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A non-additive decision-aid for venture capitalists' investment decisions

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Abstract

The current study uses theory from the resource-based view of strategy to hypothesize that VCs use non-additive decision policies when making their investment decision. A policy capturing experiment finds that VCs do indeed use non-additive decision policies. Specifically, we find that interactions between leadership experience and other internal resources, and between leadership experience and environmental munificence, affect venture capitalists' decision-making. Although venture capitalists always prefer greater general experience in leadership, they value it more highly in large markets, when there are many competitors, and when the competitors are relatively weak. Previous start-up experience of the venture's management team may substitute for leadership experience. Building on these results, we tested a main-effects-only decision-aid and a decision-aid that included interaction terms (non-additive) and found that both outperformed VCs' own decisions.

Keywords: Leadership experience; Venture capitalist; Non-additive decision policies; Decision-aid

1. Introduction

Venture capital (VC) is an important source of equity for those new ventures that revitalize the economy. In a study of all firms that received VC between 1970 and 2000, it was found that VC-backed firms created one out of every nine jobs and these firms also accounted for over 11% of the country's GDP (NVCA, 2002). It is well worth asking then, what factors affect VCs' decisions (Sapienza and Korsgaard, 1996). VCs choose to invest in those firms that they believe have the potential to generate high returns. Resource-based view (RBV) suggests that new ventures possess specific resource endowments that may lead to superior performance (Amit and Schoemaker, 1993; Barney, 1991). In short, firm resources can provide the basis for competitive advantage that enables firms to earn rents. As such, VCs can evaluate a venture's potential by examining its resource assets.

Fundamental to the resource-based perspective is the belief that those resources and capabilities

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that are valuable, rare, costly to imitate, and non-substitutable become core competencies and serve as a source of the firm's competitive advantage over its rivals (Barney, 1991). Resources and capabilities lead to a competitive advantage, however, only when a strategy is chosen and implemented that allows the firm to best exploit its core competencies in the external environment (Amit and Schoemaker, 1993). Therefore, the strategic leadership of the top management team (the ability to anticipate, envision, maintain flexibility, and empower others to create strategic change) is important to achieving above average returns (Ireland and Hitt, 1999). For example, the team may be able to leverage proprietary technology to establish a longer lead-time over potential entrants thereby earning higher rents (Shepherd and Shanley, 1998). Or, the team that has greater market experience should be able to best position the company to take advantage of the opportunity. The basic premise is that entrepreneurship is as much about opportunity recognition as exploiting the opportunity. Thus, we ask whether strategic leadership is equally critical to VCs' investment assessments in all situations and if not, whether a decision-aid that includes non-additive relationships can help improve a VC firm's investment decision.

This paper examines how VCs evaluate entrepreneurs' leadership experience, a firm resource that can lead to a competitive advantage, in conjunction with other important criteria for predicting new venture success. We then construct a decision-aid and test its performance. In doing so, we shed light on the managerial decision of investing a VC firm's resources and offer a decision-aid to guide this complex investment process. [2] By constructing decision-aids the managers of VC firms have the opportunity "to enhance the degree of conformity and coherence between the evolution of the decision-making process and the value systems and objectives of those involved in the process" (Roy, 1990, p. 324) and those values and objectives most desirable for the firm. This aim is achieved when a firm's decision-aids can help its VCs make better decisions "in the presence of ambiguity, uncertainty, and an abundance of bifurcations" (Roy, 1990, p. 324).

The paper proceeds as follows. Section 2 develops hypotheses based upon the RBV of the firm. Specifically, we propose that VCs place considerable weight on the entrepreneur's leadership experience, but place more weight on leadership when it complements other firm resources and when the market is munificent. Section 3 discusses the "policy capturing" research method used in this study, the sample, and the survey instrument. We develop a refined decision-aid that leads to improved performance over and above VCs' own assessments. Section 4 reviews the results in light of the strategy literature and our understanding of VCs' decision-making. Concluding comments are given in Section 5.

2. Conceptual framework

How do people acquire strategic leadership abilities? While the process is complicated, we do know that the amount of experience people have affects the strategic choices they make and the models they use to make those decisions (Hitt and Tyler, 1991). The cognitive science literature suggests that experience is a good proxy for expertise (Choo and Trotman, 1991; Simon, 1985), meaning that experienced decision makers in a given task may indeed employ better decision processes than do less experienced ones (Nosofsky, 1987). Simon (1985) argues that it takes 10 years to achieve "50,000 chunks of knowledge," which often add up to superior decision performance. Furthermore, as individuals become more experienced with respect to a particular task, they learn to focus attention primarily on the key dimensions (Choo and Trotman, 1991) and create categories of information based on a deep structure that involves more, stronger, and richer links between concepts (Frederick, 1991).

Complementary resources may increase the value of leadership experience, such that this bundle of leadership and resources are more valuable, durable, scarce, and difficult to imitate

[2] These objectives are consistent with those of OR-DA: "seeking essentially to give scientific authority to decisions of a purely managerial nature" (Roy, 1993).

than each resource by itself. Bundling the resources creates a "strategic asset" which may lead to sustainable economic rents assuming it matches the needs/desires of the market (Amit and Schoemaker, 1993). Amit and Schoemaker (1993) assert that the creation of strategic assets is a boundedly rational process. Entrepreneurs bring together resources in unique combinations based upon their interpretation of the environment. The bundle is durable to the extent that it is a function of the firm's unique resource pool and to the extent that the market continues to value the bundle. Firm specificity increases scarcity—it is difficult to recreate a competitive advantage. We assert that leadership experience is more beneficial to the firm in the presence of these resources.

Just as complementary resources increase total value, resources that are *substitutable* for each other decrease total value (Amit and Schoemaker, 1993). Firms accumulating complementary assets may develop economies of scope (Dierickx and Cool, 1989). In essence, the cost of adding complementary resources becomes progressively less on a per resource basis, but if the resources are substitutes, the firm incurs the full cost of resource acquisition. The VC decision-making literature suggests that valuable new venture resources include leadership experience, proprietary technology, market familiarity and previous start-up experience (MacMillan et al., 1985; Muzyka et al., 1996), but does not consider whether these resources are complementary or substitutable. Most of the previous VC decision-making literature views the criteria independently—as main effects (e.g., MacMillan et al., 1985; Muzyka et al., 1996; Zacharakis and Meyer, 2000). It appears that environmental conditions also significantly influence the effectiveness of leadership (Pettigrew, 1987); but again the VC decision-making literature does not sufficiently consider whether environmental conditions provide the context for leadership and may serve as a moderator of the effects of experience on decisions.

2.1. Proprietary technology and leadership experience

The resource-based model proposes that proprietary technology can lead to a competitive advantage when it helps a company neutralize threats and/or exploit opportunities (is valuable); is not possessed by others (is rare); is difficult and costly to imitate; and has no strategic equivalents (is non-substitutable) (Mata et al., 1995). But ownership of proprietary technology is not sufficient. It is often difficult to protect a product's proprietary nature as competitors can hire away key individuals, reverse engineer the technology and so forth. Leaders must enable their organizations to exploit the technology in the market (Ireland and Hitt, 1999; Mata et al., 1995). The opportunity to exploit proprietary technology increases the firm's options, or strategic degrees of freedom. It is when strategic degrees of freedom are high that choosing the "best" course of action has the greatest impact on new venture success (Porter, 1980; Quinn, 1980). Thus, strong leadership and proprietary technology are complementary resources:

Hypothesis 1. VCs value general leadership experience more when the technology is more proprietary.

2.2. Market familiarity and leadership experience

Intangible resources such as knowledge are considered valuable and a potential source of competitive advantage. In particular, knowledge generated from market familiarity provides a good indication of the entrepreneur's ability to cope with changing market circumstances (Roure and Madique, 1986). The more deeply entrepreneurs understand the market, the better they are at anticipating converging trends and opportunities, as well as competitor moves and threats. Combining market familiarity with leadership experience enables the new venture to develop and execute an effective strategy. Leadership experience and market familiarity are complementary; together they increase the value of the resource bundle by making it more rare and more difficult to imitate (Amit and Schoemaker, 1993).

Hypothesis 2. VCs value general leadership experience more when the team's market familiarity is high.

2.3. Start-up experience and leadership experience

VCs also value previous experience with start-ups (MacMillan et al., 1985). Serial entrepreneurs better understand how to organize start-ups (Wright et al., 1997). By their nature, new organizations experience conflict and confusion in recognizing the tasks that need to be performed and allocating people to those tasks. Entrepreneurs with start-up experience understand these issues and have likely developed strategies to resolve them. Stuart and Abetti (1990) found that managerial experience in previous ventures had the most significant positive influence on subsequent start-ups. Wright et al. (1997) found that 75% of 55 UK VCs preferred to invest in serial entrepreneurs because of their wider management experience, demonstrated motivation, and proven track record.

However, other research calls into question the value of past start-up experience. Birley and Westhead (1994) investigated 408 new businesses and found no evidence to suggest that new businesses established by "habitual" founders with prior experience in business venturing are particularly advantaged compared to inexperienced entrepreneurs. In addition, Wright et al. (1997) find that VCs did not report serial entrepreneurs as performing any better than first time entrepreneurs did. Why this apparent discrepancy between studies? There are a number of possible explanations. First, "experienced entrepreneurs... may attempt to repeat actions that were successful in an earlier venture in new circumstances that are quite different (Westhead and Wright, 1998). Second, an entrepreneur's motivation to succeed may lessen, particularly if their previous venture was successful (Starr and Bygrave, 1992). Third, serial entrepreneurs may not recognize their own limitations (Wright et al., 1997). Thus, as a main effect, start-up experience is ambiguous. However, general leadership experience may enhance the power of previous start-up experience making it scarcer, more durable, and more difficult to imitate than either factor separately. Thus, we argue that start-up experience complements general leadership experience.

Hypothesis 3. VCs value leadership experience more when the team also has previous start-up experience.

2.4. Environmental conditions and leadership experience

Some environments are complementary to leadership experience, while others act as substitutes. An environment that can support sustained growth by a particular organization is described as "munificent" (Castrogiovanni, 1991; Goll and Rasheed, 1997). Castrogiovanni (1991) distinguishes among three kinds of munificence: (1) capacity, or market size (Child, 1972), (2) rate of market growth (Dess and Beard, 1984), and (3) opportunity, or resource availability in excess of industry usage (Castrogiovanni, 1991). Highly competitive environments indicate low levels of resource availability beyond industry usage and therefore low munificence (Castrogiovanni, 1991). For example, population ecologists argue that populations have a carrying capacity that is fully utilized where there are not enough resources to support the entry of new competitors and still support those already in the industry (e.g., Brittain and Freeman, 1980; Lambkin and Day, 1989). The VC decision-making literature is consistent with the munificence construct in that VCs view market size, growth, and competition as key attributes to consider in making their investment decision (MacMillan et al., 1985; Muzyka et al., 1996).

Hrebiniak and Joyce (1985) assert that the external resource dependence and other environmental influences, together with leadership's role in competitive positioning and organizational design, jointly affect organizational performance. In a situation where munificence (benign environment with low external threats [Hrebiniak and Joyce, 1985]) is low and, consequently, competitive forces are high, the firm is highly dependent upon the environment, and therefore a leader's strategic choices are severely limited (Hrebiniak and Joyce, 1985; Lawless and Finch, 1989). However, where munificence is high and competitive forces are low, there are multiple means of achieving desired outcomes (Hrebiniak and Joyce, 1985), and

therefore a strong leader has more opportunity to influence a company's ultimate success (Goll and Rasheed, 1997).

We would therefore expect that VCs would place greater importance on leadership experience in environments that are more munificent. We propose that the environment is more munificent when the target market is large and its projected growth rate is high. Large markets likely have longer operating history. Hence, the problems ventures are likely to face are understood and easier to identify. In such a market, strong entrepreneurial leaders can use this information to make decisions that lead to superior performance. Less accomplished leaders may not interpret the industry as effectively. Growing markets, on the other hand, are forgiving. One or two bad decisions can be learning points. Thus, effective leaders can have a greater impact in munificent environments. If a new venture can capture 5% of a large market, it can derive significant sales often without incurring the ire of other market participants. And if the market is growing, new entrants typically go after new customers rather than those of their competitors. In a small market, venture growth is constrained not only by market size but also by competitor awareness. Thus, a leader's decision effectiveness is similarly constrained. [3] Thus,

Hypothesis 4. VCs value general leadership experience more for markets that are (a) larger, and (b) faster growing.

Hypothesis 5. VCs value leadership experience more when competitors are (a) fewer and (b) relatively weaker.

2.5. A non-additive decision-aid for venture capitalists

VCs often rely on "gut feel" when making the investment decision (Khan, 1987), which may make the decision prone to biases (Shepherd et al., 2003; Zacharakis and Meyer, 2000). Biases and heuristics inhibit optimal decisions (e.g., Hogarth and Makridakis, 1981). The availability bias, for example, may encourage decision makers to recall past successes rather than failures (Dawes et al., 1989). Therefore, a VC is apt to assess the success of a current venture prospect by how similar the current prospect is to a past success. If the venture under consideration uses the same technology, or has the same lead entrepreneur, such available information may bias the VC to overlook other information that suggests the current venture is likely to fail. Likewise, a VC utilizing a satisfying heuristic might reject new venture proposals when the minimum requirement for any one criterion is not met, even if all other remaining factors are substantially higher than the minimum requirements. As such, the VC may eliminate potentially profitable investments from further consideration because of a heuristic rule (s)he is using to keep the task manageable.

A decision-aid that decomposes the decision into its component parts helps the VC focus on a series of smaller decisions, thereby minimizing the gestalt process of the "gut decision." Zacharakis and Meyer (2000) found that a main effects decision-aid outperformed VCs in making the screening decision. The current paper extends previous work into VC decision-aids by asking whether a non-additive decision-aid might further improve a VC's decision. Some decision-making scholars have argued that main-effect models capture the majority of the variance (e.g., Louviere, 1988; Slovic and Lichtenstein, 1971). However, since VCs focus on identifying high potential ventures (those ventures that can generate returns in excess of 50%) we argue that even a marginal improvement in explained variance may have a dramatic improvement on the VC's success in "picking winners" and therefore the VC firm's return on investment. We now explore the use of models as decision-aids and then compare the performance of these decision-aids to the performance of the VCs from which it was created.

A common type of decision-aid uses expert input to define important criteria; such models are called bootstrap models (Dawes and Corrigan, 1974; Fischhoff, 1988; Slovic, 1972). Bootstrap

[3] A possible alternate explanation is that the room for error is less in slower growing markets and therefore leadership experience would be more valued.

models aim to capture the expert's cognitive system, including both the criteria and relative weights actually used by VCs in past decisions. Equal weighting models are a simplified version of bootstrap models and aim to capture the criteria used by VCs but assume that each criterion is of equal importance to the judgment being made. A number of studies across a variety of decision contexts have found that each of these statistical models outperforms actual decision-makers (Camerer, 1981; Dawes, 1971; Osherson et al., 1997; Lyness and Cornelius, 1982; Libby and Libby, 1989). For example, Einhorn (1974) found that a bootstrap model outperformed expert pathologists in predicting a patient's survival from cancer based on nine histological cues.

We propose that bootstrap models have the potential to increase a VC firm's return on investment by improving a VC's decision accuracy. Bootstrap models do this because they are consistent, they are not biased by a non-random sample, they optimally weight information factors, and they reduce the decision-maker's cognitive load (Camerer, 1981). Zacharakis and Meyer (2000) developed an equal weighted model as a decision-aid for evaluating VC proposals. Their model outperformed VCs in differentiating between those proposals that would generate returns and those that would fail. We argue that if VCs use the non-additive relationships proposed above, then the performance of a decision-aid can be improved by constructing a decision-aid that incorporates these non-additive relationships. Thus,

Hypothesis 6. (a) The main-effects-only decision-aid will outperform VCs' own assessments. (b) The non-additive decision-aid will outperform VCs' own assessments.

3. Research method

3.1. Policy capturing

This study uses policy capturing, a technique that requires respondents to make a series of judgments based on a set of attributes from which the underlying structure of their decisions can be decomposed by means of hierarchical linear modeling (HLM). This method allows the researcher to examine how the respondent processes non-additive relationships (Hitt and Barr, 1989), without relying on the respondent's (generally inaccurate) introspection (Fischhoff, 1988).

3.2. Research instrument and experimental design

To identify the pertinent attributes, we asked VCs outside the sample of the study (primarily VCs based in Chicago and New York) to provide actual investment decision scenarios, complete with business plans. From these plans, the lead researcher extracted information factors of interest, providing the entire list, with a description of each factor, to a colleague unfamiliar with the business plans. Both judges then independently coded all appropriate attributes. Value ranges given to each attribute allowed it to be compared across profiles (Stewart, 1988). For attributes of the new venture's management team (general leadership experience, market familiarity, and experience with start-ups), values are defined as averages for the whole management team. When possible, we used concrete values (e.g., market size), but representative distributions are appropriate for subjective attributes (Stewart, 1988). For the two subjective information factors (proprietary technology and competitor strength), we used a five-point scale from 1 (lowest) to 5 (highest). Overall, inter-judge reliability was 87.5%. Based on Berelson's (1952) report that inter-judge reliability typically ranges from 66% to 95%, we deem our coding reliable.

3.3. Sampling plan, survey method, and sample

The sample for this experiment was 41 practicing VCs from three entrepreneurial "hotbeds," (1) the Colorado Front Range (primarily the Denver/Boulder metro area), (2) the Silicon Valley in California, and (3) Boston. The Colorado and California data was collected in 1995 and the

Boston data was collected in 1998 using the same instrument. [4] The typical VC in the sample was male (90%), 42 years old (range 29 to 72; s.d. = 11.7), had a master's degree (most likely in business), and had been a VC for 9 years (s.d. 6.6). The typical firm for which the VC worked had $215 million under management (range $2 million to $5 billion; s.d. = $323 million), employed 14 investment professional (range 1–65; s.d = 16.6), focused primarily on early stage ventures, had been in business for 13.3 years (range 1–32; s.d. = 7.8), and invested $4.1 million per venture (s.d. = 3.9). This sample is relatively representative of the US VC community as a whole, although slightly biased towards the more successful, well-known firms. For example, 7 of the 10 top VC firms that invest in early stage deals, as rated on 10 metrics, are represented in the sample (Aragon, 2001) and the sample firms tend to be larger ($215M versus $155M for population [Venture Economics, 2000]).

3.4. Independent variables, levels, and dependent variable

The experimental design required each VC to assess 50 randomized ventures on eight attributes (see Appendix A for a sample profile). To supplement the 20 actual venture scenarios, we used a random case generator from Policy PC software package (Executive Decision Services, 1991), which creates a manageable number of statistically derived cases. MANOVA verifies that the statistical cases are from the same population as the actual cases. The independent variables have equal variance between real and generated cases and the multi-variate means are equivalent. Furthermore, a consulting expert VC identified those cases that were not feasible (i.e., combination of cue values that rarely occurs in reality). Infeasible scenarios were dropped from the sample of potential candidates.

Five of the original profiles were replicated to allow a test–retest measure of reliability. The independent variables (attributes assigned to the venture scenarios) were derived from previous studies (e.g., Tyebjee and Bruno, 1984; MacMillan et al., 1985). The eight attributes were leadership experience (average number of years of experience the management team has in leadership positions), proprietary technology (on a five-point scale ranging from no protection to extremely high proprietary protection), market familiarity (mean number of years experience team has in market), start-up record (mean number of past start-up experiences for team members), market size (total revenues for most recent year), market growth (percentage growth in revenues over last five years), number of competitors (number of direct competitors), and competitor strength (relative concentration of market on a five-point scale ranging from a few dominant competitors to an emerging market). The instructions specified that all attributes not included in the experiment were to be presumed constant across all venture profiles.

Rate of return is an appropriate dependent variable for VCs' decisions (Roure and Keeley, 1990). Therefore, the dependent variable for this experiment is the VC's assessment of how likely the venture is to succeed, as measured on a seven-point Likert Scale anchored by "10× or more on investment" and "complete loss of investment."

The more assessments each participant completes, the higher the reliability and stability of the results yet too many profiles may tire the judge and limit participation. A rule of thumb is to have a minimum of five profiles for every attribute being tested (Executive Decision Services, 1991). Five cases times eight attributes equals 40 cases. In addition, we had five repeated cases to assess response reliability. We rounded the number to 50 profiles. Fatigue is unlikely to be of concern in this experiment. First, the number of attributes in each treatment was relatively low (Hitt et al. (2000) had 30 profiles with 14 attributes), and the mean time taken to complete the experiment was less than 30 minutes. Second, the order of the profiles was

[4] We conducted a post hoc test that included a dummy variable for the collection dates (0 for 1995 and 1 for 1998) and found that the results did not differ substantially from those reported below. This suggests that the decision policies of the VCs who participated in 1995 did not differ substantially from those that participated in 1998.

randomized for each experiment, and the results were consistent across individuals. Third, individuals were relatively consistent in their responses (test–retest reliability of 72% is comparable with Shepherd's (1999) 69%).

3.5. Building a non-additive decision-aid

To test Hypothesis 6 we need to construct a main-effects-only decision-aid and a non-additive decision-aid. First, a main-effects-only aid uses the eight identified attributes and the aggregate standardized coefficients derived from our sample of VCs.

$$Y = \beta_1(\text{lead}) + \beta_2(\text{fam}) + \beta_3(\text{start-up}) + \beta_4(\text{prop}) + \beta_5(\text{size}) + \beta_6(\text{grow}) + \beta_7(\text{comp}) + \beta_8(\text{strength}),$$

where lead is the leadership experience, fam, market familiarity, start-up, start-up record, prop, proprietary technology, size, market size, grow, market growth, comp, number of competitors, strength, competitor strength.

The second decision-aid is based on a non-additive model using all eight attributes and leadership's interaction with each other attribute.

$$\begin{aligned} Y = {} & \beta_1(\text{lead}) + \beta_2(\text{fam}) + \beta_3(\text{start-up}) + \beta_4(\text{prop}) \\ & + \beta_5(\text{size}) + \beta_6(\text{grow}) + \beta_7(\text{comp}) \\ & + \beta_8(\text{strength}) + \beta_9(\text{lead} \times \text{fam}) \\ & + \beta_{10}(\text{lead} \times \text{start-up}) + \beta_{11}(\text{lead} \times \text{prop}) \\ & + \beta_{12}(\text{lead} \times \text{size}) + \beta_{13}(\text{lead} \times \text{grow}) \\ & + \beta_{14}(\text{lead} \times \text{comp}) + \beta_{15}(\text{lead} \times \text{strength}). \end{aligned}$$

The models are tested on those 20 cases (out of 50) that were based on actual ventures and that received funding and had a measurable outcome. Seventy percent of the actual cases were successful (achieving a realized return on investment [ROI] of 15% or greater [Dean and Giglierano, 1990]), 30% of the ventures resulted in an ROI of less than 15% or complete loss of investment. Considering that the 70/30 ratio veers from the norm of most VC portfolios where approximately 40–60% provide a favorable return (Timmons, 1999), we also tested the models against a distribution of actual cases that included 50% success and 50% failure leaving us with 12 actual cases. We excluded those cases with the highest ROI (retaining the six success cases closest to the 15% success breakpoint) because this represents a more conservative test for discriminating success from failures. [5] Failures were dummy coded 0 and successes dummy coded 1.

The models' predictions coincided with the seven-point Likert scale used as the dependent variable. If the model's prediction ranged from 4.5 to 7, it was coded as a success. Failure predictions ranged from 1 to 3.49 and neither success or failure ranged from 3.5 to 4.49. Predictions of success were dummy coded 1, predictions of failure were dummy coded 0, and predictions of neither success nor failure were not included in subsequent analyses.

To determine decision accuracy, the VC's predictions were compared to the actual outcome, either a success or a failure. VCs' predictions were recoded from a seven-point scale to success, failure, or neither success nor failure. Predictions of success were operationalized by scores of 5, 6, and 7, predictions of failure by scores of 1, 2, and 3, predictions of neither success nor failure by a score of 4. Each prediction was scored a 1 if it matched the actual outcome and 0 if it did not. We calculated the accuracy rate as a ratio of total predictions correct to the total number of predictions. This procedure was repeated for each VC and for each model.

We then compared the accuracy rate for the main-effect model with the accuracy rate of each VC. If the main-effect model's accuracy rate was higher than a particular VC then we recorded a 1 and if it was lower then we recorded a 0. The number of ties were recorded but not used in subsequent analyses. A chi-squared test was used to test whether the main-effect model more often outperformed the VCs. The same procedure and test was used for comparing the accuracy of the non-additive model with all VCs.

[5] Using only 12 cases did not change the accuracy of the non-additive model (60%). The main-effects model improved by 5% (45–50%) and the mean for the VCs actual decisions improved by less than 1%.

Table 1
Intercorrelation matrix

	Mean (sd)	1	2	3	4	5	6	7	8
1. Success	3.96 (1.66)	1.000							
2. Market familiarity	11.52 (7.92)	0.221	1.000						
3. Leadership experience	6.82 (4.60)	0.166	0.165	1.000					
4. Start-up experience	1.46 (1.35)	0.100	0.147	0.156	1.000				
5. Proprietary technology	2.68 (1.46)	0.095	0.120	−0.255	0.095	1.000			
6. Market size	723.68 (649.38)	0.188	0.146	−0.045	0.297	0.038	1.000		
7. Market growth	36.50 (26.94)	0.122	0.085	0.073	0.241	−0.021	0.323	1.000	
8. Number of competitors	5.74 (3.63)	−0.211	−0.171	−0.003	0.217	−0.076	0.090	0.323	1.000
9. Strength of competition	4.80 (1.91)	−0.220	0.073	−0.257	−0.058	0.163	−0.096	0.072	0.198

$n = 1900$.

4. Results

Table 1 provides an intercorrelation matrix and specifies the mean and standard deviations for each variable. The experiment provides 50 observations per VC and therefore 1900 observations for the sample. While this means that there are a large number of degrees of freedom for the subsequent analysis, there may be autocorrelation because the assessments on these 50 observations are nested within individuals. HLM accounts for variance among individuals such that the 1900 observations can be considered independent—this technique is well suited for analyzing nested data. We generated both a main-effects-only model and a non-additive model, the results of which are displayed in Table 2. [6,7]

Presented in the top section of Table 2 are the coefficients (from HLM of standardized values), and corresponding standard error, *t*-ratio and levels of significance for the main-effects-only model. This indicates that VCs' prediction of success is higher for those ventures with more

Table 2
VCs' assessment policies

	Coefficient[a]	Standard error	*t*-ratio
Main-effects model			
Market size	0.20	0.06	3.413***
Market growth	0.23	0.04	5.39***
Proprietary technology	0.02	0.04	5.26***
Market familiarity	0.22	0.04	5.01***
Leadership experience	0.20	0.04	4.95***
Start-up experience	0.02	0.04	0.521
Number of competitors	−0.34	0.04	−8.66***
Strength of competition	−0.30	0.06	−4.52***
Intercept	3.96	0.09	46.51***
Full model			
Market size	−0.03	0.08	−0.416
Market growth	0.30	0.11	2.82***
Proprietary technology	0.17	0.05	3.08***
Market familiarity	0.29	0.06	4.69***
Leadership experience	0.41	0.12	3.48***
Start-up experience	0.20	0.08	2.47**
Number of competitors	−0.49	0.07	−6.79***
Strength of competition	−0.10	0.09	−1.03
Leadership × size	0.27	0.07	3.88***
Leadership × growth	−0.10	0.12	−0.83
Leadership × prop. tech.	0.01	0.08	0.112
Leadership × familiarity	−0.13	0.09	−1.56
Leadership × start-up exp.	−0.22	0.07	−3.01***
Leadership × competitors	0.24	0.09	2.58**
Leadership × strength	−0.30	0.10	−3.05***
Intercept	3.96	0.09	46.51***

$n = 1900$.
** $p < 0.05$.
*** $p < 0.01$.
[a] All variables were standardized and group centered.

[6] We also ran regression analysis for each individual using mean centered variables. We found an aggregated mean R^2 of 0.62 and that multi-collinearity was unlikely to have impacted the regression results (all VIFs were under 3 which is well below 10—the rule of thumb for acceptable VIFs).

[7] We tested for differences in decision policies among the sample of VCs. Age and VC experience were a priori the demographic variables mostly likely to distinguish between decision policies. We included these two level two variables in a HLM analysis to determine if those that are older or more experienced had a significantly different decision policy than those that were younger or less experienced. We did not find any significant differences.

leadership experience (coefficient = 0.20; $p < 0.01$), more proprietary technology (coefficient = 0.20; $p < 0.01$), greater market familiarity (coefficient = 0.22; $p < 0.01$), faster market growth (coefficient = 0.23; $p < 0.01$), larger market (coefficient = 0.20; $p < 0.01$), and fewer (coefficient = −0.34; $p < 0.01$) and weaker (coefficient = −0.30; $p < 0.01$) competitors. It appears that VCs do not significantly use start-up experience (coefficient = 0.02; $p > 0.05$).

The coefficients, and corresponding standard error, *t*-ratio and level of significance for the non-additive model are presented in the lower section of Table 2. In the non-additive model, the significant variables are leadership (coefficient = 0.41; $p < 0.01$), proprietary technology (coefficient = 0.17; $p < 0.01$), market familiarity (coefficient = 0.29; $p < 0.01$), market growth (coefficient = 0.30; $p < 0.01$), and number of competitors (coefficient = −0.49; $p < 0.01$), and the interactions between leadership experience and start-up experience (coefficient = −0.22; $p < 0.01$), leadership experience and market size (coefficient = 0.27; $p < 0.01$), leadership and number of competitors (coefficient = 0.24; $p < 0.05$), and leadership and competitor strength (coefficient = −0.30; $p < 0.01$).

For internal resources, the interaction between leadership and start-up experience was significant (coefficient = 0.20; $p < 0.01$). Start-up experience moderates the relationship between leadership experience and the VC's assessment of success. The form of this interaction is plotted in Fig. 1 and indicates that while VCs always prefer more leadership experience, that preference is greater when start-up experience is low. It appears that start-up experience is a *substitute* for general leadership experience rather than a complement as proposed in Hypothesis 3. Hypotheses 1 and 2, which posited leadership's interaction with proprietary technology (coefficient = 0.01; $p > 0.05$), and market familiarity (coefficient = −0.13; $p > 0.05$), were not supported.

Leadership experience interacts with market size (coefficient = 0.27; $p < 0.01$), number of competitors (coefficient = 0.24; $p < 0.05$), and competitor strength (coefficient = −0.30; $p < 0.01$). The nature of the interactions is plotted in Figs. 2–4. In all cases, VCs prefer greater leadership experience.

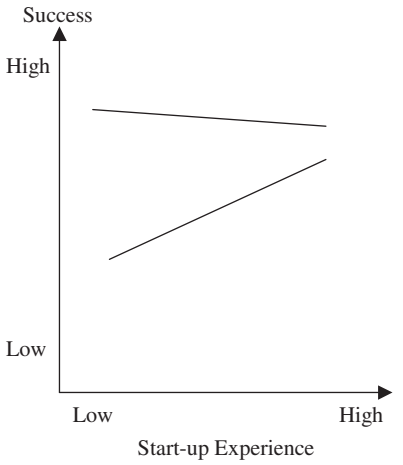

Fig. 1. Start-up experience × leadership.

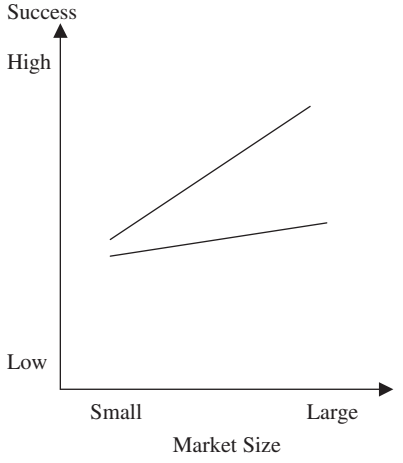

Fig. 2. Market size × leadership.

VCs value leadership more when the market size is larger (Fig. 2) and when the relative competitor strength is less (Fig. 4). These findings provide support for Hypothesis 4a and 5b respectively. For the leadership × number of competitors interaction we hypothesized that leadership experience be valued more by VCs when the number of competitors is low. As shown in Fig. 3 we found the opposite providing no support for Hypothesis 5a. Hypothesis 4b, which suggested that leadership experience interacts with market growth in VCs'

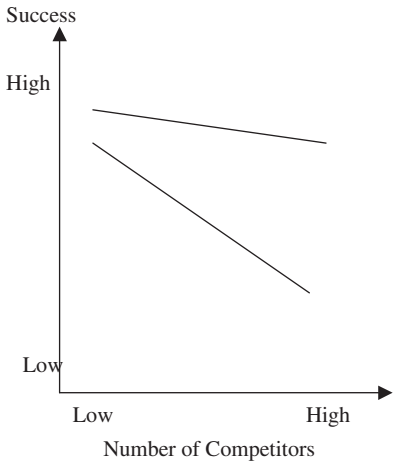

Fig. 3. Competitors × leadership.

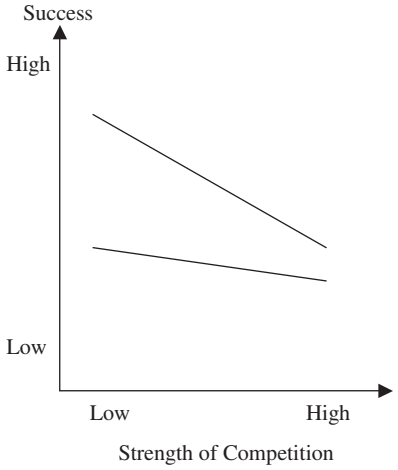

Fig. 4. Comp strength × leadership.

prediction of success, was also not supported (coefficient = −0.10; $p > 0.05$).

Decision-aids appear to improve decision performance. The main-effect model had an accuracy rate of 0.50 and outperformed VCs 66% of the time, under-performed VCs 18% of the time, and was equal with VCs 16% of time. The main-effect model outperformed VCs more than VCs outperformed the main-effect model and this difference was significant (chi-squared = 10.13; $p = 0.001$), providing support for Hypothesis 6a. The non-additive model had an accuracy rate of 0.60 and outperformed VCs 89% of the time, under-performed VCs 5% of the time, and was equal with VCs 5% of time. The non-additive model outperformed VCs more than VCs outperformed the main-effect model and this difference was significant (chi-squared = 28.44; $p = 0.000$), providing support for Hypothesis 6b.

4.1. Post hoc test

The accuracy of VCs and the main-effect model are close to what we would expect simply by chance. To determine if the non-additive model is accurate more often than chance we conducted a post hoc test. We used a random generator to produce 456 values with a value of either 0 or 1 and a probability of 0.50. These values were used as replacements for the predictions of each VC (i.e., the first 12 randomly generated values represented the predictions of the first VC, the second 12 the second VC, and so on). We then compared the accuracy of the non-additive model to each of the VCs, as above. We found that the non-additive model outperformed predictions at random 76% of the time, under-performed VCs 21% of the time, and was equal with VCs 3% of time. The non-additive is more accurate than chance predictions (chi-squared = 11.92; $p = 0.001$).

5. Discussion

The two major contributions of the study are that VCs' decision policies are indeed non-additive and a non-additive decision-aid improves decision accuracy over and above the VCs' actual decisions. Moreover, the paper illustrates the power of using theory, RBV, to generate the key attributes and predict and explain interaction effects not only in capturing VCs' decision policies but also in building powerful decision-aids.

5.1. Non-additive decision policies

We find that VCs use non-additive decision policies; the more munificent the environment (large market and weaker competitors), the more importance the VC attaches to general experience

in leadership. Somewhat surprisingly, it appears that start-up experience is a *substitute* for general leadership experience. The greater the entrepreneur's previous start-up experience, the less important is his/her general leadership experience. Considering that start-up experience isn't significant in the main-effects model, it is possible that VCs look at leadership experience first; if it is weak, they may consider start-up experience as compensating for weaker leadership experience. The finding that start-up experience substitutes for leadership experience adds to our understanding of VCs' decision policies over and above those studies that find for the main-effect-only use of these attributes and may explain the contradictory findings in previous studies.

The interaction between leadership and number of competitors was opposite of what we hypothesized (see Fig. 3). VCs place greater emphasis on leadership experience in environments that have a greater number of competitors. A possible explanation is that an increasing number of competitors (holding other attributes of environmental munificence constant) increases the VC's reliance on a leader to act and react to the many possible, and a priori unforeseeable, competitive interactions, i.e., rely on the leader's tactical ability. Moreover, VCs may like to see other competitors as it validates the opportunity's existence.

We know that decision makers typically rely more on main-effect relationships and less on non-additive relationships (Louviere, 1988). While this appears to be the case in this study we argue that these two-way interactions are likely to be important in an absolute sense owing to the significant cost (in both outlay and opportunity) of an incorrect assessment. That is, considering non-additive relationships may critically affect the ultimate financial performance of the VC's portfolio and leads to this paper's second contribution.

5.2. Decision-aids with non-additive relationships

VC is an industry predicated on hitting "homeruns;" investments that can generate 10 times the investment or more. In a typical portfolio of companies, a VC expects to hit only one or two homeruns out of 10 investments. Even marginal improvements in investment decisions can have a dramatic impact on portfolio performance. In this article, we found evidence that decision-aids constructed from bootstrap models have the potential to improve VCs' decision accuracy and thereby increase a VC firm's return on investment. Specifically, a non-additive decision-aid, a decision-aid based on a bootstrap model that incorporated interaction terms for leadership with all other attributes, had a higher hit rate in accurately "picking winners" from a sample of 12 ventures than did the VCs' actual decisions. The improvement in decision accuracy from using a decision-aid occurs because bootstrap models are consistent, they are not biased by a non-random sample, they optimally weight information factors, and they reduce the decision-maker's cognitive load (Camerer, 1981).

Although we only used a sample of 12 cases with known outcomes, our findings provide some evidence that decision-aids could be a useful technique to help VCs with their investment decision and possibly improve a VC firm's return on investment. The decision-aid we have developed relies on theory and past decisions of practicing VCs. This generic model demonstrates the power of VC decision-aids, but to achieve a competitive advantage, VC firms may benefit from fully specifying a firm specific decision-aid based upon the accumulated knowledge and expertise of its VC professionals.

Shepherd and Zacharakis (2002) argued that decision-aids also allow VCs to acquire expertise faster than do current educational and training methods—decision-aids can provide cognitive feedback, which is some measure of the person's cognitive processes used in the decision. Cognitive feedback helps people come to terms with their decision environment and has been found to be markedly superior to outcome feedback. While outcome feedback is often an effective learning mechanism, in the venture investment decision outcome feedback is delayed detracting from the learning experience; it takes many years for VCs to earn a return on their investment. Furthermore, outcome feedback can be costly. The VC may learn because a portfolio company has burned through the investment and failed. Cognitive

feedback has the potential to minimize these costs because the learning takes place before investments are made.

Although we have demonstrated the potential of decision-aids to improve a VC's decision accuracy and others have suggested that it can be used as a learning tool, decision-aids have not been widely adopted by VCs. In our sample, only 20% of the VCs used some sort of multi-attribute decision-aid. Often, these decision-aids were used ex post as a mechanism to keep the history of decisions made. The culture within the industry is to use expert intuition (Khan, 1987). There is an underlying distrust of "machine" that inhibits adoption of such techniques across a wider array of fields (Holt, 1986). A common explanation of this reluctance is that decision models remove responsibility for the decision (Hastie, 1994). Although a decision-aid might be able to predict psychosis, is the psychologist willing to take responsibility if the model is wrong? Or would the psychologist feel better if (s)he made that final decision even if there is potential for more mistakes? In today's litigious society, one has to wonder if malpractice insurance would cover the misdiagnosis of a decision-aid built from a bootstrap model. Such questions pose an interesting quandary that may explain the low usage of such models and the tendency to identify "broken legs" or exceptions that invalidate the model (Goldberg, 1968).

Recognizing the reluctance to use such models, it seems that the most appropriate place within the VC decision process to begin would be at the initial screening stage. The decision-aid proposed here quickly focuses attention on the critical issues thereby saving the VCs time and reducing the possibility that "high potential" plans are prematurely discarded and that "low potential" plans are needlessly passed on to the next level of analysis. Such use of the decision-aid also does not remove the VC's control or responsibility over the decision. The decision-aid is to assist VCs, not replace them. In fact, there is evidence to suggest that a combination of human judgment and decision models results in more accurate decisions than either method alone (Whitecotton et al., 1998; Blattberg and Hoch, 1990; Donihue, 1993). While the research in this article takes an important step towards highlighting the importance of decision-aids for VCs, more research is required into the development of decision-aids and their use within VC firms.

5.3. Future research

This study uses the RBV of strategy to hypothesize leadership's interaction with other venture and environmental characteristics. However, we are not proposing that the RBV is the only perspective that can provide insight into VCs' decision policies, in fact we encourage the investigation of VCs' decisions from a number of different theoretical perspectives. The Industrial Organization (IO) perspective of strategy, for example, could provide additional insight into the relationships between important industry characteristics (some of which are represented in this study). Not only may the use of different theories provide a deeper understanding of VCs' decision policies but these different theories could also provide avenues for VCs to improve the accuracy of their assessments. For example, a different theoretical perspective may suggest other non-additive relationships that will increase the explained variance of VCs' assessments. Similarly, using theoretical frameworks to study the decision policies of expert VCs might provide important feedback to current theories suggesting the need for theory modifications and/or new theories.

While this study provides evidence that decision-aids have the potential to improve decision accuracy and VC firm performance, there is also an opportunity to improve the decision-aid proposed here by representing other interactions and even curvilinear relationships. For example, maybe there is a U-shaped relationship between the number of competitors and VCs' assessment of success, i.e., a small number of competitors could be interpreted by VCs as a negative because the industry lacks legitimacy although too much competition might be seen as a negative because it drives down prices and profitability. Do VCs' use non-linear decision policies? Can these non-linear decision policies be incorporated into a decision-aid to significantly increase a VC's decision accuracy?

This study focuses on VCs' assessment on new ventures, i.e., investment proposals seeking seed to

development capital. An interesting question then becomes—do VCs weight criteria differently in their assessments of businesses in different stages of development (e.g., mezzanine financing or leveraged buyouts)? Also, while the environmental factors in this study likely capture industry differences, there is the opportunity to create a sample of VCs that are experts in a particular industry and model their decisions based on the scenarios specific to that industry. Whether for a different stage of venture development or for specific industries, there is the opportunity to create more narrowly focused decision-aids in attempt to further improve decision accuracy.

Scholars face a number of challenges. First, these decision-aids can only improve VC firm performance if they are used. Why are only 20% of VCs (based on our sample) using some form of multi-attribute decision-aid? What are the obstacles for its use? What are effective means to overcome these obstacles? Second, it is difficult to measure the decision accuracy of a VCs' assessment of a venture's future success. Reflecting these difficulties decision-aid scholars have used process measures of decision quality, such as, reliability (Ashton, 1983), consensus (Einhorn, 1974), and performance relative to a bootstrap standard (Camerer, 1981). We argue that both process and outcome measures can be used to measure the quality of decisions but researchers should also investigate the inter-relationship between the two.

5.4. Possible limitations

Policy capturing, as with all techniques, has limitations, although throughout the design and administration of this study, attempts were made to minimize these limitations. Nonetheless, a few of the drawbacks should be addressed. As with any experiment, the issue of reductionism must be considered. Although the scenarios are based on actual firms that received venture backing, the subjects are exposed to a decision situation that does not perfectly mirror the "real life" decision. Such "paper tests" affect the external validity of many lens model experiments (Brehmer and Brehmer, 1988). But "professional judgment may ... involve some abstract coding of the cues, similar to that provided by policy capturing tasks" (Brehmer and Brehmer, 1988, p. 89). Moreover, since the VC screening decision has a large "paper" component in the real world (i.e., much of the VC's information comes from business plans), correlation between the experimental task and the "real world" decision should be even higher.

The experiment also forces VCs to make decisions based upon the presented cues. In reality, VCs would (1) have access to a multitude of possible information cues and (2) use interactive due diligence and other methods to clarify and assess reliability of chosen cues. A common theme in the follow up interviews is that VCs like to reserve final judgment until they have a chance to meet with the lead entrepreneur. There is also the possibility that respondents could attach importance to attributes merely because they are presented in the experiment; this limitation is more likely with novice decision makers than with the experienced venture capitalists sampled here. Therefore, while the information within the decision exercise does not perfectly mirror the more complex "real life" decision, policy capturing experiments are still a valid method for deriving what information decision-makers actually use (Hitt et al., 2000; Hitt and Middlemist, 1979). While these criticisms of policy capturing have merit and do represent limitations of the technique, our approach is consistent with that of other policy capturing studies (e.g., Hitt and Tyler, 1991) and the construction of bootstrap models.

It is also important to point out that after the decision is made the outcome is normally delayed for a number of years (Timmons, 1999). There is a history effect as the entrepreneur adjusts the original plan. Moreover, Gupta and Sapienza (1992) point out that VCs not only provide financial resources, but also non-financial resources such as advice, network contacts to suppliers, customers and so forth. These services are typically offered after the investment has been made and before the VC realizes any return from their investment. [8] Furthermore, environments are in constant flux

[8] The fact that the cases were all VC-backed somewhat controls for the history effect.

and change from the point of the original investment. In spite of the history effects, our decision-aid achieved a hit rate of 60%. In sum, we believe this is a good first test of the power of non-additive decision-aids in the VC context.

5.5. Conclusion

The current study makes two important contributions to the literature on VC decision-making. First, it uses theory to hypothesize and support the contention that VCs use interaction terms in making their decisions. Second, the paper builds a non-additive decision-aid that better predicts outcome than VCs actual predictions. The implications are clear. VC firms may improve portfolio return and create a competitive advantage by developing a non-additive decision-aid based upon the expertise of its senior VCs. We hope that the finding of non-additive decision policies and the improvements in decision performance from non-additive decision-aids encourages decision-aid scholars to consider incorporating interaction terms in their models and encourages VC firms to consider the possibilities that decision-aids offer.

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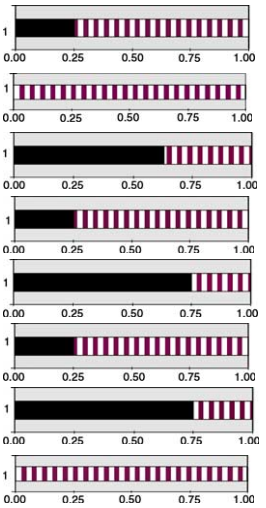
Appendix A

VENTURE 1

Start-up record	1 previous start-ups
Market familiarity	0 average years experience for team (including lead entrepreneur)
Leadership experience	9 average years experience for team (including lead entrepreneur)
Proprietary protection	1 low protection
Market size	$1.1B
Market growth	15%
Number of competitors	9 direct competitors
Competitor strength	1 low strength



				Probability of success				
Lowest	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7	Highest
				Confidence in assessment				
Lowest	○ 1	○ 2	○ 3	○ 4	○ 5	○ 6	○ 7	Highest

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