robustness of my findings by running the model with more relaxed assumptions regarding common effects among the dependent variables. Table B-11 in Appendix B shows these additional results. A log likelihood test does show that the common effects is more significant (p=.000) than the multinomial logit model, while the freely correlated effects model is not more significant. Both models produce similar results to the MNL analysis, with two exceptions. First, risk variance no longer has a significant effect on investment termination. Second, market risk no longer has a significant effect on either follow-on or termination, although it does retain its negative sign for reinvestment and positive sign for investment termination.

In this section, I have depicted the descriptive statistics and provided the results of the control model and hypothesis tests. I also have presented the results of several supplemental analyses. The following chapter will discuss the meaning and implications of those results.

CHAPTER 6: IMPLICATIONS AND DISCUSSION

In this dissertation, I have offered explanations for why venture capitalists embrace some risks while they reject others that appear to be equally risky. I theorized that venture capitalists depend on their prototypes of winning investments in order to determine if a portfolio company is worthy of a follow-on investment. On the other hand, I argued that if a portfolio company exhibits the characteristics of a losing investment, investment termination will occur if a central risk characteristic is less controllable, but not if the risk dimension is more controllable. This section will discuss the implications of the analysis, as well as limitations of this study and suggestions for future research.

I predicted the influence of financial risk, market risk, technology risk and management risk on the likelihood of VC follow-on investment or investment termination. After analyzing 542 observations of 57 portfolio companies in two funds of a major venture capital firm observed quarterly over five years, I found that – as predicted – financial risk positively influences both follow-on investment and investment termination. I also found that market risk (a less controllable risk) negatively influences follow-on investment, but positively influences investment termination, again supporting my hypotheses. Finally, I found that management risk (a more controllable risk) negatively influences follow-on investment and has no significant impact on investment termination, also supporting my hypotheses.

Contrary to my predictions, technology risk did not have a significant effect on either follow-on investment or investment termination.

Risk Dimensions: Equivocality, Centrality, and Controllability

As my results show, financial risk leads to action, but that action can be either increasing commitment to a portfolio firm or terminating investment. The reason that the same type of risk can lead to apparently opposite actions is that financial risk is an equivocal signal that can indicate either health or sickness for a young firm, and especially one backed by early-stage venture capital. This implies that researchers examining entrepreneurial businesses must go beyond the use of accounting data as risk indicators because they underspecify influences on investors' risk-based decisions. Other, "softer" indicators, such as the central risk characteristics used in this study, are more reliable indicators of a VC's assessment of the future prospects of an entrepreneurial firm. The VC uses those central characteristics to decide whether or not to continue to support a portfolio firm because they are better proxies for the potential sale value of a firm that may not yet have sales revenue or even a marketable product.

While financial risk predicted apparently opposite choices by the VC, it also had the strongest effect, with a standardized coefficient of 4.73 on follow-on investment and 3.35 on investment termination. This outsize effect (relative to the other three risk dimensions) reveals the degree to which increasing financial risk increases the urgency for VC action. When a young firm draws down its cash reserves and requires millions

of dollars of additional investment before investors can hope to break even, the VC faces a stark choice. It can provide additional capital so that the portfolio company can continue to survive and hopefully grow into a self-sustaining business (and profitable exit for the VC). Or the VC can terminate the investment by default, because the portfolio company is unlikely to survive without additional funding. Holding the company in the portfolio without providing additional funding often is simply not an option.

My findings show that the VC's specific decision to reinvest, hold or terminate is determined by two central characteristics: market risk and management risk. However, the VC uses a somewhat different logic to decide to make a follow-on investment vs. the logic used to terminate an investment. In the case of follow-on, the VC will increase financial commitment to a portfolio firm that looks like a winning investment prototype, depending on the same criteria as for the initial investment. One the other hand, a different logic is invoked if a portfolio firm no longer "looks like" the prototype of a winner. Instead, the VC must consider the controllability of a risk dimension: if a risk is more controllable, then the VC will attempt to mitigate the risk rather than terminate the investment.

A portfolio firm's market risk is less controllable by the VC because the investee company is affected by external entities (customers, competitors, suppliers) that have no contractual obligations to the VC. The implication of this is that, while the VC may advise a portfolio firm on how to respond to the market, it is not in a position to

actually change the market. For example, it appears that when a portfolio firm gets into trouble, e.g. a so-called "living dead" firm that is only persisting due to VC support, adverse market forces appear to be the most significant contributor to failure, not causal factors controllable by the VC (Ruhnka, Feldman, & Dean, 1992). My findings support the logic that a VC would respond to a high market risk by being less likely to make a follow-on investment in a firm and more likely to accept a loss in exiting from a firm, in both cases because the VC is unlikely to be able to improve market munificence.

On the other hand, management risk is clearly a more controllable risk because the composition of portfolio company leadership is more likely to be under the contractual control of the VC. My results show that the VC avoids reinvesting in firms in response to increasing management risk, but that investment termination is unaffected. This finding reflects that idea that the VC is more likely change the composition of an unsatisfactory management team than terminate investment. In fact, in this sample, in close to 25% of the company-quarters when management risk was assessed high, management risk was rated lower in the following quarter. Internal records show that the VC's general partners actively participated numerous times in the recruiting and selection of members of the management team, including replacing the CEO.

It is important to note that the effect size for market risk is relatively small with a standardized coefficient of 1.923 (p=.054) for follow-on investment and 1.88 (p=.60) for investment termination. In fact, while the signs stay the same, market risk is no

longer significant when the analysis allows for a common effect among the three decision options, probably because three additional degrees of freedom are consumed. On the other hand, the effect of management risk on follow-on investment one follow-on investment is stronger, with a standardized coefficient of -2.811 (p=.049). The relative effect of market vs. management risk echoes the findings regarding venture capital investment criteria that suggest that – while both are important - management characteristics are a stronger influence on VC commitment than market characteristics.

Technology risk does not appear to have a significant effect on either reinvestment or investment termination. I believe that one reason for the lack of results is that this risk category may not fit neatly in either the winner/loser prototype or the less/more controllable dichotomy. Instead, high technology risk may be an indication that a portfolio firms needs additional investment to pursue research and development. Also, while the VC does not have direct control over the technology, the VC can solicit advice from experts and recruit high-powered technologists to join portfolio firm management team. In addition, there may be a kind of pecking order in the importance of different risks: in the analysis of the sample splits, when either market risk or management risk was held constant, technology risk became a significant positive influence on investment termination.

Combined Risk Effects

The dual effect of financial risk implies that the VC considers additional factors in conjunction with its assessment of the financial condition of a portfolio firm. I

attempted to identify the nature of those additional considerations. The interaction model was not significant, and the only significant interaction with in that model was between management and financial risk. As the graph in Figure 4 shows, when management risk is low (implying that VC confidence in the management team is high, then increasing financial risk leads to a greater likelihood of follow-on investment. On the other hand, when management risk is medium or low, increasing financial risk decreases the likelihood of follow-on investment.

It is possible that the VC's don't use the logic of a multiplicative interaction, but are influenced more by discrete thresholds of risk. I found some support for this logic. If management risk is high, then the VC will avoid reinvesting in response to increasing financial risk. If management risk is medium/low, then the VC will react to increasing financial risk by making a follow-on investment. On the other hand, if either market risk or technology risk are high, then the VC will be more likely to terminate investment as financial risk increases; however if market and technology risk are medium/low, then the VC will be less likely to terminate as financial risk increases.

Aggregate Risk

I also analyzed the effects of aggregate risk because multiple prior studies acknowledge different risk dimensions, but assume that they can be summed to a single metric (Baird & Thomas, 1985; Yates & Stone, 1992b). I did not create a hypothesis for aggregate risk because the VC firm's partners explained to me that they

started out with a single aggregate risk measure that they did not consider to be useful. Instead, while they appeared to take a noncompensatory approach to risk: because each dimension provides information in its own right, low risk in one facet does not necessarily compensate for high risk in another. Instead, they made portfolio decisions based on separate, but simultaneous, considerations of the four individual functional risks. Therefore, I did not expect aggregate risk to be a significant influence on their decisions.

I tested for the effect of aggregate risk in two ways – by including risk variance in the model and by omitting risk variance. The model that included risk variance implies that a decision maker may depend on some overall metric, but is also aware of the variety of inputs that contribute to the risk metric. I found that when risk variance is included in the model, aggregate risk does positively and significantly affect investment termination, but has no significant effect on follow-on investment. I also tested a model without risk variance in order to reflect the idea that a single, compensatory metric, without any sense of the nature of the underlying risk dimensions, can influence a VC's risk-based decision. In that model, aggregate risk had no significant effect on either follow-on investment or investment termination

My finding reinforces prior findings that undifferentiated risk is simply not that meaningful to managers. Instead, they take a nuanced view of risk as a multidimensional construct, with complex dynamics among the dimensions that cannot be reduce to a single metric (March & Shapira, 1987; Shapira, 1995).

Control Variable Implications

In order to hone in on financial, market, technology and management risk, I utilized control variables that prior researchers had determined affect VCs' and other managers' risk-based decisions. This study extended some of those findings by incorporating several decision options (increase, retain at the same level, reject) in the same model, rather than using binomial outcomes. Specifically, I will address the apparent effects of escalation of commitment, portfolio company stage, and risk variance.

Escalation of commitment appears to play a significant role in the decision to make a follow-on investment in a portfolio company. Follow-on investment becomes increasingly likely with increasing VC ownership of the portfolio firm, duration of the investment, and the previous formal investment rounds in the firm. This finding is consistent with prior research that determined that VCs' late round investments appear to be influenced by political and institutional considerations and that may be necessary in the overall context of the VC's standing in the industry and relationship to coinvestors, but suboptimize the return on the specific investment (Guler, 2007). Escalation of commitment may also be influenced by psychological factors, like the desire to rationalize prior decisions (Beauvois et al., 1993).

Because I used three different variables to proxy escalation of commitment, the findings hint at different influences of institutional vs. psychological factors. When the VC has greater ownership in a portfolio company, it plays a more active leadership

role than investment syndicate members with lesser ownership. As a result the VC may be expected to model confidence in a portfolio company by investing additional funds in the firm, irrespective of its risk assessment. Furthermore, if the VC has a greater ownership in a firm, it may be drawn into further investment in order to avoid having its ownership stake being diluted, thus reducing both the VC's influence and its potential future returns (Guler, 2003). Increasing investment duration also may create emotional investment on the part of the VC, resulting in a greater desire to support a portfolio firm. Finally, each follow-on investment is a public indication of VC commitment; a refusal to reinvest becomes a public contradiction to prior behavior, making it psychologically and politically difficult to withhold additional funds.

On the other hand, ownership level positively influences investment termination, if only at a marginal level ($p=.057$). In other words, increasing ownership increases the likelihood of both follow-on investment and investment termination. One explanation for this dual effect is that ownership implies leadership within a venture capital syndicate (De Clercq et al., 2008),and leadership implies action. Therefore, increasing levels of ownership will impel the VC to be more likely to take some action (either positive or negative) in lieu of simply holding the investment. It is also interesting to note that investment duration and post-investment cumulative rounds have no significant effect on investment termination. If follow-on investment and investment termination were truly opposite responses to the same stimuli, then it would be been expected for ownership level, investment duration and cumulative post-investment

rounds would all have a negative influence on investment termination. Instead, it appears that the phenomenon known as escalation of commitment is quite complex, where the decision to increase commitment is not necessarily the opposite of the decision to terminate commitment.

A second interesting finding regarding the control variables is that late stage companies are more likely to be exited at a loss, but there appears to be no stage influence on follow-on investment. The lack of relationship with follow-on investment is a manifestation of the practice of staging investment: because VCs limit their capital at risk by making additional investment contingent on achieving milestones throughout the portfolio firm's development, follow-on rounds may be required from the earliest days of the firm well into full market ramp-up (Gompers, 1995). On the other hand, it appears that VCs delay investment termination until demand for a portfolio firm's product or service has been determined by the market. One possible explanation is cognitive: investors tend to delay realizing their losses (Kahneman et al., 1991). But a rational, information-based explanation may hold as well: it is difficult to determine a firm's value until its products and/or services have been tested in the market, thus confirming or disconfirming the viability of its business model.

Finally, risk variance appears to affect different portfolio actions differently. Variance among the four functional risks has no significant effect on follow-on investment, but negatively and significantly influences investment termination. This

difference may be caused by inertial forces in organizational decision making: managers continue to pursue a strategy unless prior or prospective poor performance forces them to search for a new approach (Bromiley, 2005; Cyert & March, 1992). Like holding, a follow-on investment is a tactical continuation of an existing strategy regarding a portfolio company. Therefore, the VC is more likely to attend to the potential hazards of specific risks, but not necessarily on the consistency among the risk dimensions. Therefore, it is not surprising that there is no significant effect of risk variance on reinvestment vs. holding.

On the other hand, investment termination is a difficult decision in two ways. First, it entails recognizing a financial loss, which managers (like most people) are averse to doing (Kahneman et al., 1991; Shefrin & Statman, 1985). For example, loss aversion leads investors to delay stock sales in order to delay recognizing losses in their portfolios (Shefrin & Statman, 1985). Second, investment termination entails departing from the strategy that was previously put in place at the time of the initial investment, which requires the VC to overcome the inertia and status quo preference inherent in organizational decision making (Anderson, 2003; Kahneman et al., 1991; Samuelson & Zeckhauser, 1988). This status quo bias combines with individuals' confirmation bias, i.e. our selective attention to information that supports our preconceived ideas while ignoring information that does not support our initial perspective (Nickerson, 1998).

When risk variance is high but at least one less-controllable risk is severe, the VC considering investment termination is faced with making an irreversible decision that requires public acknowledgement of loss (via financial reports to limited partners). However, if different risk dimensions are sending different signals, the temptation is to focus on the low-risk dimensions as more reliable indicators of potential portfolio firm success. This tendency may be especially strong in venture capitalists because VC lore includes multiple anecdotes about "the one that got away," meaning ultimately successful ventures that were rejected by potential or current investors (Harris, 2008).

Practitioner Implications

Given that VCs have difficulty articulating their investment decision processes (Zacharakis & Meyer, 1998), this paper's differentiation of underlying dimensions may also help increase practitioners' insights into their risk-based decision making. While it is well-established that managers view risk as multidimensional (Shapira, 1995), their use of functional terms as shorthand for types of risk explain the relative acceptability of different risk dimensions. Instead, while managers may believe on some level that they can "make their own luck" by shaping the outcome of a risky decision over time, they also do distinguish among risks and prefer those that are more controllable (MacCrimmon & Wehrung, 1986).

The question then becomes how to overlay controllability onto managers' functional risk shorthand. This dissertation has argued that risks affected by external entities or trends are less controllable than risks that are internal and/or are under the

venture capitalist's contractual control. The conclusion is that more external, less controllable risks should be avoided, while more internal and controllable risks can be embraced because their effects can be mitigated.

Another practitioner issue implied in this research is the question of when to exit from a bad investment (or a losing strategy). Prior research has shown that managers tend to wait too long to take the irreversible step of recognizing a loss by abandoning a strategy or investment (Guler, 2007; Jackson & Dutton, 1988; Shefrin & Statman, 1985; Staw & Ross, 1987). Other research has shown that escalation of commitment can be attenuated through organizational decision rules and protocols (McNamara, Moon, & Bromiley, 2002; Simonson & Staw, 1992).

This analysis used a one-period lag (one calendar quarter) because it minimized the reduction in sample size and had the strongest predictive power for the model with all possible outcomes. However, lags of two or even three periods (six to nine months) were equally predictive of investment termination, implying that the VC chose to wait for a more extended period before taking the irreversible step of realizing the loss. In other words, the VC could have acted more quickly on its earlier negative risk assessments, thus conserving managerial attention and resources, when terminating an investment.

Limitations

The findings of this research are subject to a number of limitations. First, the sample is taken from a single venture capital firm, which may be operating quite

idiosyncratically. Second, the analysis uses composite risk measures rather than the underlying assessment items, thus calling into question their psychometric reliability. Third, the observation period is both left and right-censored, which may mean that findings might have been different if the full 10-year time period were available. While, I believe that the research design largely addresses these issues, care must be taken in generalizing from this analysis.

As discussed in the methods chapter, the sample is composed of observations of portfolio companies in two funds of a single venture capital firm. While I had access to far richer data than this focus allows can be obtained from secondary sources, this study assumes that the firm operates sufficiently in the mainstream that the findings can be generalized to other early-stage VCs.

A second set of concerns is the reliability of the risk measures used in the analysis. My analysis used the functional risk measures that were reported in the quarterly reports to limited partners. An alternative data set would have been the actual underlying items that informed these risk measures, although they were not reported to the limited partners. I did not do so for several reasons. First, hundreds of internal detailed quarterly assessments were missing (due to staff turnover) or incomplete (because the general partners did not feel all items were relevant to specific portfolio companies at specific times). Second, the VC internal and external communications emphasized the summary functional risk assessments, consistently using these numbers in their internal decision-making meetings and external reports. Third, the

VC's functional risk assessments appear to be formative, not reflective measures. In other words, each of the underlying items appears to combine to form the functional risk assessment – they must be used as a group to define the functional risk measure (MacKenzie, Podsakoff, & Jarvis, 2005). Classic measures of reliability that are used for items within a reflected measure (e.g. intraclass correlation or Cronbach's alpha) would be misleading and irrelevant. However, I do acknowledge that my use of the functional measures, while more granular and detailed than most studies of managers' risk-based decisions, does ignore the underlying items that the VC archived.

Third, the observation period is both left- and right-censored. The left censoring is due to the fact the VC did not formalize its risk assessments until 2001, several years into the life of the two fund portfolios. The right censoring is due the fact that funds will not be terminated until 2009 and 2010. I attempted to address this issue using control variables that might be affected by passage of time, such as how many years were left in the life of each fund, the level of the NASDAQ at the time of the initial investment and the current decision, the duration of the investment and the stage of the portfolio company. However, the controls may not fully account for the effect of missing data on both ends of the time period.

Opportunities for Future Research

This dissertation points to numerous opportunities for future research. One set of opportunities would be to explore more deeply the antecedents of different risk dimensions and how risk dimensions affect each other. A second set of opportunities

would be to extend the concerns of this dissertation to a broader population of managerial decision makers. A third set of opportunities would be to examine the impact of risk dimensions on managerial decisions outside the venture capital arena.

It would be interesting to understand how risks affect other risks both cross-sectionally and over time. My analysis generated tantalizing results regarding the direction of financial risk given the level and presence of other risks, but these relationships could not be teased out. For instance, is management risk an early warning sign of technology/product risk or financial risk? How do each of the risk dimensions, and the mix of different levels and types of risk among multiple portfolio firms, affect overall portfolio performance? Also, it would be valuable to revisit this sample after both funds have terminated, when it would be feasible not only to examine how the deadline pressure inherent in fund termination would interact with risk to affect the VC's reinvestment and exit decisions.

More broadly within the venture capital context, it would be interesting to replicate and extend these results by examining other VC firms' risk-based portfolio decisions. While it may not be feasible to obtain the depth of access that this study received, it may be possible to gather similar data using repeated surveys over time to a panel of venture capital firms. Also, it would be of value to develop an understanding of how risk assessments, as well as other contextual factors, relate to the decision to exit at a profit, a rare, but obviously important outcome. Finally, it would be interesting to consider how risk assessments may influence VCs'

interventions at the portfolio firm level, e.g. replacement of the CEO or various strategic changes.

While the VC context shows risk taking in high relief, it would also be of value to consider how prototypes and risk controllability affect the risky decisions of other types of managers. This dissertation suggests that conformity with a "winning" prototype leads to increased commitment, but that rejecting a pre-existing commitment entails a different dynamic, whereby the VC takes into account the controllability of the risk dimension that is violating the winner prototype. However, in the VC context, portfolio firm failure, while unpleasant, is quite common. In a mature corporate setting, a lower tolerance for failure may mean that downside concerns are more prevalent.

Finally, although I use a longitudinal data set, this dissertation does not consider whether or not any learning takes place over the duration of the VC portfolio. However, Figure B-3 shows that the means of the risk dimensions gradually decrease over time. This may imply that the average risk assessment is declining simply because the VC is more comfortable and familiar with whatever risks exist within the portfolio. Or, declining average risk may simply an indication of the maturation of the firms in the portfolio, implying lower risk is a byproduct of the shifting composition of the portfolio, as more member firms evolve to the stage where they have products, customers and revenue. On the other hand, declining average risk may indicate that the VC has learned to decrease portfolio risk over time – either by jettisoning

nonperformers or intervening to improve portfolio company performance. It would be interesting to try to tease out the different effects of individual portfolio company maturation, overall portfolio composition evolution, and venture capitalist learning.

CHAPTER 7: CONTRIBUTION

While strategic management and entrepreneurship literatures have primarily focused on managers' considerations regarding initial risk-based decision, their subsequent actions are also vital to ultimate success or failure of those decisions. This dissertation contributes to both literatures by analyzing specific determinants of post-investment decisions: how VC risk assessments influence the decision to increase a portfolio company commitment by making a follow-on investment or reject the commitment by terminating the investment.

Focus on the Decision Maker's Perspective

Since Bowman's (1980) counterintuitive observation that risk appears to be inversely related to performance, much of the strategic management risk literature has used an a priori definition of risk (often some version of performance variance) to explain managerial decisions. However, for several possible reasons, subsequent findings have been mixed. One problem may be the level of analysis. Because it is often difficult to obtain data at the decision level, researchers may use risk taking proxies at the organizational level, such as prior performance variance (Bowman, 1980), uncertainty regarding future earnings (Bromiley, 1991), and the lower partial moment of prior performance, i.e. downside risk (Bowman, 1980; Miller & Leiblein, 1996; Miller & Reuer, 1996). The concern with organizational-level data is that it represents the accumulation of multiple decisions made at multiple points in time – it becomes difficult to determine specific decision influences. While a few studies have

examined influences on decisions regarding corporate strategic direction (Greve, 1998, 2003b; Shapira, 1995) and commercial lending (McNamara & Bromiley, 1997, 1999), this dissertation builds on that decision-level research by extending the focus to a high-risk context where managers repeatedly revisit their prior strategic decisions.

A second possible cause of prior mixed findings is that some researchers' risk definitions may not be meaningful to managers and therefore not consistently predictive of their actions. While much strategic management research make use of a statistical, variance-based definition of risk, managers define risk as the hazard of loss, not as variance with both an up and down side (Yates & Stone, 1992a). Rather than impose a risk definition, this dissertation adopts the risk considerations that were actually used by my sample's decision makers.

Finally, prior survey research has found that managers tend to avoid consolidated risk metrics and prefer to consider risks separately in their decision-making, thus implying that different considerations drive decisions in the presence of different hazards (March & Shapira, 1987; Shapira, 1995). However, much empirical strategic management research has focused on unitary risk measures that can be obtained from publicly reported accounting data. This dissertation builds on those earlier survey-based insights by examining in-use risk categories in actual managerial decisions, which are also reflective of the risk categories in broad use in the venture capital industry (MacMillan et al., 1985; Tyebjee & Bruno, 1984).

Categories and Dimensions

Prior research has shown that managers use their own terms of art to describe facets of risk (Shapira, 1995). While functional risk categories may have meaning for managers, they do not explain why high risk in one dimension is more acceptable than another and how risk preferences might vary based on the nature of the decision. In this dissertation, I have clearly delineated the differences between follow-on investment and investment termination, and how each decision type flows from a different logic. I extend recent research that acknowledges the power of prototypes for entrepreneurs' and VCs' prospective decisions by then considering the role of prototypes after an initial strategic commitment has been made.

The preference for controllability has been identified in numerous studies of both managers and the general population (Klein & Kunda, 1994; Langer, 1975; MacCrimmon & Wehrung, 1986; March & Shapira, 1987; Slovic et al., 1985; Stotz & Von Nitzsch, 2005). Based on the financial and management control emphasis in VCs' contractual terms with their investee companies (Fiet, 1995; Kaplan & Stromberg, 2004), I infer that VCs have greater real and perceived control over financial risk and management risk than market risk. Therefore, I advance the literature by integrating the atheoretical functional risk categories with the concept of controllability, which helps explain which risk dimension a manager is more likely to reject.

Real Decisions Executed Over Real Time

This dissertation also contributes empirically to the entrepreneurship and management literatures by relating managers' internal, nonpublic risk assessments with their subsequent investment and exit decisions over time. First, this dissertation advances the entrepreneurship literature, by examining the little-studied phenomenon of VCs' ongoing portfolio decisions. Second, this panel study avoids that causality concerns inherent in cross-sectional studies.

Third, my use of a multinomial logit analysis takes into account the full range of possible VC financial actions regarding a portfolio company. This approach makes it possible to determine that two apparently opposite actions may both be positively influenced by the same antecedents. The multinomial analysis also sheds light on escalation of commitment, which traditionally was studied by comparing binomial choices rather than the more complex situation where doing nothing is as viable an option as increasing or rejecting commitment.

Conclusion

This research addresses several research opportunities suggested by Bromiley et al. in their review on risk in strategic management research (Bromiley et al., 2001). First, they point out that researchers want "to understand managerial strategic decisions, but lack research on actual decisions." I build on prior research on commercial lending decisions (McNamara & Bromiley, 1997), by conducting the first study of ongoing reinvestment and termination decisions within the venture capital context. This

dissertation breaks ground empirically by using nonpublic records to capture actual, real-time risk assessments, rather than depending on simulations, experiments, or managers' recollections. A second concern is that scholars may use risk measures that do not reflect the way managers think. While this research does analyze the risk assessments that the VC partners actually use, I also put those risks into a theoretical context of prototype theory and behavioral decision theory. A third opportunity is to better understand "the lag structure of risk-return relations." While I do not look at overall portfolio return, the longitudinal design of this research does make it possible to analyze the lag relationships between risk assessment and subsequent investment/exit.

In summary, this research opens up the black-box of risky decision making. By relating VCs' internal risk assessments to their subsequent actions, this dissertation increases scholarly understanding about why managers embrace or reject risk.

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Appendix A – VC Risk Dimension Worksheet

Table A-1

VC Risk Dimension Worksheet (As of December 2006)

Category	Item	Low Risk	Medium Risk	High Risk
Financial Risk	Cash Runway	Long - ≥ 12 months of cash	Short to medium – Between 6 and 12 months of cash	Action! – Less than 6 months of cash
	Debt + Equity to Breakeven	Small - ≤ $5 million	Medium - ≤ $15 million	Very high - ≥ $15 million
	Business Model Risk	Low – Number of months required to breakeven ≤ 12	Medium – Number of months required to breakeven ≤ 18	High – Number of months required to breakeven ≥ 18
	VC Control	High – Lead or colead investor/Large shareholder (≥ 20%)	Medium – Lead or colead investor/Large shareholder (≥ 15%)	Low – Conflict emerging between shareholders/founders or < 15%)
	Resource Availability	High – 2 other deep pocket syndicate members	Medium – 1 other deep pocket syndicate member	Low – No other deep pocket syndicate members
	Investor Eagerness	Very high – Likely able to raise outside capital at flat or up-round	Medium – Challenging to raise outside capital at flat round	Low – Internal round is only option
Market Risk	Market Timing	Near-term opportunity – Market ramp expected ≤ 12 months	Medium -term opportunity – Market ramp expected in 12-24 months	Long -term opportunity – Market ramp expected in ≥ 12-24 months
	Market Timing	Near-term opportunity – Market ramp expected ≤ 12 months	Medium -term opportunity – Market ramp expected in 12-24 months	Long -term opportunity – Market ramp expected in ≥ 12-24 months
	Market Size	Large – Addressable market ≥ $500 million within 3 years	Average - Addressable market ≥ $300 million within 3 years	Low - Addressable market < $300 million within 3 years
	Market Competition	Leader - #1 (by revenue) in the market	Strong competitor - #2-3 (by revenue) in the market	Trailing – 3 or more higher revenue competitors
	Market Traction	Strong - >$20 million in revenue in next 12 months	Good - >5 million of revenue in next 12 months	Unproven - <$5 million in next 12 months
	Revenue Track Record	Good – Forecast miss < 10% over past 2 quarters	Needs improvement – Forecast miss < 30% over past 2 quarters	Poor or TBD – Forecast miss >30% or pre-revenue

Category	Item	Low Risk	Medium Risk	High Risk
Technology Risk (compo-nents)	Product Feasibility	Very likely – First product released	Foreseeable – Beta product released	TBD – Prototype (alpha) stage or earlier
	Proof of Intellectual Property	Sustainable – Defensible patents on architecture and application	Underway – Patents on architecture and application filed	TBD - Patents on architecture and application being defined or not yet defined
	Product Acceptance	High – Product tested and working in ≥ 2 customer environments	Underway– Beta release tested successfully in ≥ 2 customer environments	Started – Product untested (trials inconclusive to date or in ≤ 2 customer environments)
	Development/Delivery Track Record	Good – Average historic delay on milestones ≤ two months	Fair – Average historic delay on milestones ≤ six months	Poor – Average historic delay on milestones ≥ six months
	Core Technical Team	Low – Industry leading technical team (top 2-3 teams in the world), all critical skills sets in place	Medium – Strong team with directly relevant experience, ≥ 80% of skill sets in place	High – Related but not direct experience or incomplete team
	Product Development Continuity	Very likely – No major technical hurdle after 1st release (late stage of development of 2nd release)	Foreseeable – Clear product development roadmap after 1st release	TBD – No clear product development roadmap after 1st release
Manage-ment Risk	Mgmt Team Completeness	High – No > than 1 interim or missing VPs relative to plan	Strong – No > than 2 interim or missing VPs relative to plan	Incomplete - More than 2 interim or missing VPs relative to plan
	Mgmt Team Leadership	Assured – World class CEO	Adequate – CEO suited for company stage	Weak or no adequate CEO in place
	Mgmt Team Experience	Relevant – History of success in relevant area	Adequate – Adequate background, or success in other areas	Unproven – Lack of proven success
	Mgmt Team Dynamics	Very good – No conflict between any management team members	Good – No dangerous conflict between any mgmt team members	To be controlled – Some conflicts between certain team members
	Execution Track Record	Excellent – Almost always hits plan (cash burn, milestones, etc.)	Good – Usually hits plan (cash burn, milestones, etc.)	Weak – Misses plan often (cash burn, milestones, etc.)
	Board of Directors	Excellent – World class independent(s) & quality VCs (high value-add)	Adequate – Quality independent(s) & quality VCs	Needs improvement – Only VCs and management

Appendix B – Additional Tables

Table B-1

Risk Dimension Cronbach Alphas - Overall and by Quarter

	Financial	Market	Technology	Management
Overall	.600	.450	.583	.626
Quarter 1	.577	.246	.674	.629
Quarter 2	.695	.502	.607	.353
Quarter 3	.795	.578	.667	.710
Quarter 4	.785	.279	.614	.670
Quarter 5	.522	.324	.543	.698
Quarter 6	.530	.361	.551	.708
Quarter 7	.507	.454	.622	.747
Quarter 8	.483	.486	.673	.710
Quarter 9	.428	.575	.721	.898
Quarter 10	.460	.379	.778	.614
Quarter 11	.530	.602	.645	.531
Quarter 12	.700	.687	.691	.783
Quarter 13	.721	.625	.396	.515
Quarter 14	.708	.611	.478	.538
Quarter 15	.690	.602	.319	.533
Quarter 16	.582	.600	.334	.577
Quarter 17	.668	.574	.503	.608
Quarter 18	.640	.566	.564	.594
Quarter 19	.552	.482	.652	.705
Quarter 20	.664	.379	.722	.626

Table B-2

Principal Factor Analysis of Underlying Risk Worksheet Items

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	9.98754	3.84384	0.5291	0.5291
Factor2	6.14369	4.62292	0.3255	0.8546
Factor3	1.52077	0.84768	0.0806	0.9352
Factor4	0.67309	0.16934	0.0357	0.9708
Factor5	0.50375	0.34889	0.0267	0.9975
Factor6	0.15486	0.15486	0.0082	1.0057

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Uniqueness
breakeve	0.9115	0.3722	-0.0960	-0.0613	0.1336	0.0072	-0.0002
busmod	0.8290	0.5274	-0.0827	0.1414	-0.0799	0.0680	-0.0032
control	-0.8310	0.5534	-0.0410	0.0267	0.0297	-0.0134	-0.0003
resavail	-0.0897	-0.8729	-0.1278	0.0333	-0.1084	0.2098	0.1569
inveag	0.8310	-0.5534	0.0410	-0.0267	-0.0297	0.0134	-0.0003
mktsize	0.8055	0.2078	0.4009	0.1288	-0.1778	-0.1774	0.0676
mktcomp	0.1101	-0.9291	0.0810	-0.2796	0.2000	-0.0858	-0.0074
mkttrac	0.9115	0.3722	-0.0960	-0.0613	0.1336	0.0072	-0.0002
revtrack	0.5121	0.7076	-0.0515	0.0083	-0.2917	0.1828	0.1158
revgrwth	-0.3178	-0.4443	-0.3827	0.2572	0.3819	0.0857	0.3358
suprisk	-0.6760	0.6430	0.1661	0.0307	0.1032	0.0184	0.0901
prodacc	0.9115	0.3722	-0.0960	-0.0613	0.1336	0.0072	-0.0002
servrel	-0.9115	-0.3722	0.0960	0.0613	-0.1336	-0.0072	-0.0002
servevol	0.0722	0.6347	0.7096	0.0294	0.2773	0.1048	-0.0003
regenvi	-0.0398	-0.6239	0.7714	0.0682	0.0296	0.0963	-0.0007
mgtlead	0.8310	-0.5534	0.0410	-0.0267	-0.0297	0.0134	-0.0003
mgtexp	0.9115	0.3722	-0.0960	-0.0613	0.1336	0.0072	-0.0002
recrrec	-0.8310	0.5534	-0.0410	0.0267	0.0297	-0.0134	-0.0003
execrec	0.4443	-0.2638	-0.0245	0.6798	0.0318	-0.0700	0.2643
bofd	0.8310	-0.5534	0.0410	-0.0267	-0.0297	0.0134	-0.0003

Table B-3

Risk Dimension Correlations by Quarter

-> quartid = 1

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.2381	1.0000		
tchrisk	0.1235	0.2738	1.0000	
mgtrisk	0.3582	0.3854	0.4514	1.0000

-> quartid = 2

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.1018	1.0000		
tchrisk	0.2737	0.2484	1.0000	
mgtrisk	0.2800	0.2589	0.6192	1.0000

-> quartid = 3

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.1181	1.0000		
tchrisk	0.3313	0.2132	1.0000	
mgtrisk	0.4129	0.2675	0.5501	1.0000

-> quartid = 4

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.2313	1.0000		
tchrisk	0.3553	0.1579	1.0000	
mgtrisk	0.1467	0.2869	0.4542	1.0000

-> quartid = 5

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.2338	1.0000		
tchrisk	0.2087	0.0778	1.0000	
mgtrisk	0.2449	0.3013	0.2913	1.0000

-> quartid = 6

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.3419	1.0000		
tchrisk	0.1501	0.2835	1.0000	
mgtrisk	0.3288	0.3600	0.5068	1.0000

-> quartid = 7

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.5798	1.0000		
tchrisk	0.3245	0.5259	1.0000	
mgtrisk	0.5854	0.4834	0.5909	1.0000

-> quartid = 8

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.5834	1.0000		
tchrisk	0.4322	0.4650	1.0000	
mgtrisk	0.7154	0.5320	0.5947	1.0000

-> quartid = 9

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.4572	1.0000		
tchrisk	0.3478	0.4136	1.0000	
mgtrisk	0.4727	0.5257	0.5286	1.0000

-> quartid = 10

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.4703	1.0000		
tchrisk	0.5304	0.3046	1.0000	
mgtrisk	0.5881	0.4868	0.5226	1.0000

Table B-3 Continued

-> quartid = 11

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.4669	1.0000		
tchrisk	0.2261	0.6191	1.0000	
mgtrisk	0.3495	0.5372	0.4297	1.0000

-> quartid = 12

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.5196	1.0000		
tchrisk	0.3800	0.7605	1.0000	
mgtrisk	0.4173	0.6058	0.6519	1.0000

-> quartid = 13

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.6523	1.0000		
tchrisk	0.4273	0.6249	1.0000	
mgtrisk	0.5981	0.6175	0.5840	1.0000

-> quartid = 14

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.6752	1.0000		
tchrisk	0.4624	0.6034	1.0000	
mgtrisk	0.6592	0.6336	0.4608	1.0000

-> quartid = 15

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.6706	1.0000		
tchrisk	0.5692	0.7116	1.0000	
mgtrisk	0.5757	0.6306	0.6159	1.0000

-> quartid = 16

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.5912	1.0000		
tchrisk	0.5466	0.6156	1.0000	
mgtrisk	0.4900	0.6729	0.4939	1.0000

-> quartid = 17

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.5283	1.0000		
tchrisk	0.4079	0.5331	1.0000	
mgtrisk	0.5969	0.5516	0.5092	1.0000

-> quartid = 18

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.4178	1.0000		
tchrisk	0.2739	0.5238	1.0000	
mgtrisk	0.4778	0.4485	0.5139	1.0000

-> quartid = 19

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.4779	1.0000		
tchrisk	0.2507	0.4834	1.0000	
mgtrisk	0.4086	0.4230	0.5113	1.0000

-> quartid = 20

	finrisk	mktrisk	tchrisk	mgtrisk
finrisk	1.0000			
mktrisk	0.5722	1.0000		
tchrisk	0.3182	0.4453	1.0000	
mgtrisk	0.3665	0.3371	0.3464	1.0

Table B-4

Frequency of Transitions Among Risk Severity Levels

Financial Risk	Financial Risk			
	1	2	3	Total
1	108	18	2	128
	84.38	14.06	1.56	100.00
2	16	130	34	180
	8.89	72.22	18.89	100.00
3	6	20	208	234
	2.56	8.55	88.89	100.00
Total	130	168	244	542
	23.99	31.00	45.02	100.00

Market Risk	Market Risk			
	1	2	3	Total
1	67	8	3	78
	85.90	10.26	3.85	100.00
2	8	172	21	201
	3.98	85.57	10.45	100.00
3	4	22	237	263
	1.52	8.37	90.11	100.00
Total	79	202	261	542
	14.58	37.27	48.15	100.00

Technology/Prod.Risk	Technology/Product Risk			
	1	2	3	Total
1	108	8	3	119
	90.76	6.72	2.52	100.00
2	17	243	11	271
	6.27	89.67	4.06	100.00
3	0	15	137	152
	0.00	9.87	90.13	100.00
Total	125	266	151	542
	23.06	49.08	27.86	100.00

Management Risk	Management Risk			
	1	2	3	Total
1	194	15	3	212
	91.51	7.08	1.42	100.00
2	13	218	18	249
	5.22	87.55	7.23	100.00
3	1	17	63	81
	1.23	20.99	77.78	100.00
Total	208	250	84	542
	38.38	46.13	15.50	100.00

Table B-5

Summary Statistics by Decision Type

Decision Type: Hold

Variable	Mean	Std. Dev.	Min	Max	Observations
Fund 1	.286031	.4524059	0	1	N = 451
Software	.2172949	.4128629	0	1	N = 451
Initial NASDAQ	2708.801	1095.301	1320.91	4914.79	N = 451
Current NASDAQ	1888.958	371.4872	1139.9	2415.29	N = 451
Qs to Fund End	21.98448	5.72342	9	32	N = 451
Late Stage	.5676275	.4959556	0	1	N = 451
Ownership	.1540807	.0846275	.0054	.4427	N = 451
Invest. Duration	11.7051	6.66663	1	31	N = 451
Cumulative Rounds	.6363636	.7185845	0	3	N = 451
Risk Variance	.2547589	.2173246	0	1	N = 394
Financial Risk	2.083756	.7979555	1	3	N = 394
Market Risk	2.317259	.7470768	1	3	N = 394
Technology Risk	2.045685	.7225514	1	3	N = 394
Management Risk	1.766497	.7071387	1	3	N = 394

Decision Type: Follow-On Investment

Variable	Mean	Std. Dev.	Min	Max	Observations
Fund 1	.2598425	.4402849	0	1	N = 127
Software	.3385827	.4751019	0	1	N = 127
Initial NASDAQ	2846.034	1144.685	1320.91	4914.79	N = 127
Current NASDAQ	1938.622	331.7606	1139.9	2415.29	N = 127
Qs to Fund End	21.49606	5.567585	11	32	N = 127
Late Stage	.6377953	.4825411	0	1	N = 127
Ownership	.2197669	.0933167	.045	.45	N = 127
Invest. Duration	13.72441	6.276281	2	29	N = 127
Cumulative Rounds	1.03937	.8203907	0	3	N = 127
Risk Variance	.2859375	.2311233	0	1	N = 120
Financial Risk	2.408333	.7275588	1	3	N = 120
Market Risk	2.316667	.6348868	1	3	N = 120
Technology Risk	2.033333	.6208335	1	3	N = 120
Management Risk	1.633333	.6208335	1	3	N = 120

Decision Type: Investment Termination

Variable	Mean	Std. Dev.	Min	Max	Observations
Fund 1	.5714286	.5039526	0	1	N = 28
Software	.1428571	.3563483	0	1	N = 28
Initial NASDAQ	3219.511	1022.255	1498.8	4798.13	N = 28
Current NASDAQ	1822.157	320.3937	1139.9	2317.04	N = 28
Qs to Fund End	22.46429	4.517309	10	31	N = 28
Late Stage	.75	.4409586	0	1	N = 28
Ownership	.1660964	.1184052	.0077	.45	N = 28
Invest. Duration	15.96429	5.343616	4	28	N = 28
Cumulative Rounds	1.035714	.7444681	0	3	N = 28
Risk Variance	.2451923	.2214463	0	.6875	N = 26
Financial Risk	2.884615	.4314555	1	3	N = 26
Market Risk	2.807692	.4019185	2	3	N = 26
Technology Risk	2.461538	.7060181	1	3	N = 26
Management Risk	2.230769	.6516252	1	3	N = 26

Table B-6

Risk Dimension Means By Quarter

Over	Mean	Std. Err.	[95% Conf.	Interval]
	Financial Risk			
1	2.555556	.1087041	2.342069	2.769042
2	2.542857	.1253087	2.29676	2.788954
3	2.485714	.1255002	2.239241	2.732187
4	2.628571	.0924523	2.447002	2.810141
5	2.416667	.1219875	2.177092	2.656241
6	2.382353	.1336096	2.119954	2.644752
7	2.354839	.1432975	2.073413	2.636264
8	2.310345	.1497407	2.016265	2.604424
9	2.259259	.1470759	1.970413	2.548105
10	2.25	.1504823	1.954464	2.545536
11	2.115385	.1501479	1.820505	2.410264
12	2	.1601282	1.68552	2.31448
13	2.037037	.1643556	1.714255	2.359819
14	2	.1569412	1.691779	2.308221
15	1.928571	.1536898	1.626736	2.230407
16	1.925926	.1594678	1.612743	2.239109
17	1.851852	.1481481	1.5609	2.142804
18	1.793103	.1348171	1.528333	2.057874
19	2.033333	.1476508	1.743358	2.323309
20	1.965517	.1528285	1.665373	2.265661
	Market Risk			
1	2.472222	.1090079	2.258139	2.686306
2	2.542857	.1110898	2.324685	2.761029
3	2.6	.1020792	2.399524	2.800476
4	2.657143	.09994	2.460868	2.853418
5	2.472222	.1090079	2.258139	2.686306
6	2.588235	.1044265	2.383149	2.793321
7	2.451613	.1298362	2.196624	2.706602
8	2.37931	.1351317	2.113922	2.644699
9	2.333333	.1412198	2.055988	2.610678
10	2.208333	.1471858	1.919271	2.497395
11	2.153846	.1434981	1.872026	2.435666
12	2.222222	.1540834	1.919614	2.524831
13	2.148148	.1574702	1.838888	2.457408
14	2.275862	.1394619	2.001969	2.549755
15	2.321429	.1366025	2.053151	2.589706
16	2.185185	.1415929	1.907107	2.463263
17	2.148148	.1381987	1.876736	2.41956
18	2.172414	.1319517	1.913271	2.431557
19	2.166667	.1276069	1.916056	2.417277
20	2.137931	.1286931	1.885187	2.390675

Table B-6 Continued on Following Page

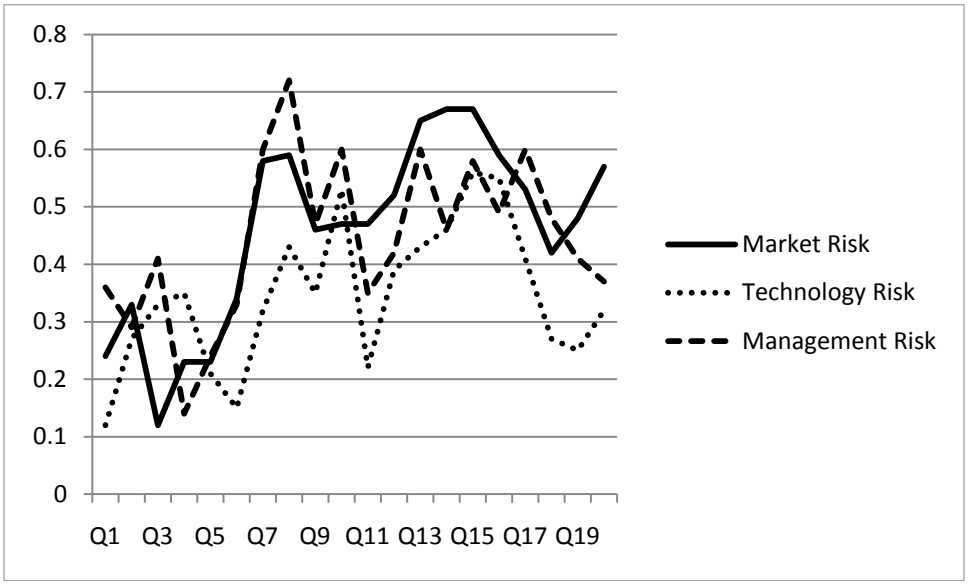
Table B-6 Continued

Over	Mean	Std. Err.	[95% Conf.	Interval]
	Technology Risk			
1	2.194444	.1248456	1.949257	2.439632
2	2.257143	.1253087	2.011046	2.50324
3	2.228571	.1235723	1.985885	2.471258
4	2.257143	.1110898	2.038971	2.475315
5	2.166667	.1091089	1.952385	2.380949
6	2.117647	.1098103	1.901988	2.333306
7	2.129032	.1290323	1.875623	2.382442
8	2.103448	.1345017	1.839297	2.3676
9	2.148148	.1381987	1.876736	2.41956
10	2.041667	.1532163	1.740761	2.342572
11	1.961538	.141212	1.684209	2.238868
12	2.074074	.1404706	1.7982	2.349948
13	2.074074	.1404706	1.7982	2.349948
14	1.965517	.1357588	1.698897	2.232137
15	2	.1360828	1.732744	2.267256
16	2	.1307441	1.743228	2.256772
17	1.851852	.127475	1.6015	2.102203
18	1.793103	.1253499	1.546926	2.039281
19	1.8	.1304281	1.543849	2.056151
20	1.827586	.1222628	1.587471	2.067701
	Management Risk			
1	1.833333	.1290994	1.579792	2.086875
2	1.971429	.1327518	1.710714	2.232143
3	1.942857	.1292698	1.688981	2.196733
4	2.057143	.1080216	1.844996	2.269289
5	1.805556	.1040409	1.601227	2.009884
6	1.823529	.1073966	1.612611	2.034448
7	1.741935	.1132866	1.519449	1.964422
8	1.724138	.1205136	1.487458	1.960818
9	1.777778	.1343268	1.51397	2.041586
10	1.666667	.1432878	1.38526	1.948073
11	1.692308	.1443205	1.408873	1.975742
12	1.703704	.1492127	1.410661	1.996746
13	1.703704	.1492127	1.410661	1.996746
14	1.862069	.1547614	1.558129	2.166009
15	1.75	.142028	1.471068	2.028932
16	1.62963	.1323484	1.369707	1.889552
17	1.62963	.1211078	1.391783	1.867476
18	1.586207	.1054809	1.37905	1.793363
19	1.666667	.1206623	1.429695	1.903638
20	1.655172	.1243294	1.410999	1.899346

Figure B-1

Correlation Trends Among Risk Dimension Variables

a. Financial Risk Correlations With Other Risk Dimensions



b. Market Risk Correlations With Other Risk Dimensions

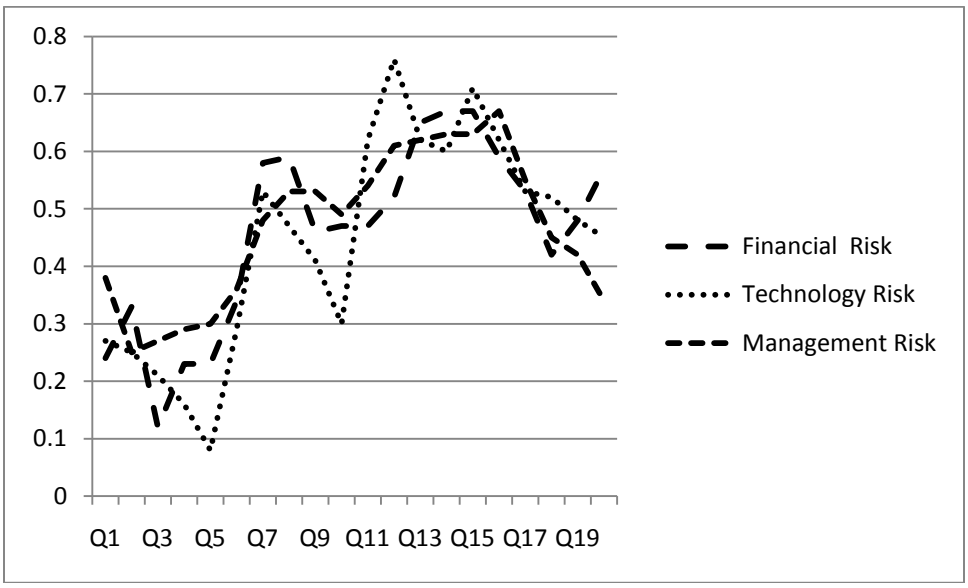
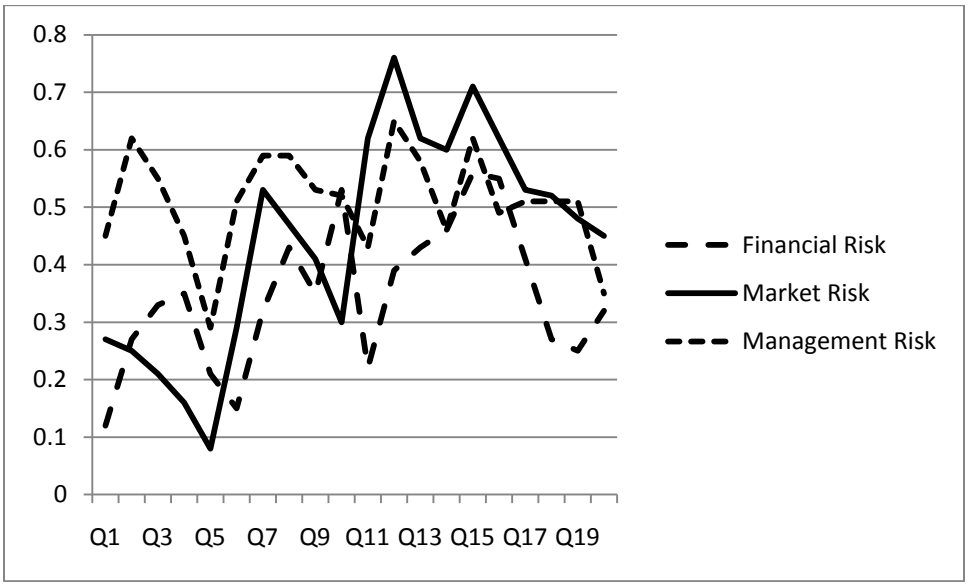


Figure B-1 Continued

c. Technology Risk Correlations With Other Risk Dimensions



d. Management Risk Correlations With Other Risk Dimensions

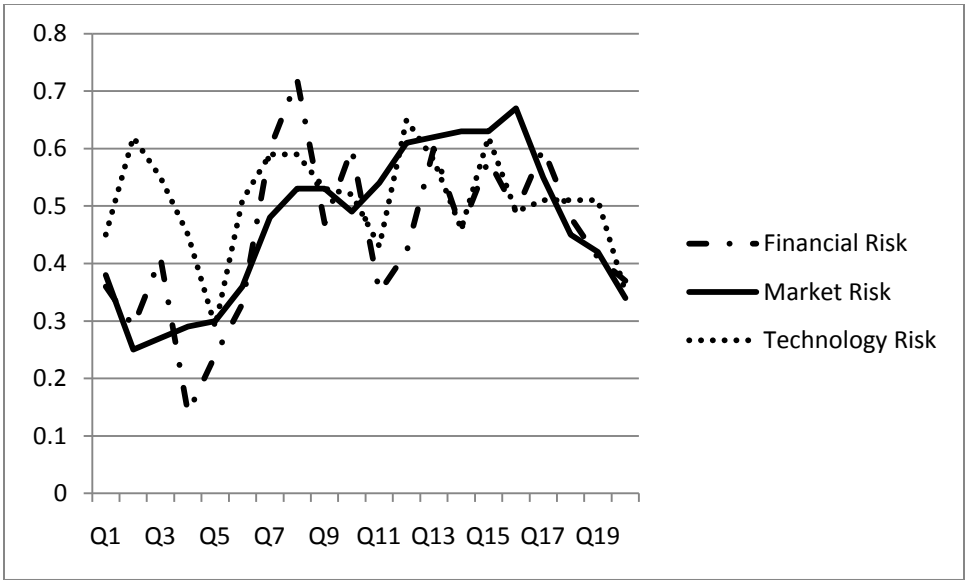


Table B-7

Supplementary Analysis – Aggregate Risk

	Control No Risk Var		Agg. Risk No Risk Var		Control W/ Risk Var		Agg. Risk W/ Risk Var	
Follow-On	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p
Constant	-3.397	0.001	-3.427	0.001	-3.425	0.000	-3.564	0.004
Fund 1	-1.952	0.051	-1.500	0.134	-1.504	0.133	-1.332	0.183
Software Sector	3.244	0.001	3.236	0.001	3.235	0.001	3.360	0.001
Initial NASDAQ	-2.412	0.016	-2.308	0.021	-2.309	0.021	-2.400	0.016
Current NASDAQ	0.933	0.351	1.198	0.231	1.196	0.232	1.307	0.191
Time to Fund Term	2.506	0.012	2.610	0.001	2.608	0.009	2.630	0.009
Late Stage Company	0.389	0.698	0.408	0.683	0.406	0.685	0.635	0.529
Ownership Level	6.434	0.000	6.279	0.000	6.282	0.000	6.182	0.000
Investment Duration	3.369	0.001	3.073	0.002	3.088	0.004	2.979	0.003
Cumulative Rounds	2.929	0.003	2.932	0.003	2.931	0.003	3.005	0.003
Risk Variance					0.825	0.410	-0.668	0.504
Aggregate Risk			0.829	0.407			0.676	0.499
Investment Termination								
Constant	-2.892	0.004	-2.994	0.003	-2.976	0.003	-4.435	0.000
Fund 1	1.045	0.296	1.450	0.147	1.426	0.154	3.304	0.001
Software Sector	-0.527	0.599	-0.545	0.586	-0.545	0.584	-0.625	0.532
Initial NASDAQ	-0.080	0.036	0.123	0.902	0.114	0.910	1.555	0.120
Current NASDAQ	0.599	0.549	1.112	0.266	1.084	0.279	1.812	0.070
Time to Fund Term	2.098	0.036	2.307	0.021	2.289	0.024	1.161	0.246
Late Stage Company	1.278	0.201	1.259	0.208	1.258	0.208	3.049	0.002
Ownership Level	1.534	0.125	1.251	0.211	1.263	0.207	1.643	0.100
Investment Duration	2.312	0.021	1.978	0.048	1.991	0.046	0.352	0.725
Cumulative Rounds	0.844	0.398	0.873	0.383	0.871	0.384	0.563	0.574
Risk Variance					1.04	0.300	-5.294	0.000
Aggregate Risk			1.081	0.280			5.301	0.000
Info Statistics								
Log Likelihood	-361.264		-360.340		-360.398		-338.970	
AIC	1.287		1.294		1.301		1.243	
BIC	1.505		1.533		1.533		1.495	
HQIC	1.372		1.387		1.387		1.335	
Pseudo R-Squared	0.162		0.164		0.164		0.214	
Chi Squared	139.901 (p=0.000)		141.746 (p=0.000)		141.633 (p=0.000)		184.492 (p=.000)	

Table B-8: Supplemental Analysis – Interactions

Follow-On	Std Coeff	p
Constant	-3.538	0.000
Fund 1	-1.187	0.235
Software Sector	3.340	0.001
Initial NASDAQ	-2.279	0.023
Current NASDAQ	1.481	0.139
Time to Fund Term	2.007	0.045
Late Stage Company	0.214	0.831
Ownership Level	5.294	0.000
Investment Duration	1.886	0.059
Cumulative Rounds	3.735	0.000
Risk Dimension Variance	-1.614	0.107
Financial Risk	2.700	0.007
Market Risk	-1.112	0.266
Technology Risk	0.811	0.417
Management Risk	0.936	0.349
Market * Financial Risk	0.654	0.513
Tech Risk * Financial Risk	0.274	0.784
Mgmt * Financial Risk	-1.993	0.046
Investment Termination		
Constant	-2.984	0.003
Fund 1	3.143	0.002
Software Sector	-1.078	0.281
Initial NASDAQ	1.480	0.139
Current NASDAQ	1.677	0.093
Time to Fund Term	0.775	0.438
Late Stage Company	2.776	0.006
Ownership Level	1.757	0.079
Investment Duration	0.096	0.924
Cumulative Rounds	0.677	0.499
Risk Dimension Variance	0.056	0.956
Financial Risk	-0.451	0.652
Market Risk	0.216	0.829
Technology Risk	-1.128	0.260
Management Risk	0.757	0.445
Market * Financial Risk	0.247	0.805
Tech Risk * Financial Risk	1.509	0.131
Mgmt * Financial Risk	-0.645	0.519
Info Statistics		
Log Likelihood	-320.560	
AIC	1.232	
BIC	1.623	
HQIC	1.385	
Pseudo R-Squared	0.257	
Chi Squared	221.310 (p=0.000)	

Table B-9
Supplemental Analysis – Counts of Observations With Financial Risk in Presence of High vs. Low/Medium Market and Management Risk

	High Market and High Management	High Market and Med/Low Management	Medium/Low Market and High Management	Medium/Low Market and Medium/Low Management	TOTAL
Low Financial Risk	4	13	0	111	128
Medium Financial Risk	18	73	5	85	181
High Financial Risk	47	108	6	72	233
Total	69	194	11	268	542

Table B-10

Supplemental Analysis – High vs. Med Low Market, Tech. and Management Risk Sample Splits

Conditions:	High Market Risk		Med-Lo Mkt Risk		High Tech Risk		Med-Lo Tech		High Mgmt Risk		Med-Lo Mgmt	
Follow-On	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p
Constant	-3.434	0.001	-3.352	0.001	-3.208	0.001	-3.218	0.001	-3.680	0.000	-3.248	0.001
Fund 1	-1.628	0.103	-1.628	0.104	-1.807	0.071	-1.809	0.070	-1.475	0.140	-1.474	0.140
Software Sector	3.188	0.001	3.188	0.001	3.022	0.003	3.004	0.003	3.338	0.001	3.338	0.001
Initial NASDAQ	-2.494	0.013	-2.493	0.013	-2.416	0.016	-2.384	0.017	-2.548	0.011	-2.548	0.011
Current NASDAQ	1.164	0.244	1.165	0.244	1.165	0.244	1.152	0.249	1.120	0.273	1.120	0.263
Time to Fund Term	2.767	0.006	2.789	0.006	2.781	0.005	2.777	0.006	2.741	0.006	2.740	0.006
Late Stage Comp.	0.255	0.799	0.254	0.800	0.176	0.860	0.127	0.899	0.350	0.726	0.350	0.726
Ownership Level	6.200	0.000	6.204	0.000	6.261	0.000	6.267	0.000	6.297	0.000	6.296	0.000
Invest. Duration	3.213	0.001	3.212	0.001	3.185	0.001	3.184	0.002	3.166	0.002	3.165	0.002
Cum. Rounds	3.033	0.002	3.033	0.002	2.921	0.004	2.897	0.004	3.231	0.001	3.233	0.001
Risk Dim. Variance	0.432	0.666	0.429	0.668	1.343	0.179	1.290	0.197	-0.222	0.825	-0.227	0.821
Financial Risk	-0.940	0.347	0.947	0.344	0.008	0.994	0.182	0.856	-2.218	0.027	2.226	0.026
Market Risk	NA	NA	NA	NA	-0.324	0.746	-0.311	0.756	-0.597	0.551	-0.597	0.5506
Technology Risk	1.095	0.276	1.090	0.276	NA	NA	NA	NA	0.908	0.364	0.909	0.363
Management Risk	-1.622	0.105	-1.621	0.105	-1.152	0.249	-1.112	0.266	NA	NA	NA	NA

Table B-10 continued on following page

Table B-10 (Continued)

Conditions:	High Market Risk		Med-Lo Mkt Risk		High Tech Risk		Med-Lo Tech		High Mgmt Risk		Med-Lo Mgmt	
Investment Termination	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p	Std Coeff	p
Constant	-3.250	0.001	-3.642	0.000	-3.326	0.001	-3.755	0.000	-3.940	0.000	-3.957	0.000
Fund 1	2.797	0.005	2.796	0.005	2.873	0.004	2.914	0.004	2.778	0.006	2.778	0.006
Software Sector	-0.664	0.506	-0.663	0.508	-0.385	0.700	-0.443	0.658	-0.555	0.579	-0.555	0.579
Initial NASDAQ	0.613	0.540	0.611	0.541	0.487	0.626	0.492	0.622	0.262	0.793	0.261	0.794
Current NASDAQ	1.356	0.175	1.356	0.175	1.415	0.157	1.437	0.151	1.309	0.191	1.308	0.191
Time to Fund Term	1.547	0.122	1.549	0.121	1.548	0.122	1.556	0.120	1.751	0.080	1.751	0.080
Late Stage Comp.	2.750	0.006	2.750	0.006	2.992	0.003	2.966	0.003	2.664	0.008	2.664	0.008
Ownership Level	1.546	0.122	1.544	0.123	1.191	0.234	1.269	0.205	1.450	0.147	1.450	0.147
Invest. Duration	1.172	0.241	1.173	0.241	0.846	0.398	0.847	0.397	1.345	0.179	1.346	0.178
Cum. Rounds	0.638	0.524	0.638	0.524	0.841	0.400	0.802	0.422	0.496	0.620	0.496	0.620
Risk Dim. Variance	-3.031	0.002	-3.03	0.003	-2.907	0.004	-3.019	0.003	-4.045	0.000	-4.046	0.000
Financial Risk	2.657	0.008	-2.65	0.008	2.405	0.016	-2.358	0.018	0.173	0.863	-0.167	0.867
Market Risk	NA	NA	NA	NA	2.410	0.016	2.414	0.016	2.620	0.009	2.622	0.009
Technology Risk	2.109	0.035	2.110	0.035	NA	NA	NA	NA	1.766	0.077	1.768	0.077
Management Risk	0.902	0.367	0.904	0.366	0.448	0.654	0.531	0.596	NA	NA	NA	NA
Info Statistics												
Log Likelihood	-342.042		-342.049		-341.438		-341.518		-341.576		-341.557	
AIC	1.263		1.263		1.261		1.262		1.262		1.262	
BIC	1.568		1.568		1.566		1.566		1.566		1.566	
HQIC	1.382		1.382		1.380		1.380		1.380		1.380	
Pseudo R-Squared	0.207		0.207		0.208		0.208		0.208		0.208	
Chi Squared	178.346 (p=0)		178.332(p=0)		179.555 (p=0)		179.395 (p=0)		179.277 (p=0)		179.317(p=0)	

Table B-11

Model Estimation Incorporating Common and Correlated Effects

	Common Latent Effect		Freely Correlated Effects	
Follow-On	Std Coeff	p	Std Coeff	p
Fund 1	-1.220	0.223	-1.241	0.215
Software Sector	2.435	0.015	2.400	0.016
Initial NASDAQ	-2.294	0.022	-2.337	0.019
Current NASDAQ	0.379	0.705	0.378	0.705
Time to Fund Term	0.897	0.370	0.901	0.367
Late Stage Company	-0.409	0.682	-0.406	0.685
Ownership Level	2.888	0.004	2.879	0.004
Investment Duration	0.779	0.436	0.756	0.450
Cumulative Rounds	3.264	0.001	3.304	0.001
Risk Dimension Variance	-1.049	2.944	-1.070	0.285
Financial Risk	3.236	0.001	3.272	0.001
Market Risk	-1.100	0.271	-1.104	0.268
Technology Risk	0.548	0.584	0.569	0.569
Management Risk	-2.213	0.027	-2.220	0.026
Investment Termination				
Fund 1	1.341	0.180	1.393	0.164
Software Sector	-0.045	0.964	-0.025	0.980
Initial NASDAQ	0.881	0.379	0.937	0.349
Current NASDAQ	0.694	0.488	0.708	0.479
Time to Fund Term	0.228	0.820	0.226	0.822
Late Stage Company	1.950	0.051	1.973	0.049
Ownership Level	1.015	0.310	1.052	0.293
Investment Duration	0.435	0.663	0.472	0.637
Cumulative Rounds	0.014	0.989	-0.024	0.981
Risk Dimension Variance	0.350	0.727	0.369	0.712
Financial Risk	1.789	0.074	1.821	0.069
Market Risk	1.063	0.288	1.083	0.279
Technology Risk	1.061	0.289	1.102	0.271
Management Risk	0.510	0.610	0.510	0.610
Info Statistics				
Log Likelihood	-292.461		-292.440	
AIC	1.120		1.130	
BIC	1.468		1.500	
HQIC	1.255		1.274	
Random Parameters	Std Coeff	p	Std Coeff	p
Means: 1	-1.219	0.223	-1.215	0.224
2	-2.218	0.027	-2.269	0.023
3	0.000	1.000	0.000	1.000