Online Appendix
to
Managerial Beliefs and Corporate Financial Policies

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January 7, 2010

In this Online Appendix, we provide a simple theoretical framework to examine the capital structure predictions of one specific variation in managerial beliefs: CEO (over-)confidence. The model formalizes the hypothesis development of the main paper and helps to clarify the more subtle predictions such as the conditions under which the preference of overconfident CEOs for debt over equity are reversed.

We define overconfidence as the overestimation of mean future cash flows. The emphasis on the mean distinguishes our approach from previous theoretical literature on overconfidence. Hackbarth (forthcoming) models the underestimation of variance to generate different capital-structure implications. Heaton (2002) models an upward shift in the probability of the good (high cash flow) state, which does not disentangle which theoretcial results are generated by the implied bias in means and which by the implied bias in variance. Relatedly, one theoretical contribution of our paper lies in showing that the overestimation of cash flows in non-default states (i.e. overvaluation of the residual claim) generates a preference between risky debt and equity. The modeling approach of Heaton (shift in probabilities) does not allow for this mechanism.

We abstract from market frictions like agency costs and asymmetric information. However, such factors do not change our predictions as long as they affect managers uniformly and are not sufficient to create boundary solutions (e.g. full debt financing for a rational CEO).

We consider a manager's decision to undertake and finance a single, non-scalable investment project with cost I and stochastic return $\tilde{R}$, given by R_G with probability $p \in (0;1)$ and R_B with probability $1-p$, where $R_G > I > R_B$. The investment cost and the return distribution are common knowledge. To fix the rational capital-structure choice, we allow for two frictions, taxes and bankruptcy costs. The firm pays a marginal rate τ on the net return $\tilde{R} - I$ if $\tilde{R} > I$ and incurs a deadweight loss L in the case of bankruptcy. We assume perfectly competitive debt and equity markets and normalize the risk-free interest rate to zero. The firm has existing assets A and internal funds C. The CEO maximizes the perceived value of the company to existing shareholders. Note that a shareholder-value maximizing CEO never buys back shares since it is a zero-sum game from the perspective of shareholders: Some current shareholders are helped at the expense of other current shareholders. We allow for the possibility that the CEO overestimates (after-tax) project returns $\tilde{R} - \tau 1_{\{R>I\}}(\tilde{R} - I)$: $\hat{E}[\cdot] > E[\cdot]$. He may also overestimate the value of assets in place A, $\widehat{A} > A$.

We proceed in two steps. We first consider the unconditional choice between internal and external financing. We then condition on accessing external financing and analyze the choice between risky debt and equity.

Starting from the unconditional choice between internal and external financing, we first compare using cash and riskless debt, denoted by $c \leq C$, to using equity. (Later, we consider the possibility that the CEO exhausts cash and riskless debt capacity, creating a choice between risky debt and equity.) We assume that the firm has $s > 0$ shares outstanding and denote by $s' \geq 0$ the number of new shares issued as part of the financing plan. We also assume that the bias in the CEO's expectation of project returns and in his valuation of existing assets does not depend on c.[1]

Proposition 1 *Overconfident CEOs strictly prefer internal finance to equity and use weakly more internal financing than rational CEOs.*

Proof. The participation constraint of new shareholders to provide equity financing is

$$\frac{s'}{s+s'}\Big(E[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]+A+C-c\Big)=I-c$$

Thus, the manager's perception of the value of current shareholders' claims after equity financing is

$$\begin{aligned} G &= \left(1-\frac{s'}{s+s'}\right)\Big(\widehat{E}[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]+\widehat{A}+C-c\Big) \\ &= \frac{\widehat{E}[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]+\widehat{A}+C-c}{E[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]+A+C-c}\Big(E[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]+A+C-I\Big) \end{aligned}$$

Then

$$\frac{\partial G}{\partial c} = \frac{\Big(\widehat{E}[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]-E[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]\Big)+\Big(\widehat{A}-A\Big)}{\Big(E[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]+A+C-c\Big)^2}\cdot \Big(E[\tilde{R}-\tau\mathbf{1}_{\{R>I\}}(\tilde{R}-I)]+A+C-I\Big)$$

Notice that the numerator of the fraction is zero if the CEO is rational, $\hat{E}[\cdot]=E[\cdot]$ and $\widehat{A}=A$, and that it is positive for overconfident CEOs by the definition of overconfidence.

[1] Formally, we assume $\frac{\partial}{\partial c}\hat{E}[\tilde{R}-\tau 1_{\{R>I\}}(\tilde{R}-I)]=0$ and $\frac{\partial}{\partial c}\widehat{A}=0$.

Hence, $\frac{\partial G}{\partial c} = 0$ for unbiased CEOs, and $\frac{\partial G}{\partial c} > 0$ for overconfident CEOs if and only if $E[\tilde{R} - \tau 1_{\{R>I\}}(\tilde{R} - I)] + A + C - I > 0$. That is, as long as firm value is positive, an overconfident CEO maximizes the perceived value on $c \in [0, I]$ by setting the internal financing c as high as possible. A rational CEO, instead, is indifferent among all financing plans and, hence, uses weakly less internal funding than overconfident CEOs. Q.E.D.

The intuition for Proposition 1 is that overconfident CEOs perceive the price investors are willing to pay for new issues s' to be too low since they believe markets underestimate future returns. This logic immediately extends to the CEO's preference between internal finance (if available) and risky debt if the CEO overestimates cash flows in the default state (R_B): Since he overestimates cash flows going to creditors, he perceives interest payments on debt to be too high. Thus, overconfident CEOs have a strict preference for internal financing over any form of external finance and exhaust cash reserves and riskless debt capacity before issuing risky securities.

Next, we analyze the choice between the two types of risky external financing, risky debt and equity, conditional on accessing external capital markets. From Proposition 1, overconfident CEOs will exhaust all cash and riskless debt capacity before raising risky capital. Thus, for simplicity, we set cash and existing assets (which can be collateralized) equal to 0, $\widehat{A} = A = C = 0$. Conditional on implementing the project, the resulting maximization problem is:

$$\max_{\text{d,s}} \quad \frac{s}{s+s'}\hat{E}[(\tilde{R} - \tau \mathbf{1}_{\{R>I\}}(\tilde{R} - I - [w-d]) - w)^+] \tag{1}$$

$$\text{s.t.} \quad \frac{s'}{s+s'}E[(\tilde{R} - \tau \mathbf{1}_{\{R>I\}}(\tilde{R} - I - [w-d]) - w)^+] = I - d \tag{2}$$

$$E[\min\{w, \tilde{R} - L\}] = d \tag{3}$$

$$R_B \leq d \leq I \tag{4}$$

where w is the face value of debt, d the market value of debt, and L the deadweight loss from bankruptcy. Interest payments $w - d$ are tax deductible. The CEO maximizes the perceived expected returns accruing to current shareholders after subtracting taxes and repaying debt. Constraints (2) and (3) are the participation constraints for new shareholders and lenders, respectively. Note that the compensation required for equity and debt financing depends on investors' unbiased beliefs rather than managerial perception. Condition (4) reflects that we are considering the case of risky debt, i. e., the choice between debt and equity after exhausting all riskless debt capacity created by the project.

The following Proposition characterizes the financing choice of rational CEOs ($\hat{E}[\cdot] = E[\cdot]$):

Proposition 2 *Rational CEOs finance the risky portion of investment, $I - R_B$, using only risky debt if the tax benefits are high relative to bankruptcy costs, $\frac{\tau(I-R_B)}{1-\tau} > L$. They use only equity if the tax benefits are low relative to bankruptcy costs, $\frac{\tau(I-R_B)}{1-\tau} < L$. They are indifferent if $\frac{\tau(I-R_B)}{1-\tau} = L$.*

Proof. For notational simplicity, define $Q \equiv E[(\tilde{R} - \tau 1_{\{R>I\}}(\tilde{R} - I - [w - d]) - w)^+]$. Using the participation constraint for shareholders (2) and the fact that $E[\cdot] = \hat{E}[\cdot]$ for rational CEOs, we can re-write the maximand as $Q - (I - d)$. We consider separately the case in which the CEO uses at least some risky debt ($w > d > R_B$) and the case in which the CEO uses no risky debt, $w = d = R_B$. The latter case is the lower boundary of (4).

In the first case, i.e. if $w > R_B$, the firm defaults in the bad state and, hence Q becomes

$$\begin{aligned} Q &= (1-\tau)pR_G + p\tau I - (1-\tau)pw - p\tau d & (5) \\ \iff Q - (I-d) &= (1-\tau)pR_G - (1-p\tau)I - (1-\tau)pw + (1-p\tau)d. \end{aligned}$$

Using (3) to substitute for w, the maximand $Q - (I - d)$ becomes:

$$Q - (I-d) = (1-\tau)pR_G - (1-p\tau)I + (1-\tau)(1-p)(R_B - L) + \tau(1-p)d. \quad (6)$$

Since d enters positively, value is maximized by setting d as high as possible. Thus, given boundary (4), the optimal level of debt is $d^* = I$. Substituting back into the maximand yields

$$Q - (I - d^*) = (1-\tau)[pR_G + (1-p)(R_B - L) - I].$$

In the second case, $w = R_B$, the firm uses only riskless debt and equity. Thus, there is no default, and we have:

$$\begin{aligned} Q &= (1-\tau)pR_G + p\tau I + (1-p)R_B - d & (7) \\ \iff Q - (I-d) &= (1-\tau)pR_G - (1-p\tau)I + (1-p)R_B & (8) \end{aligned}$$

Comparing the value function at the two boundaries, we find that the manager will choose full debt financing if:

$$(1-\tau)[pR_G + (1-p)(R_B - L) - I] > (1-\tau)pR_G - (1-p\tau)I + (1-p)R_B, \qquad (9)$$

which simplifies to $\frac{\tau(I-R_B)}{1-\tau} > L$. For the reverse inequality, the manager will choose full equity financing, and he is indifferent in the case of equality. **Q.E.D.**

If a CEO chooses to raise debt, it is optimal to set the debt level as high as possible since tax benefits are increasing in the amount of debt while bankruptcy costs are fixed. If the CEO chooses full equity financing, he avoids bankruptcy costs, but gives up the tax benefits of debt. The optimum, then, is either full debt or full equity financing, depending on whether the expected tax benefits, $\tau p(w-d)$, outweigh expected bankruptcy costs, $(1-p)L$. Note that, in the simple two-state setup, the optimal capital structure never includes both risky debt and equity. However, interior leverage choices become optimal if we add an intermediate state in which the firm may or may not default depending on the level of debt chosen.

Now consider a CEO who overestimates the returns to investment, $\hat{E}[\cdot] > E[\cdot]$. Specifically, assume that the CEO overestimates returns by a fixed amount Δ in the good state, $\hat{R}_G = R_G + \Delta$, but correctly perceives returns in the bad state, $\hat{R}_B = R_B$. This assumption allows us to isolate the mechanism which generates a preference for risky debt: over-valuation of the residual claim on cash flows in the good state.

Proposition 3 *For the risky portion of investment, overconfident CEOs choose full debt financing (rather than equity financing) more often than rational CEOs.*

Proof. Let $Q \equiv E[(\tilde{R} - \tau \mathbf{1}_{\{R>I\}}(\tilde{R} - I - [w-d]) - w)^+]$. Denote as $\widehat{Q}$ an overconfident manager's perception of Q. Then, $\widehat{Q} = Q + p(1-\tau)\Delta$. Using (2), we can write the objective function of the overconfident CEO's maximization problem as $[Q - (I-d)]\frac{\widehat{Q}}{Q}$.

Consider first the case that the CEO uses at least some risky debt ($w > d > R_B$). Then, using equations (5) and (6) and constraint (3), the maximand becomes

$$
\begin{aligned}
[Q-(I-d)]\frac{\widehat{Q}}{Q} &= [Q-(I-d)]\left[1+\frac{p(1-\tau)\Delta}{Q}\right] \\
&= [(1-\tau)pR_G-(1-p\tau)I+(1-\tau)(1-p)(R_B-L)+\tau(1-p)d]\cdot \\
&\quad \left[1+\frac{p(1-\tau)\Delta}{(1-\tau)pR_G+p\tau I-(1-\tau)[d-(1-p)(R_B-L)]-p\tau d}\right]
\end{aligned}
$$

Differentiating with respect to d yields

$$
\frac{\partial}{\partial d}\left[\frac{Q-(I-d)}{Q}\widehat{Q}\right]=\tau(1-p)+\frac{\tau(1-p)p(1-\tau)\Delta}{Q}+\frac{p(1-\tau)\Delta\,[(1-\tau)+p\tau]}{Q^2}\,[Q-(I-d)]\,.
$$

The derivative is strictly positive if $Q>0$ and hence $s/(s+s')Q=Q-(I-d)>0$. We know that $Q\geq 0$ since it is defined as the expectation over values truncated at 0 ($Q\equiv E[(\tilde{R}-\tau 1_{\{R>I\}}(\tilde{R}-I-[w-d])-w)^+]$). Since $Q=p[(1-\tau)(R_G-w)+\tau(I-d)]$ in the case of risky debt by (5), and $R_G-w\geq 0$ (since $w>R_G$ would yield lower payoffs to bondholders and stockholders than $w=R_G$ due to default costs in both states), and since $I-d\geq 0$ by (4), $Q=0$ if and only if $R_G-w=0$ and $I-d=0$. Thus, we have either $Q>0$, in which case the derivative is strictly positive and the manager sets d as high as possible, $d^*=I$, or we have $Q=0$, which occurs also for $d=I$. In both cases, the maximand becomes:

$$
[Q-(I-d)]\frac{\widehat{Q}}{Q}=\widehat{Q}=(1-\tau)[pR_G+(1-p)(R_B-L)-I]+p(1-\tau)\Delta
$$

Now consider the case that $w=d=R_B$. Then, the firm finances I using only riskless debt and equity. There is no default and using (7) and (8) the maximand becomes

$$
\begin{aligned}
[Q-(I-d)]\frac{\widehat{Q}}{Q} &= [Q-(I-d)]\left[1+\frac{p(1-\tau)\Delta}{Q}\right] \\
&= [(1-\tau)pR_G-(1-p\tau)I+(1-p)R_B]\cdot \\
&\quad \left[1+\frac{p(1-\tau)\Delta}{(1-\tau)pR_G+(1-p)R_B-R_B+p\tau I}\right]
\end{aligned}
$$

Comparing the values of the objective function using the optimal amount of risky debt and all equity, we find that the manager chooses risky debt financing if and only if

$$\begin{aligned} & (1-\tau)[pR_G + (1-p)(R_B - L) - I] + p(1-\tau)\Delta \\ > & \left[1 + \frac{p(1-\tau)\Delta}{(1-\tau)pR_G + (1-p)R_B - R_B + p\tau I}\right][(1-\tau)pR_G - (1-p\tau)I + (1-p)R_B] \end{aligned}$$

Or,

$$\tau(1-p)(I-R_B) + \left\{p(1-\tau)\Delta\left[1 - \frac{(1-\tau)pR_G + (1-p)R_B - I + p\tau I}{(1-\tau)pR_G + (1-p)R_B - R_B + p\tau I}\right]\right\} > (1-\tau)(1-p)L$$

Comparing this condition to condition (9) in Proposition 1, we see that the overconfident CEO will be more likely to use debt if and only if the term in { } is positive. Since $I > R_B$ by assumption, the term in [ ] is positive, yielding the result. **Q.E.D.**

An overconfident CEO is more likely to choose full debt financing than a rational CEO for two reasons. First, the CEO overestimates the tax benefits of debt since he overestimates future returns (i.e., overestimates cash flow R_G by Δ). Second, he perceives equity financing to be more costly since new shareholders obtain a partial claim on Δ without paying for it. In our simple set-up, the CEO agrees with the market about the fair interest rate on risky debt since there is no disagreement about the probability of default or the cash flow in default states.

In our simple setting, overconfidence does not affect the decision to implement a project, conditional on external financing. Since capital markets do not finance negative net present value projects, overconfident CEOs destroy value 'only' by using risky debt in some cases in which equity would be cheaper. If we re-introduce A or C, overconfident CEOs may over-invest since they overvalue returns from investment and can finance negative net present value projects by diluting A or spending out of C. Likewise, if we allow for CEOs to perceive $\widehat{A} > A$, overconfident CEOs might under-invest due to concern over diluting claims on existing assets.[2]

Since we used $\hat{R}_B > R_B$ to argue that overconfident CEOs prefer internal finance to risky debt, we briefly consider the choice between risky debt and equity for a CEO who overestimates not only R_G but also R_B, e.g. $\hat{R}_B = R_B + \Delta$. If $\hat{R}_B \geq w \geq R_B$, overconfident CEOs mistakenly believe that they will not default in the bad state. If the probability of default is large and

[2]Propositions 1 and 2 of Malmendier and Tate (2004) derive these results formally in a parallel setup for external investment projects (mergers).

Δ is small, the CEO may misperceive debt financing to be more costly than equity financing, reversing the preference for risky debt over equity. Hence, Proposition 3 may fail in some cases. Intuitively, creditors seize all of Δ in the event of default on risky debt, but equity holders receive only a fraction of Δ in the bad state.

Overall, our analysis demonstrates that overconfidence can generate a preference for risky debt over equity, conditional on accessing external capital markets. This preference arises because overconfident CEOs prefer being the residual claimant on the full cash flow in non-default states to giving up a fraction of cash flows in all states. In addition, overconfident CEOs may exhibit debt conservatism. They raise little external financing of any kind, in particular less risky debt than rational CEOs. In other words, the absolute amount of debt used by overconfident CEOs can be smaller even if leverage is higher (due to less frequent equity issuance), as illustrated in Figure 1.

References

[1] Malmendier, Ulrike, and Tate, Geoffrey A., 2004, Who Makes Acquisitions? CEO Overconfidence and the Market's Reaction, NBER Working Paper 10813.