Behavioral Finance in a Principal-agent Model of Capital Budgeting

By

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Behavioral Finance in a Principal-agent Model of Capital Budgeting.

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Abstract

Recent behavioral research in corporate finance has attempted to analyse the implications of managerial irrationality in capital structure and capital budgeting decisions. In this paper, we focus on the effects of managerial irrationality in capital budgeting. We develop a principal-agent model which provides the basis for an experiment to test for three behavioral factors; a) reciprocal trust between an investor and a manager, b) framing behavior resulting in irrational commitment to a project that should be abandoned, and c) framing behavior combined with managerial overconfidence resulting in excessive effort levels. We conclude by discussing possible ways of designing an experimental game in order to test for these factors.
Behavioral Finance in a Principal-agent Model of Capital Budgeting

Introduction.

Standard research into corporate finance is based on the assumption that agents are self-interested, rational utility-maximisers. For example, the principal-agent problem that exists between investors and managers is based on selfish managerial rationality.

Recent behavioral research in corporate finance has attempted to analyse the implications of agents’ irrationality. Investor irrationality has been used to explain stock price bubbles (Blanchard and Watson 1982). Researchers have examined the role of managerial irrationality in capital structure decisions (Heaton 2002, Shefrin 1999), and capital budgeting (Statman and Caldwell 1987, Gervais et al 2003, and Shefrin 1999). By way of contrast, Stein (1996) analyses the combined effects of managerial rationality and investor irrationality on optimal capital budgeting methods.

There are, of course, many definitions of irrationality. Some authors analyse the effects of bounded rationality on decision making (Mattson and Weibull 2002). Bounded rationality is based on the idea that investors or managers are incapable or unwilling to process all of the available information, and hence only consider a subset. In prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992) and regret theory (Bell, 1982; Loomes and Sugden, 1982), agents tend to place too much weight on low probability gambles, and too little weight on high probability gambles. This induces risk averse behavior over positive income domains, but risk-seeking behavior over negative ranges. At the extreme of behavioral analysis, we may

In this paper, we examine the effect of behavioral factors, and specifically managerial irrationality, in capital budgeting. We develop a principal-agent model of capital budgeting which provides the basis for an experiment to test for three behavioral factors; a) reciprocal trust between an investor and a manager, b) framing behavior resulting in irrational commitment to a project that should be abandoned, and c) framing behavior combined with managerial overconfidence resulting in excessive effort levels.

**Reciprocal Trust Games.**

In standard principal-agent models, the principal often moves before the agent. This may lead to the following moral hazard problem. The rational self-interested agent may have an incentive to pursue a strategy that hurts the principal. Given this problem, the principal, in making the first move, may pursue a strategy that hurts the agent.

For example (and relevant to our study), a firm may require an investor (the principal) to finance a new project. However, once the funds have been provided, the manager (the agent) may have an incentive to pursue value-reducing strategies (perhaps through exerting low effort, choosing a pet negative NPV project, or simply stealing the money). A rational investor, aware of this moral hazard problem, may choose not to provide finance in the first place, and the project cannot then be taken. This may hurt both parties.
It may be the case that both parties’ wealth would be maximised if the manager could commit not to take value-reducing actions, and therefore the investor would not be afraid to provide initial finance. However, since the investor provides finance, and \textit{then} the manager chooses his actions, there is a commitment problem.

Some researchers (for example, Berg et al 1995, McCabe et al 2003) have analysed reciprocal trust as a means of eliminating this moral hazard problem, such that both parties gain. According to McCabe et al (2003), intentions become important in a reciprocal trust game. The first mover may follow his dominant strategy in order to make a sure-gain, or he may follow a different strategy in the anticipation of future benefit. If the second mover then follows his dominant strategy, the first mover loses.

This loss is player 1’s opportunity cost of not following the dominant strategy.

The idea is that, by taking this risk, the first mover signals his trust in the second mover. The second mover may then reciprocate that trust by not pursuing his dominant strategy, but by pursuing a strategy that benefits them both. The larger the opportunity cost (the larger the risk that the first mover takes by not playing his dominant strategy), the higher the signal that he trusts player 2, and the more likely player 2 is to reciprocate.

In our example of the moral hazard problem facing the investor and manager, the investor’s dominant strategy may be to not provide finance, but to keep his money (the sure-thing), since he knows that the manager intends to invest it in the value-reducing project. Both players lose. However, in the reciprocal trust game, the investor may not follow his dominant strategy, but may risk investing in the firm. This may signal his trust in the manager, who may reciprocate by not following his dominant strategy, instead investing in the value-maximising project. The reciprocal trust game then predicts that the larger the difference between the investment funds
and the loss to the investor if the manager does not reciprocate, the larger the signal that the investor trusts the manager, and the more likely the manager is to reciprocate. Hence, very large investments into the firm should be rewarded by the manager ‘doing the right thing.’

Framing behavior and Irrational non-abandonment of projects.

Statman and Caldwell (SC 1987) consider the effects of managerial irrationality in capital budgeting, and particularly in the decision to abandon projects. The authors describe cases where managers are reluctant to terminate projects, even if NPV analysis determines that the project should be abandoned. The abandonment decision should only be made based on future expected cashflows. Previous losses are ‘sunk’, and, according to standard economic theory, should be ignored.

SC distinguish between economic accounting, where the sunk costs are ignored, and mental accounting, where the sunk costs are included. The authors argue that managerial reluctance to abandon arises from a process called ‘framing’ (in which the manager forms a mental account including the sunk cost) combined with prospect theory and regret aversion.

They provide an example in which a project has currently lost $2000 (which is sunk). If the project is continued, there is an equal chance of success (which will provide an income of + $2000) or failure (which provides an income of 0). If it is abandoned, it will provide a liquidation income of $1000. Under proper economic accounting (ignoring the sunk loss), a risk-averse manager will abandon the project. Now consider the ‘framing’ process. The manager forms a mental account, including the
sunk loss. Now success provides an income of \(-2000 + 2000 = 0\). Failure provides an income of \(-2000 + 0 = -2000\). Abandonment provides an income of \(-2000 + 1000 = -1000\). Under prospect theory, the manager will prefer the gamble associated with project continuation, rather than the sure loss from abandonment.

The manager’s desire to allow the project to continue is strengthened by regret aversion, which states that agents prefer to postpone the pain of loss. Furthermore, SC argue that the incentive to continue the project is further strengthened by the manager’s commitment to the project (this is termed ‘entrapment’). Hence, a manager who has been heavily involved in the initial decision to take the project (a ‘project champion’) is more likely to become committed to and entrapped in the project. A manager who did not make the initial decision to take the project may find it easier to subsequently abandon it.

**Framing Behavior and Managerial Overconfidence.**

The manager’s commitment to continuing the project may be further affected by another behavioral factor identified by researchers; managerial optimism or managerial overconfidence. Heaton discusses the experimental and survey evidence that demonstrates a) “people are more optimistic about outcomes that they believe they can control …. Managers underplay inherent uncertainty, believing that they have large amounts of control over the firm’s performance”, and b) people are more optimistic about outcomes to which they are highly committed… managers generally appear committed to the firm’s success.”
The Modelling Approach.

We develop a model, and an experiment, that tests for three specific behavioral factors; a) reciprocal trust between an investor and a manager, b) framing behavior resulting in irrational commitment to a project that should be abandoned, and c) framing behavior combined with managerial overconfidence resulting in excessive effort levels.

We consider two variants of the model. In each variant, an investor initially decides whether to provide finance, and then the manager firstly chooses between two projects (one value-adding, and one value destroying). Since the manager gains higher private benefits from the latter project, a potential moral hazard problem exists. However, we analyse the role of reciprocal trust in providing the impetus for the investor to provide finance, and the manager to take the value-adding project. In each variant of the game, we then analyse the effect of managerial framing behavior. In the first variant, we analyse the effect on a project abandonment/continuation decision. In the second variant, we analyse the combined effect of framing and managerial overconfidence on effort levels.

An interesting implication of our model is that irrational managerial behavior can be value-adding or value-destroying. A rational, purely self-interested, manager, who owns none of the equity, may take the inferior, value-destroying project. The behavioral factor of reciprocal trust can induce the manager to take the superior, value maximising project. However, irrational behavior relating to framing, overconfidence, and loss aversion induces the manager to take value-reducing actions (that is, irrational project continuation, and irrational excessive effort).
The rest of the paper is organised as follows. In the next section, we consider the basic trust game. Then, we extend the basic trust game to analyse the effects of managerial framing behavior on the decision to abandon or continue the project. Then we extend the basic trust game to analyse the combined effects of framing and managerial overconfidence on the manager’s effort levels. In each case, we derive testable hypotheses. Finally, we suggest an experimental set-up.

**The Basic Trust Game.**

The basic trust game is depicted in figure 1, and is based upon the game analysed by McCabe et al (2003).

We consider a game in which a manager seeks finance from an investor in order to undertake one of two mutually exclusive projects. Specifically, the timing of events is as follows.

Date 0: Two mutually exclusive projects become available to the firm. Either project requires investment of $I$. The firm has no internal finance, and therefore the manager approaches the investor for the required funds.

At this stage, the investor makes one of two possible choices. He decides whether to provide the funds (‘invest’) or not provide the funds, and therefore keep the money (‘don’t invest’). If he does not invest, the game ends, with the payoffs of 0 and $I$ for the manager and the investor respectively.

If the investor invests at date 0, the game proceeds to date 1.
Date 1: If the investor provides the required finance $I$, the manager then chooses between the two possible projects. We assume that the manager has no equity in the firm, but receives private benefits. The investor has all of the equity. If the manager chooses Project 1, this provides him with the private benefit $B_1$. The investor receives income of $X_1$. If the manager chooses project 2, this provides him with private benefits $B_2 < B_1$. The investor receives income of $X_2$, where $X_2 > I > X_1$. The game ends.

We solve by backward induction. Consider the case where the investor has provided date 0 finance (ie ‘invest’). Since $B_2 < B_1$, the sub-game perfect equilibrium (SPE) at date 1 is for the manager to choose project 1. This provides payoffs of $(B_1, X_1)$. Therefore, at date 0, the investor does not invest, since $I > X_1$.

Furthermore, we assume that $B_2 + X_2 > B_1 + X_1 > I$. That is, it is Pareto optimal for the investor to provide date 0 finance, and for the manager to choose project 2.

Hence, there is a moral hazard problem. However, this problem may be resolved if we consider the trust game. In the trust game, the investor may provide finance in order to signal a trust in the manager, which he hopes will be reciprocated by the manager taking project 2. This trust, and the reciprocation, is a function of the investor’s opportunity cost of investing, if the manager takes project 1. This opportunity cost equals $I - X_1$. This represents the risk that the investor takes from investing in the firm. The investor could have just kept the money $I$. By investing in the firm, he risks the manager taking project 1, which will give the investor $X_1 < I$. The larger the gap between $X_1$ and $I$, the greater the risk the investor takes, and therefore the more trust
he places in the manager. Therefore, trust games predict that the larger is the
opportunity cost \( I - X_i \), the more reciprocation there will be from the manager. That
is the larger is \( I - X_1 \), the greater the proportion \( 1 - P_i \) of managers investing in
project 2.

From this analysis, we derive two hypotheses.

**Hypothesis 1:** No investor will ever provide finance.

**Hypothesis 2:** The proportion \( 1 - P_i \) of managers investing in project 2 is positively
related to the investor’s opportunity cost \( I - X_i \).

Hypothesis 1 is a test of the moral hazard problem. If we reject hypothesis 1, then this
will provide supporting evidence of reciprocal trust.

If we fail to reject hypothesis 2, this will also provide supporting evidence of
reciprocal trust.

**Extending the Trust Game: adding a continuation/abandonment decision.**

This version of the game is depicted in figure 2.

We extend the basic trust game as follows. The sequence of events for date 0 and 1 is
the same as the basic case, except as follows. Project 2 is now a two period project. In
date 1, project 2 now has two possible outcomes. With probability 0.5, the project can
provide an income of \( X_2 \) or \( -X_2 \). Whichever state is realised, the manager receives
private benefits of $B_2$. Furthermore, whichever state is realised, the manager makes the decision to abandon or continue the project into date 2. If he abandons the project, liquidation of the assets realises income of $0.5X_2$. If he allows the project to continue into date 2, then there is a probability of 0.5 that the project will succeed or fail in date 2. If the project succeeds, it will achieve income in date 2 of $X_2$. If it fails in date 2, it will achieve zero income in date 2.

Note that the date 0 expected value of project 2, whether the manager is expected to continue it or abandon it, is $V_2 = 0.5X_2$. We assume that $0.5X_2 > I > X_1$, and $B_2 + 0.5X_2 > B_1 + X_1 > I$. Hence, the investor will only provide finance if he expects the manager to take project 2. Furthermore, it is Pareto optimal for the investor to provide finance, and the manager to take project 2.

This game is represented in figure 2. Consider the payoffs. Firstly, consider the case where the manager takes project 2, and it succeeds in date 1 (ie provides date 1 income of $X_2$). If the manager then allows it to continue, and it fails in date 2, the cumulative payoff is $(B_2, X_2)$. If the manager allows it to continue, and it succeeds in date 2, the cumulative payoff is $(B_2, 2X_2)$. If the manager abandons the project at the end of date 1, the cumulative payoff is $(B_2, 1.5X_2)$.

Next, consider the case where the manager takes project 2, and it fails in date 1 (ie provides date 1 income of $-X_2$). If the manager then allows it to continue, and it fails in date 2, the cumulative payoff is $(B_2, -X_2)$. If the manager allows it to continue, and it succeeds in date 2, the cumulative payoff is $(B_2, 0)$. If the manager abandons the project at the end of date 1, the cumulative payoff is $(B_2, -0.5X_2)$.
In this model, we are testing for both reciprocal trust at date 0/ date 1, and framing behavior in the manager’s continuation/ abandonment decision at date 2. Note that, since the opportunity cost of investing is unaffected by our modifications to project 2, the reciprocal trust hypothesis remains as in hypothesis 1. The investor provides finance in the hope that the manager will reciprocate by choosing project 2.

The manager’s abandonment/continuation decision should be unaffected by the date 1 realisation, since that is sunk at the time of the decision. Let the manager use economic accounting. Recall that abandonment provides sure income from asset liquidation of $0.5X_2$. Continuation provides an equal probability of achieving date 2 income of $X_2$ or zero. It is obvious that the correct decision under risk aversion is to liquidate the project.

If $X_2$ is achieved at date 1, then even if the manager uses framing behavior (ie he uses mental accounting), he should abandon the project at date 1. We can observe this by adding $X_2$ to the date 2 payoffs. The date 1 payoff plus abandonment provides sure income from asset liquidation of $X_2 + 0.5X_2 = 1.5X_2$. Continuation provides an equal probability of achieving date 1 plus date 2 income of $X_2 + X_2 = 2X_2$ or $X_2 + 0 = X_2$. So, even under framing behavior, if $X_2$ is achieved at date 1, a risk averse manager should abandon the project.

If $-X_2$ is achieved at date 1, then, under framing behavior, the date 1 plus date 2 payoffs are as follows. The date 1 payoff plus abandonment provides sure income from asset liquidation of $-X_2 + 0.5X_2 = -0.5X_2$. Continuation provides an equal probability of achieving date 1 plus date 2 income of $-X_2 + X_2 = 0$ or
\[-X_2 + 0 = -X_2.\] Since this is in the negative domain, framing behavior now leads to risk-loving behavior, and the manager will continue the project.

**Hypothesis 3:**

a) If \( X_2 \) is achieved at date 1, no manager will continue the project (whether he uses framing behavior or not).

b) If \( -X_2 \) is achieved at date 1, all managers abandon the project (evidence of non-framing behavior).

c) If \( -X_2 \) is achieved at date 1, all managers allow the project to continue (evidence of framing behavior).

**Extending the Trust Game: adding managerial effort to test for overconfidence.**

This version of the game is depicted in figure 3.

In this version of the game, the sequence of events for date 0 and date 1 are as in trust game 1. However, at the end of date 1, the manager does not make an abandonment/continuation decision. He must allow the project to continue. However, now there are two possible project 2 realisations at date 2. In the good state, project 2 achieves income of \( 2X_2 \). In the bad state, the project achieves zero income. The probability of the date 2 good state is \( q = 0.5 + ye \), where \( e \) is the manager’s effort level in date 2, and \( y \) represents the manager’s ability to affect the date 2 good state.
The manager has a cost of effort \( C(e) = \beta e^2 \). At date 0, the expected value of project 2 is \( V_2 = 2qX_2 = X_2 + 2\gamma eX_2 \). The game is depicted in figure 3.

Since the investor’s opportunity cost of investing remains the same as in the previous cases, hypothesis 1 remains.

We are wishing to test for the effects of the date 1 realisation on the date 2 effort level. In the non-framing case, the manager chooses his date 2 effort to maximise date 2 expected value, \( V_2 \), net of his effort costs: that is, he maximises:

\[
V_2 - c(e) = X_2 + 2\gamma eX_2 - \beta e^2. \tag{1}
\]

His optimal effort level is therefore \( e^* = \frac{\gamma X_2}{\beta} \). Note that this is increasing in his measure of confidence \( \gamma \).

Next, consider the framing case. We assume that if \( X_2 \) is realised at date 1 (the project is a success), the manager ignores this date 1 realisation, even in the framing case. Hence, the manager still maximises (1), and the optimal effort level is still \( e^* = \frac{\gamma X_2}{\beta} \).

If \( -X_2 \) is realised at date 1 (the project is a failure), we assume that in the framing case, the manager includes this in his date 2 effort decision, as follows. He believes that if he can achieve a good date 2 realisation, this will eliminate the pain, or regret,
of the date 1 loss. If he achieves a bad date 2 realisation, the pain of the date 1 loss remains. Therefore, he mistakenly considers date 2 value to be

\[ V_2 = 2qX_2 + (1-q)(-X_2). \]

Substituting for \( q = 0.5 + \gamma e \), we obtain

\[ V_2 = 3\gamma e X_2 - 0.5X_2. \]

Hence, given the date 1 bad realisation, the framing manager maximises

\[ V_2 - c(e) = 3\gamma e X_2 - 0.5X_2 - \beta e^2. \]

Therefore, his optimal effort level is \( e^{**} = 1.5 \frac{\gamma X_2}{\beta} = 1.5e^* \).

It will be useful to consider the difference in optimal effort levels in the framing and non-framing cases;

\[ e^{**} - e^* = 0.5 \frac{\gamma X_2}{\beta}. \]

We note the following. At the lowest level of managerial confidence \( \gamma = 0 \), the manager exerts zero effort level in the framing and non-framing cases \( e^{**} = e^* = 0 \). As the manager increases in confidence, he exerts higher effort level in both the
framing and non-framing cases \( (\partial e^*/\partial \gamma > 0, \partial e^{**}/\partial \gamma > 0) \), and the difference between the optimal effort level in the framing and non-framing cases increases \( (\partial(e^{**} - e^*)/\partial \gamma) > 0) \).

This provides the following hypothesis.

**Hypothesis 4:**

a) Following a good date 1 realisation, effort level is positively correlated with the manager's measure of confidence. Effort level is not correlated with the date 1 realisation.

b) Following a bad date 1 realisation, effort level is positively correlated with the manager’s measure of confidence. Effort level is positively correlated with the date 1 loss (evidence of framing). The difference between effort levels in the framing and non-framing cases is positively correlated with the manager's measure of confidence. The difference between effort levels in the framing and non-framing cases is positively correlated with the date 1 loss.

**Brief Discussion of an Experimental Set-up.**

We now outline a possible experimental set-up to test the hypotheses arising from our models.
a) **Basic Trust Game.**

As a control, we can firstly set up the basic trust game, without the extensions relating to abandonment and overconfidence. This experiment will be similar to that described in McCabe et al (2003). The experiment will pair investors with managers. Each investor will decide whether to provide finance to the manager. Then the manager will decide whether to invest in project 1 or project 2. The values of the parameters \( I, X_1, X_2, B_1, B_2 \), will be set to satisfy our assumptions.

Therefore, the experiment will provide a test of hypothesis 1 and hypothesis 2.

b) **The Trust Game plus a continuation/abandonment decision.**

Once the basic trust game is set up, extension to include the abandonment/continuation decision is straightforward. At date 2, a coin is tossed to determine the realised date 2 value. Then the manager makes his abandonment/continuation decision.

This will allow us to test hypothesis 3.

c) **The Trust Game plus managerial overconfidence.**

Since we now wish to test the effect of managerial overconfidence and date 1 realisation on the effort level, this game will be more difficult to set up. We require a game design such that the manager indicates an effort level, and a measure of overconfidence. Then, by allowing the date 1 loss to vary, we can test hypothesis 4.
Conclusion.

We have developed a model that analyses a) reciprocal trust between managers and investors, b) the effect of managerial framing behavior on the project abandonment/continuation decision, and c) the combined effects of managerial framing behavior and overconfidence on managerial effort levels.

From this analysis, we have developed a number of testable hypotheses, and we have suggested possible experimental set-ups to test these hypotheses. Appropriately designed, these experiments will test for the extent of irrational behavior. Hence, important future research will develop the experiment further, and then actually use it to derive results.

Figure 1: Basic Trust Game.
Figure 2: Trust Game Plus Continuation/abandonment Decision.

Figure 3: Trust Game Plus Managerial Overconfidence.
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