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# A Theory of Entrepreneurial Overconfidence, Effort, and Firm Outcomes

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## ABSTRACT

We present a theory of entrepreneurial behavior that explores the relationship between overconfidence and successful firm outcomes, such as acquisition or IPO. In our model, increasing overconfidence produces two conflicting effects on the probability of a successful outcome: it not only induces an entrepreneur to increase the riskiness of a venture (which lowers the likelihood of successful exit), but also drives higher entrepreneurial effort, increasing likelihood of a successful exit. Due to this conflict, a kinked or U-shaped relationship may exist between overconfidence and positive outcomes. Furthermore, our model suggests that increased outside equity mitigates the effects of overconfidence.

Keywords: Overconfidence, Entrepreneurship, Cognitive Bias, IPO, Mergers & Acquisitions
JEL Codes: G32, G34, L26, M13

## I. Introduction

In our theoretical analysis, entrepreneurial overconfidence may induce the entrepreneur to increase the volatility of the start-up, resulting in a greater probability of failure. However, it may also induce higher entrepreneurial efforts, increasing the

[1] The authors would like to thank our anonymous referee and also the participants of the Academy of Entrepreneurial Finance 2010 Annual Meeting for their helpful feedback.

probability of a successful outcome. Trading-off these two factors, our model suggests that the relationship between overconfidence and the probability of success may be kinked, which could manifest itself empirically as a roughly U-shaped relationship. Thus the highest probabilities of entrepreneurial success arise from the extremes of either low or high overconfidence.

According to data published by the U.S. Small Business Administration, from 2000 to 2004 there were consistent employment losses among large firms. During that same period, there were consistent employment *gains* among small businesses (defined as less than 20 employees). In 2004, small business generated 29% of total new jobs, but if job losses are netted out for that year, small businesses are actually responsible for 96% of overall employment gains (SBA, 2007).

Startup firms account for approximately one-third of small business job growth in the U.S. Economy (SBA, 2007). As such, they are a critical engine for economic growth and a potentially rich source of returns for investors. Unfortunately, the return on investment in private startups is not higher than public equity returns, even though it carries substantially higher risk (Moskowitz and Vissing-Jorgensen, 2002). The poor average investment performance is driven primarily by the high failure rate of startup firms. Half of new companies close within four years and only 40% are still in existence after six years (Headd, 2003).

As a primary driver of employment growth, entrepreneurship is generally viewed as a net economic benefit to society. But if starting a business involves too much risk for too little return, then why do people do it? It is clear that entrepreneurs are not mainly motivated in their business efforts by philanthropic urges to help the macro economy. They start businesses because they identify an opportunity to succeed and be profitable, and even though they are statistically unlikely to achieve that goal it does not appear to stop them from trying. The fact that entrepreneurs expend effort and resources in the pursuit of improbable success can be intuitively interpreted as overconfidence. This paper addresses the questions of how the level of entrepreneurial overconfidence impacts both the success and failure of startup firms, and the degree to which outside investment mitigates the negative effects of overconfidence.

Although there are many theories that address the motivations of entrepreneurs, most can agree that at its heart, entrepreneurship is a principle of action (McMullen & Shepherd, 2006). Indeed, action is the defining distinction between an entrepreneur and a dreamer. There is a burgeoning body of literature that tries to get inside the seemingly irrational mind of the entrepreneur. Two facts emerge about what makes these people tick: 1) they tend to be overconfident in their abilities and 2) they tend to be overconfident in their likelihood of success (Hayward et al., 2006).

This may be bad news for outside investors, who presumably prefer that a business plan be realistic and account for risk appropriately. An overconfident entrepreneur will have difficulty being fully rational in evaluating the firm's investment opportunities because, by definition, overconfidence in either ability or likelihood of success will cause the opportunity to be overvalued. Since a typical stockholder's primary desire is to maximize financial returns, it is not beneficial if the entrepreneur has other motivations, such as the thrill of managing a new venture in a high-risk industry. Thus, it is important that the entrepreneur has his incentives aligned tightly with the outside stockholders.

It stands to reason, therefore, that overconfidence may be associated with lower success. Success in the world of externally funded startups is commonly defined as having a successful exit, meaning that the firm is acquired by another company or goes public via initial public offering (IPO). Either of these two events generally allows existing investors to liquidate their equity position in the firm – and hopefully at a profit.

Overconfidence has been deeply investigated as it relates to the behavior of investors in efficient or nearly efficient markets, such as public equity markets. In such environments, overconfidence is considered a negative factor, since it causes the investor to deviate from optimal decisions.

However, a debate exists regarding whether overconfidence is necessarily an undesirable entrepreneurial characteristic. There are compelling arguments on both sides. For example, Statman and Tyebjee (1985), Pruitt and Gitman (1987), Heaton (2002), and Malmendier and Tate (2002), argue that overconfident managers overestimate the quality of their projects in the capital budgeting process, and hence overinvest into value-destroying projects. Gervais et al. (2003) employ a real-options game theoretic framework in which managerial risk-aversion may induce a manager to delay investment sub-optimally. Overconfidence may mitigate this problem, since it induces a manager to invest early. Kahnemann and Lovallo (1993) argue that managerial optimism may lead to managers making "bold forecasts" regarding prospective projects, while at times making timid choices due to risk-aversion.

In terms of capital structure, Shefrin (1999), and Hackbarth (2002) have argued that overconfidence may induce managers to take on excessively high levels of value-destroying debt for their corporations. However, similar to our analysis, Fairchild's (2005) capital structure analysis demonstrates that overconfidence may have negative (excessive debt levels, resulting in higher financial distress costs) and positive effects (overconfidence results in higher value-creating effort levels).[2] A firm's value experiences a trade-off between the negative and positive attributes of overconfidence.

Overconfidence within the operational management of a firm, however, has additional motivational effects that do not apply to passive investors in public securities markets. An overly optimistic self-view, or an unreasonably low estimate of project risk, can motivate the manager to undertake more ambitious goals and persist in the face of adversity (Benabou and Tirole, 2002). The presence of outside investors, however, may have a disciplinary effect on the entrepreneur, hopefully leading him to circumscribe his overconfident behavior and make rational decisions for the benefit of the firm and all its investors.

This paper posits a game theoretical model of a kinked relationship between overconfidence and the firm's ultimate disposition. The contribution of this paper is to provide a theoretical explanation of how overconfidence and entrepreneurial effort are related, and why the association between overconfidence and outcomes may not be smooth and linear.

## II. Background and Related Literature

Relevant research papers on overconfidence are found in various fields, including (but not limited to) entrepreneurship, finance, economics, psychology and strategy. The factors that we address in this paper with respect to their impact on the final disposition of a startup firm are: 1) the overconfidence of the entrepreneur/founder and its potential effects on performance, and 2) the mitigating impact of outside venture capital on the effects of overconfidence.

### *A. Cognitive Origins of Overconfidence*

Overconfidence is essentially a distorted view of the world where the actor has expectations of personal performance that exceed the level that would be otherwise

[2] This idea is consistent with Knight's (1921) stance that entrepreneurial action depends, at least in part, upon the actor's belief that he can successfully exploit the identified opportunity.

justified by an unbiased examination of the facts. These systematic distortions of reality are called cognitive biases. It is commonly understood that the human brain has developed these biases as shortcuts to deal with having to process too much information in too short a time (Baron, 1998).

There are three primary categories of overconfidence: 1) overconfidence in knowledge, 2) overconfidence in prediction, and 3) overconfidence in abilities (Hayward et al., 2006). Overconfidence in knowledge refers to the entrepreneur's view that he is more knowledgeable than is truly the case. This can either be a tendency to overestimate the correctness of an original estimate and cling to it (Bazerman, 1994), or simply excessive certainty about one's command of the relevant facts of the situation (Busenitz and Barney, 1997). Within the entrepreneurial context, overconfidence in prediction refers to the systematic underestimation of the risk involved in a new venture (Yazdipour and Constand, 2010). Entrepreneurs are notoriously susceptible to this bias. 81% of firm founders estimate their chance of success at greater than 70% and a full third of founders estimate their chance of success at an unfathomable 100% (Cooper, Woo and Dunkleberg, 1988). An entrepreneur who is overconfident in ability may correctly estimate the risk of a venture, but believes that, unlike his peers, his unique skills will allow him to overcome the odds and succeed anyway (Hayward, Shepherd and Griffin, 2006). Overconfidence in ability is not unique to entrepreneurs, but is common in professions that are highly complex. For example, 94% of college professors feel that they have higher ability than their peers (Gilovich, 1991). In this paper, we focus on the effects of ability overconfidence.

### *B. Overconfidence in Ability*

The primary driver of overconfidence in ability, skill or knowledge is attribution bias. This refers to the tendency of people to attribute successes to their own ability, while attributing their failures to outside factors. When an actor applies Bayes Rule to update his beliefs about his own ability, there will be a tendency to overweight successes and underweight failures. Over time, however, this bias diminishes as the evidence becomes overwhelming and the overconfident actor ultimately becomes aware of his true ability level (Gervais and Odean, 2001). Successful entrepreneurs have been shown to possess lower levels of attribution bias than their unsuccessful peers (Baron, 1998), confirming the intuition that there is a negative relationship between this type of overconfidence and performance.

The interrelated factors of age, experience and education have also been shown to influence overconfidence in ability. Taylor (1995) shows that both age and amount of management experience are negatively related to confidence. A higher level of education, on the other hand, appears to make people more sure of themselves than is justified (Lichtenstein and Fichoff, 1977). Likewise, the behavior of young, small firms is consistent with overconfident managers (Forbes, 2005). Gender has also been shown to be a factor, with men being consistently more overconfident than women in activities such as investing (Barber and Odean, 2001).

### *C. Measuring Overconfidence*

A difficulty with testing the effects of overconfidence on financial decision-making is finding a good measure for overconfidence itself, which is a fundamentally unobservable characteristic. The most influential early attempt was provided by Malmendier and Tate (2002), who used executive stock option exercise decisions[3] as a proxy for overconfidence. Subsequently, Malmendier and Tate (2005) used an alternative measure: press releases that described individual entrepreneur characteristics as optimistic or pessimistic. Barros and da Silveira (2008) used a simple classification: entrepreneurs and non-entrepreneurs. Combined with this, they analyze other, more directly observable characteristics, such as gender, level of education, and age. Oliver (2010) used the Michigan consumer sentiment index.

Hence, due to the non-observability of managerial overconfidence, researchers have either employed managerial *actions* (such as executive stock option exercise) as *indirect* proxies for overconfidence, or *direct* reports from outside observers, such as press releases.

In this paper, we suggest entrepreneurial level of effort (or alternatively changes in level of effort) as a proxy for overconfidence. Negative changes in effort may result from increasing overconfidence as the entrepreneur becomes 'more comfortable' with his firm, while positive changes in effort may be due to an escalation of commitment/project entrapment (see, e.g. Statman and Caldwell, 1987). Regardless, it is intuitively clear that

[3] Malmendier and Tate (2002) argue that an overconfident executive would delay exercise of stock options too long, rather than rationally diversify as soon as possible.

an entrepreneur will only expend effort on the enterprise if he is confident that his effort will positively impact the enterprise's probability of success. Otherwise he would be knowingly wasting effort. One approach to measuring entrepreneurial effort is the one used by Bitler, Moskowitz and Vissing-Jorgensen (2005), who use hours worked by the entrepreneur as a proxy for level of effort.

## III. Model of Entrepreneurial Overconfidence and Effort

### *A. Model Setup*

We consider an entrepreneur $E$ who runs a start-up business. The objective of the E is to take the start-up towards a successful exit outcome, such as IPO or acquisition. The E has an equity stake $\alpha \in [0,1]$ in the business, with the remainder of equity $1-\alpha$ being held by outsiders. All players are risk neutral, and the risk-free rate is zero.

The E makes two choices: a) which project to invest in (a safe or a risky project), and b) how much effort to exert in developing the start-up towards exit. The specific timeline of the game is as follows:

**Date 0**: The entrepreneur chooses between two projects: a risky one or a safe one.[4] The safe project achieves Date 2 success for sure, which brings Date 2 income $S > 0$. The risky project has two possible Date 2 outcomes: 'success' (that is, a successful exit) or failure. In the case of success, the risky project provides Date 2 income $R > S > 0$. In the case of failure, the risky project provides zero Date 2 income. The probability of success or failure is affected by the E's Date 1 effort level, as described below.

**Date 1**: If the E chose the safe project, it will succeed for sure, and the E does not need to exert any effort. If the E chose the risky project, he exerts effort $e$ in taking the venture towards an exit. The E faces a cost-of-effort $\beta e^2$ (which demonstrates increasing marginal cost of effort).

[4] The reader may wonder about the realism of this scenario – what kind of entrepreneur chooses a 100% safe project? It may be useful to think of this project choice from the standpoint of a *potential* entrepreneur, who is deciding whether to keep his day job, which is completely safe, or to quit the day job and take the plunge into full-time entrepreneurship, which would be the risky project.

His effort affects the probability of success for the risky project. Specifically, the probability of success is $P_R = \gamma e,$ where $\gamma$ represents entrepreneurial ability.

In our model, the E may be overconfident in his ability. We model this as follows. The E's perceived ability parameter in the case of the risky project is $\hat{\gamma} \geq \gamma$. In the case that $\hat{\gamma} = \gamma,$ the E is rational/well-calibrated. Increasing overconfidence is represented by increasing $\hat{\gamma}$ in excess of $\gamma$.

**Date 2**: The chosen project either succeeds or fails, and the E, and the outside investors, receive their payoffs.

We solve the game by backward induction. First, we take as given the E's Date 0 project choice, and solve for his optimal Date 1 effort level. Then we move back to Date 0 to solve for his equilibrium project choice. Our objective is to examine the effects of overconfidence on these decisions.

### *B. Date 1: E's Effort Choices*

If the E chose the safe project[5] at Date 0, it succeeds for certain. Hence, he does not need to exert any effort. The value of the safe project is (trivially):

$$V_S = S. \tag{1}$$

The E's payoff is

$$\prod_E = \alpha S. \tag{2}$$

Now, consider the case where the E has chosen the risky project at date 0. The expected value of the project is

$$V_R = PR = \gamma e R. \tag{3}$$

[5] We assume that the firm consists of only the one project chosen. Hence, throughout, we refer to the firm and the project interchangeably. Effectively, the value of the project is identical to the value of the firm.

The E is overconfident, and *perceives* the value of the project[6] to be:

$$\hat{V}_R = \hat{P}R = \hat{\gamma}eR. \tag{4}$$

He chooses his effort level to maximize his perceived payoff

$$\hat{\prod}_E = \alpha\hat{\gamma}eR - \beta e^2. \tag{5}$$

We emphasize that this is the E's perceived payoff (represented by the 'hat'), since it incorporates the perceived ability parameter, which may be greater than the true ability parameter: $\hat{\gamma} \geq \gamma$. We obtain his optimal effort level by solving $\frac{\partial \hat{\prod}_E}{\partial e} = 0$. Next, we substitute this optimal effort level into his perceived payoff (5).

We also substitute his optimal effort level into the *true* success probability $P_R = \gamma e$, and the *true* firm value $V = P_R R = \gamma eR$.

We thus obtain our first result in the case of the risky and safe projects.

**Proposition 1:**

a) If the E has chosen the risky project at date 0, his optimal effort level, his perception of success probability, his perception of firm value, and his perceived payoff, is as follows:

$$e_R{*} = \frac{\alpha\hat{\gamma}R}{2\beta},\ \hat{P}_R{*} = \frac{\alpha\hat{\gamma}^2 R}{2\beta},\ \hat{V}_R{*} = \frac{\alpha\hat{\gamma}^2 R^2}{2\beta},\ \hat{\prod}_R{*} = \frac{\alpha^2\hat{\gamma}^2 R^2}{4\beta}.$$

He is overconfident ($\hat{\gamma} \geq \gamma$), and the true success probability, true firm value, and his true payoff, is as follows:

$$P_R{*} = \frac{\alpha\hat{\gamma}\gamma R}{2\beta},\ V_R{*} = \frac{\alpha\hat{\gamma}\gamma R^2}{2\beta},\ \prod_R{*} = \frac{\alpha^2 R^2[2\hat{\gamma}\gamma - \hat{\gamma}^2]}{4\beta}.$$

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[6] Throughout the text, variables identified with $\hat{X}$ refers to the E's perceived value (due to overconfidence). Variables without the 'hat' refer to the true values.

b) If the E has chosen the safe project, his optimal effort level is zero, since the project succeeds for sure. Therefore, the success probability, firm value, and his payoff is as follows[7]:

$$P_S^* = 1, \quad V_S^* = S, \quad \Pi_S^* = \alpha S.$$

We note the following. In Proposition 1a), the overconfident E overestimates his ability, and hence overestimates the effect of his effort on the success probability. Hence, his effort level is increasing in overconfidence. Also, he overestimates the value of the venture, and thus overestimates the payoff from the risky project.

### *C. Date 0: E's Choice of Project*

We now move back to consider the effect of overconfidence on the E's choice of project, effort level, success probability, and venture value. In order to do so, we simply compare the results in Proposition 1.

First, we note that the E chooses the risky project if and only if his perceived payoff from doing so exceeds his perceived payoff from the safe project: that is, iff

$$\frac{\alpha^2 \hat{\gamma}^2 R^2}{4\beta} \geq \alpha S. \tag{6}$$

In order to make the analysis interesting, we assume the following:

$$\frac{\alpha^2 \gamma^2 R^2}{4\beta} < \alpha S. \qquad \text{(Assumption 1).}$$

[7] Note that in the case of the safe project, we assume that he is well-calibrated, so that his perception of success probability, firm value, and his payoff is correct (in contrast to the risky project, where he is overconfident).

That is, the E's true payoff under the safe project is higher than that under the risky project. Therefore, a well calibrated E (for whom $\hat{\gamma} = \gamma$) will choose the safe project.

We define a critical level of overconfidence $\hat{\gamma}_1$ at which the E will switch from the safe to the risky project. Thus, $\hat{\gamma}_1$ satisfies (6) as an equality. Hence,

$$\hat{\gamma}_1 = \sqrt{\frac{4\beta S}{\alpha R^2}}. \tag{7}$$

Next, we derive the critical overconfidence parameter at which the value of the risky firm rises to equal the value of the safe firm. Now, since $R > S > 0,$ there exists a critical *perceived* success probability $\hat{P}_{11}$ (and therefore critical overconfidence level $\hat{\gamma}_{11}$)
) at which the value of the risky project rises to equal the value of the safe project. Since $V_R = PR,$ and $V_S = S,$ this critical probability is

$$\hat{P}_{11} = \frac{S}{R} < 1. \tag{8}$$

In order to derive the critical overconfidence level, we equate (from proposition 1):

$$\frac{\alpha \hat{\gamma} \gamma R^2}{2\beta} = S. \tag{9}$$

When considering the effect of overconfidence on E's choice of project, we considered the E's *perceived* payoff. Now, when considering the effect of overconfidence on firm value, we consider *true* firm value.

The critical overconfidence level that satisfies (9) (that is, that equates the value of the risky and the value of the safe project) is

$$\hat{\gamma}_{11} = \frac{2\beta S}{\alpha \gamma R^2.} \tag{10}$$

Next, it is interesting to consider the effect of overconfidence on the probability of success for the safe project. First, we note that, at the critical overconfidence parameter

$\hat{\gamma}_{11}$, where the value of the safe and risky projects are equated, the true success probability of the risky project is

$$P_R * = \frac{\alpha \hat{\gamma} \gamma R}{2\beta} = \frac{S}{R} < 1. \tag{11}$$

The implication of this is that overconfidence may result in a lower success probability for the risky project compared with the safe project, but the risky project may have the higher expected value. Indeed, for $\gamma > \hat{\gamma}_{11}$, the probability of success for the risky project will be lower than that for the safe project, but the expected value of the risky project will be higher (due to the higher outcome in the case of success).

Hence, empirical analysis that examines success probability only may be understating the effect of overconfidence on expected value. We need to consider both the success probability, and the outcome in the case of success (that is, we need to consider the expected outcome). The success probability may be low, but the outcome in the case of success may be high.

Finally, it is interesting to note that, for the risky project, the probability of success can never reach 1. This is because, as the overconfident E's perceived ability increases, we reach the critical level of overconfidence $\hat{\gamma}_C$ where the E's perceived success probability reaches 1; that is:

$$\hat{P}_R * = \frac{\alpha \hat{\gamma}^2 R}{2\beta} = 1 \Rightarrow \hat{\gamma}_C = \sqrt{\frac{2\beta}{\alpha R}}. \tag{12}$$

Since the E perceives the success probability to be 1, any further increase in perceived ability will not draw forth any further effort increases (as, in the E's perception, this would be wasted effort: he believes that the project already succeeds for sure). Hence the true success probability of the risky project[8] is 'capped' at

$$P_R * = \frac{\alpha \hat{\gamma} \gamma R}{2\beta} = \gamma \sqrt{\frac{\alpha R}{2\beta}} = \frac{\gamma}{\hat{\gamma}_C} < 1. \tag{13}$$

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[8] For a proof of Equation 13, please see Appendix A.

To complete the analysis, we compare the critical overconfidence parameters given in (7) and (10). Equating (7) and (10), we note the following:

Lemma 1:

a) If the E's true ability is sufficiently low: $\gamma < \sqrt{\frac{\beta S}{\alpha R^2}}$; then $\hat{\gamma}_{11} > \hat{\gamma}_1$.

b) If the E's true ability is sufficiently high: $\gamma \geq \sqrt{\frac{\beta S}{\alpha R^2}}$; then $\hat{\gamma}_1 \geq \hat{\gamma}_{11}$.

The intuition behind this result is that the E's true ability parameter affects the comparison of the true value of the risky and safe project (given by $\hat{\gamma}_{11}$), but does not affect the E's choice of project (given by $\hat{\gamma}_1$), since he focuses on his *perceived* ability. We draw this discussion together in our main results:

**Proposition 2**: Effect of E's overconfidence on project choice, success probability, and firm value, when the E's true ability is low:

If $\gamma < \sqrt{\frac{\beta S}{\alpha R^2}}$; such that $\hat{\gamma}_{11} > \hat{\gamma}_1$, then

a) If $\hat{\gamma} \in [\gamma, \hat{\gamma}_1]$, the E chooses the safe project. Success probability is 1. The value of the safe project exceeds the value of the risky project: $V_S > V_R$.
b) If $\hat{\gamma} \in (\hat{\gamma}_1, \hat{\gamma}_{11}]$, the E switches to the risky project. Success probability falls below 1. However, success probability increases as E's overconfidence increases in this interval. The E's choice of project is inefficient, since the value of the safe project remains higher than the value of the risky project: $V_S > V_R$.
c) If $\hat{\gamma} > \hat{\gamma}_{11}$, the E continues to take the risky project. Success probability continues to rise as overconfidence increases. The E's choice of project is now efficient. Overconfidence is sufficiently high, such that $V_R > V_S$.

Furthermore,

**Proposition 3**: Effect of E's overconfidence on project choice, success probability, and firm value, when the E's true ability is high:

If $\gamma \geq \sqrt{\frac{\beta S}{\alpha R^2}}$; such that $\hat{\gamma}_1 > \hat{\gamma}_{11}$, then

a) If $\hat{\gamma} \in [\gamma, \hat{\gamma}_{11}]$, the E chooses the safe project. Success probability is 1. The value of the safe project exceeds the value of the risky project: $V_S > V_R$.
b) If $\hat{\gamma} \in (\hat{\gamma}_{11}, \hat{\gamma}_1]$, the E continues to take the safe project. Success probability is still 1. The E's choice of project is inefficient, since the value of the risky project is now higher than the value of the safe project; $V_R > V_S$.
c) If $\hat{\gamma} > \hat{\gamma}_1$, the E switches to the risky project. Success probability falls below 1, but rises as overconfidence increases. The E's choice of project is now efficient: $V_R > V_S$.

The only difference between Propositions 2 and 3 is in the interim interval given in Proposition 2b) and 3b).

Propositions 2 and 3 emphasize the importance of considering both the success probability and the outcome in the case of success. The risky project may have lower success probability, but may have higher expected value due to the higher outcome in the case of success.

### *D. Numerical Example*

In order to clarify the analysis, we now consider a numerical example[9], with the following parameters:

$S = 50,\ R = 100,\ \alpha = 0.5,\ \gamma = 5,\ \beta = 5{,}000.$

Note that we have chosen true ability parameter $\gamma = 5$. We noted in lemma 1 (and Proposition 2 and 3) that there exists a critical value for the true ability, such that

[9] The numerical example parameters are just arbitrarily given. Gamma is not necessarily between 0 and 1. The gamma demonstrates the effect of the Entrepreneur's effort on success probability, as P = γ * effort. We, of course, set the parameters to ensure that P does not exceed 1. The β value relates to the cost-of-effort. It is not a dollar value. Cost of effort relates to physical/psychological costs. As cost of effort is β * $e^2$, a higher beta increases the slope of the cost (and marginal cost) of effort function.

if true ability is low, then Proposition 2 applies, and if it is high, then Proposition 3 applies. Given our parameter values in this example, the critical true value is

$$\sqrt{\frac{\beta S}{\alpha R^2}} = 7.071.$$

Therefore, we focus on low true ability parameter, such that proposition 2 holds. Substituting the parameter values into proposition 1, we note that the true success probability is given by

$$P_R{*} = \frac{\alpha\hat{\gamma}\gamma R}{2\beta} = 0.05\hat{\gamma}.$$

Therefore, the true value of the risky project is

$$V_R{*} = \frac{\alpha\hat{\gamma}\gamma R^2}{2\beta} = 2.5\hat{\gamma}.$$

E's perceived payoff is

$$\hat{\Pi}_R{*} = \frac{\alpha^2\hat{\gamma}^2 R^2}{4\beta} = 0.125\hat{\gamma}^2.$$

The critical overconfidence parameter at which E switches from the safe to the risky project is

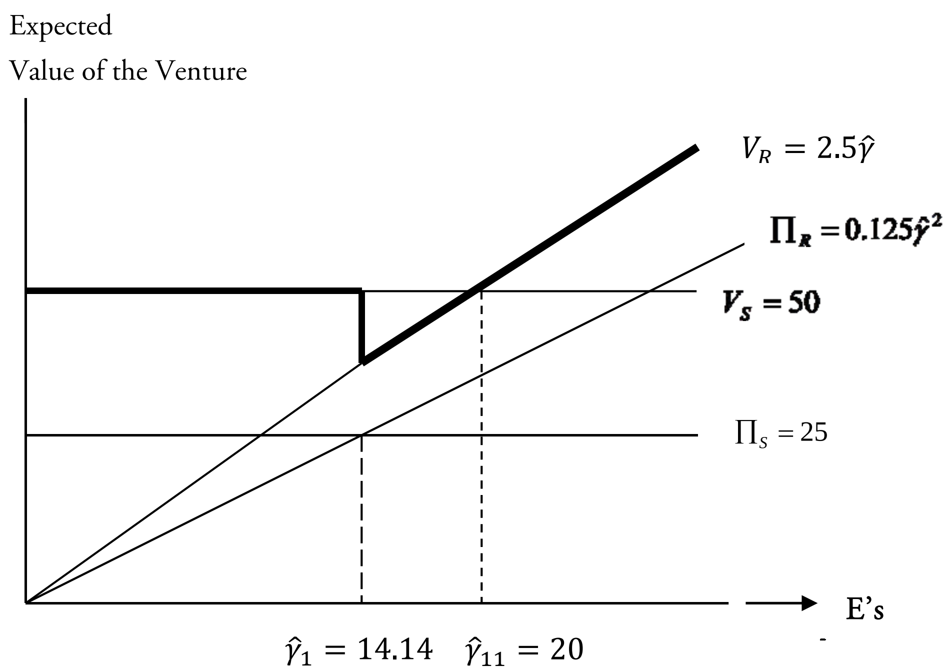
$$\hat{\gamma}_1 = \sqrt{\frac{4\beta S}{\alpha R^2}} = 14.14.$$

The critical overconfidence parameter at which the value of the risky project becomes larger than the value of the safe project is

$$\hat{\gamma}_{11} = \frac{2\beta S}{\alpha\gamma R^2.} = 20.$$

Therefore, $\hat{\gamma}_{11} > \hat{\gamma}_1$, such that Proposition 2 applies. We may thus present the following diagram.

**Figure 1. The Effect of entrepreneurial overconfidence on the expected value of the venture.** Increasing overconfidence beyond a critical level causes the entrepreneur to switch from the safe to the risky project. However, it has the positive effect of driving higher effort levels.




The E's choice of project is represented by the thick line. Up to the critical value $\hat{\gamma}_1 = 14.14$ he chooses the safe project. After this critical value, he switches to the risky project. Until $\hat{\gamma}_{11} = 20$, this is inefficient, as the safe project continues to provide the higher value. However, after $\hat{\gamma}_{11} = 20$ overconfidence is sufficiently high that the risky project provides higher value (due to E's higher effort level). In summary, the analysis contributes to the debate surrounding managerial overconfidence. We have demonstrated that overconfidence can be value-reducing (it causes entrepreneurs to take too much risk: in the model, switching from the safe to the risky project).[10] However, it can be value-increasing, as overconfident entrepreneurs work harder.

The next chart considers the success probability. In our model, this U-shape arises because overconfidence causes the E to switch from safe to risky projects, but, as his overconfidence becomes sufficiently large, this drives higher effort. Combining the two charts, we observe that we need to consider the effect of overconfidence both on the success probability and the expected value. Although the probability of success is lower in the risky case than the safe case, the risky project has higher expected value once the level of overconfidence becomes sufficiently large (above $\hat{\gamma}_{11} = 20$).

### *E. Outside equity and monitoring*

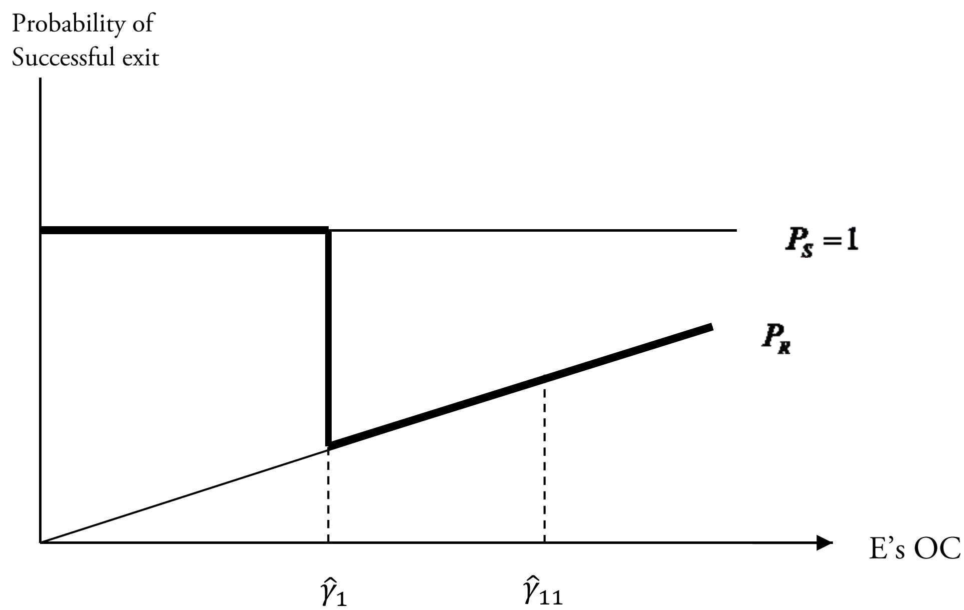
Thus far, we have assumed that the start-up entrepreneur is free to choose his project (safe or risky) unhindered by outside influence. Now, we introduce the idea that outsider equity-holders may be able to monitor the entrepreneur and affect his choice of project.

Since the entrepreneur holds an equity stake $\alpha \in [0,1]$ in the business, outside equity-holders hold the balancing equity-stake $1-\alpha$. We model their monitoring effort as a binary decision as follows. They can monitor the entrepreneur at cost $M > 0$. Monitoring is perfect, in that it enables them to prevent the entrepreneur form taking the risky project. On the other hand, they may choose not to monitor, in which case the entrepreneur is free to make his project choice without hindrance.

We continue to focus on the case where the entrepreneur has low true ability (proposition 2). Firstly, we note that, in the case where the entrepreneur has low overconfidence in his ability (Proposition 2a: $\hat{\gamma} \in [\gamma, \hat{\gamma}_1],$ ), he takes the safe project. As this is the value-maximizing choice, outside equity-holders will not wish to monitor him.

[10] The left halves of both Figures 1 and 2 are consistent with Hmielski & Baron (2009) who find that there is a point at which increasing optimism can negatively affect firm performance. Our model differs in the right half, where that negative impact is eventually dominated by the results of increased effort.

**Figure 2. The Effect of entrepreneurial overconfidence on the probability of a successful exit.**
Increasing overconfidence beyond a critical level causes the entrepreneur to switch from the safe to the risky project. However, it has the positive effect of driving higher effort levels.




In the case where the entrepreneur has high overconfidence in his ability (Proposition 2c: $\hat{\gamma} > \hat{\gamma}_{11},$), he switches to the risky project. However, his overconfidence is sufficiently high that he works hard enough for the value of the risky project to exceed the value of the safe project. Again, the outside equity-holders will not wish to monitor him, as their expected wealth is maximized by his choice.

The outside equity-holders' monitoring decision is relevant in the case where the entrepreneur has medium overconfidence (Proposition 2b: $\hat{\gamma} \in (\hat{\gamma}_1, \hat{\gamma}_{11}],$). In this case, the entrepreneur chooses the risky project, but the safe project has the higher value. In this interval, if the outside equity holders do not monitor, their expected payoff is

$$\prod_O = (1-\alpha)V = (1-\alpha)\frac{\alpha\hat{\gamma}\gamma R^2}{2\beta}.$$

If they monitor, their expected payoff is

$$\prod_O = (1-\alpha)S - M.$$

Therefore, they monitor if and only if:

$$(1-\alpha)(\frac{\alpha\hat{\gamma}\gamma R^2}{2\beta}-S)\geq M.$$

That is, they monitor if their monitoring costs are sufficiently low, and if their equity stake is sufficiently high. Note that, as outside equity decreases/inside equity increases, both $\hat{\gamma}_1$ and $\hat{\gamma}_{11}$ decrease. Nevertheless, in that interval, we may state the following result:

**Proposition 4**: Given that the entrepreneur wishes to invest in the risky project, and given that this choice is value-reducing, outside equity-holders will monitor if their outside equity is sufficiently high, given the monitoring costs. Monitoring forces the entrepreneur to choose the safe project, increases the probability of success, and increases the expected firm value.

If outside equity ownership is below a critical level, the outsiders do not monitor the entrepreneur, and he takes the risky project, which reduces the probability of success, and reduces expected venture value.

Hence, our model supports the idea that there may be a positive relationship between outside equity and success of the start-up, due to increased incentives for outsiders to monitor.

## IV. Implications

It is interesting to note that, in agency/moral hazard models of capital structure, such as Jensen and Meckling (1976), an increase in inside equity/decrease in outside equity is desirable to align managerial incentives with outside equity-holders. In our current model, we achieve the opposite result. Why is this?

The answer comes from considering the behavioral aspects of the model. The entrepreneur believes that he is making the optimal choice of project, but in fact is overconfident. Now, increasing his equity stake may actually worsen the problem. Therefore, outside equity-holders are needed to monitor him.[11] This could be tested by

[11] This argument is similar to that made by Shefrin (1999), who argues that, if bad managerial decisions are simply caused by self-interested moral hazard, this can be corrected through managerial incentive

extending empirical tests of a standard signaling model to see if there are diminishing (or negative) signaling effects at higher levels of founder ownership because suboptimal behavior is being driven by overconfidence rather than moral hazard.

The basic propositions of this paper are that below a certain confidence in his/her own ability, the entrepreneur will choose the safe project and that as confidence becomes overconfidence, there will be a structural breakpoint where the entrepreneur will switch to the risky project and experience suboptimal results. As overconfidence increases from there, though, the enhanced effort will increase the probability of success and payoff, as predicted in our theoretical model. Testing this empirically requires measures for the entrepreneur's actual ability, overconfidence, project choice, as well as a measure for the success or failure of the firm. This may be well suited for an experimental setting. Alternatively, there is an intuitive real-world scenario where the entrepreneur makes the choice to abandon the safe project for the risky project, which is the moment the potential entrepreneur quits his day job in favor of full-time pursuit of the new business idea.

Researchers testing our theory should keep in mind that as the entrepreneurs move from left to right on the continuum of overconfidence, abandoning the safe projects for the risky endeavors, by definition they are changing the risk profile of their business. Consequently, the volatility of outcomes will tend to increase with overconfidence and thus the researcher must test any empirical test of our model for heteroskedasticity. The same caveat is valid for any study that attempts to measure associations between overconfidence and performance.

In the real world, it may be much more straightforward to simplify the model, building a measure for overconfidence in ability as the independent variable with firm outcome as the dependent variable. Either a U-shaped relationship, or a piecewise analysis with a steeper positive slope at high levels of overconfidence, would support the propositions of this paper. For example, Simon & Shrader (2012) found a U-shaped relationship between the entrepreneur's satisfaction with company performance and their

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schemes (such as increasing the manager's equity stake). However, if bad managerial decisions come from behavioral biases (the manager believes that he is doing the right thing for shareholders, but in reality is mistaken), then this is much more difficult to correct through incentive schemes. Now education (or monitoring) may be more effective.

level of overconfidence. Assuming that satisfaction with performance is positively correlated with actual performance, the theory presented in our paper may explain their empirical results.

It is interesting to note that we have assumed that outside investors are fully rational, and are thus able to objectively monitor the manager. However, there is a body of evidence that outsiders, such as venture capitalists, may be equally overconfident in the success of the venture. It would be interesting to include this in the model. However, we leave this for future research.

## V. Conclusion

Startup firms account for approximately one-third of small business job growth and thus are a critical engine for economic growth. Their efficacy as an investment is less assured, since they carry such a high risk of failure. Half of new companies close within four years.

Unless they are irrational, entrepreneurs must either overestimate their personal ability to succeed in the face of very long odds, or alternatively, they must not believe that the odds are really that long. These two distortions of reality can be explained by cognitive biases documented in psychology literature. The one that we address in this paper is attribution bias.

Attribution bias refers to the tendency to attribute good outcomes to our superior ability, while attributing bad outcomes to bad luck or other external forces. The result is overconfidence in personal ability. Overconfidence can lead to suboptimal management behaviors, such as overinvestment. On the other hand, confidence is also positively related to motivation levels, which could mitigate some of the ill effects of overconfidence. In the short-term, overconfidence may reduce the probability that the firm will fail, due to the entrepreneur refusing to quit even when quitting is the most rational decision. Ultimately, however, a failing firm must fail, so a longer horizon study should reveal a kinked or curvilinear relationship between overconfidence and firm failure over time, where overconfidence reduces probability of failure in the short-run yet increases that probability of failure in the long-run. This is a topic for further study.

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APPENDIX A:

Proof of Equation 13 (capped inequality)

$At\ \hat{\gamma}_c$:

$$P_R^* = \frac{\alpha\hat{\gamma}\gamma R}{2\beta} = \gamma \cdot \frac{\alpha\hat{\gamma} R}{2\beta}$$

$$from\ (12){:}\ \hat{\gamma}_c = \sqrt{\frac{2\beta}{\alpha R}}$$

$$\therefore\ P_R^*(\hat{\gamma}_c) = \gamma \cdot \frac{\alpha R}{2\beta}\sqrt{\frac{2B}{\alpha R}}$$

$$= \gamma\sqrt{\frac{\alpha R}{2\beta}} \equiv \frac{\gamma}{\hat{\gamma}_c} < 1$$

Mathematical support for part (a) of Lemma 1:

Using Equation (10), the critical overconfidence level that equates the values of the risky and safe projects is

$$\hat{\gamma}_{11} = \frac{2\beta S}{\alpha\gamma R^2}.$$

Using Equation (7), we define the critical level of overconfidence at which the entrepreneur will switch from the safe to the risky project as

$$\hat{\gamma}_1 = \sqrt{\frac{4\beta S}{\alpha R^2}}.$$

$$\hat{\gamma}_{11} > \hat{\gamma}_1\ iff\ \frac{2\beta S}{\alpha\gamma R^2} > \sqrt{\frac{4\beta S}{\alpha R^2}}$$

$$\Rightarrow \frac{4\beta^2 S^2}{\alpha^2\gamma^2 R^4} > \frac{4\beta S}{\alpha R^2}$$

$$\Rightarrow \frac{\beta S}{\alpha\gamma^2 R^2} > \frac{1}{1}$$

$$\Rightarrow \beta S > \alpha\gamma^2 R^2$$

$$\Rightarrow \gamma^2 > \frac{\beta S}{\alpha R^2}$$

$$\Rightarrow \gamma > \sqrt{\frac{\beta S}{\alpha R^2}}$$