Police-powers, regulatory takings and the efficient compensation of domestic and foreign investors

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Abstract

We develop of model of environmental regulation and foreign direct investment in the presence of uncertainty and asymmetric information; we examine the efficiency and distributional properties of a police powers carve-out (PPCO) for environmental regulation. We show that a strict compensation rule, such as that spelled out in text of the NAFTA's investment chapter, Chapter 11, will induce efficient regulation by host governments but lead to over-investment. We design a family of compensation rules and PPCOs that induce efficient regulation and investment, and show that even the PPCO most favorable to the host government still leaves foreign investors better off then like domestic firms, leaving domestic and foreign firms in inherently "unlike circumstances."

Keywords: foreign direct investment, regulatory takings, expropriation, NAFTA, National Treatment, environment

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1 Introduction

International investment treaties give foreign investors the right to file a compensation claim against a host using an international tribunal instead of the host's domestic court system. This option, not available to domestic investors, protects the foreign investor from the host's "fiscal illusion", where the host undervalues the investor's lost profits when making decisions. The belief that foreign investors are more vulnerable than domestic investors to fiscal illusion is an important justification for these treaties. Most international investment treaties contain broad definitions of expropriation, such that a regulation to protect health, safety, or the environment can be construed as a regulatory taking worthy of compensation. Some tribunals, however, have been reluctant to adhere to the letter of the treaties in this regard and instead apply a "police-powers carve-out' (PPCO) from the definition of expropriation - treating actions that constitute the legitimate use of a state's police powers to protect public interest as non-compensable. We study the efficiency and distributional implications of a PPCO in a setting where the host has fiscal illusion with respect to foreign but not domestic investment. The international tribunal has imperfect information, so it cannot determine precisely whether a regulation results from fiscal illusion, or whether it is a legitimate exercise of police powers. A family of PPCOs is capable of inducing both optimal regulation and optimal investment. In many circumstances, the host prefers broader PPCOs from this family. Compensation for takings, even with a broad PPCO, benefits foreign investors relative to domestic investors. Therefore, the expropriation clause creates a conflict with the requirement of National Treatment in international treaties, because the former causes the circumstances of the two types of firms to be inherently "unlike".

Both fairness and efficiency feature heavily in the debate over compensation rules. Those in favor of strict compensation rules tend to focus on the need to make the state internalize the full costs of their actions in order to ensure that they do not regulate or otherwise take private property more often than is optimal. They also claim that it is unfair that private individuals bear the costs of actions providing broader public benefits. The most prominent case in recent news which illustrates these concerns is Kelo v. New London, where an elderly woman was forced from her home to make way for a private redevelopment project[1]. In recent U.S. State level shifts toward strict compensation requirements, a major motivator has been farmers losing the value of their properties as potential urban developments as a result of green zoning restrictions.

On the other side of the debate, those arguing against strict compensation rules have also used both efficiency and fairness arguments. In their seminal article, Blume, Rubinfeld, and Shapiro (1984) show that full compensation for lost private value will lead to excessive investment as the property owner will fail to account for the possibility that the investment will be

[1]Kelo v. New London, 125 Supreme Court 2655 (2005)

sacrificed for some greater public good. Miceli and Sergeson (1994) describe an Ex Post rule for compensation, whereby the state pays full market value compensation only when the social value of the expropriation is less than the value of the private investment. Limiting their attention to cases with full information, Miceli and Segerson show this Ex Post rule induces efficient investment and regulation even when the state suffers from fiscal illusion. This Ex Post rule is essentially a full information version of an efficient PPCO. The distributional appeal of a PPCO is easily motivated in the context of international investment agreements where, for example, governments wishing to introduce new environmental regulations might otherwise have to compensate foreign multinationals. Empirical evidence suggests that this scenario is more than merely an alarming theoretical possibility. Host governments claimed protection of the public good as the primary motive for their allegedly expropriatory actions in nearly a quarter of the international investment agreement cases for which we were able to find information.[2] The actions which have been disputed under the terms of the investment chapter of the North American Free Trade Agreement (NAFTA) alone include refusing to permit hazardous waste disposal operations (Metalclad v. Mexico), strengthening mine site remediation requirements (Glamis Gold v. United States), banning the import of one gasoline additive (Ethyl Corp v. Canada) and banning the use of another (MTBE; Methanex v. United States).[3]

A sizable literature addresses the question of how much and when compensation should be paid in order to induce optimal takings on behalf of the government and investment by the private property holder. Numerous different schemes have been proposed which have advantages under a range of different modeling assumptions, but many of which are very different to current legal practice.[4] Our primary purpose is not to design the ideal compensation scheme, but rather to analyze the efficiency and distributional properties of the existing compensation rules in international investment agreements. We focus particularly on the role of a PPCO, as this is a major point of debate among international legal scholars.[5] A key contribution of this paper is the introduction of asymmetric information to the analysis of a PPCO. We assume that the arbitration tribunal, which determines the level of compensation required, is not able to observe the host's private information about the social benefit of the regulation or taking. This is a theoretically and empirically important innovation as it means that there is a positive probability that the investor will take a claim to an arbitration tribunal, and that the host will

[2]Seven cases out of twenty nine. Source: the website of the International Centre for the Settlement of Investment Disputes.

[3]Authors' list, compiled from information available on the US State Department's Documentation of NAFTA Investor-State arbitration cases, available at http://www.state.gov/s/l/c3439.htm

[4]Important contributions include Fischel and Shapiro (1989) and Nosal (2001) who propose schemes given politically motivated government preferences, and Hermalin (1995) who proposes a compensation scheme that is efficient even if both government and private property holder have private information.

[5]See for example (Been and Beauvais, 2003), (Tschen, 1999), and (Turk, 2005).

be ordered to pay compensation. In this case, Miceli and Sergeson (1994)'s simple Ex Post rule is no longer efficient. The assumption of asymmetric information is also consistent with the large and rising number of compensation claims that are being brought under the terms of international investment agreements.

The fact that compensation will be paid with positive probability means that an optimal compensation scheme must include rules about how much compensation should be paid. Consistent with much of the existing literature, we find that full market value compensation will generally not be optimal as it will cause the private property holder to over-invest. This is important as all modern international investment agreements use full market value as the basis for compensation. Restricting our attention to simple linear rules based on information most readily available to arbitration tribunals, we show that compensation will lead to efficient levels of investment if it is proportional to the expected value of the investment, less the cost of the investment. We also show that this rule can induce efficient regulation if the breadth of the PPCO is chosen appropriately.

The rest of this paper is organized as follows. Section 2 describes the requirements for an efficient compensation scheme for domestic investors. The host government is assumed to fully value the welfare of domestic investors in its regulation decisions. Section 3 describes the requirements of a scheme to induce efficient regulation of foreign investors, whose welfare the host government does not consider. We show that efficient regulation can be achieved with or without a PPCO, but that a PPCO will be preferred by the host government. Furthermore, in many cases the host's welfare is monotonically increasing in the size of the PPCO. Section 3.2 considers the additional requirement of inducing efficient levels of investment by foreign firms. We show that a family of compensation schemes, indexed by a single parameter and corresponding to a range of different PPCOs, can achieve both efficient regulation and efficient investment. In Section 4 we consider issues raised by the interaction of compensation requirements with national treatment requirements which are also often a feature of international investment agreements. Section 5 concludes.

2 Compensation of domestic investors

The host government is assumed to act benevolently with regard to domestic investors. That is, the host internalizes the welfare of domestic investors and does not suffer from what is sometimes referred to as 'fiscal illusion'. This assumption means that the host will always regulate domestic investment efficiently. Thus an efficient compensation scheme for domestic investors requires only that efficient levels of investment are achieved. In this section we examine domestic investment in isolation; we defer any discussion concerning market interactions between potential domestic and foreign firms to section 4.

In our model, firms are price takers and production occurs for the Host market. This assumption means that the host obtains consumer surplus from production. In the first period the firm decides how much to invest (possibly 0). In the second period the regulator observes environmental damages, H, and decides whether to regulate. Regulation means that the society avoids H and the firm closes down (so that consumer and producer surpluses equal 0).

Investment is k and the cost of a unit of capital is r. The level of k determines the cost of production, $c(q,k)$, where q is the level of output. The demand function is $q(p)$ and the equilibrium price $p(k)$ satisfies $p(k) = c_q(q,k)$. Consumer surplus is $U(p(k))$, the competitive firm's variable profits are $\pi = pq - c$ and social surplus is $S(k) = U + \pi$. Because firms are price takers, $S'(k) = -c_k(q,k)$ evaluated at $q = q(p(k))$.

Regulation causes a loss of surplus of $S(k)$ and avoids the environmental cost H. The regulator knows H at the time of regulation. At the investment stage, when the firm chooses k, H is a non-negative random variable with pdf $f(H)$, cdf $F(H)$.

It is efficient to regulate if and only if $H > S(k)$, so the probability of (efficient) regulation is $1 - F(S(k))$. Under efficient regulation, the expected social welfare for given k is

$$V(k) \equiv E_H \max\{0, S(k) - H\} = \int_0^{S(k)} (S(k) - H) f(H) dH.$$

The socially optimal level of k maximizes $V(k) - rk$ giving the first order condition

$$S'(k)F(S(k)) = r,$$

which simplifies to

$$-c_k(q(p(k)), k) F(S(k)) = r. \tag{1}$$

We use * to denote the optimal level of a variable or function, so k^* is the socially optimal level of investment and $F^* = F(S(k^*))$.

If domestic firms obtain compensation $C(k)$ in the event of regulation, their problem is to maximize

$$F(S(k))(\pi(k)) + (1 - F(S(k)))C(k) - rk. \tag{2}$$

The compensation is a pure transfer, so it affects social welfare only insofar as it effects the equilibrium choice of k. If the firm takes the probability of regulation as given[6], its first order

[6]The appendix considers the case where the firm recognizes that the level of compensation depends on its investment.

condition for investment is

$$-F^{*}c_{k}\left(q,k\right)+\left(1-F^{*}\right)C'(k)=r. \tag{3}$$

Because the firm takes price as given, it behaves as if $\pi'\left(k\right)=-c_{k}(q,k)>0$. Comparison of equation (1) and (3) shows that a sufficient condition for the firm to invest at the socially optimal level is $C'\left(k\right)\equiv 0$; that is, the firm receives a lump sum compensation. Absent compensation, the firm's expected profits are $F^{*}\pi-rk$. A necessary condition for optimality is $C'\left(k^{*}\right)=0$ (and the maximand in expression (2) is concave).

We emphasize the linear compensation scheme (as in BRS):

$$C(k)=\delta\pi\left(k\right)+\gamma rk. \tag{4}$$

For the linear compensation

$$C'(k^{*})=-\delta c_{k}(q\left(p\left(k^{*}\right)\right),k^{*})+\gamma r=-\delta c_{k}-\gamma c_{k}F^{*}=-\left(\delta+\gamma F^{*}\right)c_{k},$$

where the second equality uses equation (1). Setting this expression equal to 0 gives the condition

$$-\gamma=\frac{\delta}{F^{*}},$$

so this compensation scheme reduces to

$$C(k)=\delta\pi(k)-\frac{\delta}{F^{*}}rk=\frac{\delta}{F^{*}}(F^{*}\pi(k)-rk).$$

The linear compensation is a subsidy equal to a multiple $\frac{\delta}{F^{*}}$ of the expectation of gross profits absent the compensation. Subject to notational translation, this is the same as Theorem 2 in BRS; assuming state contingent consumption contracts and independence of regulation and investment levels, they show that efficient compensation is a scalar of the ex ante (expected) profits of the at-risk firm. Under this linear scheme, the firm's expected profits (including compensation) are

$$F^{*}\pi+\frac{\left(1-F^{*}\right)\delta}{F^{*}}\left(F^{*}\pi-rk\right)-rk=\left(1+\frac{(1-F^{*})\delta}{F^{*}}\right)\left(F^{*}\pi-rk\right).$$

In summary, we have

Remark 1 *The only linear compensation scheme that induces efficient investment for the domestic firm is equivalent to an ad valorem subsidy of* $\frac{(1-F^{*})\delta}{F^{*}}$ *on expected profits; this policy is a tax if* $\delta<0$.

It is possible that the maximum expected profits in the absence of compensation is negative ($F^*\pi^* - rk^* < 0$) and that investment at k^* is still socially optimal (because $U > 0$). In this case, setting $1 + \frac{(1-F^*)\delta}{F^*} < 0$)would keep the firm from exiting because it's expected payoffs would be positive. However setting $1 + \frac{(1-F^*)\delta}{F^*} < 0$ would not induce the firm to invest optimally, because with a negative coefficient to expected profits, k^* minimizes the firm's objective. Instead, a lump sum transfer can be used to induce the firm to invest. Hereafter we assume that $F^*\pi^* - rk^* > 0$: the firm would undertake the optimal level of investment even in the absence of compensation when regulation occurs.

Before concluding this section, we note that, in practice, no government currently holds a legal obligation to compensate domestic investors for regulatory takings; when government suffers no fiscal illusion with respect to domestic firms, then when viewing domestic firms in isolation this is efficient. Accordingly, when comparing value for domestic and foreign investors in sections to follow, we will implicitly assume that $\delta = 0$ for domestic firms.

3 Regulation of foreign investors

In contrast to the case of domestic investors, the host does not consider the welfare of foreign investors. We therefore study the problem of regulating a foreign investor in two parts. We first examine a compensation scheme that induces the efficient level of regulation, for a given level of investment. We then impose an additional restriction on the compensation scheme so that it also induces the efficient level of investment. As in the previous section, we examine the case of a foreign investor in isolation, deferring to section 4 analysis of any interactions between different investors.

The host observes the level of damages when deciding whether to regulate. The tribunal observes a noisy signal of damages when deciding whether to accept the police powers carve-out, or to require the host to compensate the foreign firm.

The carve-out means that the tribunal accepts the police powers defense (and does not require that the host compensate the firm) if it receives sufficiently convincing evidence that regulation is justified. If the host regulates, and the tribunal rejects the police powers defense, the host must compensate the firm. We will show that optimality of investment and regulation requires that the level of compensation and the breadth of the carve out be inversely related: larger compensation means that the court must adopt a more liberal interpretation of police powers.

3.1 The regulation stage

At the regulation stage, the level of k is predetermined. The host does not care about foreign profits. It regards compensation as a cost (as distinct from a pure transfer in the case of regulation of domestic firms). In the absence of required compensation, the host wants to regulate whenever $H > U(k)$, i.e. regulation occurs at inefficiently small values of H. This excessive regulation would lead to insufficient foreign investment. We want to determine the efficient compensation scheme for a foreign firm.

The third party tribunal observes a noisy signal of damages, $H\eta$, where η is a random variable with density and cdf g, G. For simplicity of exposition we assume that the support of η is the positive half-line, except where we explicitly state otherwise. We also assume the distribution of η has no mass points. If the signal is unbiased, then $E\eta = 1$. If the court is equally likely to overstate as to understate true damages, then $G(1) = 0.5$.

Suppose that the international legal system adopts a compensation function that includes a carve-out. The court accepts the police powers defense (and does not require the host to compensate the investor) if it is persuaded that regulation is in the public interest. In our setting, the court accepts the police powers defense if its signal of environmental damages is sufficiently large: $H\eta > \chi(k)$. The function $\chi(k)$ is an inverse measure of the police powers carve-out. Hereafter we refer to $\chi(k)$ as simply the carve-out. Given two carve-outs, $\chi(k)$ and $\tilde{\chi}(k)$, we say that $\chi(k)$ is a broader carve-out if $\chi(k) \leq \tilde{\chi}(k)$ and the inequality is strict for a set of positive measure. A smaller value of $\chi(k)$ increases the probability that the court will accept the host's police powers defense. If the court receives a lower damage signal it rejects the police powers defense, requiring the host to compensate the investor $\theta(k)$. We denote this scheme as $M(k, H\eta)$:

$$M(k, H\eta) = \left\{ \begin{array}{c} 0 \text{ if } H\eta > \chi(k) \\ \theta(k) \text{ if } H\eta \leq \chi(k) \end{array} \right\}. \tag{5}$$

The regulator knows the value of H. In the absence of regulation, the host's payoff is

$$V^N(k, H) = U(k) - H$$

and with regulation the expected payoff is

$$V^R(k, H) = -E_\eta(M(k, H\eta)) = -\theta(k) G\left(\frac{\chi(k)}{H}\right).$$

The host decides to regulate if and only if

$$V^N = U(k) - H < -\theta(k) G\left(\frac{\chi(k)}{H}\right) = V^R. \tag{6}$$

The function $V^N(k, H)$ is increasing in k, and $V_k^R(k, H) = -\theta' G - \theta g \chi'$, which we assume is negative, as illustrated in Figure 1. Denote $k(H)$ as the critical level of k, where the host is indifferent between the two actions:

$$V^N(k(H), H) = V^R(k(H), H); \tag{7}$$

$k(H)$ is an increasing function, and the host wants to regulate if and only if $k < k(H)$. A narrower carve-out (shifting up the function $\chi(k)$) reduces $V^R(k, H)$ without changing $V^N(k, H)$ and therefore causes $k(H)$ to fall.

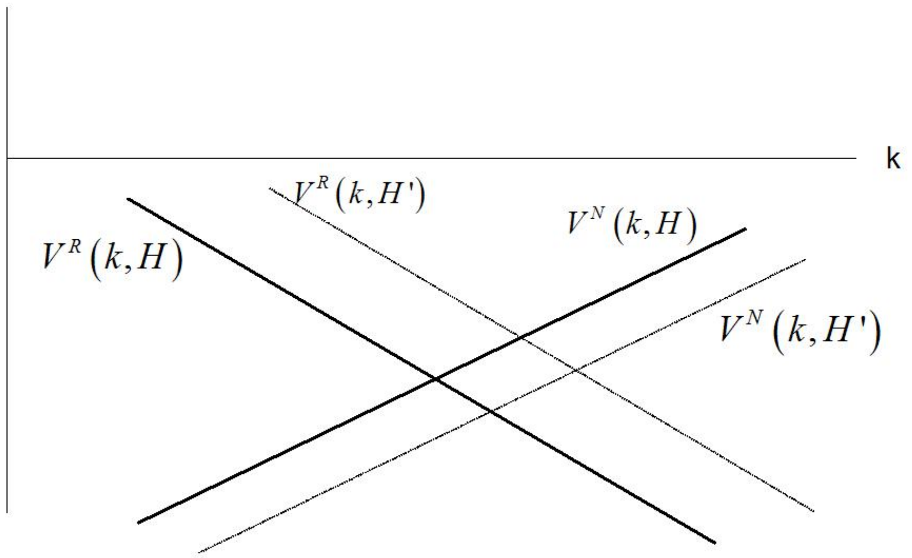

Figure 1: Graphs of V^N and V^R for two values of environmental harm, with $H' > H$

Optimality of regulation requires that the host regulates if and only if $H > S(k)$. This condition is equivalent to the requirements that the critical level $k(H)$, i.e. the solution to $V^N(k(H), H) = V^R(k(H), H)$, also solves $H = S(k)$. Using the second equation to eliminate H from the first equation produces

$$\begin{aligned} U(k) - S(k) &= -\theta(k) G\left(\frac{\chi(k)}{S(k)}\right) \Longleftrightarrow \\ \pi(k) &= \theta(k) G\left(\frac{\chi(k)}{S(k)}\right). \end{aligned} \tag{8}$$

Equation (8) implies several obvious facts about an efficient compensation scheme, described in the following Remarks.

Remark 2 *Strict compensation ($\theta(k) = \pi(k)$, and $\chi(k) = \infty$) induces efficient regulation. Any compensation scheme that involves a carve-out ($\chi(k) < \infty$) requires $\theta(k) > \pi(k)$.*[7] *All carve-out schemes that induce efficient regulation require that the host's expected compensation equal the firm's lost profits $\pi(k)$ when realized H equals $S(k)$.*

We now consider the case where the court adopts some carve-out. The court must be prepared to reject the police powers defense in order to discourage excessive regulation. The court commits a type II error if it rejects the police powers defense when regulation is socially efficient (i.e. when $H > S(k)$). The compensation function θ determines the carve-out, from equation (8), and thus determines the probability that the court commits a type II error.

Remark 3 *For the compensation function $\theta(k)$, the efficiency-inducing carve-out $\hat{\chi}(k)$ is given by the formula*

$$\hat{\chi}(k) = S(k)\phi(k) \text{ with } \phi(k) \equiv G^{-1}\left(\frac{\pi(k)}{\theta(k)}\right). \tag{9}$$

(Confirm this claim by solving for $\chi(k)$ in equation (8).) The probability that the court commits a type II error, conditional on H, is

$$\Pr(\textit{type II error} \mid H) = G\left(\frac{S(k)\,G^{-1}\left(\frac{\pi(k)}{\theta(k)}\right)}{H}\right) \tag{10}$$

Remark 4 *As $\theta(k) \to \pi(k)$ (from above) $\frac{\pi(k)}{\theta(k)} \to 1$ so $\phi(k) = G^{-1}\left(\frac{\pi(k)}{\theta(k)}\right)$ approaches the upper limit of the support of η. If this support is unbounded above, then $G^{-1}\left(\frac{\pi(k)}{\theta(k)}\right) \to \infty$, so the probability of the type II error approaches 1. This case corresponds to strict compensation: the host regulates only if $H > S(k)$ but always pays compensation. If least upper bound of the support is $\hat{\eta} < \infty$, the probability of a type II error is $G\left(\frac{S(k)\hat{\eta}}{H}\right) < 1$ for $H > S(k)$. In this*

[7] This statement relies on the assumption that the support of η is unbounded above. Suppose instead that the least upper bound of the support of η is $\hat{\eta} < \infty$. In this case, strict compensation transfers expected rents to the investor without promoting efficiency, because there are circumstances where the court awards compensation even though it knows that regulation is justified. For any signal greater than $S(k)\hat{\eta}$ the court knows that regulation is justified. The compensation scheme can set $\theta = \pi$ (its lower bound) and use the carve-out $\chi(k) = S(k)\hat{\eta}$. The host's expected savings relative to the strict carve-out is

$$\pi \int_{S(k)}^{\infty} \left(1 - G\left(\frac{S(k)\hat{\eta}}{H}\right)\right) f(H)dH.$$

case, there is a positive probability that the court accepts the police powers defense, and again the host regulates only for $H > S(k)$.

If $\theta(k) > \pi(k)$, the probability of a type II error is always less than 1; we do not need to distinguish between the case of a bounded and an unbounded support for η. Because regulation occurs only if $H > S(k)$, and because the probability of a type II error is decreasing in H, the least upper bound of the probability of a type II error is $\frac{\pi(k)}{\theta(k)}$. If $\theta(k) = \psi\pi(k)$ for ψ equal to a constant greater than 1, then ϕ simplifies to the constant $G^{-1}\left(\frac{1}{\psi}\right)$. In this case, the upper bound on the probability that the court commits a type II error is $\frac{1}{\psi}$.

Conditional on $H > S(k)$ (so that the host regulates), the host's expected compensation payout is $\theta(k)\, G\left(\frac{\chi(k)}{H}\right)$. This expectation is decreasing in H, with the supremum $\pi(k)$ independent of the compensation scheme. For $H > S(k)$ the conditional expected payments are strictly less than $\pi(k)$. This observation implies:

Remark 5 *For any efficiency-inducing compensation scheme with a carve-out, the expectation (conditional on regulation), over H, of the host's compensation is strictly less than $\pi(k)$.*

Thus, the host prefers any compensation scheme that involves a carve-out, compared to strict compensation.

Our main result in this section provides conditions under which the host's expected payout decreases with the breadth of the carve-out. This condition involves the elasticity of the cdf of the court's observation shock, defined as $\mu(\eta)$:

$$\mu(\eta) \equiv \frac{dG(\eta)}{d\eta}\frac{\eta}{G(\eta)} = g(\eta)\frac{\eta}{G(\eta)}.$$

We also introduce a parameter ρ in order to discuss a change that increases the carve-out. Let $\chi(k)$ be an arbitrary carve-out and let $\epsilon(k) \geq 0$ be an arbitrary function, where the inequality is strict for an interval that includes the current value of k. Define $\chi(k;\rho) = \chi(k) - \rho\epsilon(k)$, with $\rho \geq 0$, so $\chi_\rho \leq 0$; the inequality is strict for an interval that includes the current value of k. Thus, a larger value of ρ corresponds to a broader carve-out. The following proposition uses distributions with unbounded support, but it is straightforward to confirm that the result is unchanged when η or H have finite supports. We have

Proposition 1 *(a) Define $z(H) = \frac{\chi(k;\rho)}{H}$ and $\bar{z} = \frac{\chi(k;\rho)}{S(k)}$ (which is independent of H). Within the class of compensation schemes that induce efficient investment, a necessary and sufficient condition for a broader carve-out to reduce the host's expected payment is:*

$$\int_{S(k)}^{\infty} G(z)\left(\frac{g(z)}{G(z)}z - \frac{g(\bar{z})}{G(\bar{z})}\bar{z}\right) f(H)dH > 0 \tag{11}$$

(b) A sufficient condition for a broader carve-out to reduce the host's expected payout is that $\mu(\eta)$ is a decreasing function for all $\eta \geq \frac{\chi(k;\rho)}{S(k)}$.

For some distributions, the host's expected payment under an efficient regulation is non-monotonic in the breadth of the carve-out. We know from Remark 5 that a carve-out (i.e. one under which the police powers defense is sometimes accepted) leads to lower expected costs for the host, compared to a zero carve-out. Therefore, it is not possible – for any distribution of η – that broadening the carve-out always *increases* the host's expected costs. In order to show that the expected payoff can be non-monotonic in the breadth of the carve-out, it is sufficient to show that in some cases inequality (11) is violated. We demonstrate this possibility using the following:

Example 1 *Suppose that $\eta \sim N(1, \sigma^2)$ (so that the signal is unbiased) and let $H \sim U[0, b]$ with $b > 1$; let $S = 1$, so $\bar{z} = \chi$. Making a change of variables, we can write the integral in inequality (11) as*

$$\frac{\chi}{b}\Theta \quad \textit{with} \quad \Theta \equiv \int_{\frac{\chi}{b}}^{\chi} \left(g(z)\, z - \frac{G(z)}{G(\bar{z})} g(\bar{z})\, \bar{z} \right) \frac{dz}{z^2}.$$

We assume that $\chi > 0$, so a broader carve-out increases the host's expected costs if and only if $\Theta < 0$. Define p as the probability that the court rejects the police powers defense when $H = S$. Suppose that $b = 2 = \sigma$. Figure 2 shows the graph of p as a function of the carve-out χ (the solid curve) and the graph of 10Θ. For this example, $\Theta < 0$ iff $\chi < 2.45$, at which value $p \approx 0.77$. Thus, the host benefits from a broader carve-out iff under the status quo carve-out the probability that the court rejects the police powers defense (when $H = S$) is greater than 0.77.

The sufficient condition for the host to prefer a broader carve-out (unlike the necessary and sufficient condition) is independent of the distribution of harm. For a number of well-known distributions, it is easy to confirm that $\mu(\eta)$ is either (a) decreasing for all η or (b) decreasing for η sufficiently large. For narrow carve-outs, where $\chi(k)$ is large, the sufficient condition that $\mu(\eta)$ is decreasing for $\eta \geq \frac{\chi(k;\rho)}{S(k)}$ is easier to satisfy. This observation is consistent with Remark 5, which states that some carve-out is always better for the host than no carve-out.

The following Remark gives examples of distributions and ranges for which $\mu(\eta)$ is decreasing. In all cases, the proofs rely on direct calculation; these are available on request.

Remark 6 *a) For the exponential and the Weibull distributions, $\mu(\eta)$ is strictly decreasing. When $\eta \sim U[a, b]$, $\mu(\eta)$ is strictly decreasing for $a > 0$. b) For the Gamma and the Chi-squared distributions, a sufficient condition for $\mu(\eta)$ to be decreasing is $\eta \geq E\eta$. For the Beta*

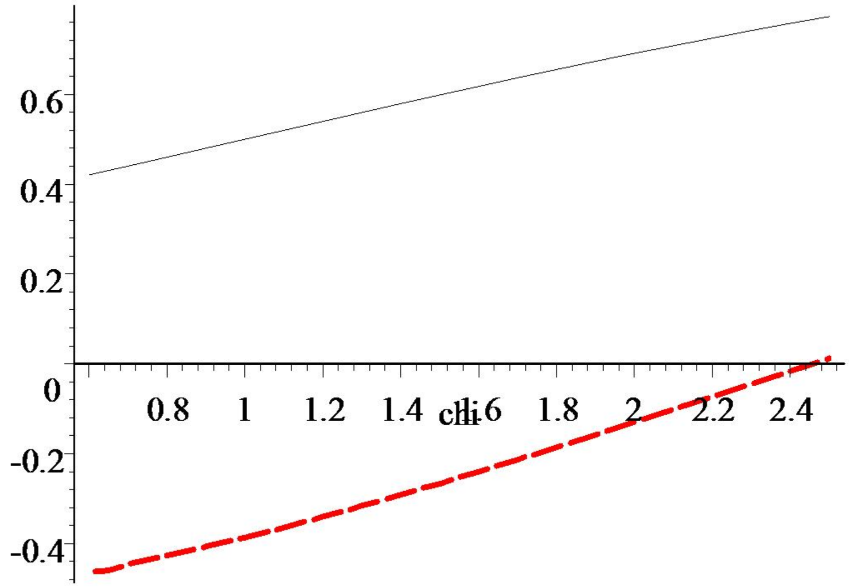

Figure 2: Solid curve: graph of probability that court rejects police powers defense when $H = S$. Dashed curve: 10Θ

distribution, a sufficient condition for $\mu(\eta)$ to be decreasing is that η is greater than or equal to a constant that depends on the parameters of the distribution.[8] *For the Normal distribution (with mean $\bar{\eta}$ and variance σ^2), a necessary and sufficient condition for $\mu(\eta)$ to be decreasing is that $\eta \geq 1.16\sigma + \bar{\eta}$. (The probability that this inequality is satisfied is approximately 0.12.)*

For example if η is Normal, Proposition 1 and Remark 6 imply that a broader carve-out (a smaller $\chi(k)$) always benefits the host if $\chi(k) \geq S(k)(1.16\sigma + \bar{\eta})$. Using the parameters from Example 1 ($\bar{\eta} = 1 = S$, and $\sigma = 2$) this inequality requires $\chi \geq 3.32$. However, Example 1 shows that (when the harm is uniformly distributed), the host prefers a broader carve-out whenever $\chi \geq 2.45$. The difference in bounds shows that the sufficient condition does not provide a tight bound. For the Gamma and Chi-squared distributions, a broader carve-out benefits the host if $\chi(k) \geq S(k)E(\eta)$; for the exponential, Weibull and (positive) Uniform distributions, a broader carve-out *always* benefits the host.

The results above assume that the court does not perfectly observe the host's damages. For completeness, we consider the case where the court knows the true damages:

[8] The Beta density is $\frac{\eta^{v-1}(1-\eta)^{w-1}}{B(v,w)}$, where v and w are positive parameters, with $E\eta = \dfrac{v}{v+w}$. The constant mentioned in Remark 6 is $\frac{v}{w+v}\frac{v+w}{w+v-1}$.

Remark 7 *If the court observes H without noise, any carve-out that satisfies $\chi(k) \geq S(k)$, together with the compensation rule $\theta = \pi$ induces efficient regulation.*

In the case where $\chi(k) > S(k)$ the host has to compensate the investor for $S < H \leq \chi$ even though the tribunal knows that regulation is socially optimal. This is akin to Miceli and Segerson's (1994) Ex Post rule, which stipulates that the regulator pays strict compensation if and only if the taking is socially inefficient given (realized) benefits. Miceli and Segerson (1994) consider only the case in which the court perfectly observes the benefits (akin to foregone damages in our model) from a taking; our variant on this rule stipulates that, when the court observes H perfectly, any rule that renders the host liable for compensation whenever realized H is less than $S(k)$ induces efficient regulation.

In summary, strict compensation induces efficient regulation. It is possible to induce efficient regulation using a carve-out. Under any such scheme, the host's expected payments equal (approximately) π when the host has only a slight preference to regulate. There always exists a non-trivial carve-out under which the host's expected payments are less than under strict compensation. If the elasticity of the CDF of the tribunal's observation error is a decreasing function of the realization of the error, then broadening the carve-out always decreases the host's expected payments. This condition always holds for some distributions, and it holds for sufficiently large observation shocks for other distributions.

3.2 The investment stage

Here we consider the regulation stage, under the assumption that the foreign firm takes the probabilities of regulation and compensation each as given.[9] The ex ante probability that the investor receives compensation is

$$R\left(k, \chi\left(k\right)\right) = \int_{S(k)}^{\infty} G\left(\frac{\chi\left(k\right)}{H}\right) f(H)dH.$$

Let the equilibrium level of k be $\tilde{k}$ and denote the equilibrium values of the probabilities as $\tilde{G} = G\left(\frac{\chi(\tilde{k})}{S(\tilde{k})}\right)$, $\tilde{F} = F(S\left(\tilde{k}\right))$ and $\tilde{R}\left(\tilde{k}; \chi\left(\tilde{k}\right)\right)$.

From the standpoint of global welfare (as distinct from the host's perspective) the compensation is a pure transfer. If the compensation scheme induces efficient regulation, then the efficient level of investment is k^*, the solution to equation (1). In this case, the probability of regulation is F^* and the probability of compensation is $R^* = R\left(\left(k^*; \chi\left(k^*\right)\right)\right)$.

[9]We do not consider the case in which the firm's strategically adjust k so as to influence these probabilities. We note in the Appendix that even when there is no fiscal illusion this situation does not produce clear results. Matters are even more complicated when a foreign firm invests.

Suppose that the international system uses a compensation scheme that induces efficient regulation, i.e. equation (8) is satisfied. The firm's expected profits are

$$\tilde{F}\pi(k) + \tilde{R}\theta(k) - rk,$$

and the firm's first order condition for investment is

$$\tilde{F}\pi'(k) + \tilde{R}\theta'(k) = r. \tag{12}$$

The probability that the court rejects the policy powers defense must be positive; otherwise, the host would regulate even when it is not socially optimal to do so. Therefore, $\tilde{R} > 0$. This inequality, and comparison of equation (12) with equation (1) shows that the former produces k^* if and only if

$$\theta'(k^*) = 0. \tag{13}$$

We obtained an analogous result in the case of domestic investment, where we noted that $C'(k^*) = 0$ must hold if the regulator pays compensation. With domestic investors, zero compensation is consistent with efficient investment and regulation. In contrast, regulation of foreign investment requires some level of compensation.

We noted below Remark 3 that a compensation rule $\theta(k) = \delta\pi(k)$ for δ equal to a constant greater than 1 induces efficient regulation. However, this rule cannot also induce efficient investment, because it does not satisfy equation (13). If we use a linear compensation scheme $\delta\pi + \gamma rk$, then satisfaction of equation (13) requires

$$\gamma = -\frac{\delta\pi'(k^*)}{r} = -\frac{\delta}{F^*}.$$

If the compensation scheme gives firms a multiple of their lost profits, it must also subtract a multiple of their investment costs, in order to keep the firm from over-investing. With this scheme, the level of compensation is

$$\theta = \frac{\delta}{F^*}\left(F^*\pi(k) - rk\right) \tag{14}$$

Using equation (9), the carve-out is

$$\hat{\chi}(k) = S(k)\phi(k;\delta) \text{ with } \phi(k;\delta) \equiv G^{-1}\left(\frac{F^*\pi}{\delta\left(F^*\pi - rk\right)}\right) = G^{-1}\left(\frac{\pi}{\theta}\right).$$

Thus, under the linear compensation scheme with carve-out, there is a one-parameter family of rules, indexed by δ, that induces the efficient level of investment and regulation.[10] The court rejects the police powers defense if and only if its estimate of harm, $H\eta$, is less than $\phi(k)\,S(k)$. If the court rejects the police powers defense, the firm receives a fraction $\frac{\delta}{F^*} > 1$ of its expected *gross* profits absent compensation, $F^*\pi - rk$. The compensation depends on gross profits (i.e. inclusive of investment costs) rather than variable profits.

How does this compensation rule compare to those proposed elsewhere in the Takings literature and the letter of international treaties? NAFTA's Chapter 11 stipulates that "[c]ompensation shall be equivalent to the fair market value of the expropriated investment immediately before the expropriation took place".[11] That is, NAFTA requires "strict" compensation which depends only on variable profits and ignores sunk costs. However, like BRS we find that strict compensation would be distortionary: unless compensation is lump sum or proportional to the investor's objective function absent compensation, it will incent inappropriate investment levels.[12,13] Conversely, Miceli and Segerson's Ex Post rule mandates strict compensation, a result that is sensitive to the information environment. In their model the courts can perfectly observe social benefits and costs from a taking, and so they will award compensation only when a taking is inefficient. Anticipating this, regulators will only regulate/take a project when it is socially efficient, and thus *compensation is never paid* in any states of the world; using our notation, under Miceli and Segerson's Ex Post rule, with perfect information the firms' expected payoffs are $F^*\pi - rk$, and so investment is efficient. In our model with asymmetric information, the ex ante probability of compensation must be positive, i.e. $R > 0$, otherwise the host will regulate too often. With $R > 0$, under strict compensation the firm's ex ante expected profits would equal $[F^* + R]\pi(k) - rk$, which will incent over-investment.

We now examine the extent to which a carve-out of a given size transfers expected rents from the host to the investor. We choose units so that $\pi^* = 1$, so the condition $\theta > \pi^*$ (by Remark 2) implies $\theta > 1$. Denote the expected compensation, prior to the realization of H, as

[10] Of course not all $\delta > 0$ will do; the condition $\theta > \pi$ necessitates $\delta > \frac{F^*\pi(k^*)}{F^*\pi(k^*) - rk^*}$.

[11] *North American Free Trade Agreement between the Government of Canada, the Government of the United Mexican States, and the Government of the United States of America* Article 1110, Paragraph 2.

[12] In some cases distorting investment choices might be desirable. Consider the case where damage equals $= Hh(k)$ where H is a random variable and $h'(k) > 0$. In this case, there is an externality associated with investment that investors will ignore even if regulation is efficient and compensation is lump-sum. However, for this problem a simple investment tax is sufficient. It is straightforward to show that a first-period capital tax $\tau^* \equiv h'(k^*)\int_0^{S(k^*)/h(k^*)} Hf(H)dH$ induces efficient investment when paired with the following compensation scheme: $\theta(k) = \frac{\delta}{F^*}[F^*\pi(k) - (r+\tau^*)k]$ and $\hat{\chi}(k) = S(k)\phi(k;\delta)$ with $\phi(k;\delta) \equiv G^{-1}\left(\frac{F^*\pi}{\delta(F^*\pi - [r+\tau^*]k)}\right) = G^{-1}\left(\frac{\pi}{\theta}\right)$. Notably, the efficient investment tax would be identical for foreign and domestic investors.

[13] Unlike BRS, under our compensation rule there will be states in which regulation (a taking) occurs but the investor receives no compensation.

$T(\theta)$:

$$T\left(\theta\right)=\theta R\left(k;SG^{-1}\left(\frac{1}{\theta}\right)\right)=\theta\int_{S}^{\infty}G\left(\frac{G^{-1}\left(\frac{1}{\theta}\right)S}{H}\right)f(H)dH. \tag{15}$$

We noted that when the observation error is exponentially distributed, a larger carve-out decreases the host's expected payment. In order to get an idea of the order magnitude of this effect, we consider the case where both the damage parameter H and the observation errors are exponentially distributed. Let $g\left(\eta\right)=e^{-\eta}$ (so that $E\eta=1$) and $f(H)=\lambda e^{-\lambda H}$, so $EH=\frac{1}{\lambda}$. For this specialization, we have $G^{-1}\left(\frac{1}{\theta}\right)=-\ln\left(\frac{\theta-1}{\theta}\right)$. Using this relation we have

$$\begin{aligned} R\left(k;SG^{-1}\left(\frac{1}{\theta}\right)\right) &= \int_{S}^{\infty}G\left(\frac{-S\ln\left(\frac{\theta-1}{\theta}\right)}{H}\right)\lambda e^{-\lambda H}dH \\ &= \int_{S}^{\infty}\left(1-\exp\left(\frac{S\ln\left(\frac{\theta-1}{\theta}\right)}{H}\right)\right)\lambda e^{-\lambda H}dH, \end{aligned}$$

so

$$T=\theta\int_{S}^{\infty}\left(1-\exp\left(\frac{S\ln\left(\frac{\theta-1}{\theta}\right)}{H}\right)\right)\lambda e^{-\lambda H}dH. \tag{16}$$

The model has two primitive parameters, S, the social surplus at the efficient level of investment, and λ, the hazard rate for damages, and one policy variable, θ. From Proposition 1 and Remark 6 we know that T is a decreasing function of θ. From Remark 4 (or directly from equation (16)) we know that as $\theta\rightarrow1^{+}$, $R\rightarrow1-F^{*}$, i.e. the court never accepts the police powers defense, so the host compensates whenever it regulates. As $\theta\rightarrow\infty$, using l'Hôpital's Rule we have $T\rightarrow\int_{S}^{\infty}\left(\frac{S}{H}\lambda e^{-\lambda H}\right)dH$. Although this integral does not have a closed form expression, it is useful for our numerical example.

Example 2 *Suppose that $S=2$ and $\lambda=1.15$. In view of the normalization $\pi=1$, the choice $S=2$ means that consumers and the firm share equally in the social surplus (given the efficient level of investment). The choice $\lambda=1.15$ means that $F^{*}=0.899\,74$, i.e. there is approximately a 10% chance of regulation. From the comments above, the upper bound on T (as $\theta\rightarrow1^{+}$) is $1-0.899\,74=0.100\,26$ and the minimum value (as $\theta\rightarrow\infty$) is $\int_{S}^{\infty}\left(\frac{S}{H}\lambda e^{-\lambda H}\right)dH=0.0748$. Figure 3 shows the expected transfer as θ ranges between $1+10^{-8}$ and 7. Over this interval, T falls from 0.10025 to 0.076, close to the theoretical max and min. The firm's total expected profits ($F^{*}\pi+T$) range from $0.999\,99$ to $0.975\,74$. Expected host welfare ($F^{*}\left(S-\pi\right)-T$) ranges from $0.799\,5$ to $0.823\,7$. The possibility of receiving compensation means that for all θ the foreign investor has higher total expected profits than the corresponding domestic firm (which does not receive compensation and therefore has expected profits of 0.9). Foreign investment reduces the value of consumer surplus minus compensation payments by 8.4% to*

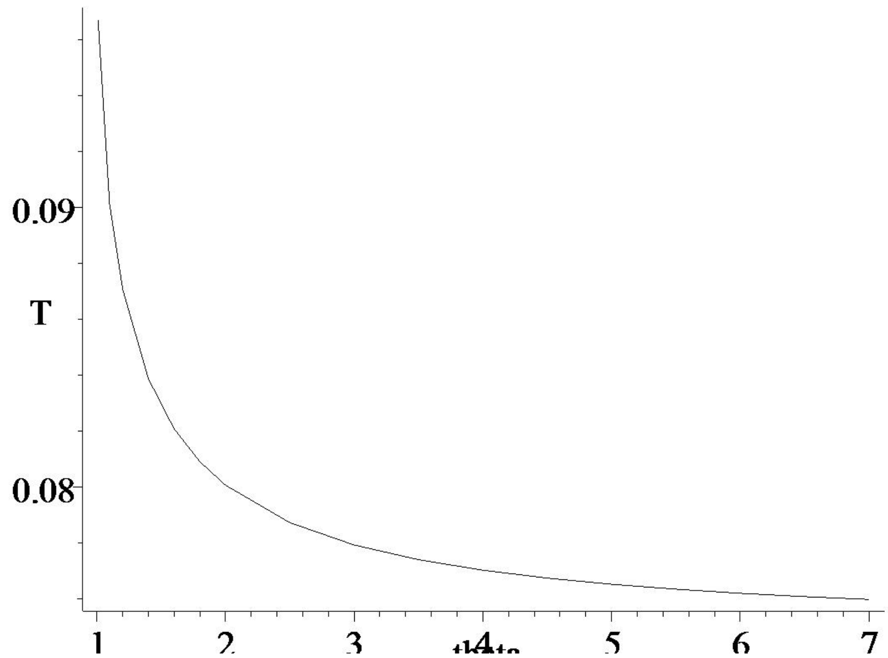

Figure 3: Expected transfer as a function of θ for the exponential model with $S = 1$ and $\lambda = 1.15$.

11%,, compared to the case of domestic investment (where compensation is neither required, nor, in practice, granted). These amounts bound the percentage chance of efficient regulation, 10%.

4 National treatment

The host has a moral hazard problem under foreign but not under domestic investment. An efficient solution (using the linear rule in equation (14)) imposes a cost on the host, but confers a benefit to the foreign firm. How does this compare to domestic firms? There is no country that has laws requiring domestic firms be compensated for regulatory takings; thus, if we think about there being one compensation/PPCO scheme for foreign investment (as laid out by investment treaties) and one for domestic investment, the δ for foreign firms is larger than that for domestic (to be precise, δ is zero for domestic firms).

Thus, the domestic firm's expected variable profit is $F^*\pi$ and the foreign firm's expected variable profit is $F^*\pi + T$. Example 2 shows that foreign profits can be higher than domestic profits by a percentage approximately equal to the chance of regulation. Expected consumer surplus minus expected compensation payments equal $F^*(S - \pi)$ in the case of domestic investors, and $F^*(S - \pi) - T$ in the case of foreign firms.

In summary, the need to remedy the moral hazard problem for foreign but not for domestic investment (and the problem of asymmetric information between the host and the tribunal) lowers the host's benefit from foreign investment, and increases the foreign investor's payoff, relative to that of the domestic investment. The remedy to the moral hazard problem means that the foreign and the domestic firms are inherently in "unlike circumstances".

The National Treatment clause in (many) international treaties requires that foreign and domestic investors in like circumstances be treated equally. In some treaties this requirement extends to rights of establishment. The National Treatment and the Expropriation clauses are contradictory, because the latter causes domestic and foreign investors to be in "unlike circumstances", but the former does not recognize this induced difference.

Where domestic and foreign firms are non-rival, the unlevel playing field arising from different compensation/PPCO schemes generates no inherent inefficiency. However it is easy to imagine scenarios in which domestic and foreign investors are rival. For example, suppose firms of a particular nationality are heterogeneous, differentiated by their fixed costs of entry, and that firms of all types are linked through the output market. Then, absent fiscal illusion and any compensation rules, we would expect the market would sort out firms, with high fixed-cost firms of either nationality abstaining from entering the market. With host fiscal illusion regarding foreign firms, however, and the compensation/PPCO scheme outlined in the previous sections, foreign firms that choose to enter the market effectively receive a subsidy on their ex ante variable profits. It would be straightforward to show that this subsidy would cause some high fixed cost foreign firms to enter the market (firms that would otherwise abstain), crowding out some relatively more efficient domestic producers. Moreover, we would expect total industry size to be inefficiently large as a result of the net entry. In sum, the remedy to the moral hazard and over-investment problems associated with foreign investment may in turn generate other inefficiencies: an industry that is both inefficiently large and characterized by an inefficient mix of domestic and foreign firms.

Of course, we should point out one solution to the problem of inefficient mix of domestic and foreign firms is to simply entitle all firms, both domestic and foreign, to the same compensation/PPCO scheme. This would not, however, solve the problem of industry expansion.

5 Conclusion

Most modern international investment agreements include strict compensation rules which require host governments to compensate foreign investors the full market value for any 'takings', regardless of intent. The justification for these strict rules is that foreign investors are disenfranchised and that efficient regulation requires that host governments be forced to internalize investor welfare. Our analysis suggests that the argument that strict compensation requirements are necessary to achieve efficiency is flawed on two grounds. Firstly, in a context similar to that used by Blume, Rubinfeld, and Shapiro (1984), we show that full market value compensation will generally be inefficient because it will cause firms to over-invest. Secondly, we show that efficient regulation only requires that the host internalizes the investor's welfare at the relevant margin.

As was shown by Miceli and Sergeson (1994), given full information, efficient investment and regulation can be achieved if the host pays full market compensation when they regulate inefficiently, and no compensation otherwise. That is, full market value compensation can be efficient if used in combination with an efficient police-powers carve-out. However, in the case where the social value of the regulation is private information for the host, there is error in determining when the host has regulated efficiently. This means that the host will regulate and be required to pay compensation with positive probability, even when an efficient police-powers carve-out is used. In this case, full market value compensation will once again lead to over-investment. An alternative compensation rule which achieves efficient investment requires compensation proportional to the expected value of the investment, less the cost of the investment.

The family of efficient compensation schemes ranges from no police-powers carve-out (compensation is always paid) to large carve-outs (where compensation is rarely paid). The existence of some, non-trivial, carve-out reduces the host's expected compensation and thereby increases its expected welfare. The carve-out thus transfers welfare from the foreign investor to the host. Under a range of assumptions regarding the tribunal's information about the social benefits of the regulation, a broader carve-out always lowers the expected transfer, so a broader carve-out benefits the host.

We also consider the interaction of expropriation conditions with national treatment requirements which appear in many international investment agreements. An efficient compensation scheme benefits foreign investors relative to domestic investors; the efficient scheme transfers surplus from the host to the foreign investor. Thus, an efficient compensation scheme creates "unlike circumstances" for the foreign and domestic investors. Application of the National Treatment clause needs to recognize this difference.

Appendix

Domestic firm takes regulation probability as endogenous

In this case, the firm's first order condition is

$$-Fc_k(q,k) + (1-F)\,C'(k) + F'(S(k))\,S'(k)\,(\pi(k) - C(k)) = r. \tag{17}$$

Comparing equations (1) and (17) we see that in order to induce the optimal level of investment it is sufficient to set

$$(1-F)\,C'(k) + F'(S(k))\,S'(k)\,(\pi(k) - C(k)) = 0.$$

Divide by $1-F$, use the definition of the hazard α, and $S\prime = -c_k$ to write this condition as

$$C'(k) = \alpha(k)c_k(k,q)\,(\pi(k) - C(k)). \tag{18}$$

Given a boundary condition, such as $C(0) = 0$, we can solve the ordinary differential equation (18) to obtain a unique compensation rule. We then need to confirm that this compensation rule leads to a concave problem for the firm. We have the following

Remark 8 *Suppose that some investment is necessary for production, so that* $\pi(0) = S(0) = 0$*, and* $\pi'(0) > 0$*. The boundary condition* $C(0) = 0$*, equation (18) and the previous assumption that* $f(0) > 0$ *(so that* $\alpha(0) > 0$*) imply that* $C''(0) = \alpha(0)c_k(0,q(0))\pi'(0) < 0$*. This inequality and equation (18) imply that* $C(k)$ *is a negative and decreasing function for all* $k > 0$*.*[14]

Although the "first order approach" above does produce an efficiency-inducing compensation scheme (subject to concavity), its complexity makes its usefulness doubtful. To solve the ODE we need to know the cost and demand functions (in order to be able to compute the equilibrium $q(k)$). In contrast, implementation of a linear scheme simply requires knowing profits and investment costs for the observed value of k. However, in general, the linear scheme cannot implement efficient investment when the firm recognizes that regulation is endogenous. To confirm this claim, substitute the linear scheme into equation (18) to obtain an equation involving the two parameters δ, γ that must hold identically in k; satisfaction of this identity would require very special primitive functions.

[14]Equation (18) and $C(0) = 0$ imply that $C'(0) = 0$. Concavity at $k = 0$ implies that $C < 0$ in the neighborhood of $k = 0$. Whenever $C < 0$ the right side of equation (18) is negative, so C continues to decrease as k increases.

Proof of Proposition 1

Proof. Part(a) Since we consider only compensation schemes that induce efficient regulation, regulation will occur if and only if $H > S(k)$. Thus the ex ante probability the host will have to pay compensation is

$$\begin{aligned} R\left(k,\chi\left(k;\rho\right)\right) &= \int_{S(k)}^{\infty} G\left(\frac{\chi\left(k;\rho\right)}{H}\right) f(H)dH \Rightarrow \\ \frac{dR}{d\rho} &= \int_{S(k)}^{\infty} g\left(\frac{\chi\left(k;\rho\right)}{H}\right)\frac{\chi_{\rho}\left(k;\rho\right)}{H} f(H)dH. \end{aligned} \tag{19}$$

The expected level of compensation is therefore

$$T\left(\rho\right) \equiv \theta R\left(\chi\left(k;\rho\right)\right) = \frac{\pi\left(k\right)R\left(\chi\left(k;\rho\right)\right)}{G\left(\frac{\chi(k;\rho)}{S(k)}\right)},$$

where the equality uses equation (8). With this definition

$$\begin{aligned} T'\left(\rho\right) &= \pi\left(k\right)\frac{G\left(\frac{\chi(k;\rho)}{S(k)}\right)\frac{dR}{d\rho} - Rg\left(\frac{\chi(k;\rho)}{S(k)}\right)\frac{\chi_{\rho}(k;\rho)}{S(k)}}{\left(G\left(\frac{\chi(k;\rho)}{S(k)}\right)\right)^{2}} = \frac{\pi\left(k\right)\chi_{\rho}\left(k;\rho\right)}{\left(G\left(\frac{\chi(k;\rho)}{S(k)}\right)\right)^{2}} \times \\ & \left[G\left(\frac{\chi\left(k;\rho\right)}{S\left(k\right)}\right)\int_{S(k)}^{\infty} g\left(\frac{\chi\left(k;\rho\right)}{H}\right)\frac{f(H)dH}{H} - g\left(\frac{\chi\left(k;\rho\right)}{S\left(k\right)}\right)\frac{1}{S\left(k\right)}\int_{S(k)}^{\infty} G\left(\frac{\chi\left(k;\rho\right)}{H}\right)f(H)dH\right] \end{aligned}$$

The coefficient of the term in square brackets is negative ($\chi_{\rho}\left(k;\rho\right) < 0$), so the sign of $T'\left(\rho\right)$ is the negative of the sign of the term in brackets. This term can be written as

$$\frac{G\left(\frac{\chi(k;\rho)}{S(k)}\right)}{\chi\left(k;\rho\right)}\int_{S(k)}^{\infty} G\left(\frac{\chi\left(k;\rho\right)}{H}\right)\left(\frac{g\left(\frac{\chi(k;\rho)}{H}\right)}{G\left(\frac{\chi(k;\rho)}{H}\right)}\frac{\chi\left(k;\rho\right)}{H} - \frac{g\left(\frac{\chi(k;\rho)}{S(k)}\right)}{G\left(\frac{\chi(k;\rho)}{H}\right)}\frac{\chi\left(k;\rho\right)}{S\left(k\right)}\right)f(H)dH. \tag{20}$$

Defining $z = \frac{\chi(k;\rho)}{H}$ and $\bar{z} = \frac{\chi(k;\rho)}{S(k)}$, then $T'\left(\rho\right) < 0$ iff inequality (11) is satisfied.

Part (b) A sufficient condition for inequality (11) to be satisfied is that the integrand in the expression is positive, i.e.

$$\frac{g\left(\frac{\chi(k;\rho)}{H}\right)}{G\left(\frac{\chi(k;\rho)}{H}\right)}\frac{\chi\left(k;\rho\right)}{H} - \frac{g\left(\frac{\chi(k;\rho)}{S(k)}\right)}{G\left(\frac{\chi(k;\rho)}{S(k)}\right)}\frac{\chi\left(k;\rho\right)}{S\left(k\right)} > 0 \tag{21}$$

for all $H > S(k)$. Recalling definitions $z = \frac{\chi(k;\rho)}{H}$ and $\bar{z} = \frac{\chi(k;\rho)}{S(k)}$ then $H > S(k)$ implies

$\bar{z} > z$. We can write the left side of inequality (21) as

$$\frac{g(z)}{G(z)}z - \frac{g(\bar{z})}{G(\bar{z})}\bar{z} = \mu(z) - \mu(\bar{z}).$$

If μ is a decreasing function, inequality (21) is satisfied. ■

Alternative Mechanisms

An alternative to the carve-out is to require strict compensation, and to tax the foreign firm in order to induce the efficient level of investment. If the firm has to pay an ad valorem tax of $\frac{1-F^*}{F^*}$ on each unit of capital, and receives compensation whenever regulation occurs, its first order condition,

$$\pi' = \frac{r}{F^*} \Rightarrow \frac{1}{F^*}\left(F^*\pi' - r\right) = 0,$$

results in the optimal level of investment. This alternative requires foreign firms to pay an up-front tax that is not levied on domestic firms, and therefore runs afoul of the National Treatment provision.

The transfer (from the host to the foreign investor) under the tax could be greater or smaller than the transfer under a carve-out scheme. Under the tax scheme foreign gross profits are

$$\frac{1}{F^*}\left(F^*\pi - rk\right),$$

i.e. they are $\left(\frac{1-F^*}{F^*}\right) \times 100\%$ higher than gross profits of domestic firms. Under the carve-out scheme, the foreign gross profits are $\frac{T}{F^*\pi - rk} \times 100\%$ higher than the domestic gross profits. The former exceeds the latter if and only if

$$\frac{\left(1-F^*\right)\left(F^* - rk\right)}{F^*} > T; \tag{22}$$

here we again set $\pi = 1$ by choice of units, so rk equals investment costs as a fraction of variable profits. For the exponential example, where the maximum value of T is $1 - F^*$, inequality (22) is not satisfied when θ is close to 1 (i.e. the carve-out is small). Using the numerical values in Example 2, where the minimum value of T is 0.0748, equation (22) is satisfied if θ is sufficiently large (i.e. the carve out is large) and $rk^* < 0.228$. Thus, depending on the magnitude of the carve-out and the ratio between investment costs and variable profits, the tax scheme might be either more or less costly for the host. Of course, a two-part tax, involving a lump sum transfer from the investor to the host, can be used to alter the distribution; this transfer would certainly violate rules of National Treatment.

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