The Adverse Effect of Information on Governance and Leverage

On-line Appendix

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Proof of Lemma 3

$\bar{\mu}_1 = \zeta_n(1)$, where $\zeta_n(D)$ is the non-manipulable firm indifference curve through $D_1(0)$. So the relevant indifference curve has the form $I_n(\zeta, D) = C$, which can be written in the following way when $D = 1$:

$$\bar{\mu}_1 = \frac{\Pi(C - \Pi R_\tau + \Pi\tau + 1 - \tau)}{\Delta(C - \Pi R_\tau + \Pi\tau)}.$$

We have

$$\begin{aligned} C &= I_n(\zeta = 0; D = \bar{D}) \\ &= \Pi R_\tau - 1 + \bar{D}_1(1 - \Pi). \end{aligned}$$

It follows by direct substitution that

$$\bar{\mu}_1 = \frac{\tau\Pi(1 - \Pi)(1 - \bar{D}_1)}{\Delta\left(1 - \Pi\tau - \bar{D}_1\tau(1 - \Pi)\right)}.$$

Direct differentiation yields

$$\begin{aligned} \frac{\partial\bar{\mu}_1}{\partial\bar{D}_1} &= -\frac{\tau\Pi(1 - \Pi)(1 - \tau)}{\Delta\left(1 - \Pi\tau - \bar{D}_1\tau(1 - \Pi)\right)^2} < 0; \\ \frac{\partial\bar{D}_1}{\partial\tau} &= -\Pi\frac{(\Pi R - 1) + k(1 - \Pi)/\Delta}{(1 - \tau(1 - \Pi))^2} < 0; \\ \left.\frac{\partial\bar{\mu}_1}{\partial\tau}\right|_{\bar{D}_1 \text{ fixed}} &= \frac{\Pi(1 - \Pi)(1 - \bar{D}_1)}{\Delta\left(1 - \Pi\tau - \bar{D}_1\tau(1 - \Pi)\right)^2} > 0. \end{aligned}$$

We then have

$$\begin{aligned}
\frac{\partial \bar{\mu}_1}{\partial R} &= \frac{\partial \bar{\mu}_1}{\partial \bar{D}_1}(1-\tau)\frac{\partial \bar{D}_1}{\partial R_\tau} < 0; \\
\frac{\partial \bar{\mu}_1}{\partial k} &= -\frac{\partial \bar{\mu}_1}{\partial \bar{D}_1}\frac{\Pi}{\Delta(1-\tau(1-\Pi))} > 0; \\
\frac{\partial \bar{\mu}_1}{\partial \Delta} &= -\frac{\bar{\mu}_1}{\Delta} + \frac{\partial \bar{\mu}_1}{\partial \bar{D}_1}\frac{k\Pi}{\Delta^2(1-\tau(1-\Pi))} < 0 \\
\frac{\partial \bar{\mu}_1}{\partial \tau} &= \frac{\partial \bar{\mu}_1}{\partial \bar{D}_1}\frac{\partial \bar{D}_1}{\partial \tau} + \left.\frac{\partial \bar{\mu}_1}{\partial \tau}\right|_{\bar{D}_1 \text{ fixed}} > 0.
\end{aligned}$$

Proof of Lemma 4

First, note that, when $\mu < \bar{\mu}_1$, so that Shirking Equilibria are possible with an information system, Shirking Equilibria generate higher expected headquarters surplus than the Incentive Equilibria. This result is immediate by inspection of Figure 5, because Shirking Equilibria lie on the thick dashed line, which intersects indifference curves below the ones through M.

It follows that the headquarters strictly prefers not to implement an information system when $\mu \leq \bar{\mu}_1$. To show that it never makes a governance intervention we must therefore demonstrate that $\bar{\mu}_1 \leq \bar{\mu}_0$.

Shirking Equilibria are possible with an information system precisely when $\mu \leq \bar{\mu}_1$: when this condition is satisfied, Shirking Equilibria can occur for a continuum of D when the non-manipulable firm indifference curve through $\bar{D}_1$ crosses the line $D = 1$ above $\zeta = \mu$ (see Figure 5). In other words, there are Shirking Equilibria (which co-exist with the Incentive Equilibrium) when the following condition is satisfied:

$$I_n(D = 1, \zeta = \mu) > I_n(D = \bar{D}_1, \zeta = 0).$$

This requirement reduces to the following condition:

$$\tau(1-\Pi)D_0 \leq (1-\Pi)\tau + (1-\tau)\left(1 - \frac{\Pi}{\Pi - \mu\Delta}\right) - \tau(1-\Pi)\frac{\Pi(1-\mu)}{1-\tau(1-\Pi}\frac{k}{\mu\Delta}. \tag{27}$$

The condition for non-shirking without an information system is Equation (14), which we can write as follows:

$$\tau(1-\Pi)D_0 \geq \tau(1-\pi) - (\mu\Delta R_\tau - k). \tag{28}$$

Conditions (27) and (28) can be satisfied simultaneously, so that $\bar{\mu}_0 < \bar{\mu}_1$, precisely when

Condition (29) holds:

$$(1-\tau)\left(1-\frac{\Pi}{\Pi-\mu\Delta}\right)-\tau(1-\Pi)\frac{\Pi(1-\mu)}{1-\tau(1-\Pi}\frac{k}{\mu\Delta}\geq\mu\Delta\tau-(\mu\Delta R_\tau-k). \tag{29}$$

Because $\bar{D}_0 < 1$ we have

$$\mu\Delta\tau-(\mu\Delta R_\tau-k)>-(1-\tau)\frac{\mu\Delta}{\Pi},$$

and, because the right-hand side of this expression exceeds $(1-\tau)(1-\Pi/(\Pi-\mu\Delta)) = -(1-\tau)\mu\Delta/(\Pi-\mu\Delta)$, Condition (29) cannot be satisfied.

Proof of Lemma 8

The proof proceeds in two steps. We first consider the case where the participation constraint of bondholders is binding, which we assume throughout the paper. Let D_n and $D_m \neq D_n$ be the respective debt levels of non-manipulable and manipulable projects in a separating equilibrium. We must have $D_m \leq \bar{D}_1(\zeta)$, since otherwise manipulable projects, whose type is revealed in equilibrium, have negative value and, hence, do not attract funding. Hence, by Lemma 7, $D_m = \bar{D}_1 < D_n$, and the equilibrium assessment ζ must be zero for both types of project. But, for fixed ζ, shareholder value is increasing in the debt level D. Hence, a headquarters with a manipulable project will choose to imitate one with a non-manipulable project, thus violating the separating assumption.

We now show that there exists no separating equilibrium where the non-manipulable firm leaves money on the table to signal a high probability of success. Assume, on the contrary, that the non-manipulable firm sets $D = 1$ and $B > \frac{1}{\Pi}$ (with bondholders' assessment $\zeta = 0$) and that the manipulable firm chooses $D = \bar{D}_1$, so that shirking does not occur: bondholders assess $\zeta = 0$ and bonds are fairly priced at $\bar{D}_1/\Pi$. B must satisfy the self-selection constraint of the manipulable firm, who must elect not to set $D = 1$ instead of $D = \bar{D}_1$. This requirement reduces to

$$(\Pi-\Delta)(R_\tau-B)+\tau(\Pi-\Delta)(B-1)\leq\Pi R_\tau-1+\tau\bar{D}_1(1-\Pi)-k. \tag{30}$$

The non-deviation criterion for a non-manipulable firm is

$$\Pi(R_\tau-B)+\tau\Pi(B-1)\geq\Pi R_\tau-1+\tau\bar{D}_1(1-\Pi). \tag{31}$$

Conditions (30) and (31) can be satisfied simultaneously whenever

$$(\Pi - \Delta)(R_\tau - B) + \tau(\Pi - \Delta)(B - 1) + k \leq \Pi(R_\tau - B) + \tau\Pi(B - 1),$$

which reduces to

$$k \leq \Delta(R_\tau - B) + \Delta\tau(B - 1). \tag{32}$$

Recall from Equation (16) that $\bar{D}_1 \left(1 - \tau(1 - \Pi)\right) = \Pi \left(R_\tau - k/\Delta\right)$. We can therefore write Condition (32) as follows:

$$\frac{\Pi B(1-\tau) + \tau\Pi}{1 - (1-\Pi)\tau} \leq \bar{D}_1. \tag{33}$$

But for $B > 1/\Pi$ we have

$$\frac{\Pi B(1-\tau) + \tau\Pi}{1 - (1-\Pi)\tau} > \frac{1 - \tau + \tau\Pi}{1 - \tau + \tau\Pi} = 1 > \bar{D}_1,$$

which contradicts Condition (33), so that the candidate equilibrium cannot exist.

Proof of Lemma 9

The pooling equilibrium is sustained by a posterior bondholder belief $\zeta = 1$ for any $D > \bar{D}_1$. This belief ensures that any deviation by a manipulable firm renders its bonds fairly priced so that, by Equation (4), its participation constraint is violated.

A non-manipulable firm also does not deviate since the increase in shareholder value is then negative: If it deviates, it is optimal to choose $D = 1$, which, by Equation (4), yields a negative shareholder value for bondholder belief $\zeta = 1$ so that the firm cannot finance itself.

We must also demonstrate that the pooling equilibrium is robust to the Intuitive Criterion. This is true because any type could benefit from deviation under the belief $\zeta(D) = 0$, so that the Intuitive Criterion places no restriction upon off-equilibrium beliefs in this case.

Finally, we demonstrate uniqueness. By Lemma 8, any equilibrium in which shirking is prevented must be a pooling equilibrium, with $D \leq \bar{D}_1$. And by Lemma 7, there is no equilibrium with $D < \bar{D}_1$.

Proof of Lemma 11

Suppose for a contradiction that such an equilibrium exists. The manipulable firm must mix amongst points on a single indifference curve. Let x and y be points on the curve that the manipulable firm selects with positive probability, as in Figure 1. The non-manipulable firm strictly prefers y because, as illustrated, it lies on a lower indifference curve. Hence, a debt level choice D_x reveals the project to be manipulable, so that $\zeta_x = 1$. The indifference curve along which manipulable firms mix therefore violates the manipulable firms' participation constraint.

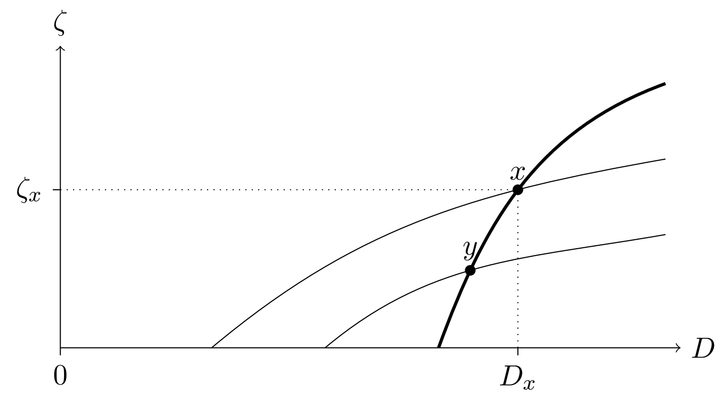

Figure 1. **Non-existence of equilibria in which manipulable firms mix**. If manipulable firms mixed between x and y then both points would have to lie on a common manipulable firm indifference curve, illustrated as a thick line in the Figure. The lower point would be strictly preferred by a non-manipulable firm, so that choosing debt D_x would reveal a firm to be manipulable and, hence, because $D_x > \bar{D}_1$, would imply that x violated the participation constraint.

Proof of Lemma 12

If there is a partially separating equilibrium, it must involve mixing by non-manipulable firms. Such mixing can only occur on an indifference curve below $\zeta_n(D)$, along which the outside option associated with the commitment point M is achieved. Such an indifference curve is illustrated as a bold curve in Figure 2. If a non-manipulable firm mixes between at least two points on this curve, then the manipulable firm will select the rightmost point, since this point lies on the most attractive manipulable firm indifference curve. All other points must therefore have $\zeta = 0$ and, hence, the non-manipulable firm can mix between only two points, illustrated in Figure 2 with capital levels $\hat{D}$ and $\tilde{D}$. The market belief $\hat{\zeta}$ when $D = \hat{D}$ at the right-hand point must lie above μ (because all manipulable and not all non-manipulable firms select this debt level) and below $\bar{\mu}_1$ (since the bold indifference curve must lie below the outside option $\zeta_n(\cdot)$). Hence, partially separating equilibria are feasible only if $\mu < \bar{\mu}_1$. If this condition holds, then a partially separating equilibrium can be sustained along any indifference curve below $\zeta_n(\cdot)$ with $\tilde{D}$ and $\hat{D} > D^*_\mu$ as illustrated, with off-equilibrium beliefs $\zeta = 1$.

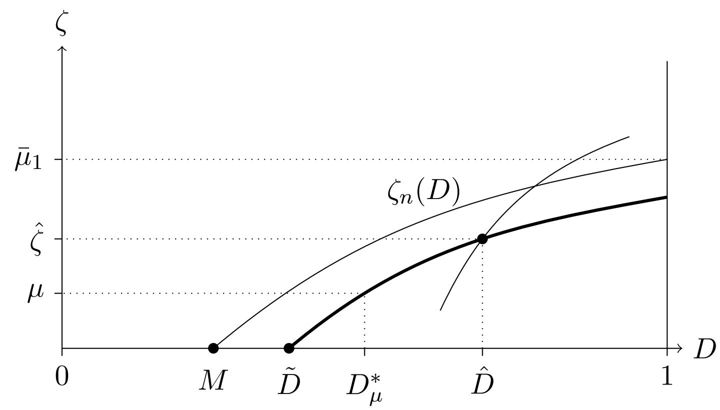

Figure 2. **Partially separating equilibria**. Equilibria in which non-manipulable firms mix exist if and only if there is a non-manipulable firm indifference curve below $\zeta_n(\cdot)$ that intersects the ζ-axis above μ, as illustrated by the bold line in the Figure. In such equilibria non-manipulable firms mix between the D-axis intercept $\tilde{D}$ and any $\hat{D} > \tilde{D}$; manipulable firms always set $D = \hat{D}$.

Proof of Proposition 3

When information systems are not observable, suppose that bondholders believe that when $D \leq \bar{D}^u_1$, the firm prefers to implement an information system rather than not to do so, and not to perform a governance intervention. With this belief, the firm's debt repayment if it sets $D \leq \bar{D}^u_1$ is D/Π. It follows that the headquarters derives the following shareholder value from assuming debt level $D \leq \bar{D}^u_1$ and implementing an information system:

$$V^{u,ns}_1 \equiv \Pi R_\tau - 1 - (1 - \Pi\tau)\delta - \mu k + \tau(1 - \Pi)D. \tag{34}$$

The firm's value if it sets $D = \bar{D}^u_1$ in order to benefit from cheap debt and nevertheless shirks is V^{dev}, which is obtained by replacing $p(q)$ with π and setting $B = \bar{D}^u_1/\Pi$ in Equation (6):

$$V^{dev} = \pi R_\tau - 1 + \bar{D}^u_1\left(1 - \frac{\pi}{\Pi}\right) + \frac{\pi}{\Pi}\bar{D}^u_1\tau(1 - \Pi). \tag{35}$$

We have

$$V^{dev} - V_1^{u,ns} = -(\Pi - \pi)R_\tau + (1 - \Pi\tau)\delta + \mu k + \bar{D}_1^u \frac{\Pi - \pi}{\Pi}\left(1 - \tau(1 - \Pi)\right). \tag{36}$$

The bondholders' belief is sustainable in equilibrium precisely when $V^{dev} - V_1^{u,ns} \leq 0$; this is true for D less than or equal to the debt level $\bar{D}_1^u$ of Equation (21).

Given this belief set, the headquarters chooses between (i) implementing an information system, setting $D = \bar{D}_1^u$, and performing a governance intervention when the project is manipulable; (ii) not implementing an information system, setting $D = \bar{D}_0$, and performing a governance intervention; and (iii) setting $D = 1$, not implementing an information system, and not performing a governance intervention. Option (i) dominates option (iii) if and only if

$$\begin{aligned} V_1^{u,ns} - V_0^s = \mu\Delta R_\tau - k - \tau\left((1-\pi) - (1-\Pi)\bar{D}_0\right) \\ + \left(\frac{1 + \tau(1-\Pi)(\Pi/(\Pi-\pi) - 1)}{1 - \tau(1-\Pi)}\right)\left(k(1-\mu) - (1-\Pi\tau)\delta\right) \geq 0. \end{aligned} \tag{37}$$

Option (ii) dominates option (iii) if and only if Condition (14) is satisfied. Hence, shirking is prevented precisely when Condition (38) is satisfied:

$$\begin{aligned} \mu\Delta R_\tau - k \geq \tau\left((1-\pi) - (1-\Pi)\bar{D}_0\right) - \\ \left(\frac{1 + \tau(1-\Pi)(\Pi/(\Pi-\pi) - 1)}{1 - \tau(1-\Pi)}\right)\max\left(k(1-\mu) - (1-\Pi\tau)\delta, 0\right). \end{aligned} \tag{38}$$

$\bar{\mu}^u$ is the value of μ at which Condition (38) is satisfied with equality, so that Condition (38) is equivalent to the requirement that $\mu > \bar{\mu}^u$.

Finally, option (i) dominates option (ii) when

$$V_1^{u,ns} - V_0^{ns} = \left[\frac{\Pi - \pi + \pi\tau(1-\Pi)}{(\Pi-\pi)(1-\tau(1-\Pi))}\right]\left(k(1-\mu) - (1-\Pi\tau)\delta\right) \geq 0. \tag{39}$$

This condition is equivalent to the statement that $\mu < \mu_1^{\max,u}$.

In short, we have:

1. $\mu \leq \bar{\mu}^u$: option (iii) is dominant: the headquarters sets $D = 1$, does not implement an information system, and never makes a governance intervention;

2. $\bar{\mu}^u < \mu \leq \mu_1^{max,u}$: option (i) is dominant: the headquarters sets $D = \bar{D}_1^u$, implements an

information system, and performs a governance intervention if the project is manipulable;

3. $\mu > \mu_1^{max,u}$: option (ii) is dominant: the headquarters sets $D = \bar{D}_0$ and always performs a governance intervention.