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An entrepreneur's choice of venture capitalist or angel-financing: A behavioral game-theoretic approach

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ABSTRACT

We develop a game-theoretic model that analyzes the effects of economic and behavioral characteristics on an entrepreneur's choice of financier (venture capitalist or angel). After the entrepreneur has chosen his financier, the dyad faces double-sided moral hazard problems in the form of ex ante effort-shirking, and ex post project-expropriation. In making his choice of financier, the entrepreneur trades-off the following factors. The venture capitalist has higher value-creating abilities than the angel. However, the entrepreneur anticipates a closer, more empathetic and trusting relationship with the angel. Entrepreneur/angel empathy and trust mitigates the double-sided shirking and expropriation threats. Our model contributes to two strands of venture capitalist research; the entrepreneur's choice of financier in the face of double-sided moral hazard problems, and the effect of behavioral factors, such as empathy and trust, on the creation of 'relational rents'.

1. Executive summary

Venture capitalists and angels provide important alternative sources of funding for entrepreneurs seeking start-up finance for innovative projects. However, there is little academic understanding regarding the economic and behavioral factors which motivate an entrepreneur's choice of financier. Despite the fact that venture capitalists usually provide managerial and value-adding contributions towards the success of the venture, entrepreneurs often prefer to use angel-financing. Indeed, quantitative analysis suggests that angel-financing dominates venture capital financing globally, both in terms of the number of new firms receiving funding, and the value of financial investment.

In this paper, we address the following important question: what are the behavioral and economic factors affecting an entrepreneur's choice of financier (venture capitalist or angel), and how does this choice affect venture performance? In order to address these issues, we develop a behavioral game-theoretic model in which a venture capitalist has greater value-creating abilities than an angel, but in which the entrepreneur and angel enjoy a closer, more empathetic and trusting relationship than is the case in the entrepreneur–venture capitalist relationship.

We analyze the following stages in the development of the entrepreneur–financier dyad. First, the entrepreneur must choose either the venture capitalist or the angel to provide finance and become his partner. Next, the entrepreneur and his chosen financier provide value-creating efforts in the development of the venture towards a (hopefully) successful initial public offering. At this stage, incentive problems exist, since each partner may not work to the best of his or her ability. In the academic literature, this is termed the double-sided moral hazard (or double-sided effort-shirking) problem.

After a period of time, the success or the failure of the venture is revealed. At this stage, the entrepreneur and the financier may take the venture to IPO, or they may simultaneously decide to 'steal' the project (the double-sided project-expropriation problem).

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This involves either, or both of them, walking away from the venture, taking some of its ideas with them. Project-expropriation destroys some of the value of the venture.

Our model demonstrates that the entrepreneur's choice of financier is affected by a combination of factors. We assume that the venture capitalist and the angel possess different economic and behavioral characteristics. For example, we assume that the venture capitalist possesses greater value-adding ability than the angel. There is considerable evidence that angels tend to be unsophisticated investors, unable to add significant value to the firm.

Some researchers suggest that angels tend to enjoy a more informal and relational partnership with their entrepreneurs, based on trust and empathy, compared to the more formal and distant relationships existing between entrepreneurs and venture capitalists. We incorporate this feature into our analysis. In our model, although the angel is assumed to have lower value-adding ability than the VC, the entrepreneur and the angel empathize with each other to a certain extent. Empathy is closely related to mutual trust between the entrepreneur and the angel. We consider how trust in the entrepreneur–angel dyad can reduce the incentive problems discussed previously; that is, by inducing higher mutual effort levels at the value-creation stage, and by eliminating the expropriation problems at the stealing stage.

We find that the entrepreneur's choice of financier, and the resulting value of the venture, is affected by the level of entrepreneur/angel empathy relative to the VC's value-adding abilities. In the case of very low angel empathy, the entrepreneur focuses on the financiers' value-creating abilities, and therefore prefers to choose the venture capitalist. For higher levels of entrepreneur–angel empathy, the situation becomes more complex. Now, the entrepreneur's choice of financier is crucially affected by the level of entrepreneur–angel empathy relative to the VC's value-adding abilities. One key result of our analysis is that the entrepreneur may be induced to choose the angel, due to high empathy, even though the VC possesses greater value-creating abilities.

An interesting and insightful feature of our analysis is that empathy induces the entrepreneur to choose the angel through two reinforcing mechanisms. Firstly, entrepreneur–angel empathy is an attractive quality, since it promotes mutual trust, which reduces the double-sided moral hazard problems during the venture's development, enhancing the entrepreneur's (and the angel's) expected payoff. Secondly, empathy means that the entrepreneur has feelings for the angel, which further induces him to choose the angel over the VC. We interpret this as a 'warm-glow' feeling, or a feeling of comfort at working with an empathetic financier. An implication of this analysis is that, under particular levels of angel empathy and VC ability, the entrepreneur will choose the angel, due to the 'warm-glow' feeling, but a choice of venture capital would have maximized firm value.

We conclude our analysis by considering the policy implications suggested by our model. At the descriptive level, we suggest that angel-financing is more likely to dominate venture capitalist financing (as is observed in practice) when the venture capitalist sector has relatively low value-creating abilities, while the angel–finance sector is characterized by less formal, more empathetic, trusting entrepreneur–angel relationships. At the normative level, our model has implications for entrepreneurs, financiers and policy makers alike. We suggest that entrepreneurs need to consider economic and behavioral factors when making their choice of financier. For example, if entrepreneurs focus on the relational aspects of angels (empathy and trust), ignoring the value-creating potential of VCs, they may make an inefficient choice. Furthermore, in a world in which financiers compete to supply start-up finance, angels and venture capitalists may enhance their chances of becoming the entrepreneur's financier of choice by improving both their value-adding capabilities and their relational characteristics, such as trust and empathy. From the perspective of policy makers, we suggest that they should consider both economic and behavioral factors when designing policies to enhance the value-creating potential of the private-equity sector.

2. Introduction

Innovative start-up companies often face difficulties in obtaining finance from traditional sources, such as banks or public stock markets. This 'equity-gap' has been filled by private investors, such as venture capitalists (VCs) or angels. Hence, the private-equity sector has the potential to be a significant source of economic wealth creation and growth. In this paper, we analyze the economic and behavioral factors that affect an entrepreneur's choice of financier (venture capitalist or angel), and the resulting value-creating performance of the venture.

According to Chemmanur and Chen (2006), "little is known about the important economic differences between venture capital and angel-financing." In response to this gap in the research, scholars are beginning to examine the factors affecting an entrepreneur's choice of financier. This work has typically focused either on the entrepreneur's choice between venture capitalist or bank-financing (e.g., Landier, 2001; Ueda, 2004; de Bettignies and Brander, 2007) or (as in this paper) the entrepreneur's choice of venture capital or angel-financing (e.g. Leshchinskii, 2002; Chemmanur and Chen, 2006; Schure, 2006).

An understanding of the factors affecting an entrepreneur's choice of venture capitalist or angel is important, particularly when we consider the evidence that angels tend to provide much more finance than VCs to start-ups. Freear et al. (1996) note that, in the US, "around 250,000 angels invest between $10 billion and $20 billion in around 30,000 firms annually. This compares with around $6.6 billion committed in the venture sector of the organized private-equity market in 1995, making the angel market several times larger.[1]" In a later analysis, Wong (2002) notes that "the National Venture Capital Association assesses the size of the angel market to be $100 billion in the United States while the institutional venture capital market is less than half this size at $48.3 billion."

The evidence that financing from angels dominates venture capital financing is puzzling from an economic perspective. There is considerable evidence that angels tend to be unsophisticated investors, unable to add significant value to the firm (Ehrlich, 1994;

[1] Quoted in Chemmanur and Chen (2006).

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Prowse, 1998; Wong, 2002; Quindlen, 2000; Hochberg, 2002) in comparison to VCs. So why do entrepreneurs appear to predominantly choose angels when venture capitalists tend to add more value?

We argue that existing research is missing an important ingredient. A complete analysis of the entrepreneur's choice of financier should include economic and behavioral factors. Indeed, although venture capitalists may add more value than angels, there is evidence that, compared to VCs, angels enjoy a more informal and relational partnership with their entrepreneurs. For example, according to Wong (2002), angels do not rely on the traditional control mechanisms employed by VCs. Instead, they rely on more informal methods. Indeed, Wong (2002) states that "the entrepreneur appeals to sociological networks and uses local ties to generate internal funding for the venture. The angels rely on trust in lieu of formal control."

Similarly, Goldfarb et al. (2007) note that "angels ..... invest in very early stage deals but demand fewer controls (than VCs)," and state that "angels have stronger social ties to the entrepreneurs in whose companies they invest."

Furthermore, according to Elitzur and Gavious (2003), angels may be relatives of the entrepreneur, or former successful entrepreneurs from the same industry, seeking to help similar new companies. We use this observation to motivate our assumption that angels and entrepreneurs may enjoy closer and more empathetic relationships than entrepreneurs and venture capitalists.

In order to address these issues, we develop a behavioral game-theoretic model in which an entrepreneur (E) chooses between a VC and an angel to provide start-up finance for his venture. After the E has chosen his financier, our model incorporates double-sided moral hazard problems at two stages of the venture's development. Firstly, the E and the financier simultaneously exert privately-observable effort in developing the venture and creating value. Hence, double-sided moral hazard problems exist in the form of bilateral effort-shirking. Later on, if the venture is successful, the entrepreneur and the financier face a further double-sided moral hazard problem. That is, they may take the venture to an IPO, or either or both may expropriate (steal) some of the project (the ex post 'double-sided expropriation' problem). Project-expropriation is value-reducing.

In our analysis, the VC possesses higher value-creating ability than the angel. However, the angel and the entrepreneur enjoy a closer, more empathetic and trusting relationship. These behavioral characteristics mitigate the two double-sided moral hazard problems that we consider (effort-shirking and project-expropriation).

In summary, our model contributes to three major areas of venture capital research. First, we build upon the existing work that analyzes the double-sided moral hazard problems that beset entrepreneur/venture capitalist relationships and performance. Second, we develop the emerging research relating to the entrepreneur's choice of financier. Third, the major contribution of our model is that it incorporates economic and behavioral factors.

Early research took as given that an entrepreneur had chosen a venture capitalist as his financier, and focused on the double-sided moral hazard problems affecting the partners' relationship and performance. Scholars have typically studied two types of moral hazard problem. First, since the E and the VC may both exert value-creating efforts in the venture, some authors have analyzed the problem of double-sided effort-shirking.[2] Second, at a certain stage in the life of the venture, the E and/or the VC may hold increased bargaining power, and attempt to force renegotiation of the contract in his or her favour (the hold-up problem) or even walk away from the venture, stealing some of the project's ideas (the expropriation problem). These two threats may be referred to as 'ex post[3] opportunism'. This 'ex post' threat may affect 'ex ante' effort incentives.[4]

According to Bigus (2002), much of the research into the hold-up/expropriation threat has focused on entrepreneurial moral hazard.[5] However, he presents a model in which the VC can hold-up the entrepreneur. Specifically, the VC forces renegotiation of the equity-allocation by threatening to steal the project if the E refuses. The author's focus is on the impact of patent law in protecting the entrepreneur.[6]

Landier (2001) takes the analysis of ex post opportunism further by recognizing that the E and the VC may hold-up each other once the venture is under way. In his model, the VC can deny further funding, while the E can withdraw from the venture. Motivated by this observation, our model incorporates double-sided expropriation problems.[7] In short, we contribute to the literature on double-sided moral hazard problems by combining both types of problem (double-sided effort-shirking and double-sided project-expropriation).

Secondly, we develop the emerging research relating to the entrepreneur's choice of financier.[8] This work has typically focused either on the entrepreneur's choice between venture capital or bank finance (Landier, 2001; Ueda, 2004; Winton and Yerramilli, 2004; de Bettignies and Brander, 2007), or (as in this paper) the choice between venture capital and angel-financing (Leshchinskii, 2002; Chemmanur and Chen, 2006; Schure, 2006).

[2] For papers that analyze double-sided effort-shirking, see, for example, Houben (2003), Casamatta (2003), Schmidt (2003), Repullo and Suarez (2004), Casamatta and Haritchabalet (2004), Fairchild (2004), Cassiman and Ueda (2006), Bernile et al. (2007), and de Bettignies (2008).

[3] 'Ex ante' and 'ex post' refer to events that occur before and after the venture has achieved success or failure.

[4] For papers that analyze the hold-up or expropriation threat, see, for example, Smith (1998), Landier (2001), Repullo and Suarez (2004), Chemla et al. (2004), Skeie (2004), Gebhardt and Schmidt (2006), and Bigus (2002).

[5] See Bigus (2002) for a review of the literature focusing on the entrepreneur's hold-up/expropriation threat.

[6] In this paper, our focus is on the effect of behavioral factors, such as trust and empathy, on mitigating the hold-up/expropriation problem. Therefore, we do not consider the effect of the legal system and property rights protection (such as patents) on reducing such problems. For papers that analyze the effect of the legal system, see, for example, Anton and Yao (1994), Anton and Yao (1995), and Hellmann (2007).

[7] In a previous version of this paper, we focused on the venture capitalists' ex post threat. An anonymous referee suggested that we analyze a double-sided expropriation threat, since Es and VCs are capable of holding-up each other. We are grateful to the referee for motivating this improvement to our model.

[8] We do not analyze the growing literature on an individual's choice to become an entrepreneur or remain as an employee with a firm. For such work, see Anand et al. (2004), and Hellmann (2007).

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Leshchinskii (2002) considers a model in which an entrepreneur seeks finance for two complementary projects, choosing either a VC or an angel. As in our model, the VC has higher ability than the angel. Leshchinskii models this as follows; the VC can provide value-adding assistance to both projects, whereas the angel only has the ability to focus on one project. As in our model, the two financiers compete to supply finance by offering monetary investment in return for a share in the project.

Chemmanur and Chen (CC 2006) consider a dynamic model in which an entrepreneur chooses between VC and angel-financing over time. The E has more information about his project than either of the financiers. However, this informational advantage reduces over time as the financiers learn about the project. In CC's model, VCs have value-adding abilities (together with the E), while the A does not have any ability to create value. However, VC-financing is scarce relative to A-financing.

Schure (2006) considers the effects of project-characteristics on an entrepreneur's choice of venture capitalist or angel. In similar spirit to our model, he considers two stages in a venture's development. Firstly, the E and his chosen financier both exert effort to create venture value. Secondly, the partners can force renegotiation of the contract by threatening to leave the venture. In Schure's model, the angel has higher ability than the VC, in sharp contrast to Leshchinskii's (2002) model, Chemmanur and Chen's (2006) model, and our model.

Our model is closely related to that of De Bettignies and Brander (dB 2007), who consider the effect of double-sided effort-shirking problems on an entrepreneur's choice of VC or bank finance. However, we develop their analysis in several ways. The obvious difference is that, rather than considering the choice of VC or bank finance, we focus on the entrepreneur's choice of VC or angel-financing. Secondly, our model incorporates double-sided effort-shirking and double-sided expropriation problems, while dB only considers double-sided effort-shirking. Thirdly, dB assumes that the E's and VC's value-creating abilities are substitutes, while we assume that they are complements.

A major difference between our analysis and dB's model is embodied in the factors that affect the E's choice of financier. In dB's model, the VC possesses value-adding ability, while the bank does not. However, under the terms of a bank loan, the E has all of the equity, while, in the VC contract, the E shares the equity with the VC. Hence, in making his choice of financier, the E trades-off the higher value-creating abilities of the VC against the E's higher equity stake in the bank's loan contract.

In our model, regardless of whether the E chooses the VC or the angel, the E and the financier have half of the equity each (we do not consider bargaining over equity shares). This enables us to focus on a different trade-off in the E's decision. That is, given that he obtains the same equity stake (50%) either with the VC or the angel, the E trades-off the higher value-adding ability provided by the VC against the higher trust and empathy inherent in the E/A dyad. In short, we develop dB's (2007) analysis by incorporating economic and behavioral factors.

Hence, our third major contribution is that we analyze economic and behavioral factors affecting the E's choice of financier, and the performance of the venture. We provide a formal analysis of the procedural justice literature, which recognizes that the performance of venture capitalist/entrepreneur dyads may be affected by behavioral factors such as fairness and trust. De Clercq and Sapienza (2001) coined the term 'relational rents,' referring to the value-creating potential of fairness and trust in venture-backed firms. However, these authors note that "no in-depth analysis has been made of how relational rents might be created for both parties in the dyad." Our model begins to address this issue.

Although no formal behavioral game-theoretic models exist regarding entrepreneur/financier relationships, conceptual approaches abound, analyzing the role of procedural justice in venture capital/entrepreneur relationships.[9] This approach focuses on the effects of fairness and trust in enhancing venture performance. Therefore, in attempting to develop a formal behavioral game-theoretic analysis, the modeler must decide on an appropriate approach. After a search of the literature, we decided to focus on the effects of trust and empathy.[10]

Our behavioral approach to empathy and trust is closest in spirit to that of Levine (1998), Sally (2001), and Herold (2008). All of these authors have developed models of social- or 'other-regarding' preferences. These models recognize that, in contrast to traditional economic analysis, players are not completely self-interested, but may also consider the effects of their actions on the payoffs of others. Levine (1998) pioneered an approach in which players place a weighting on other players' payoffs, reflecting a 'feeling' for others' welfare. Sally (2001) further developed this idea by interpreting this weighting as an 'empathy' or 'closeness' parameter.

We build on Levine's (1998) and Sally's (2001) work by incorporating an empathy parameter into the E/A dyad. Sally's empathy parameter consists of two components; geographical/physical closeness, and psychological closeness. This is particularly appropriate for our model, since we have already noted that Es may choose angels due to their geographical closeness. Furthermore, Es and angels may be psychologically close (as noted, angels are often ex-entrepreneurs, who are aiming to help new entrepreneurs to develop their start-up businesses). It is interesting to note that Sally also describes the empathy parameter as a 'fellow-feeling' parameter.

In our model, we focus on the link between empathy and trustworthy behavior. Our approach is closest to Herold's (2008) analysis of the effect of trust on incentive problems in innovation. She develops a principal-agent model in which both partners in a project may both exert value-creating efforts (hence, potential double-sided effort-shirking problems exist). In her analysis, a trustworthy agent gains utility from her own payoff (her wage less her effort costs) plus a feeling for the success of the project as a whole. An increase in this feeling induces the agent to exert higher effort levels (and, if efforts are complementary, the principal

[9] For literature on the role of procedural justice in venture capital performance, see Busenitz et al. (1997), Cable and Shane (1997), Lehtonen et al. (2004), Sapienza and Korsgaard (1996), Sapienza et al. (2000), De Clercq and Sapienza (2001), Shepherd and Zacharakis (2001), and Utset (2002), among others.

[10] Hence, we decided against considering fairness. For theoretical and experimental analyses of fairness, see e.g.: Rabin (1993), Fehr and Schmidt (1999a,b), Bolton and Ockenfels (2000), and Fehr et al. (2004, 2006). We leave the analysis of the effects of fairness in venture performance for future research.

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will also work harder). Herold interprets this as an increase in trust. However, we note that Herold does not consider the behavioral factor of empathy between players. Higher effort is driven by a feeling for the project, not by a feeling for one's partner.

Similarly, in our model, an increase in empathy between the E and the angel reduces double-sided moral hazard problems (effort-shirking and expropriation), which we also interpret as an increase in trust.[11] However, in contrast to Herold, we view this as a behavioral factor (psychological closeness between the E and the angel).

The rest of the paper is organized as follows. In Section 3, we develop a model of an entrepreneur's choice between VC and angel-financing. In Section 4, we solve for the entrepreneur's optimal choice of financier. Section 5 presents a numerical example. Section 6 concludes with a summary of our model, managerial and policy implications, and suggestions for future research.

3. The model

We consider an entrepreneur (E) who has an idea for an innovative venture, requiring start-up finance $I>0$. The entrepreneur has no financial resources of his own, and so must seek finance from either a venture capitalist (VC) or an angel (A). The E, VC and A are all risk-neutral, and they discount future cash-flow at a zero discount rate.

The sequence of events in the development of the venture is as follows.

Date 0: The entrepreneur offers the right to finance his project to both financiers, denoted as $i \in \{VC, A\}$. These financiers bid for the right to supply finance to the E, and to become the E's partner (we refer to this partnership as a dyad). The bidding game is such that each financier simultaneously offers funding $I_i \geq I$ to the E. The E considers the bids and accepts one of the financiers to provide funding, and form a dyad. We demonstrate in our analysis that the E considers both economic and behavioral factors in making his choice of financier.

Having formed a dyad, we take as given that the E and his chosen financier agree to allocate their equity stakes in the venture equally.[12]

Date 1: The partners both exert simultaneous, unobservable effort in developing the business. Specifically, the project may either succeed with probability p, or fail with probability $1-p$. In the case of success, the project provides income $R>0$. In the case of failure, the project provides zero income.

The partners' effort levels affect the probability of success as follows; $p = \gamma_{E,i}(e_E e_i)^{\frac{1}{2}}$, where i denotes the E's choice of financier (that is, $i=VC$ or $i=A$). Therefore, the expected value of the venture is

$$V = PR = \gamma_{E,i}(e_E e_i)^{\frac{1}{2}}.$$

Note that the functional form for the success probability p means that the partners' efforts are complements. Since effort levels are unobservable, each player faces possible shirking problems from his partner (that is, double-sided moral hazard problems in the form of mutual effort-shirking).

Furthermore, $\gamma_{E,i}$ represents the synergistic, value-creating abilities of the E/i dyad. We normalize the E/A dyad's synergy parameter as follows; $\gamma_{E,A}=1$. For the E/VC dyad, $\gamma_{E,VC}\geq 1$. That is, the E/VC dyad possesses greater value-creating synergies than the E/A dyad (we discuss this further below).

Date 2: The project either succeeds or fails, with the probabilities described previously. In the case of failure, the project provides zero income, and the game ends with each player receiving a payoff of zero.

In the case of success, the project provides income $R>0$, in which case, the game proceeds to the Date 3 stealing game.

Date 3: The partners take their payoffs ($\frac{R}{2}$ each, according to the equal equity stakes agreed at Date 1) into the Date 3 stealing sub-game. In this sub-game, each player simultaneously decides whether to steal the project or not. Hence, at this stage, we consider a double-sided moral hazard problem in the form of mutual project-expropriation. (We describe this game in more detail when we solve the game in the next section).

In this paper, we are interested in considering the effects of economic and behavioral characteristics on the E's choice of financier, and the resulting expected venture value. Specifically, we assume (as noted previously) that the E/VC dyad possesses greater synergistic, value-creating, ability than the E/A dyad, since $\gamma_{E,A}=1$, $\gamma_{E,VC}\geq 1$. As noted in our literature review, there is considerable evidence that VCs are capable of adding more value than angels. In addition to the evidence, we motivate our assumption as follows. Research suggests that VCs and Es possess complementary value-adding abilities. For example, Houben (2003) identifies that VCs provide marketing, networking, product market, and advisory expertise, while Es possess technological, production, and innovation expertise. Therefore, there may be substantial synergistic, value-adding effects in the E/VC dyad. In contrast, angels are often friends, relatives, and/or ex-entrepreneurs. Therefore, the E's and the A's capabilities may be 'too similar' to provide much synergistic value.

[11] In a previous version of this paper, trust was an exogenously-given characteristic of financier-type. That is, we assumed that angels were trustworthy (did not expropriate the project at the stealing stage), and we assumed that VCs were untrustworthy (they expropriated at the stealing stage). In effect, our approach was similar to Al-Najjar and Casadesus-Masanell (2001), who consider exogenously-given trustworthy and untrustworthy types in a principal-agent framework. The question posed by an anonymous referee was, why would angels be more trustworthy than VCs? This motivated us to consider empathy as the 'missing ingredient' that may explain why Es and As enjoy a closer, more trusting relationship than VCs and Es. We are grateful to the referee for motivating this improvement in our analysis.

[12] Therefore, we do not consider bargaining over the equity stake in this model. See Fairchild (2004) for a model that considers venture capitalist–entrepreneur bargaining over cash-flow rights. However, in that model, the author does not consider behavioral factors.

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On the face of it, since the VC provides more value-adding capabilities than the angel, intuition would suggest that the E would unambiguously prefer VC-financing. However, the contribution of our model is to consider both economic and behavioral characteristics affecting the E's choice of financier, and the resulting expected venture value. Specifically, although the A offers lower value-adding capabilities, the E and the A may enjoy a closer, more empathetic relationship then in the E/VC dyad. As noted in the literature review, there is considerable supporting evidence.

We model empathy as follows. If the E chooses the VC to supply finance, each player only cares about his own payoff (denoted $\prod_E$ and $\prod_{VC}$ respectively). However, if the E chooses the A, each player cares to some extent about the other player's payoff. That is, E's and A's respective utility functions are $U_E = \prod_E + \hat{\theta}\prod_A$ and $U_A = \prod_A + \hat{\theta}\prod_E$, where $\hat{\theta} \in [0, 1]$ is the weighting that each player attaches to its partner's payoff, and represents equilibrium (actual) empathy.

We consider a dynamic model of empathy in which the E and the A are forward-looking, considering and anticipating empathy throughout the game. Particularly, we consider an exogenously-given level of potential empathy θ, and an actual level of empathy $\hat{\theta}$. At the Date 1 effort stage, the E and the A correctly anticipate their actual empathy level $\hat{\theta}$ at the Date 3 stealing stage (which may, or may not, equal the potential empathy level θ). This actual level then becomes the empathy level at the Date 1 effort stage. In other words, empathy is consistent throughout the game.

In our model, the E's and A's decision at the stealing stage affects actual empathy as follows. If both players choose not to steal, then the actual empathy level equals the potential empathy level; $\hat{\theta} = \theta$. If one or both players steal, actual empathy is destroyed for both players ($\hat{\theta} = 0$).

In summary, our formulation of empathy captures the following ideas. Firstly, the players correctly anticipate empathy throughout the game, and this affects decisions made at each stage. Secondly, empathy can be destroyed by actions, such as stealing. We discuss this further in Section 3.1.

By incorporating empathy into the analysis, we are considering a behavioral game-theoretic approach in which the E considers economic and behavioral factors in making his choice of financier. Although the VC may possess higher value-adding abilities, the E may choose the A due to empathy.

In summary, the E/VC dyad possesses greater, synergistic, value-adding ability than the E/A dyad. However, the players are completely self-interested in the E/VC dyad, whereas in the E/A dyad, there is a degree of empathy which reduces the double-sided moral hazard problem, both at the effort stage and the ex post expropriation stage. The E trades-off these factors in choosing his financier, and this affects the expected venture value.

We proceed to solve the game by backward induction.

3.1. Date 3 stealing game

Researchers have identified that a threat commonly faced by Es and financiers, such as VCs, is that of ex post stealing (e.g.; Bigus, 2002; Ueda, 2004). We model this as follows. At Date 3, following project success (such that venture achieves income $R > 0$), the E and his chosen financier $i \in \{VC, A\}$ make a simultaneous decision[13] whether to steal the project (S), or not steal (NS). Since the players face a simultaneous binary decision (steal or not steal), we can represent this game as a normal form game, as shown in the table below.

E\i	NS	S
NS	1, 2	3, 4
S	5, 6	7, 8

In our model, the players' simultaneous stealing/non-stealing decision affects the players' payoffs as follows. If both players decide on NS, they both receive payoffs according to the equity stakes agreed at date 0; that is, they receive half of the venture's success value each; $\frac{R}{2}$. If one player steals unilaterally, this destroys some project value, such that the firm is now worth μR, with $\frac{R}{2} < \mu R < R$. The culprit obtains all of this, while the non-stealer achieves a payoff of zero. If both players steal, total project value becomes $\phi R < R$, with each player achieving half of this; $\frac{\phi R}{2}$.

As noted previously, we model empathy in the stealing game as follows. In the E/VC relationship, there is no empathy. In the E/A dyad, the potential empathy parameter is θ. Each player's utility is a combination of his own payoff and his partner's payoff as follows: $U_i = \prod_i + \hat{\theta}\prod_j$, where $\hat{\theta}$ represents equilibrium (actual) empathy. If neither player steals, actual empathy equals potential empathy; $\hat{\theta} = \theta$. If at least one player steals, actual empathy is destroyed; $\hat{\theta} = 0$.

Note that we assume rationality and consistency throughout the game. If players anticipate that empathy is going to be destroyed in the stealing game, it is also destroyed from the start of the game (the players have perfect foresight: a feature of game-theoretic models[14]).

Our assumption that empathy/psychological closeness is destroyed by the players' strategy choices ('steal' or 'not steal') deserves further comment.

[13] In the case of failure, the project achieves zero income, and the stealing decision is irrelevant.

[14] It would be interesting to consider the case where the players do not anticipate their partner's future moral hazard when making decisions at an earlier stage of the game. Indeed, Utset (2002) provides a conceptual discussion of this form of myopia. He argues that, in the early stages of an E/VC relationship, entrepreneurs may be overconfident regarding the VC's trustworthiness. Once the VC betrays that trust later on, Utset describes how the E's feelings of being let-down may drive him to vengeful, destructive behavior. We leave game-theoretic analysis of this for future research, as discussed in our concluding section.

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Camerer (1997), in his discussion of behavioral game theory, considers the effects of framing on the equilibria of games. He discusses the axiom of description invariance, which holds that changing the labels associated with strategies should not cause players to change behavior. Our stealing game could be thought of as violating the axiom of description invariance. That is, the choices are labelled as 'steal' or 'not steal'. A choice of 'steal' by either player destroys empathy between the players, which affects the equilibrium. If the choices had been described as 'A' or 'B' instead, then such choices may not be expected to change behavior.

Therefore, the payoffs are as follows.

$$U_E = U_i = \frac{R}{2}(1 + \theta_i) \quad (1),(2)$$

$$U_E = 0, U_i = \mu R \quad (3),(4)$$

$$U_E = \mu R, U_i = 0 \quad (5),(6)$$

$$U_E = U_i = \frac{\phi R}{2}. \quad (7),(8)$$

In the case where the E has chosen the VC, $\theta_{VC} = 0$.

We derive our first result.

Proposition 1. *The equilibrium of the stealing game is as follows:*

a) *In the E/VC relationship, with* $\hat{\theta}_{VC} = 0$*, each player's dominant strategy is to steal. Therefore, the equilibrium is {S, S}. This represents a prisoner's dilemma.*
b) *In the E/A relationship, in the case of low potential empathy* ($\theta \leq 2\mu - 1$)*, each player's dominant strategy is to steal, and the equilibrium is {S, S}. This represents a prisoner's dilemma. Since the players steal, empathy is destroyed, such that* $\hat{\theta} = 0$.
c) *In the case of high empathy* ($\theta > 2\mu - 1$)*, there are two equilibria of the game; {NS, NS} and {S, S}. Using a focal point argument, the players settle on the {NS, NS} equilibrium. Therefore, potential empathy is maintained in equilibrium;* $\hat{\theta} = 0$.

Proof. *We solve by employing* Eqs. (1)–(8) *in order to consider each player's best responses to the other's possible strategies, and solving for the Nash equilibrium. Full proof is available on request from the author.*

At this stage of the analysis, it is worth emphasising an important result, arising from Proposition 1, regarding the effect of E/A potential empathy on actual empathy. This is presented in Proposition 2.

Proposition 2.

a) *Actual empathy is destroyed* ($\hat{\theta} = 0$.) *for any level of potential empathy below a critical value* ($0 \leq \theta < 2\mu - 1$)*, due to lack of trust at the stealing stage.*
b) *When potential empathy rises above a critical value* ($\theta > 2\mu - 1$)*, actual empathy 'jumps' from zero to become equal to potential empathy* ($\hat{\theta} = \theta > 2\mu - 1$)*, due to the E and A becoming trustworthy at the stealing stage.*

This feature (actual E/A empathy 'jumping' from zero to a positive level) is an important result that we will return to throughout our analysis of the rest of the game.

3.2. Date 1 effort stage

We now move back to Date 1 to solve for the players' optimal effort levels. At this stage, the E and his chosen financier correctly anticipate the outcome of the Date 3 stealing game (including the equilibrium level of Date 3 empathy), and take this into account when choosing their optimal effort levels. Each partner's payoff consists of his cash-flow rights $\frac{1}{2}V$ (as he owns half of the equity) minus his cost of effort βe^2.

If the E chooses the VC at the date 0 bidding stage, the players correctly anticipate Date 3 mutual stealing at the Date 1 effort stage. Therefore, they choose their date 1 effort levels to maximize their expected payoffs;

$$\Pi_E = \frac{1}{2}\gamma(e_E e_{VC})^{\frac{1}{2}}\phi R - \beta e_E^2 \quad (9)$$

$$\Pi_{VC} = \frac{1}{2}\gamma(e_E e_{VC})^{\frac{1}{2}}\phi R - \beta e_{VC}^2 \quad (10)$$

If the E chooses the A, with weak potential empathy ($\theta < 2\mu - 1$), then the players correctly anticipate mutual stealing at Date 3, with 'destruction' of actual empathy, $\hat{\theta} = 0$. Therefore, the players choose effort levels to maximize

$$\Pi_E = \frac{1}{2}(e_E e_A)^{\frac{1}{2}}\phi R - \beta e_E^2. \quad (11)$$

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$$\Pi_A = \frac{1}{2}(e_E e_A)^{\frac{1}{2}}\phi R - \beta e_A^2. \quad (12)$$

If the E chooses the A, with strong empathy ($\theta > 2\mu - 1$), the players correctly anticipate mutual non-stealing (NS) at Date 3, with empathy maintained throughout the game ($\hat{\theta} = 0$). Therefore, they choose effort levels to maximize

$$U_E = \Pi_E + \theta\Pi_A = \frac{1}{2}(e_E e_A)^{\frac{1}{2}}R(1+\theta) - \beta e_E^2 - \theta\beta e_A^2 \quad (13)$$

$$U_A = \Pi_A + \theta\Pi_E = \frac{1}{2}(e_E e_A)^{\frac{1}{2}}R(1+\theta) - \beta e_A^2 - \theta\beta e_E^2. \quad (14)$$

In each of the relationships, we derive the E's and the financier's optimal effort levels by solving $\frac{\partial \Pi_E}{\partial e_E} = 0, \frac{\partial \Pi_i}{\partial e_i} = 0$. Furthermore, we substitute these optimal effort levels into the value-equation, $V = PR = \gamma_{E,i}(e_E e_i)^{\frac{1}{2}}$, to obtain the indirect firm values. These results are presented in Proposition 3.

Proposition 3.

a) *In the E/VC dyad, the players' optimal effort levels are* $e_E^* = e_{VC}^* = \frac{\gamma\phi R}{8\beta}$. *Therefore, the indirect firm value is* $V = \frac{\gamma^2\phi^2R^2}{8\beta}$.
b) *In the E/A dyad with weak potential empathy* ($\theta < 2\mu - 1$), *actual empathy is destroyed* ($\hat{\theta} = 0.$). *The players' optimal effort levels are* $e_E^* = e_A^* = \frac{\phi R}{8\beta}$. *Therefore, indirect firm value is* $V = \frac{\phi^2R^2}{8\beta}$.
c) *In the E/A dyad, with strong potential empathy* ($\theta \geq 2\mu - 1$), *actual empathy is maintained;* ($\hat{\theta} = 0.$). *The players' optimal effort levels are* $e_E^* = e_A^* = \frac{R[1+\theta]}{8\beta}$. *Therefore, the indirect firm value is* $V = \frac{R^2(1+\theta)}{8\beta}$.

Proposition 3 provides the following key results.

i) In the E/VC relationship, the players' effort levels, and hence firm value, are positively related to the VC/E ability parameter γ, and the anticipated value from stealing in the case of success ϕR. Effort levels and firm value are negatively related to the loss due to (correctly) anticipated Date 3 stealing (represented by parameter ϕ). There is no empathy, and no trust, in this relationship.
ii) In the case of weak E/A empathy, empathy is destroyed, and the players correctly anticipate Date 3 stealing. ComparingProposition 3a) and b), the E and the VC unambiguously exert more effort, creating greater value, than the E/A dyad with weak empathy, due to higher E/VC ability ($\gamma > 1$).
iii) In the case of strong E/A empathy, effort levels, and firm value, are positively related to empathy. It is interesting to note that E/A effort levels are higher than the E/VC effort level if $1 + \theta > \gamma\phi$. That is, although the E/VC dyad has higher value-creating ability, the players work harder in the E/A dyad if empathy is sufficiently high.

4. Will the entrepreneur choose the venture capitalist or the angel?

4.1. The date 0 bidding stage

We now move back to the date 0 bidding game to analyze whether the E will choose the VC or the A. That is, which financier will win the bid to supply finance?

Our first step is to derive the players' indirect payoffs in each of the dyads. We do so by substituting the optimal effort levels and indirect venture values from Proposition 3 into Eqs.(9)–(14). We obtain the following indirect payoffs in the E/VC dyad, the E/A empathy with weak empathy, and the E/A dyad with strong empathy, respectively;

$$\Pi_E = \Pi_{VC} = \frac{3\gamma^2\phi^2R^2}{64\beta}. \quad (15)$$

$$U_E = U_A = \frac{3\phi^2R^2}{64\beta}. \quad (16)$$

$$U_E = U_A = \frac{R^2}{64\beta}[4(1+\theta)^2 - (1+\theta)^3]. \quad (17)$$

We define our date 0 bidding game as follows. Each financier $i \in \{VC, A\}$ makes a simultaneous bid to provide finance $I_i \geq I$ to the entrepreneur. Denote the winning bidder as financier W, and the losing bidder as financier L. Furthermore, define the E's payoff from choosing financier i as $U_E(i)$.

In order to solve the bidding game, we define players' *net* payoffs as follows. Given that a financier bids $I_i \geq I$, the players' net payoffs, resulting from a successful bid, are as follows;

$$N_E = U_E(i) + I_i - I, \quad (18)$$

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$$N_i = U_i - I_i. \tag{19}$$

The first term of E's net payoff is his indirect payoff (given by Eqs. (15), (16) or (17) depending on which financier wins the bid). The second term is the amount of financing bid by the winning financier. The third term is the investment required to initiate the venture. We may consider the second term minus the third term as the excess funding supplied by the winning financier. The first term of the financier's net payoff is his indirect payoff (given by Eqs. (15), (16) or (17)). The second term is his bid.

We define the dyad's total net payoff, TN (E; i), as the sum of the E's and the financier's net payoffs. That is;

$$TN(\mathrm{E}; i) = N_{\mathrm{E}} + N_i = U_{\mathrm{E}}(i) + U_i - I. \tag{20}$$

This is the total surplus (above the required initial investment) enjoyed by the venture (it is the date 0 net present value of investing in the venture minus the players' effort costs). The financier's bid affects the allocation of this surplus to the partners in the dyad.

In order to complete the analysis, we assume that that the losing financier makes the maximum bid possible, such that his net payoff in Eq. (19) is zero. Given this assumption, we state the following result.

Proposition 4. *The VC is able to win the bid to supply finance (VC-finance dominates) iff TN (E; VC) > TN (E; A). The A is able to win the bid to supply finance (A-finance dominates) iff TN (E; A) > TN (E; VC). The E is indifferent in his choice of financier if TN (E; VC) = TN (E; A).*

Proof. See the Appendix.

Effectively,Proposition 4 states that the financier's ability to win the bid is affected by the total surplus generated by the dyad, with his bid affecting the allocation of that surplus to the E and the financier.

We now substitute the payoffs from Eqs. (15)–(17) into Eq. (20), in order to obtain the total net payoff for each of the dyads (E/VC, E/A with weak empathy, E/A with strong empathy) respectively;

$$TN(\mathrm{E}; \mathrm{VC}) = \frac{3\gamma^2\phi^2R^2}{32\beta} - I. \tag{21}$$

$$TN(\mathrm{E}; \mathrm{A}) = \frac{3\phi^2R^2}{32\beta} - I, \tag{22}$$

$$TN(\mathrm{E}; \mathrm{A}) = \frac{R^2}{32\beta}[4(1+\theta)^2 - (1+\theta)^3] - I, \tag{23}$$

4.2. Bidding when E/A empathy is weak

In the case where the E and A have weak potential empathy ($0 \le \theta < 2\mu - 1$), actual empathy is destroyed, due to lack of trust ($\theta = 0$). From Proposition 4, the VC wins the bid iff Eq. (21) > Eq. (22). Therefore, we state the following result (with the effect on firm value given by examination of Proposition 3a) and 3b)):

Proposition 5. *In the case of weak* E/A *empathy* ($0 \le \theta < 2\mu - 1$), *such that empathy is destroyed* ($\hat{\theta} = 0$.), *the VC wins the bid for all levels of VC ability, since TN* (E; VC) > *TN* (E; A) *for all* $\gamma > 1$. *This is unambiguously value-maximizing: that is, V* (E, VC) > *V* (E, A).

4.3. Bidding when E/A empathy is strong

In the case where E and A have strong potential empathy ($\theta > 2\mu - 1$), actual empathy jumps from zero to become equal to potential empathy ($\hat{\theta} = \theta > 2\mu - 1$). We derive a critical value γ_1, such that TN (E; VC) = TN (E; A). If $\gamma \in [1, \gamma_1]$, then TN (E; A) > TN (E; VC), and the A can win the bid. If $\gamma > \gamma_1$, then TN (E; VC) > TN (E; A), and the VC can win the bid. Equating Eqs. (21) and (23), we obtain

$$\gamma_1 = \frac{1}{\phi}\sqrt{\frac{4(1+\theta)^2 - (1+\theta)^3}{3}}. \tag{24}$$

In addition to analyzing the bidding game, and the E's choice of financier, we are interested in considering the effect on firm value. In the case of strong E/A empathy, We define a critical value, γ_2, which equates V (E, VC) and V (E, A). Therefore, V (E, A) > V

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(E, VC) when $\gamma \in [1, \gamma_2]$, and V (E, VC) $> V$ (E, A) when $\gamma > \gamma_2$. Solving V (E, A) $= V$ (E, VC) (from Proposition 3a) and c)), we obtain

$$\gamma_2 = \frac{1}{\phi}\sqrt{1+\theta}. \tag{25}$$

In our next result, we consider the effect of E/A empathy on these critical values.

When $\theta > 2\mu - 1$, (strong empathy), we compare Eq. (24) and (25). We note that, for any positive θ, $\gamma_1 > \gamma_2$. Further, γ_1 and γ_2 are increasing in θ, and so is the difference between them. Therefore, we state the following:

Proposition 6. *In the case of strong* E/A *empathy* ($\theta \geq 2\mu - 1$);

a) $\gamma_1 > \gamma_2$ *for any level of* $\theta \geq 2\mu - 1$.
b) $\frac{\partial \gamma_1}{\partial \theta} > 0$, *and* $\frac{\partial \gamma_2}{\partial \theta} > 0$. *Both critical levels of* E/VC *value-creating ability increase as* E/A *empathy increases. That is, as* E/A *empathy increases, the* VC *must possess higher value-adding ability to win the bid, and to create greater venture value than the* E/A *dyad.*
c) *As* E/A *empathy increases,* γ_1 *increases at a faster rate than* γ_2 $\left(\frac{\partial \gamma_1}{\partial \theta} > \frac{\partial \gamma_2}{\partial \theta} > 0\right)$. *Therefore, the interval between* γ_1 *and* γ_2 *becomes larger;* $\frac{\partial(\gamma_1 - \gamma_2)}{\partial \theta} > 0$.

Using the results in Proposition 6, we are now in a position to analyze the combined effects of E/A empathy (in the case that E/A empathy is strong) and E/VC ability, on the E's equilibrium choice of financier at the bidding stage, and the effect on venture value. These results are presented in Proposition 7.

Proposition 7. *In the case that* E/A *empathy is strong* ($\theta \geq 2\mu - 1$), *the effect of* VC/E *ability, and the* E/A *empathy, on the* E's *choice of financier and venture value is as follows:*

a) *When* $\gamma \in [1, \gamma_2]$, A *wins the bid to supply finance. This is value-maximizing:* V (E, A) > V (E, VC).
b) *When* $\gamma \in [\gamma_2, \gamma_1]$, *A wins the bid to supply finance, but this is value-minimizing:* V (E, A) < V (E, VC). *Hence, we define* $\gamma \in [\gamma_2, \gamma_1]$ *as the inefficient VC ability interval. This inefficient interval is increasing in* θ.
c) *When* $\gamma > \gamma_1$, VC *wins the bid to supply finance, and this is value-maximizing:* V (E, VC) > V (E, A).

It is worth considering Proposition 7b) in more detail. Why does the E choose the A when the VC provides higher value? To understand this, we note that empathy has two reinforcing effects on the E's decision. First, it promotes mutual trust, which reduces the double-sided moral hazard problems during the venture's development, enhancing the entrepreneur's (and the angel's) expected payoff. Secondly, empathy means that the entrepreneur has feelings for the angel, which further induces him to choose the angel over the VC. This is modelled by incorporating the A's payoff (weighted by the empathy parameter) into the E's utility function. We interpret this as a 'warm-glow' feeling, or a feeling of comfort at working with an empathetic financier. An implication of this analysis is that, under particular levels of angel empathy and VC ability (as described in Proposition 7b), the entrepreneur will choose the angel, due to the 'warm-glow' feeling, but a choice of venture capital would have maximized firm value.

We now employ Propositions 2, 5 and 7 to summarize the main results of our model. If potential empathy in the E/A dyad is low (such that actual empathy is destroyed due to lack of trust: see Proposition 2), the E chooses the VC at the bidding stage, and this is unambiguously value-maximizing (Proposition 5). If potential E/A empathy increases sufficiently, actual empathy 'jumps' from zero to become equal to potential empathy (Proposition 2). Now, the E's choice of financier, and the effect on venture value, depends critically on the combined effects of E/A empathy and E/VC ability (Proposition 7).

Intuitively, these results suggest that venture value may be increasing in both VC/E ability, and E/A empathy. For example, in the case of low E/A empathy, since the E unambiguously chooses the VC, then venture value must increase in VC/E ability. Now, increasing empathy in the low interval has no effect, since the E continues to choose the VC (Proposition 5).

However, if the E/A empathy increases sufficiently, such that we are considering the results in Proposition 7, the effect of increasing E/A empathy and increasing VC ability becomes more complex. Intuitively, increasing empathy will increase firm value in the case that the E chooses the A, while increasing VC ability will increase firm value in the case that the E chooses the VC. However, the E's choice of financier may not be value-maximizing (in the inefficient interval).

In the next section, we clarify this analysis by considering a numerical example. For further clarification, we then present the results graphically.

5. Numerical example

We consider a numerical example with the parameter values given in the following table.

In order to complete the numerical analysis, we must consider parameter values for E/A empathy. These parameter values have been chosen after consideration of the critical value for potential empathy, described in Proposition 1. Given the parameter values in Table 1, the critical value in our numerical example is $\theta = 2\mu - 1 = 0.6$.

The three values for potential E/A empathy that we consider are;

i) $\theta = 0.4 < 2\mu - 1$ (low potential empathy). According to Proposition 2, this level of low potential E/A empathy results in bilateral stealing at Date 3 (we prove this numerically in the Appendix). This results in loss of empathy throughout the game; that is, actual empathy becomes $\hat{\theta} = 0$.
ii) $\theta = 0.7 \geq 2\mu - 1$ (medium potential empathy).

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Table 1
Parameter Values for the Numerical Example.

Parameter	Description	Value
R	Success income	100
	Failure income	0
μ	Value-reduction in unilateral-stealing case	0.8
ϕ	Value-reduction in bilateral stealing case	0.5
β	Cost of effort parameter	10
γ	Dyad's synergy parameter	1 (in the E/A dyad) Greater than 1 (in the E/VC dyad)

iii) $\theta = 0.9 \geq 2\mu - 1$ (high potential empathy).[15] According to Proposition 2, our choice of values for medium and high potential E/A empathy results in mutual non-stealing at Date 3 (we prove this numerically in the Appendix). Therefore, actual empathy equals potential empathy throughout the game; $\hat{\theta} = 0$.

In the E/VC dyad, there is no empathy ($\theta = 0$), and there is mutual stealing at Date 3 (see the Appendix for the numerical proof).

Having considered the effect of our parameter values on the equilibrium of the Date 3 stealing game in each dyad, we now move back consider the effect of these parameter values on the Date 1 effort stage, the date 0 bidding stage, and equilibrium venture value, as follows.

a) In the E/VC dyad, the players correctly anticipate bilateral stealing at Date 3. Hence, at Date 1, the E and the VC correctly anticipate the date 3 success income, following stealing, to be $\phi R = 0.5\ (100) = 50$. Therefore, from Proposition 3, the optimal effort levels become $e_E^* = e_{VC}^* = \frac{\gamma\phi R}{8\beta} = \frac{50\gamma}{400} = 0.125\gamma$ (recall that $\beta = 50$ in our numerical example). The value of the venture is

$$V = \frac{\gamma^2\phi^2R^2}{8\beta} = \frac{50^2\gamma^2}{400} = 6.25\gamma^2. \tag{26}$$

The players' payoffs are $\Pi_E = \Pi_{VC} = \frac{3\gamma^2\phi^2R^2}{64\beta} = 2.34\gamma^2$. Therefore, the total net payoff is

$$T_N = \Pi_E + \Pi_{VC} - I = 4.68\gamma^2 - I. \tag{27}$$

b) In the E/A dyad, with low potential empathy, the players correctly anticipate bilateral stealing at Date 3. Hence, actual empathy is destroyed. Therefore, from Proposition 3b), the optimal effort levels become $e_E^* = e_A^* = \frac{\phi R}{8\beta} = \frac{50}{400} = 0.125$. The value of the venture is

$$V = \frac{\phi^2R^2}{8\beta} = \frac{50^2}{400} = 6.25. \tag{28}$$

The players' payoffs are $U_E = U_A = \frac{3\phi^2R^2}{64\beta} = 2.34$. Therefore, the total net payoff is

$$T_N = \Pi_E + \Pi_A - 1 = 4.68 - I. \tag{29}$$

Comparing Eqs. (27) and (29), we observe that the total net payoff in the VC/E dyad is unambiguously higher (for all levels of E/VC ability) than in the E/A dyad. Therefore, the VC can win the bid for all levels of ability. Furthermore, we observe that this is unambiguously value-maximizing (that is, comparing Eqs. (26) and (28), we observe that the VC/E venture value is higher than the E/A venture value for all levels of VC ability). This verifies Proposition 5.

c) In the E/A dyad, with medium potential empathy, the players correctly anticipate that empathy is sufficiently strong to ensure mutual non-stealing at Date 3 (effectively, empathy creates mutual trust). Hence, actual empathy equals potential empathy throughout the game. Therefore, from Proposition 3c), the optimal effort levels become $e_E^* = e_A^* = \frac{R(1+\theta)}{8\beta} = \frac{100(1.7)}{400} = 0.425$. Therefore, the value of the E/A venture is

$$V = \frac{R^2(1+\theta)}{8\beta} = \frac{100^2(1.7)}{400} = 42.5. \tag{30}$$

The players' payoffs are $U_E = U_A = 20.77$, and the total net payoff equals

$$TN = U_E + U_A - I = 41.54 - I. \tag{31}$$

[15] In our main analysis, we consider two levels of potential empathy; weak (such that actual empathy was destroyed), and strong (such that actual empathy was preserved and equal to potential empathy). In our numerical example, we consider 3 levels of potential empathy; low potential empathy (corresponding to weak potential empathy), and medium and high potential empathy (both corresponding to strong potential empathy).

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The result of the bidding game, and the effect on venture value, depends upon E/VC ability, compared with E/A empathy, as highlighted in the table, and the diagram, below.

d) In the case of high empathy, the players correctly anticipate mutual non-stealing at Date 3. Hence, actual empathy equals potential empathy throughout the game. Therefore, from Proposition 3c), the optimal effort levels become $e_E^* = e_A^* = \frac{R(1+\theta)}{8\beta} = \frac{100(1.9)}{400} = 0.475$. The value of the E/A venture is

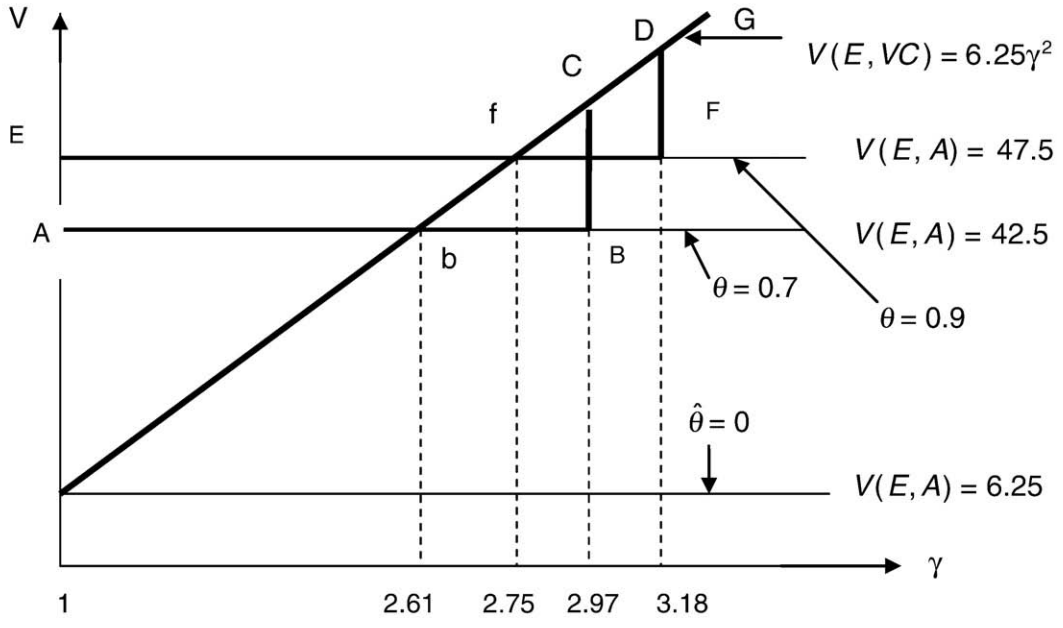
$$V = \frac{R^2(1+\theta)}{8\beta} = \frac{100^2(1.9)}{400} = 47.5. \tag{32}$$

The players' payoffs are $U_E = U_A = 23.69$, and the total net payoff equals

$$TN = U_E + U_A - I = 47.38 - I. \tag{33}$$

Again, the result of the bidding game, and the effect on venture value, depends upon E/VC ability, compared with E/A empathy, as highlighted in the table, and the diagram, below.

For clarity, we summarize the results in Table 2 below.
Next, we present these results in the following diagram.



The diagram confirms the results already discussed. That is, if E/A potential empathy is low ($\theta < 0.6$), such that actual empathy is destroyed ($\hat{\theta} = 0$) then, for any level of VC ability $\gamma > 1$, the VC unambiguously wins the bid, and this is value-maximizing : V (E,

Table 2
Summary of Results in the Numerical Example.

Dyad type	Venture value	Players' payoffs	Net payoffs	Winning bidder?
E/VC	$V = 6.25\gamma^2$.	$\prod_E = \prod_{VC} = 2.34\gamma^2$.	$T_N = 4.68\gamma^2 - I$.	
E/A dyad: low potential/zero actual empathy	$V = 6.25$.	$U_E = U_A = 2.34$.	$T_N = 4.68 - I$.	VC wins the bid to supply finance for all levels of VC ability $\gamma > 1$: value-maximizing for all levels of VC ability $\gamma > 1$
E/A dyad: medium potential/actual empathy	$V = 42.5$	$U_E = U_A = 20.77$.	$TN = 41.54 - I$.	VC can win the bid iff $\gamma > 2.97$. VC is value-maximizing if $\gamma > 2.61$. => Inefficient interval: $2.61 < \gamma < 2.97$.
E/A dyad: high potential/actual empathy	$V = 47.5$.	$U_E = U_A = 23.69$.	$TN = 47.38 - I$.	VC can win the bid iff $\gamma > 3.18$. VC is value-maximizing if $\gamma > 2.75$. => Inefficient interval: $2.75 < \gamma < 3.18$.

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VC) > V (E, A). The thick diagonal line represents the E's choice of financier (the VC), and the value of the venture.

If E/A potential/actual empathy is medium ($\theta = 0.7$), then the E chooses the A in the interval $0 < \gamma \leq 2.97$, and the E chooses the VC when $\gamma > 2.97$. This is represented by the locus ABCG. Notice that bB represents the inefficient interval (where the E chooses the A, but a choice of VC would have maximized value).

If E/A empathy is high ($\theta = 0.9$), then the E chooses the A in the interval $0 < \gamma \leq 3.18$, and the E chooses the VC when $\gamma > 3.18$. This is represented by the locus EFDG. Notice that fF represents the inefficient interval (where the E chooses the A, but a choice of VC would have maximized value).

It can be demonstrated that the critical γ-values 2.61, 2.97 (in the case of medium empathy), and 2.75, 3.18 (in the case of high empathy) are consistent with Eqs. (24) and (25). Furthermore, it may be observed that the a) the critical values are increasing as E/A empathy increases, and b) the inefficient interval is increasing as E/A empathy is increasing (confirming the results in Proposition 6).

6. Conclusions, policy implications, and future research

We have developed a model that analyzes an entrepreneur's choice of VC- or angel-financing. In contrast to existing game-theoretic research, which predominantly focuses on economic characteristics, a major contribution of our analysis is that we recognize that an entrepreneur may consider both economic and behavioral factors when making his choice of financier. Specifically, we consider a case where VCs have higher value-adding capabilities than angels, but where entrepreneurs and angels enjoy a close, empathetic, and trusting relationship, resulting in the creation of relational rents.

In analyzing the managerial and policy implications of our model, we closely follow De Bettignies and Brander's (dB 2007) method. In dB's model of the E's choice of VC- or bank-finance, market participants are fully rational. However, these authors argue that, in reality, agents may be prone to psychological and cognitive biases, particularly 'bounded rationality.' Therefore, dB states that "we view our analysis as only partly descriptive and at least as partially normative or prescriptive." In similar vein, we believe that our model can also be considered as both descriptive and normative.

At the descriptive level, our model provides a possible explanation for the puzzling evidence (discussed in our introduction) that financing from angels dominates venture capital financing globally, even though VCs tend to add more value. Our analysis suggests that behavioral factors, such as empathy and trust, are as important as economic factors, in the entrepreneur's choice of financier.

dB notes that "actual decisions often fall short of full rationality and emphasize that our analysis suggests specific insights that might be helpful to entrepreneurs (and others) in making financial decisions." In similar vein, at the normative level, our model provides insights for entrepreneurs, financiers, and policy makers.

Firstly, we suggest that entrepreneurs need to consider several factors when making their choice of angel- or VC-financing. For instance, if entrepreneurs focus on the relational aspects of angel-financing (empathy and trust), ignoring the value-creating potential of VCs, or, conversely, if they only consider the value-creating abilities of VCs, without understanding the relational aspects of angel-financing, they may make an inefficient choice. In short, Es need to consider both the economic and behavioral factors involved in angel- and VC-financing if the private-equity sector is to achieve its full value-creating potential.

From a financier's perspective, we suggest that venture capitalists and angels need to understand that entrepreneurs may be interested in both economic and behavioral factors when making the financier-choice. Therefore, in a world in which angels and venture capitalists may be competing to supply finance to entrepreneurs, it may be important for both types of financier to invest in developing value-adding capabilities, and relational aspects, such as trust and empathy towards entrepreneurs.

From the perspective of policy makers, we suggest they should consider both economic and behavioral factors when attempting to enhance the value-creating potential of the private-equity sector. For example, McNally (1995) focuses on policies to enhance VC ability. Indeed, he notes that the European Commission has called for the development of the corporate venture capital (CVC) sector in order to improve strategic value-adding services. In addition to economic factors, our model highlights the importance of behavioral factors, such as empathy and trust, in the creation of 'relational rents' (see De Clercq and Sapienza, 2001). A question for policy makers to consider is the following. Is it easier to promote economic or behavioral aspects of a dyad? It might be straight-forward to improve ability, but how can we promote empathy and trust? This may require a change in culture. Indeed, Duffner et al. (2008) conducted a survey of German venture capitalists. This revealed that these VCs placed a great deal of importance on trust in the VC/E relationship. Furthermore, the authors found a significant reciprocal positive relationship between trust and venture success.

Our analysis provides a basis for future research. We suggest that scholars develop our model to incorporate a richer menu of economic and behavioral factors. For example, the double-sided moral hazard approach could be extended to include conflicts throughout the life of the venture, from the initial selection phase, through the investment process to the exit.[16] Within this approach, it would be natural to consider the effects of financing methods, such as staged financing. Furthermore, we have focused our analysis on moral hazard problems. The model could be extended to incorporate informational asymmetries.

[16] See Tykvova (2007) for a survey of the literature on the conflicts of interest between entrepreneurs and venture capitalists at different stages of a venture's development.

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In our model, the entrepreneur and his financier have exogenously-given equal equity stakes in the venture. In future research, we intend to incorporate bargaining over cash-flow rights. For example, if the VC has higher bargaining power than the angel (in addition to the economic and behavioral factors already considered in this model), how would this affect the entrepreneur's choice of financier, and venture value?

Another development would be to consider the form of financing allocated to the partners in the dyad. In our model, we have assumed that the partners have simple equity stakes in the venture. There is much evidence that, in reality, venture capital contracts make use of many other types of financing instruments, such as convertible debt. We suggest that scholars should consider the behavioral factors affecting the choice of financial instruments. Indeed, Cumming (2005) presents evidence that the Canadian VC sector features a much higher proportion of straight common equity contracts, compared to the US VC sector (which makes heavy use of convertibles). Cumming provides a possible behavioral finance argument for this observation. That is, he argues that the greater use of equity-financing in Canada may reflect greater trust between Canadian VCs and entrepreneurs, compared to the US, as "common equity places the entrepreneur and the VC 'on the same team'". It would be interesting to attempt to model this formally.

In this paper, we have focused on cash-flow rights. We believe that It is essential for future development of our model to also consider conflicts over control rights. Furthermore, we have analyzed the role of empathy and trust in mitigating the ex post project-expropriation threat. Future analysis could also consider the effect of the legal system in constraining opportunistic behavior. It would be particularly interesting to consider whether the legal system would support, or replace, behavioral factors such as empathy and trust in constraining opportunism.[17]

In developing the behavioral aspects of our model, we have focused on empathy and trust. We believe that it is essential for future development to consider the effects of fairness (see footnote 10). Furthermore, in our model, empathy and trust are consistent over the life of the venture. That is, from the start of the game, the players fully anticipate their empathetic feelings at the later stealing stage, and these feelings are unchanged throughout the development of the venture. It would be interesting to consider a model in which the players' emotions change over time. Particularly, Utset (2002) conceptualizes that, in the early stages of a venture's development, an entrepreneur may be overconfident in the trustworthiness of a VC. Later on, when the VC engages in opportunistic behavior, the entrepreneur may react with vengeance (see footnote 14). It would be interesting to model this behavior.

Such developments to our model will deepen our understanding of the economic and behavioral factors affecting the entrepreneur's choice of financier, and the effect on value-creation.

Appendix A

Proof of Proposition 4

We assume that the losing bidder L (who knows he is going to lose the bid) will make the maximum bid possible, such that his net payoff is zero. Therefore, from Eq. (19), the losing bidder's net payoff is $N_L = U_L - I_L = 0$. Substituting this into Eq. (18), the E's net payoff if he accepted the losing bid is

$$N_E = U_E(L) + U_L - I. \tag{A.1}$$

A key result here is that, since the losing bidder makes the maximum bid, such that his net payoff is zero, the E gains all of the surplus from accepting this bid (the E gains all of the positive net present value). That is, if the E accepted the losing bid, then Eq. (A.1) would be equal to Eq. (20); $TN(E; L) = N_E$.

Therefore, the winning financier wins the bid by offering I_W, such that

$$U_E(W) + I_W - I \geq TN(E; L) = U_E(L) + U_L - I \tag{A.2}$$

In order to maximize his net payoff, the winning financier will bid I_W such that the left-hand side of Eq. (A.2) just exceeds the right-hand side.

In order to complete the analysis, we note that the winning financier will be able to win the bid by bidding I_W, and have a non-negative net payoff, iff

$$TN(E; W) = U_E(W) + U_W - I \geq U_E(W) + I_W - I. \tag{A.3}$$

Combining Eqs. (A.2) and (A.3), we note that the winning financier is able to win the bid iff $TN(E; W) > TN(E; L)$. This completes the proof.

[17] Allen and Song (2002) suggest that informal, relational factors and strong legal systems are substitutes in constraining opportunistic behavior by VCs and entrepreneurs. Indeed, their empirical analysis suggests that "Countries with less law and order have a higher degree of venture capital… This indicates that explicit contracts are not as important as the conventional wisdom suggests. In fact implicit relationships appear to provide a good substitute and this allows venture capital to fill the gap for the public markets." We leave analysis of the impact of the legal system on our model for future research.

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A.2. Date 3 stealing game: Numerical example

We consider the Date 3 stealing game in the case of success[18], in which case, the venture provides income $R = 100$.

We substitute our parameter values into the stealing game. In the E/VC dyad, empathy is zero. Therefore, the normal form game becomes;

E\VC	NS	S
NS	50, 50	0, 80−
S	80+, 0	25+, 25−

Note that VC's best responses are indicated by −, while E's best responses are indicated by +. The Nash equilibrium of the game is found where + and − appear in the same cell.

We note that each player's dominant strategy is to steal. Therefore the equilibrium is {S, S}. This is a prisoner's dilemma, because each player would have been better off if they had both chosen not to steal. The {S, S} equilibrium arises from zero empathy, which we can interpret as a lack of trust between the partners.

Next, we consider the E/A dyad. Substituting our parameter values, including low potential empathy, $\theta = 0.4$, into the normal form game, we obtain the following;

E\A	NS	S
NS	70, 70	0, 80−
S	80+, 0	25+, 25−

As in the E/VC dyad, each player's dominant strategy is to steal, and therefore, they both steal in equilibrium (this verifies the result inProposition 1b). The low E/A empathy level is insufficient to support trust at the stealing stage. The game remains as a prisoner's dilemma. Furthermore, the E and the A correctly anticipate this loss of empathy (lack of trust) from the start of the game. That is, actual empathy is destroyed from the start of the game; $\hat{\theta} = 0$.

Next, we consider medium and high potential E/A empathy, $\theta = 0.7$ and $\theta = 0.9$. In the case of medium empathy, we obtain the following normal form game.

E\A	NS	S
NS	85+, 85−	0, 80
S	80, 0	25+, 25−

In the case of high E/A empathy, we obtain the following;

E\A	NS	S
NS	95+, 95−	0, 80
S	80, 0	25+, 25−

In both cases, we have multiple equilibria, {S, S} and {NS, NS}. This verifies the result presented inProposition 1c). We employ a focal point argument to suggest that the E and the A coordinate on {NS, NS}, achieving payoff of 85 each in the medium empathy case, and 95 each in the high empathy case. We interpret this as trust in the stealing game being promoted by medium/high empathy. Furthermore, actual empathy equals potential empathy from the start of the game; $\hat{\theta} = \theta = 0.7$ (medium empathy) or $\hat{\theta} = \theta = 0.9$ (high empathy).

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[18] If the venture fails, it provides zero income at Date 2, and the Date 3 stealing game is irrelevant.

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