# Investment and capital structure of partially private regulated firms - Appendix

Carlo Cambini* and Yossi Spiegel†

July 4, 2012

**Abstract**

In this Appendix, we show that most of the results in our paper generalize to the case where regulatory independence is modeled by assuming that the regulator has limited ability to commit to the reulatory rule used to determine the regulatory price. With some probability, the regulator ends up using a more pro-consumer regulatory rule than initially anticipated.

*Politecnico di Torino and EUI - Florence School of Regulation. Address: Politecnico di Torino, DISPEA, Corso Duca degli Abruzzi, 24, 10129 Torino, Italy. email: *carlo.cambini@polito.it.*

†Tel Aviv University, CEPR, and ZEW. Address: Recanati Graduate School of Business Administration, Tel Aviv University, Ramat Aviv, Tel Aviv, 69978, Israel. email: *spiegel@post.tau.ac.il, http://www.tau.ac.il/~spiegel*

# 1 Introduction

In this Appendix, we show that most of the results in our paper generalize to the case where regulatory independence is modeled by assuming that the regulator has limited ability to commit to the regulatory rule used to determine the regulatory price. With some probability, the regulator ends up using a more pro-consumer regulatory rule than initially anticipated. As we show, virtually all of our results generalize to this case; the only exception are the comparative statics results regarding the equilibrium level of investment (Proposition 5-7). With the alternative approach used in this Appendix, the firm invests efficiently and the level of investment is independent of regulatory independence and the extent of privatization.

# 2 The model

The model is exactly as in the main text of the paper. The only difference is that now, before the firm invests, the regulator commits to set the regulated price in order to maximize the following objective function:

$$(V(k) - p)^{\gamma} \left(p - \beta\frac{\overline{c}}{2} - (1-\delta)\,\phi\,(p, D)\,T - k\right)^{1-\gamma}, \tag{1}$$

where $\gamma = \gamma_1$. However with probability $1-\rho$, the regulator behaves opportunistically and once $k$ is sunk, he uses a more pro-consumer regulatory rule than initially promised with $\gamma = \gamma_0 > \gamma_1$.[1] The idea then is that a more independent regulator has a better ability to commit to the regulatory rule (equation (1)). A less independent regulator is more likely to deviate from the rule and set a more pro-consumer price. Since we identify regulatory independence with the regulator's ability to make long-term commitments to regulatory policies (see e.g., Levy and Spiller, 1994, Gilardi 2002 and 2005, and the discussion in Edwards and Waverman, 2006), the parameter $\rho$ reflects the degree of regulatory independence.

In the main text, we modeled regulatory opportunism by assuming that with probability $1-\rho$, the regulator ignores the sunk cost of investment $k$ when he sets the regulated

[1] This modeling approach is is similar to Lyon and Li (2004): in their paper, the regulator sets $p$ to maximizing a social welfare function similar to the one that we posit, but when the firm invests, it is uncertain if $\gamma = 1$ or $\gamma = 1/2$.

price. Here, we assume instead that while the regulator always takes $k$ into account, with probability $1-\rho$, he uses a more pro-consumer rule for setting the regulated price. In both cases, there is probability $1-\rho$ that the regulator will end up setting a lower regulated price than initially promised. In the main text, the price is lower because the regulated price does not take $k$ into account, while here it is lower because the weight assigned to consumer surplus is higher. Both modeling approaches are plausible ways to capture "regulatory opportunism;" the purpose of this appendix is to show that both approaches yield virtually the same results. The only difference is that here, the firm's investment ends up being efficient and independent of the degree of regulatory independence and the extent of privatization. In the main text, the firm underinvests and more so when the firm is more private and when the regulator is more pro-consumer.

As in the main text, the strategic interaction between the firm and the regulator begins in stage 1 with the firm's managers choosing $k$ and issuing debt with face value $D$ in a competitive capital market.[2] In stage 2, the regulator sets the regulated price $p$. Finally, the firm's cost $c$ is realized, output is produced, and payoffs are realized. In what follows, we solve the game and establish the various results under the new modified model.

# 3 The regulated price

In stage 2 of the game, the regulator sets $p$ to maximize (1), where $\gamma = \gamma_1$ with probability $\rho$ (the regulator keeps his commitment to the regulatory rule), and $\gamma = \gamma_0 > \gamma_1$ with probability $1-\rho$ (the regulator behaves opportunistically and assigns a lower weight to the firm's profit in the regulatory rule). Let $I = 1$ if $\gamma = \gamma_1$ and $I = 0$ if $\gamma = \gamma_0$. Using this

[2] Our approach differs from De Fraja and Stones (2004) and Stones (2007) where the regulator, rather than the firm, chooses the capital structure of the firm. These paper also assume that the regulator must set $p$ to ensure that the firm never goes bankrupt and shareholders earn their required rate of return. Our approach also differs from Lewis and Sappington (1995) who examine the optimal design of capital structure in the context of an agency model that involves a risk-averse regulator (a principal) and a risk-neutral regulated firm (an agent) under alternative assumptions regarding the principal's ability to control the agent's capital structure.

notation and following the same steps as in Spiegel (1994), the regulated price is given by

$$p^{*}(D,k,I)=\begin{cases} D_1(k,I)+\bar{c} & D\le D_1(k,I)\,,\\ D+\bar{c} & D_1(k,I)<D\le D_2(k,I)\,,\\ D_1(k,I)+\bar{c}+M(D,I) & D_2(k,I)<D\le D_3(k,I)\,,\\ D_1(k,I)+\bar{c}+\gamma_I(1-\delta)T & D>D_3(k,I), \end{cases} \tag{2}$$

where

$$D_1(k,I)\equiv(1-\gamma_I)\,V(k)+\gamma_I\beta\frac{\bar{c}}{2}-\bar{c}+\gamma_I k, \tag{3}$$

$$M(D,I)\equiv\frac{\gamma_I(1-\delta)\frac{T}{\bar{c}}\left(D+(2-\beta)\frac{\bar{c}}{2}-k\right)}{1+(1-\delta)\frac{T}{\bar{c}}}, \tag{4}$$

$$D_2(k,I)\equiv\frac{(1-\gamma_I)\left(1+(1-\delta)\frac{T}{\bar{c}}\right)V(k)+\gamma_I\beta\frac{\bar{c}}{2}+\gamma_I k}{1+(1-\gamma_I)(1-\delta)\frac{T}{\bar{c}}}-\bar{c}, \tag{5}$$

and $D_3(k,I)$ is smaller than the value of $D$ for which $D_1(k,I)+\bar{c}+M(D,I)=D$. This solution is obtained under the assumption that $\gamma_1<\frac{V(0)-\bar{c}}{V(0)-\beta\frac{\bar{c}}{2}}$ (the regulator is not too pro-consumer). If this assumption is violated, then $D_1(k,0)=0$, though none of our results is affected. The regulated price looks exactly as in Figure 1 in the main text.

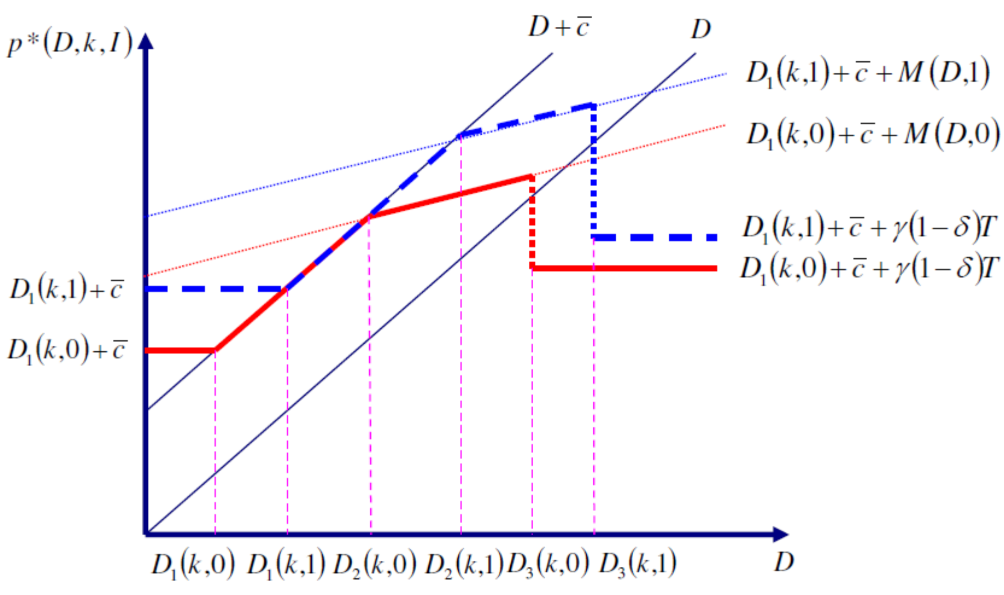


Figure 1: Illustrating the regulated price as a function of $D$ for $I=0$ (the solid red line) and $I=1$ (the dashed blue line), holding $k$ fixed

To limit the number of different cases that can arise, we assume that there exists an interval of $D$ for which $p^*(D,k,1) = p^*(D,k,0)$ by imposing following assumption (this assumption replaces Assumption 1 in the main text):

$$\begin{aligned} & \underbrace{(1-\gamma_1)\,V(k) + \gamma_1\beta\frac{\overline{c}}{2} - \overline{c} + \gamma_1 k}_{D_1(k,1)} \\ < \quad & \underbrace{\frac{(1-\gamma_0)\left(1+(1-\delta)\frac{T}{\overline{c}}\right)V(k) + \gamma_0\beta\frac{\overline{c}}{2} + \gamma_0 k}{1+(1-\gamma_0)(1-\delta)\frac{T}{\overline{c}}} - \overline{c}}_{D_2(k,0)} \\ \Rightarrow \quad & \left[\gamma_0 - \gamma_1\left(1+(1-\gamma_0)\,(1-\delta)\frac{T}{\overline{c}}\right)\right]\left(V(k) - \beta\frac{\overline{c}}{2} - k\right) < 0. \end{aligned}$$

Since (1) implies that $V(k) \geq p \geq \beta\frac{\overline{c}}{2} + (1-\delta)\,\phi\,(p,D)\,T + k$, it follows that $V(k) \geq \beta\frac{\overline{c}}{2} + k$; hence, the following is a sufficient condition for Assumption 1 to hold:

$$\gamma_0 < \gamma_1\left(1+(1-\gamma_0)\,(1-\delta)\frac{T}{\overline{c}}\right).$$

Assumption 1, together with the fact that $D_2(k,0) < D_2(k,1)$, implies that, as Figure 1 shows,

$$D_1(k,0) < D_1(k,1) < D_2(k,0) < D_2(k,1).$$

# 4 The choice of capital structure

As in the main text, the firm's managers choose the firm's debt level, $D$, and investment, $k$, to maximize the firm's expected payoff, which is given by

$$\begin{aligned} Y(D,k) &= \rho\left[p^*\,(D,k,1) - \beta\frac{\overline{c}}{2} - (1-\delta)\phi^*\,(D,k,1)\,T - k\right] \\ &\quad + (1-\rho)\left[p^*\,(D,k,0) - \beta\frac{\overline{c}}{2} - (1-\delta)\phi^*\,(D,k,0)\,T - k\right]. \qquad (6) \end{aligned}$$

The following proposition, which is virtually the same as Proposition 1 in the main text, characterizes the equilibrium choice of debt.

**Proposition 1:** *In equilibrium, the regulated firm will issue debt with face value $D_2(k,0)$ if $\rho < \rho^*$, and will issue debt with face value $D_2(k,1)$ if $\rho > \rho^*$, where*

$$\rho^* \equiv \frac{(1-\gamma_0)\,(1-\delta)\,\frac{T}{\overline{c}}}{1+(1-\gamma_0)\,(1-\delta)\,\frac{T}{\overline{c}}}. \qquad (7)$$

**Proof of Proposition 1:** Differentiating equation (6) yields

$$\begin{aligned}\frac{\partial Y(D,k)}{\partial D} &= \rho\left[\frac{\partial p^*(D,k,1)}{\partial D}-(1-\delta)\left(\frac{\partial \phi^*(D,k,1)}{\partial p^*}\frac{\partial p^*(D,k,1)}{\partial D}+\frac{\partial \phi^*(D,k,1)}{\partial D}\right)T\right] \\ &\quad +(1-\rho)\left[\frac{\partial p^*(D,k,0)}{\partial D}-(1-\delta)\left(\frac{\partial \phi^*(D,k,0)}{\partial p^*}\frac{\partial p^*(D,k,0)}{\partial D}+\frac{\partial \phi^*(D,k,0)}{\partial D}\right)T\right].\end{aligned} \tag{8}$$

Note first that when $D \leq D_2(k,0)$, $\phi^*(D,k,0)=\phi^*(D,k,1)=0$, while $\frac{\partial p^*(D,k,0)}{\partial D}\geq 0$ and $\frac{\partial p^*(D,k,1)}{\partial D}\geq 0$. Hence, $\frac{\partial Y(D,k)}{\partial D}\geq 0$ for all $D\leq D_2(k,0)$, implying that the firm's debt will be at least $D_2(k,0)$.

Second, consider the range where $D_2(k,1)<D<D_3(k,0)$. Here, $p^*(D,k,I)=D_1(k,I)+\bar{c}+M(D,I)$ and $\phi^*(D,k,I)=1-\frac{p^*(D,k,I)-D}{\bar{c}}$. Hence,

$$\frac{\partial p^*(D,k,I)}{\partial D}=\frac{\partial M(D,I)}{\partial D}=\frac{\gamma_I(1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}, \tag{9}$$

and

$$\frac{\partial \phi^*(D,k,I)}{\partial p^*}=-\frac{\partial \phi^*(D,k,I)}{\partial D}=-\frac{1}{\bar{c}}. \tag{10}$$

Substituting in (8), yields

$$\begin{aligned}\frac{\partial Y(D,k)}{\partial D} &= \rho\left[\frac{\gamma_1(1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}+(1-\delta)\left(\frac{\gamma_1(1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}-1\right)\frac{T}{\bar{c}}\right] \\ &\quad +(1-\rho)\left[\frac{\gamma_0(1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}+(1-\delta)\left(\frac{\gamma_0(1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}-1\right)\frac{T}{\bar{c}}\right] \\ &= (1-\delta)\left[\rho(\gamma_1-1)+(1-\rho)(\gamma_0-1)\right]\frac{T}{\bar{c}}<0.\end{aligned}$$

Moreover, it is easy to see from equation (2) and Figure 1 that $p^*(D,k,I)$ jumps downward at $D=D_3(k,0)$ and is independent of $D$ for all $D>D_3(k,0)$. Hence, $\frac{\partial Y(D,k)}{\partial D}<0$ for all $D\geq D_2(k,1)$, implying that the firm will never issue debt with face value above $D_2(k,1)$.

Finally, we need to consider the range where $D_2(k,0)\leq D\leq D_2(k,1)$. Figure 1 shows that in this range $p^*(D,k,1)=D+\bar{c}$, and $p^*(D,k,0)=D_1(k,0)+\bar{c}+M(D,0)$. Hence, $\phi^*(D,k,1)=0$ and $\phi^*(D,k,0)=1-\frac{p^*(D,k,0)-D}{\bar{c}}$. Noting that $\frac{\partial p^*(D,k,1)}{\partial D}=1$, and that

$\frac{\partial p^*(D,k,0)}{\partial D}$ and $\frac{\partial \phi^*(D,k,0)}{\partial p^*}$ are given by (9) and (10), and substituting in (8), yields

$$\begin{aligned}\frac{\partial Y(D,k)}{\partial D} &= \rho + (1-\rho)\left[\frac{\gamma_0 (1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}} - (1-\delta)\left(1 - \frac{\gamma_0 (1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}\right)\frac{T}{\bar{c}}\right] \\ &= \rho - (1-\rho)(1-\gamma_0)(1-\delta)\frac{T}{\bar{c}} \\ &= \left(1 + (1-\gamma_0)(1-\delta)\frac{T}{\bar{c}}\right)\left[\rho - \underbrace{\frac{(1-\gamma_0)(1-\delta)\frac{T}{\bar{c}}}{1+(1-\gamma_0)(1-\delta)\frac{T}{\bar{c}}}}_{\rho^*}\right].\end{aligned}$$

If $\rho < \rho^*$, then $\frac{\partial Y(D,k)}{\partial D} < 0$, so the firm will set $D = D_2(k,0)$. If $\rho > \rho^*$, then $\frac{\partial Y(D,k)}{\partial D} > 0$, so the firm will set $D = D_2(k,1)$. ■

As in the main text, we will say that the regulator is "independent" if $\rho > \rho^*$ (the regulator's ability to commit to the regulatory rule is relatively high) and "non independent" if $\rho < \rho^*$ (the regulator's ability to commit is relatively low). Proposition 1 shows that the threshold $\rho^*$ above which we consider the regulator as "independent" is decreasing with both $\gamma_0$ and $\delta$: other things equal, the regulator is considered to be "independent" for a larger range of values of $\rho$ if he is more pro-consumer when he behaves opportunistically (a higher $\gamma_0$) and if he faces a less privatized firm (a higher $\delta$).

Corollaries 1 and 2 now follow exactly as in the main text without any change. The next proposition, which is virtually the same as Proposition 2 in the main text, shows how debt is affected by the state's stake in the regulated firm, $\delta$, and the measure of regulatory climate (i.e., how pro-consumer the regulator is), $\gamma_I$.

**Proposition 2:** *Holding $k$ fixed, the debt level of the regulated firm is higher the lower $\delta$ and $\gamma_I$ are.*

**Proof of Proposition 2:** Differentiating $D_2(k,I)$ with respect to $\delta$ and $\gamma_I$, and recalling that $\beta = 1-\delta$ under the MPE approach and $\beta = 1$ under the SBC approach, yields:

$$\frac{\partial D_2(k,I)}{\partial \delta} = -\frac{\gamma_I (1-\gamma_I)\frac{T}{\bar{c}}\left(V(k) - \beta\frac{\bar{c}}{2} - k\right)}{\left(1+(1-\gamma_I)(1-\delta)\frac{T}{\bar{c}}\right)^2} + \frac{\gamma_I \frac{\bar{c}}{2}\frac{\partial \beta}{\partial \delta}}{1+(1-\gamma_I)(1-\delta)\frac{T}{\bar{c}}^2} < 0, \tag{11}$$

and

$$\frac{\partial D_2(k,I)}{\partial \gamma_I} = -\frac{\left(1+(1-\delta)\frac{T}{\bar{c}}\right)\left(V(k) - \beta\frac{\bar{c}}{2} - k\right)}{\left(1+(1-\gamma_I)(1-\delta)\frac{T}{\bar{c}}\right)^2} < 0, \tag{12}$$

where the inequalities follow since (1) implies that $V(k) \geq p \geq \beta\frac{\overline{c}}{2} + (1-\delta)\,\phi\,(p, D)\,T + k$, so $V(k) \geq \beta\frac{\overline{c}}{2} + k$. ■

The regulated price when the regulator is non independent ($\rho < \rho^*$) is equal to $D_2(k,0) + \overline{c}$ with probability 1. When the regulator is independent ($\rho > \rho^*$), the regulated price is equal to $D_2(k,1) + \overline{c}$ with probability $\rho$ and $D_1(k,0) + \overline{c} + M\,(D_2(k,1),0)$ with probability $1-\rho$, where $D_2(k,1) + \overline{c} > D_1(k,0) + \overline{c} + M\,(D_2(k,1),0)$. Hence, the expected regulated price when $\rho > \rho^*$ is

$$Ep^*\,(k) = \rho D_2\,(k,1) + (1-\rho)\,(D_1\,(k,0) + M\,(D_2\,(k,1)\,,0)) + \overline{c}. \tag{13}$$

We now examine how the regulated price is affected by $\delta$ and $\gamma_I$.

**Proposition 3:** *Holding $k$ fixed, the expected regulated price is higher when the regulator is independent ($\rho > \rho^*$) than it is when the regulator is non independent ($\rho < \rho^*$). Moreover, the expected regulated price is decreasing with both the state's ownership stake $\delta$, and with the measure of regulatory climate $\gamma_I$.*

**Proof of Proposition 3:** By Corollary 1, the regulated price when $\rho < \rho^*$, is equal to $D_2(k,0) + \overline{c}$. Since Proposition 2 shows that $D_2(k,0)$ decreases with $\delta$ and $\gamma_I$, so does the regulated price.

When $\rho > \rho^*$, the expected regulated price, $Ep^*(k)$, is given by (13). It is easy to see from Figure 1 that

$$D_2(k,1) + \overline{c} > D_1(k,0) + \overline{c} + M(D_2(k,1),0) > D_2(k,0) + \overline{c}.$$

Hence, $Ep^*(k) > D_2(k,0) + \overline{c}$, implying that holding $k$ fixed, the regulated price is higher in expectation when the regulator is independent than when he is not.

Using (13) along with equations (3) and (4), using (11) and (12), noting that (1) implies that $V(k) \geq p \geq \beta\frac{\overline{c}}{2} + (1-\delta)\,\phi\,(p, D)\,T + k$, so $V(k) \geq \beta\frac{\overline{c}}{2} + k$, and recalling that

$\beta = 1 - \delta$ under the MPE approach and $\beta = 1$ under the SBC approach, yields

$$\begin{aligned}
\frac{\partial Ep^*(k)}{\partial \delta} &= \left(\rho + (1-\rho)\underbrace{\frac{\gamma_0 (1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}}_{\frac{\partial M(D,0)}{\partial D}}\right)\frac{\partial D_2(k,1)}{\partial \delta} \\
&\quad - (1-\rho)\underbrace{\frac{\gamma_0\left(D_2(k,1) + (2-\beta)\frac{\bar{c}}{2} - k\right)\frac{T}{\bar{c}}}{\left(1+(1-\delta)\frac{T}{\bar{c}}\right)^2}}_{\frac{\partial M(D,0)}{\partial \delta}} + \underbrace{\frac{(1-\rho)\gamma_0\frac{\bar{c}}{2}}{1+(1-\delta)\frac{T}{\bar{c}}}}_{\frac{\partial D_1(k,0)}{\partial \beta}+\frac{\partial M(D,0)}{\partial \beta}}\frac{\partial \beta}{\partial \delta} \\
&= \left(\rho + (1-\rho)\frac{\gamma_0 (1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}\right)\frac{\partial D_2(k,1)}{\partial \delta} \\
&\quad - \frac{(1-\rho)\gamma_0(1-\gamma_1)\left(V(k) - \beta\frac{\bar{c}}{2} - k\right)\frac{T}{\bar{c}}}{\left(1+(1-\delta)\frac{T}{\bar{c}}\right)\left(1+(1-\gamma_1)(1-\delta)\frac{T}{\bar{c}}\right)} + \frac{(1-\rho)\gamma_0\frac{\bar{c}}{2}}{1+(1-\delta)\frac{T}{\bar{c}}}\frac{\partial \beta}{\partial \delta} < 0,
\end{aligned}$$

$$\begin{aligned}
\frac{\partial Ep^*(k)}{\partial \gamma_0} &= -(1-\rho)\underbrace{\frac{(V(k) - \bar{c} - D_2(k,1))(1-\delta)\frac{T}{\bar{c}} + V(k) - \beta\frac{\bar{c}}{2} - k}{1+(1-\delta)\frac{T}{\bar{c}}}}_{\frac{\partial D_1(k,0)}{\partial \gamma_0}+\frac{\partial M(D,0)}{\partial \gamma_0}} \\
&= -(1-\rho)\frac{V(k) - \beta\frac{\bar{c}}{2} - k}{1+(1-\delta)(1-\gamma_1)\frac{T}{\bar{c}}} < 0,
\end{aligned}$$

and

$$\frac{\partial Ep^*(k)}{\partial \gamma_1} = \left(\rho + (1-\rho)\underbrace{\frac{\gamma_0 (1-\delta)\frac{T}{\bar{c}}}{1+(1-\delta)\frac{T}{\bar{c}}}}_{\frac{\partial M(D,0)}{\partial D}}\right)\frac{\partial D_2(k,1)}{\partial \gamma_1} < 0.$$

This completes the proof. ■

Next, recall from Corollary 2 that the firm never becomes distressed if $\rho < \rho^*$. When $\rho > \rho^*$, the firm becomes distressed only when the regulator is opportunistic and sets a regulated price equal to $p^*(D_2(k,1), k, 0) = D_1(k,0) + \bar{c} + M(D_2(k,1), 0)$. Since the probability of this event is $1-\rho$, the overall probability of financial distress when $\rho > \rho^*$ is $(1-\rho)\,\phi^I(k)$, where

$$\begin{aligned}
\phi^{I}(k) &\equiv \underbrace{1-\frac{p^{*}\left(D_2(k,1),k,0\right)-D_2(k,1)}{\overline{c}}}_{\phi^{*}\left(D_2(k,1),k,0\right)} \\
&= \frac{D_2(k,1)-D_1(k,0)-M\left(D_2(k,1),0\right)}{\overline{c}} \\
&= \frac{\left(\gamma_0-\gamma_1\right)\left(V(k)-\beta\frac{\overline{c}}{2}-k\right)}{\overline{c}\left(1+(1-\delta)\left(1-\gamma_1\right)\frac{T}{\overline{c}}\right)}.
\end{aligned} \tag{14}$$

This expression differs from the probability of financial distress in the main text and it depends on both $\gamma_0$ and $\gamma_1$. The following result though, which follows directly from (14), shows that the main conclusions from Proposition 4 in the main text still hold:

**Proposition 4:** *Holding $k$ fixed, the probability of financial distress when an independent regulator happens to be opportunistic, $\phi^{I}(k)$, is increasing with $\delta$, $\gamma_0$, decreasing with $\gamma_1$, and is independent of $\rho$. Under a non-independent regulator, the firm never becomes financially distressed.*

# 5 The equilibrium level of investment

As Corollaries 1 and 2 show, when $\rho < \rho^{*}$, $D = D_2(k,0)$ and the regulator sets a price $D_2(k,0)+\overline{c}$, which ensures that the firm is completely immune to financial distress. By equation (6) then, the expected payoff of the firm is

$$Y^{NI}(k) \equiv Y(D_2(k,0),k) = D_2(k,0) + (2-\beta)\frac{\overline{c}}{2} - k. \tag{15}$$

When $\rho > \rho^{*}$, the firm issues debt with face value $D_2(k,1)$; with probability $\rho$, the regulator is committed and sets $p^{*}\left(D_2(k,1),k,1\right) = D_2(k,1)+\overline{c}$, which ensures that the firm never becomes financially distressed. With probability $1-\rho$, the regulator is opportunistic and sets $p^{*}\left(D_2(k,1),k,0\right) = D_1(k,0)+\overline{c}+M\left(D_2(k,1),0\right)$; with this price, the firm becomes financially distressed with probability $\phi^{I}(k)$. Substituting these expressions in equation (6), using the definition of $M(D_2(k,1),0)$, and rearranging terms, the firm's expected payoff is

$$\begin{aligned}
Y^I(k) &\equiv Y(D_2(k,1),k) = \rho\left(\overbrace{D_2(k,1)+\bar{c}}^{p^*(D_2(k,1),k,1)}\right) + (1-\rho)\left[\overbrace{D_1(k,0)+\bar{c}+M(D_2(k,1),0)}^{p^*(D_2(k,1),k,0)}\right] \\
&\quad -(1-\rho)(1-\delta)\phi^I(k)T - \beta\frac{\bar{c}}{2} - k \qquad (16)\\
&= \frac{(1-\gamma_0(1-\rho)-\gamma_1\rho)\left(1+(1-\delta)\frac{T}{\bar{c}}\right)\left(V(k)-\beta\frac{\bar{c}}{2}-k\right)}{1+(1-\delta)(1-\gamma_1)\frac{T}{\bar{c}}}.
\end{aligned}$$

Using $Y^{NI}(k)$ and $Y^I(k)$ we establish the following result:

**Proposition 5:** *The equilibrium level of investment, $k^*$, is implicitly defined by the first order condition $V'(k)=1$.*

**Proof of Proposition 5:** When $\rho < \rho^*$, the first order condition for $k^*$ is given by

$$\begin{aligned}
\frac{dY^{NI}(k)}{dk} &= \frac{\partial D_2(k,0)}{\partial k} - 1 \\
&= \frac{(1-\gamma_0)\left(1+(1-\delta)\frac{T}{\bar{c}}\right)V'(k)+\gamma_0}{1+(1-\delta)(1-\gamma_0)\frac{T}{\bar{c}}} - 1 \\
&= (1-\gamma_0(1-\rho^*))(V'(k)-1) = 0,
\end{aligned}$$

where the last equality follows by using (7). Since $V''(k) < 0$, the first order condition is sufficient for a maximum. Clearly, $k^*$ is independent of $\rho$ when $\rho^* < \rho$. From equation (16), it is clear that $k^*$ is also defined by $V'(k)=1$ when $\rho^* > \rho$. ■

From Proposition 5 it is obvious that $k^*$ is independent of the degree of regulatory independence, $\rho$, the state's stake in the firm, $\delta$, and by the regulatory climate, $\gamma_I$. Hence, Proposition 6 in the main text, which shows that $k^*$ is decreasing with $\delta$ and $\gamma$, does not generalize to the current setting:

**Proposition 6:** *The equilibrium level of investment, $k^*$, is independent of $\rho$, $\delta$ and $\gamma_I$.*

Since $k^*$ is defined by $V'(k)=1$, it is obvious that Propositions 1-4 remain in effect even if we take into account the endogenous determination of $k$:

**Proposition 7:** *Taking into account the endogenous choice of investment, the firm's debt and the regulated price are higher when $\rho > \rho^*$ (the regulator is independent) than they are when*

*$\rho < \rho^*$ (the regulator is non independent). Moreover, the firm's debt and the regulated price are both decreasing with the state's ownership stake $\delta$, and with the measure of regulatory climate $\gamma_I$. The probability of financial distress when an independent regulator happens to be opportunistic, $\phi^I(k)$, is increasing with $\delta$, $\gamma_0$, decreasing with $\gamma_1$, and is independent of $\rho$. Under a non-independent regulator, the firm never becomes financially distressed.*

Proposition 7 differs from the version in the main text only in that, in the main text, $\phi^I(k^*)$ is increasing with $\rho$, while here it is independent of $\rho$. The reason is that in the main text, $k^*$ is increasing with $\rho$, while here $k^*$ is independent of $\rho$.

# 6 Social welfare

The expected value of social welfare is given by:

$$W(k) = V(k) - \frac{\overline{c}}{2} - (1-\rho)\,\phi^*(D,k,I)\,T - k.$$

By Corollary 2, $\phi^*(D,k,I) = 0$ when the regulator is not independent. Hence, the expected social welfare, as a function of $k$, is given in this case by

$$W^{NI}(k) = V(k) - \frac{\overline{c}}{2} - k. \tag{17}$$

When the regulator is independent, equation (14) shows that $\phi^*(D,k,I) = \frac{(\gamma_0-\gamma_1)\left(V(k)-\beta\frac{\overline{c}}{2}-k\right)}{\overline{c}\left(1+(1-\delta)(1-\gamma_1)\frac{T}{\overline{c}}\right)}$. Hence, expected social welfare, as a function of $k$, is given by

$$W^I(k) = V(k) - \frac{\overline{c}}{2} - (1-\rho)\,\frac{(\gamma_0-\gamma_1)\left(V(k)-\beta\frac{\overline{c}}{2}-k\right)\frac{T}{\overline{c}}}{1+(1-\delta)(1-\gamma_1)\frac{T}{\overline{c}}} - k. \tag{18}$$

In the next proposition, we compare the equilibrium level of investment, $k^*$, with the socially optimal level that maximizes $W^{NI}(k)$ and $W^I(k)$.

**Proposition 8:** *The equilibrium level of investment, $k^*$, is socially optimal. Moreover,*

(i) *when the regulator is non-independent (i.e., when $\rho < \rho^*$), social welfare is independent of the degree of regulatory independence, $\rho$, the state's ownership stake $\delta$, and the measures of regulatory climate $\gamma_0$ and $\gamma_1$*

(ii) *when the regulator is independent (i.e., when $\rho > \rho^*$), social welfare is increasing with the degree of regulatory independence, $\rho$, and with the measure of regulatory climate under commitment, $\gamma_1$, and is decreasing with the state's ownership stake $\delta$, and with the measure of regulatory climate under opportunism $\gamma_0$.*

**Proof of Proposition 8:** Recall that the equilibrium level of investment, $k^*$, is defined implicitly by the first order condition $V'(k) = 1$. Clearly, the level of investment that maximizes (17) is also defined by the same first order condition. As for (18), the investment level that maximizes it is defined implicitly by the first order condition,

$$\begin{aligned}\frac{dW^I(k)}{dk} &= V'(k) - (1-\rho)\frac{(\gamma_0-\gamma_1)(V'(k)-1)\frac{T}{\bar{c}}}{1+(1-\delta)(1-\gamma_1)\frac{T}{\bar{c}}} - 1 \\ &= \frac{(V'(k)-1)\left(1+(1-\delta)(1-\gamma_1)\frac{T}{\bar{c}}+(1-\rho)(\gamma_0-\gamma_1)\frac{T}{\bar{c}}\right)}{1+(1-\delta)(1-\gamma_1)\frac{T}{\bar{c}}} = 0.\end{aligned}$$

It is easy to see that once again, the socially optimal investment level is defined by $V'(k) = 1$. Hence, the equilibrium level of investment coincides with the socially optimal level.

The comparative statics of welfare are obvious from equations (17) and (18). ■

Proposition 8 is virtually identical to Proposition 8 in the main text.