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Positive hurdle rates without asymmetric information

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Abstract

We present a simple model where a firm will commit to a strictly positive hurdle rate on investment proposals by managers even though the two parties are symmetrically informed about the investments' profitability. Facing a positive hurdle rate, a manager who derives partial benefits from the investment profits will have more incentive to collect information about the projects. The optimal hurdle rate trades off the benefit of more information with the cost of foregoing ex post positive Net Present Value (NPV) projects.

Keywords: Hurdle rates; Asymmetric information; Capital budgeting

1. Introduction

A stylized fact about corporate capital budgeting is that firms do not fund all positive-Net Present Value (NPV) projects even in the absence of capital constraints. Empirical evidence shows that firms often require higher rates of return on investment projects than their cost of capital (Poterba and Summers, 1992). Theories explaining hurdle rates usually attribute the under-investment to information asymmetry between a firm and its managers before investments take place (see, e.g., Antle and Eppen, 1985; Harris and Raviv, 1996, 1998, and Bernardo et al., 2001). In these papers, privately informed managers obtain information rent due to their information advantage on the profitability of investment

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projects. Therefore, the firm under-invests (in the form of imposing a higher-than-efficient hurdle rate) in order to reduce the managers' information rent.[1]

In this paper, we offer another potential explanation for hurdle rates that does *not* rely on information asymmetry between the firm and its manager. In our model, the manager does not possess private information on the profitability of investment projects but he can exert a non-contractible effort to produce (publicly observable) information about the project quality based on which the firm makes its investment decision. In this setting, we identify conditions under which a positive hurdle rate arises as an optimal solution, not to reduce the manager's information rent, but to motivate the manager's information collection effort. Our explanation adds to the existing explanation based on information asymmetry and helps understand better the prevalence of hurdle rates in corporate capital budgeting processes.

2. Model

A firm that acts on behalf of risk-neutral investors has one unit of cash for investment and faces two options: no investment (or equivalently, a safe project whose net rate of return is the firm's cost of capital, which is normalized to zero), or a risky project whose net rate of return, v, follows a normal distribution $N(0, \sigma_v^2)$.[2] Risk neutrality implies that the optimal investment rule is to invest in the risky project whenever its expected net rate of return is positive given available information. Ex ante the firm is indifferent between investing or not, and for simplicity we assume that the firm chooses not to invest.

The firm hires a manager to evaluate the profitability of the risky project. The manager, by exerting an information collection effort, e, can generate a publicly verifiable signal s, given as

$$s = v + \eta, \tag{1}$$

with $\mathrm{Cov}(v, \eta) = 0$, and $\eta \sim N(0, ((1-e)/e)\sigma_v^2)$, where $e \in [0, 1]$ is the manager's information collection effort. The manager's monetary cost of e, $c(e)$, is increasing and convex in e and satisfies $c(0) = c'(0) = 0$ and $c'(1) = \infty$.

In the first best situation when e is contractible, the optimal investment rule for the firm is to take the risky project whenever the conditional expected project return is positive, or equivalently, whenever the signal s is positive, that is,

$$\hat{v} \equiv E(v|s) = es > 0. \tag{2}$$

Thus, the firm's optimal e solves the following problem:

$$\max_e \int_0^\infty E[v|s] f(s|e)\,\mathrm{d}s - c(e),$$

[1] This is the classic result from the procurement literature (see, for example, Laffont and Tirole, 1986).

[2] Normalizing the unconditional expected return of the risky project to zero amounts to assuming competitive market so that the expected return of a randomly selected project is no more than the cost of capital.

where $f(s|e)$ is the probability density function of signal s conditional on effort e. Let $\phi(.)$ and $\Phi(.)$ be the probability density and cumulative probability functions of the standard normal distribution. (We maintain this notation throughout the paper.) The firm's problem can be simplified as

$$\max_e e\int_0^\infty sf(s|e)\,\mathrm{d}s - c(e) = \big[1-\Phi(0)\big]e\sigma_s\frac{\phi(0)}{1-\Phi(0)} - c(e) = \phi(0)\sigma_v\sqrt{e} - c(e).$$

The optimal e^{FB} satisfies

$$\frac{1}{2}\phi(0)\sigma_v = \frac{c'(e^{FB})}{\sqrt{e^{FB}}}.$$

The second-order condition is satisfied. The firm also pays the manager a fixed salary of at least $c(e^{FB})$ to make him willing to participate.

2.1. Optimal hurdle rate when effort non-contractible

In this section we show that a positive hurdle rate can arise as the optimal investment rule when e is not contractible. For simplicity, we assume that the manager's information collection effort e is observable but not contractible.[3] This assumption also maintains the information symmetry in our model so that the main result of our model is not driven by extracting the information rent from the agent. We assume that the incentive for the manager is some fixed share ($\lambda \in (0,1)$) of the firm's profit.[4] Further, the manager also

[3] This assumption can be motivated based on the following scenario, similar to the one in Hirshleifer et al. (2001). Suppose more managerial effort can help produce higher number of publicly observable signals ($n \in [0,\infty)$) with each signal s_i generated according to

$$s_i = v + \eta_i$$

with $\eta_i \sim N(0, 1/h_\eta)$, and $\mathrm{Cov}(\eta_i,\eta_j) = 0$ for $\forall i \neq j$. However, there is a non-zero probability that a signal may not arrive even though the manager spent the effort to produce it. For any given number of reports, the conditional mean of v is given as

$$E(v|s_1,\ldots,s_n) = E\left(v\Big|\bar{s} = \frac{1}{n}\sum_{i=1}^{i=n} s_i\right) = \frac{nh_\eta}{h_v + nh_\eta}\bar{s} = e\bar{s},$$

where

$$e = \frac{nh_\eta}{h_v + nh_\eta} \quad \text{or} \quad n = \frac{e}{1-e}\frac{h_v}{h_\eta}.$$

Assuming e to be observable but not contractible is equivalently to assuming that the firm cannot contract contingent on how many reports the manager should produce. This is because the manager can always claim that no information has arrived, or distort the quantity of signals.

[4] We do not model explicitly the optimal sharing rule. As long as the manager is not the only beneficiary of the firm's profits, our result goes through, that is, for any incentives that may make the manager partially responsible for the success of the project, a positive hurdle rate will provide him *additional* incentives to exert the information collection effort.

derives a small (relative to the scale of the project), private, and non-pecuniary utility ($k > 0$) from managing investment projects (e.g., the manager enjoys the power). Let $b \geqslant 0$ be the firm's committed hurdle rate for adopting projects. Then for a given b, the manager maximizes the following utility function:

$$\max_e k \Pr(\hat{v} > b) + \lambda \Pr(\hat{v} > b) E(v|\hat{v} > b) - c(e)$$
$$= k \int_b^\infty f(\hat{v}|e)\,\mathrm{d}\hat{v} + \lambda \int_b^\infty \hat{v} f(\hat{v}|e)\,\mathrm{d}\hat{v} - c(e), \tag{3}$$

where $\hat{v}$ is given in (2) and $f(\hat{v}|e)$ is the density function of the project return conditional on effort e.

Given (1) and (2), $\hat{v}$ follows the normal distribution $N(0, e\sigma_v^2)$. Applying the property of truncated normal distributions, we can simplify (3) to

$$k\left[1 - \Phi\left(\frac{b}{\sqrt{e}\,\sigma_v}\right)\right] + \lambda\sqrt{e}\,\sigma_v\phi\left(\frac{b}{\sqrt{e}\,\sigma_v}\right) - c(e). \tag{4}$$

The firm, in turn, chooses the hurdle rate b to solve

$$\max_{e,b} (1-\lambda)\int_b^\infty \hat{v} f(\hat{v}|e)\,\mathrm{d}\hat{v} - w = (1-\lambda)\sqrt{e}\,\sigma_v\phi\left(\frac{b}{\sqrt{e}\,\sigma_v}\right) - w \tag{5}$$

$$\text{s.t.} \quad e \in \arg\max_{e'} k\left[1 - \Phi\left(\frac{b}{\sqrt{e'}\sigma_v}\right)\right] + \lambda\sqrt{e'}\,\sigma_v\phi\left(\frac{b}{\sqrt{e'}\sigma_v}\right) - c(e') \tag{IC}$$

$$w + \lambda\sqrt{e}\,\sigma_v\phi\left(\frac{b}{\sqrt{e}\,\sigma_v}\right) - c(e) \geqslant \underline{D}, \tag{IR}$$

where w is the fixed salary the manager demands to participate. For simplicity, we assume that the manager's outside pecuniary utility ($\underline{D}$) is exogenous, or that the principal cannot extract the private non-pecuniary rent (k) from the manager. Alternatively, we can assume that the private benefits of the manager are sufficiently small that they do not change the efficient allocation. Harris and Raviv (1998) and Prendergast (2002) make similar assumptions.[5]

An important intermediate result is that the agent's effort e is increasing in the hurdle rate b in the positive neighborhood of $b = 0$ (i.e., for $b \searrow 0$). To see this, we write the first-order condition of (IC) as (for notational ease, we define $\alpha = b/(\sqrt{e}\,\sigma_v)$)

$$\frac{1}{2}k\frac{b}{\sigma_v}e^{-3/2}\phi(\alpha) + \frac{1}{2}\lambda e^{-1/2}\sigma_v\phi(\alpha) + \frac{1}{2}\lambda\sqrt{e}\,\sigma_v\alpha\phi(\alpha)\frac{b}{\sigma_v}e^{-3/2} - c'(e) = 0, \tag{6}$$

or

$$\frac{1}{2}\phi(\alpha)\left[k\alpha e^{-1} + \lambda\sigma_v e^{-1/2} + \lambda\sigma_v\alpha^2 e^{-1/2}\right] - c'(e) = 0. \tag{7}$$

[5] If the non-pecuniary benefit counts toward the manager's participation constraint, the first-best hurdle rate will not be zero. In order to identify one source of positive hurdle rates observed in real-world capital budgeting, we make this simplifying assumption so that the benchmark is a zero hurdle rate.

(6) defines an implicit function $e = \psi(b)$. Taking total derivatives of (6) with respect to b and using the facts that $\phi'(\alpha)|_{b=0} = 0$ and $(\partial\alpha/\partial e)|_{b=0} = 0$, we have

$$\frac{1}{2}\phi(\alpha)\left[-k\alpha e^{-2}\frac{\mathrm{d}e}{\mathrm{d}b} + ke^{-1}\frac{\partial\alpha}{\partial b} - \frac{1}{2}\lambda\sigma_v e^{-3/2}\frac{\mathrm{d}e}{\mathrm{d}b} - \frac{1}{2}\lambda\sigma_v\alpha^2 e^{-3/2}\frac{\mathrm{d}e}{\mathrm{d}b} + 2\lambda\sigma_v\alpha e^{-1/2}\frac{\partial\alpha}{\partial b}\right] - c''(e)\frac{\mathrm{d}e}{\mathrm{d}b} = 0. \quad (8)$$

Evaluating (8) at $b = 0$ ($\alpha = 0$), we have

$$\frac{1}{2}\phi(0)\left[ke^{-3/2}\sigma_v^{-1} - \frac{1}{2}\lambda\sigma_v e^{-3/2}\frac{\mathrm{d}e}{\mathrm{d}b}\right] - c''(e)\frac{\mathrm{d}e}{\mathrm{d}b} = 0 \quad (9)$$

$$\Longrightarrow \quad \frac{\mathrm{d}e}{\mathrm{d}b}\bigg|_{b=0} = \frac{(1/2)\phi(0)ke^{-3/2}\sigma_v^{-1}}{(1/4)\phi(0)\lambda\sigma_v e^{-3/2} + c''(e)} > 0.$$

(6) indicates that raising the hurdle slightly from zero to some positive level will motivate more information collection effort from the agent. The intuition for this result is as follows. With a zero hurdle rate, the precision of the information does not affect the probability of getting a project proposal accepted (because $\Pr(\hat{v} > 0) = 1/2$ regardless of the effort level). With a positive hurdle rate, however, higher effort would lead to a higher probability that $\hat{v}$ is above the hurdle. This is because a more informative signal increases the likelihood that the posterior assessment of the project return deviates from the prior assessment. Since the manager obtains private benefit from getting the project approved (as well as a share from the project profit), the marginal benefit of effort to the manager increases when the hurdle rate is raised from zero (as long as the hurdle rate is not too high to leave out too many projects with positive expected returns).

Next we present the main proposition of this paper.

Proposition 1. *The optimal solution to the problem* (4) *involves a positive hurdle rate* $b > 0$.

Proof. Because the fixed salary w can be fully adjusted to make the (IR) constraint satisfied, the firm can as well maximize the utility frontier

$$\pi = \sqrt{e}\,\sigma_v\phi\left(\frac{b}{\sqrt{e}\,\sigma_v}\right) - c(e),$$

subject to the (IR) and (IC) constraints. Let $\pi(b)$ be the value of the utility frontier when the hurdle rate is b. Because setting $b < 0$ is never optimal, it suffices to show that $\mathrm{d}\pi/\mathrm{d}b > 0$ when $b = 0$.

Note that

$$\frac{\mathrm{d}\pi}{\mathrm{d}b}\bigg|_{b=0} = \left\{\left[\frac{1}{2}e^{-1/2}\sigma_v\phi(\alpha) + \frac{1}{2}\sqrt{e}\,\sigma_v\alpha\phi(\alpha)\frac{b}{\sigma_v}e^{-3/2} - c'(e)\right]\frac{\mathrm{d}e}{\mathrm{d}b} - b\phi\left(\frac{b}{\sqrt{e}\,\sigma_v}\right)\right\}\bigg|_{b=0}$$

$$= \left[\frac{1}{2}\sigma_v\phi(0)e^{-1/2} - c'(e)\right]\frac{\mathrm{d}e}{\mathrm{d}b}\bigg|_{b=0}.$$

At $b = 0$, (7) implies that $\frac{1}{2}\lambda\sigma_v\phi(0)e^{-1/2} = c'(e)$, which, together with $\lambda < 1$, implies that $\frac{1}{2}\sigma_v\phi(0)e^{-1/2} - c'(e) > 0$. By continuity, raising the hurdle rate from zero to some positive number will increase the total profit of the firm, taking into account the manager's response in effort exertion. □

The intuition of Proposition 1 is the following: the manager bears all the cost of the effort but is getting only a partial λ fraction of the expected return. Thus, given the non-contractibility of effort, he will under-supply the information collection effort. Raising the hurdle rate from zero has both a cost and a benefit effect. On the benefit side, it provides the manager with more incentive to exert the information collection effort. As shown earlier, with a positive hurdle rate, more information collection effort increases the likelihood of project approval, which increases the expected value of the manager's non-pecuniary benefit. On the cost side, a higher hurdle rate reduces ex post profits by leaving out some positive NPV projects and accordingly reduces the benefit of effort. The optimal hurdle rate trades off the benefit and the cost, which is similar to a trade-off between type I (leaving out ex post positive NPV projects) and type II (funding unworthy projects) errors.[6] When the hurdle rate is small, the first effect dominates the second because the probability density at zero is high and the projects that are left out are the ones with low expected profitability.

3. Discussion and conclusion

There are two critical assumptions for the mechanism identified in this paper. First, the firm is able to commit to a positive hurdle rate for project selection, which is not ex post efficient. Second, the information collection effort is observable (but not contractible). It is fairly common that firms follow rigid capital budgeting rules for a long period of time (see the discussion in Harris and Raviv (1996, 1998), for example). The rigidity in budgeting rules is a form of commitment. Further, since capital budgeting is a long term, repeated game, firms also have strong incentives to commit to a fixed policy. In our model, the firm may gain from deviating from the positive hurdle rate rule in the current period, but the costs can be high if it leads to lower effort by the managers and consequently low profits in all future periods. Further, we do not require the hurdle rate b to be contractible (given the non-contractibility of effort e). Given that both b and e are common knowledge (observable) to both parties, the manager would not deviate in his effort if he believes that the firm is committed to the hurdle rate policy. Both assumptions help to highlight the effect of effort motivation by a hurdle rate in the absence of asymmetric information.

This paper shows that the optimal hurdle rate balances the ex ante marginal benefit from the manager's higher information collection effort with the ex post efficiency loss from foregoing some positive-NPV projects. Further, it is easy to verify that the hurdle rate should be higher, the larger the scale of the project (relative to the cost of hiring a manager) and the higher the ex ante uncertainty in the profitability of the risky project (σ_v^2). In both

[6] We thank the referee for pointing out this interpretation of our result.

cases, accurate information about v is more valuable to the firm. Therefore, a higher hurdle rate is needed in order to motivate more information collection effort from the manager.

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