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

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## Abstract

In customary international and public law, “takings” resulting from regulations designed to protect the public good are generally excluded from compensation rules; this exclusion is known as a police powers carve-out (PPCO). Increasingly, this PPCO is being challenged, particularly in international investment law. This paper analyzes the efficiency properties of a PPCO in a model with endogenous regulation, investment and entry. We design a one-parameter family of carve-out/compensation schemes that induce efficient regulation and firm level investment even when the regulator suffers fiscal illusion and the social benefit from regulation is private information to the regulator. We show that offering a carve-out reduces the subsidy to risky industry implicit in compensation rules; thus, a carve-out can mitigate the entry problem.

*Keywords:* regulatory takings, expropriation, environment, foreign direct investment, NAFTA,

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# 1 Introduction

Over the past decade a number of firms have launched successful lawsuits demanding compensation for “regulatory takings” arising from environmental regulations. In 1998 Canada agreed to compensate a US firm for profits lost during a ban on import of the gasoline additive MMT; at the time use of MMT was banned in many US states (Canada Department of Foreign Affairs 2004). In 2000 Mexico was ordered to compensate a US waste disposal firm \$16.7 million for refusing to permit its subsidiary to open and operate a hazardous waste facility that Metalclad had built (and for subsequently declaring the disputed site part of an ecological preserve) (U.S Department of State 2005b). After California announced its intended phaseout of the oxygenate MTBE, the Canadian firm Methanex launched a \$970 million compensation claim against the US—the claim was ultimately denied (UNCITRAL Tribunal 2005).<sup>1</sup>

These lawsuits surprised environmentalists as there is a presumption that regulations designed to protect human health and the environment are granted a standing exemption from compensation rules; this standing exemption is known as a Police Powers Carve-Out (PPCO).<sup>2</sup> However, language in the investment chapter (Chapter 11) of the North American Free Trade Act (NAFTA) challenges this carve-out, stipulating that any “measure tantamount to nationalization or expropriation”<sup>3</sup> is compensable irrespective of motive.<sup>4</sup>

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<sup>1</sup>A lawsuit launched by Canadian mining company Glamis Gold against new backfilling laws enacted in California to protect native sacred sites is still pending (U.S. Department of State 2005a).

<sup>2</sup>In most countries outright expropriation is compensable by law. In the United States the 5th Amendment makes compensation a constitutional right. While the Canadian constitution makes no mention of compensation, compensation is often paid for outright expropriation unless explicitly prohibited by legislation.

Compensation for *de facto* expropriation is far less common, although there have been isolated cases. In *Ramey v. Canada* and *Lucas v. South Carolina Coastal Council* (US) property owners were compensated for lost use or property value resulting from zoning changes; in *Queen v. Tener, Casamiro Resource Corp. v. British Columbia* and *Rock Resources, Inc. v. British Columbia* (Canada) and *Pennsylvania Coal Co. v. Mahon* (US), claimants were compensated for legislation that effectively restricted access to subsurface mineral rights; see Christie (2007). Similarly, in *Manitoba Fisheries Ltd v. The Queen* a Canadian fish exporting firm was compensated for lost “goodwill” when the Canadian government granted monopoly power over fish exports to a Crown Corporation. We do not know of any extant cases in which governments have been forced by *domestic* courts to compensate owners for losses associated with environmental regulation; however, as mentioned below, a number of legislative bills concerning compensation for compliance with the US’s Endangered Species Act would open the door for such claims.

<sup>3</sup>*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 1, emphasis added.

<sup>4</sup>Some commentators argue this language was never meant to include health or environmental regulations. At least in retrospect, Daniel Price, lead negotiator for the United States on Chapter 11, disagrees. He writes “[f]or example, assume that an investor undertakes an activity that is approved by society and determined to be beneficial. However, on the basis of new scientific evidence, the government subsequently determines that the behavior is harmful and should be prohibited. It must be decided in this case whether the government should be permitted simply to put the investor out of business without paying compensation - an act which

There have also been attempts to overturn the PPCO for environmental regulation in domestic contexts. For example, bills have been introduced into the US Congress that would render compensable losses in property values arising from the Endangered Species Act (ESA), the Clean Water Act and the Farm Bill.<sup>5,6</sup>

The legal applicability of the PPCO to environmental regulation or to other laws that might be interpreted as *de facto* expropriation, also known as regulatory takings, will ultimately be settled by case law.<sup>7</sup> We ask whether a PPCO is economically efficient when regulators suffer fiscal illusion and there is asymmetric information between regulators, investors, and the courts hearing their claims. Although our approach is motivated by cases involving international investors and environmental regulation, the principles we elucidate are quite general.

That regulators suffer fiscal illusion with respect to profits lost by foreign investors is uncontroversial. National, state, and municipal governments are elected to maximize local welfare, not the joint welfare of citizens and foreign investors; accordingly, government is likely to discount the regulatory costs borne by subsidiaries of foreign multinationals. Indeed, the potential for foreign investors to be politically disenfranchised is the major argument used in favor of the adoption of a regulatory takings doctrine in international

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would adversely affect not only the investor but also the employees of the enterprise and possibly the local economy. Alternatively, a tribunal may decide - correctly in the vast majority of cases - that the government must compensate the investor and so spread the cost of the regulatory measure. Simply designating a government measure as a conservation measure, or a health and safety measure, does not answer the basic question about who should bear its costs, and should not be enough to remove that measure from international investment disciplines.” (Price 2000, p. 425)

<sup>5</sup>Innes (2001, p.263) reports three such bills: H.R. 925, S. 605, and H.R. 2275. More recently, H.R. 3824, titled the “Threatened and Endangered Species Recovery Act of 2005” was approved by the U.S. House of Representatives. Amongst other things, this bill authorizes compensation for landowners who “enter species recovery agreements”. Arguably, this would be compensation for actions currently required by the ESA under threat of penalty. Source: GovTrack.US <http://www.govtrack.us/congress/billtext.xpd?bill=h109-3824>)

<sup>6</sup>Ballot initiatives have also appeared in a number of US states mandating compensation for some forms of regulatory takings. For example, in 2004 Oregon voters passed Ballot Measure 37, entitling a property owner to compensation for new land use regulation that “has the effect of reducing the fair market value of the property” (*Oregon State Law 197.352* n.d., Subsection 1). However O.S.L. 197.352 explicitly acknowledges a PPCO for land use regulation “for the protection of public health and safety.” (Subsection 3)

<sup>7</sup>In the *Metalclad v. Mexico* case, the tribunal confirmed the language of the NAFTA treaty, ruling that expropriation includes “...incidental interference...even if not necessarily to the obvious benefit of the host State.” (International Centre for Settlement of Investment Disputes 2000, para. 103). In contrast, in their summary of findings a different tribunal adjudicating the *Methanex v. USA* case upheld the principle of a PPCO: “...as a matter of general international law, a non-discriminatory regulation for a public purpose, which is enacted in accordance with due process and, which affects, inter alia, a foreign investor or investment is not deemed expropriatory and compensable...” (UNCITRAL Tribunal 2005, p. 278). Because precedence does not have the same standing in international law as in some domestic courts the *Methanex* ruling does not reinstate the PPCO for future NAFTA lawsuits.

investment law. Of course fiscal illusion is not exclusive to foreign investment; regulators may also suffer fiscal illusion with respect to local investors if their mandates are sufficiently narrow.<sup>8</sup>

Making regulators pay compensation for regulatory takings is one way of disciplining regulators. An alternative is to grant a PPCO for bona fide regulation. Miceli and Segerson (1994) propose an Ex Post rule under which a regulator is exempt from paying compensation if and only if the taking is socially efficient. Assuming a full information environment in which courts can perfectly observe the social costs and benefits of a taking, they find that a PPCO leads to efficient regulation.

Miceli and Segersons's analysis is not applicable if regulators cannot (or do not want to) credibly convey to the courts their true estimates of the social benefits from regulation, i.e. if there is asymmetric information. This issue is important when it comes to new environmental regulation. In many of the cases discussed above, regulators were obliged to take action in the presence of scientific uncertainty, drawing judgements from a body of inconclusive and often conflicting scientific research.<sup>9</sup> Moreover, even regulators without protectionist or NIMBY (not-in-my-backyard) motives cannot be sure the courts will interpret the body of evidence in the same way. Accordingly, regulators have an incentive to mount the most favorable defense possible by entering as evidence the most extreme point estimates of anticipated harm, even if the regulators did not place full weight on these estimates during their own deliberations. In short, we expect there to be some information private to regulators.

In Section 4 we show that an appropriately designed PPCO induces efficient regulation despite fiscal illusion even when there is asymmetric information.<sup>10</sup> One of the features of the appropriate PPCO is that,

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<sup>8</sup>For example, although the US's Endangered Species Act requires its Secretary to consider economic costs when determining critical habitat, whether a species gets listed in the first place must be based "solely on the basis of the best scientific and commercial data available...." (Endangered Species Act of 1974, Section 4.b.3; see also Innes, Polasky and Tschirhart (1998, p.47).

<sup>9</sup>In the Ethyl Corp v. Canada case, the gasoline additive in question was eventually exonerated, and many bans on its use in the United States were ultimately reversed; at the time of Canada's import ban, however, the scientific evidence in place suggested the additive could be harmful.

<sup>10</sup>Hermalin (1995) also examines compensation schemes when information is asymmetric and the regulator suffers fiscal illusion. Hermalin's analysis allows for strategic investors—our baseline model does not—but excludes the possibility of a PPCO. Hermalin argues that efficient investment and regulation are possible if the state can "demand payments from its citizens in exchange for not taking their property." (p.75) Nosal (2001) similarly proposes a scheme involving a transfer from individuals to the state. We do not grant the regulator the power to extract payments from landowners or investors, as this would generate its own moral hazard problem.

in states of the world where a regulator does end up paying compensation, the amount paid must exceed the damages suffered by the plaintiff. The question of how large compensation should be has concerned economists and legal scholars for decades. Blume, Rubinfeld and Shapiro (1984) (hereafter referred to as BRS) show that compensation insures investors against states of the world in which their land would have higher value in the hands of government; as a result, property owners over-invest if they are guaranteed compensation for subsequent takings. BRS show that lump-sum compensation remedies the compensation-as-insurance problem. In Section 5.1 we combine their lump-sum compensation prescription with a PPCO to show there exists a linear compensation scheme that induces both efficient regulation and firm level investment if investors are non-strategic.

Unlike previous research on Takings, we also examine the effect compensation and a carve-out have on entry (Section 5.2). Even lump sum compensation transfers rents from society to investors and thus is an implicit subsidy to industries subject to regulatory risk. This subsidy generates excessive entry into those industries. This section of our paper is particularly relevant in the context of international investment treaties. Because the treaties provide better compensation for regulatory takings than domestic laws, they promote entry by foreign firms at the expense of domestic firms, i.e. they create a non-level playing field. Moreover, National Treatment rules in these treaties (which require that host governments treat foreigners no less favorably than domestic investors) prevent host governments from charging foreigners up front taxes that would offset this implicit subsidy. Broadening the carve-out tends to reduce the size of the implicit transfer to investors, so granting a PPCO can mitigate the entry problem.

## **2 Model**

This section first describes the model and then studies the benchmark of socially efficient regulation and investment.

## 2.1 Agents

There are three agents in our model, a representative *investor*, a *regulator*, and a *court*. All agents are risk neutral.

The perfectly competitive *investor* chooses investment level  $k$  taking the rental price for capital,  $r$ , as given. Here we treat the number of firms in the industry (normalized to 1) as given. Section 5.2 analyzes the entry decision. An investor whose project is not regulated earns variable profits  $\pi(k)$ , where

$$\pi(k) = pq - c(k, q);$$

$q$  is output and  $c$  is a cost function that is increasing in  $q$  and decreasing in  $k$ . The equilibrium price and quantity are  $p(k)$  and  $q(p)$ , with  $p(k) = c_q(q, k)$ . Let  $U(p(k))$  denote consumer surplus while social surplus from the project is  $S(k) = U + \pi$ . Because firms are price takers,  $S'(k) = -c_k(q, k)$  evaluated at  $q = q(p(k))$ . We do not concern ourselves with possible general equilibrium consequences—changes in input prices for example—from regulation in this market.

The *regulator* decides whether to shut the project down. If the project goes unregulated the investment causes harm  $H$ ;<sup>11</sup> we refer to this harm as *environmental damage*, but other interpretations are equally valid. Regulation causes a loss of surplus  $S(k)$  and avoids the environmental cost  $H$ , and prompts an investor claim for compensation. The *court* determines whether the regulator must compensate the investor and the size of the compensation payment.

In practice there are numerous sources of uncertainty surrounding environmental regulation. Prior to the project the precise amount of ensuing environmental harm is unknown to all;<sup>12</sup> when government decides whether to shut down the project, some new evidence may be available concerning the extent to which the

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<sup>11</sup>In practice, the harm arising when the project is unregulated may be a function of  $k$ . In footnote 20 we show that in such cases an additional policy tool—a capital tax—is appropriate.

<sup>12</sup>In practice the firm may have different expectations over  $H$  than the regulator. While interesting—especially in games where host governments have the option of forbidding specific projects—the possibility of asymmetric *a priori* expectations over  $H$  is outside the scope of our model.

project causes harm but some uncertainty may linger. Moreover, when regulating the government does not know whether the courts will draw similar conclusions on the extent of harm suffered. We model all these forms of uncertainty as follows. When the investor chooses  $k$ ,  $H$  is a non-negative random variable with PDF  $f(H)$  and CDF  $F(H)$ . When the regulator decides whether to shut down the project, she knows the realized value of  $H$  but the courts do not. Instead, the court observes a noisy signal of harm,  $\eta H$ ; when the regulator decides whether to shut down the project,  $\eta$  is a random variable with PDF  $g(\eta)$  and CDF  $G(\eta)$ .<sup>13</sup>

The three stages of the model are as follows:

- First Stage [Investment]: the investor chooses investment level,  $k$
- <Nature reveals  $H$  to regulator>
- Second Stage [Regulation]: the regulator decides whether to regulate
- <Nature reveals  $H\eta$  to the court>
- Third Stage [Arbitration]: the court decides whether the regulator must pay compensation.

We use the following terms:

**Ex ante expectation:** expectation before any uncertainty is resolved

**Second stage expectation:** expectation after the level of harm is realized but before the noise in the court's signal is realized

**Ex post efficiency:** efficient given investment level  $k$  and realized harm  $H$

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<sup>13</sup>Our model does not allow for asymmetric information regarding investor profits. This restriction is reasonable when the entity impacted by regulation is a firm: the market price or share value captures the value of the "taken" enterprise. This assumption is less defensible when the subject is a household facing new restrictions on the use of private property.



## 2.2 Benchmark—Socially efficient regulation and investment

Regulation is ex post efficient if and only if  $H > S(k)$ ; the probability of (efficient) regulation is therefore  $1 - F(S(k))$ . 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

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

We use  $*$  to denote the optimal level of a variable or function, so  $k^*$  is the socially optimal level of investment and  $F^* = F(S(k^*))$ . For convenience we assume  $F^*\pi^* - rk^* > 0$ : the firm's variable profits are positive under socially efficient investment and regulation.

The following sections analyze regulation and investment in the decentralized setting. As usual we begin our analysis with the final stage of the game.

## 3 Arbitration

The court observes a noisy signal,  $H\eta$ , of damages where  $\eta$  is a random variable. For simplicity of exposition we assume that the support of  $\eta$  is the positive half-line, except where we explicitly state otherwise. We also assume that the distribution of  $\eta$  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  $G(1) = 0.5$ .

The court applies the following rule: if  $\eta H > \chi(k)$  then the regulator need not compensate the investor.

If instead  $\eta H \leq \chi(k)$  then the regulator must pay the investor compensation  $\theta(k)$ .

The function  $\chi(k)$  is the minimum level of the damage signal necessary for the court to accept a *police powers* defense from the regulator; a court who observes damage  $\eta H < \chi(k)$  rejects the police powers defense and requires compensation be paid. Thus, 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. Denote the carve-out/compensation scheme applied by the court as  $M(k, H\eta)$ :

$$M(k, H\eta) = \left\{ \begin{array}{l} 0 \text{ if } H\eta > \chi(k) \\ \theta(k) \text{ if } H\eta \leq \chi(k) \end{array} \right\}. \quad (2)$$

We assume  $M$  is predetermined by either the law of the land or an international investment agreement; the court has no discretionary power when adjudicating cases. We design  $M$  in order to induce efficient regulation and investment, conditional on previous entry; we endogenize entry in Section 5.2.

## 4 Regulatory Stage

A regulator who values a dollar of lost profits less than a dollar of consumer surplus or a dollar of environmental damage has “fiscal illusion”. We model fiscal illusion using the parameter  $\beta \in [0, 1]$ .  $\beta$  is the weight the regulator gives to a dollar of investor payoffs, relative to a dollar of consumer welfare or environmental harm;  $1 - \beta$  reflects the regulator’s degree of fiscal illusion.<sup>14</sup>

When deciding whether to shut down the project, the regulator knows  $H$  but not  $\eta$ . In the absence of

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<sup>14</sup>Brennan and Boyd (2006) employ a political support model to endogenize fiscal illusion. They argue in favor of manipulating compensation levels so as to encourage participation by under-represented parties. We abstract from political economy concerns and treat  $\beta$  as exogenous.

regulation, the regulator's payoff is

$$V^N(k, H) = U(k) + \beta\pi(k) - H$$

and with regulation the expected payoff is

$$V^R(k, H) = -[1 - \beta]E_\eta(M(k, H\eta)) = -[1 - \beta]\theta(k)G\left(\frac{\chi(k)}{H}\right).$$

The regulator shuts down the project if and only if

$$V^N = U(k) + \beta\pi(k) - H < -[1 - \beta]\theta(k)G\left(\frac{\chi(k)}{H}\right) = V^R, \quad (3)$$

or, equivalently,

$$V^N = S(k) - [1 - \beta]\pi(k) - H < -[1 - \beta]\theta(k)G\left(\frac{\chi(k)}{H}\right) = V^R. \quad (4)$$

**Proposition 1** *Under the compensation rule*

$$\theta(k) = \frac{\pi(k)}{G\left(\frac{\chi(k)}{S(k)}\right)} \quad (5)$$

*the regulator shuts down the project if and only if it is ex post efficient to do so.*

**Proof.** Regulation is ex post efficient if and only if  $S(k) - H < 0$ . The regulator will shut down the project if and only if  $V^N < V^R$ . Substituting  $\pi(k)/G\left(\frac{\chi(k)}{S(k)}\right)$  for  $\theta(k)$  in equation (4) implies regulation

occurs if and only if  $S(k) - H - (1 - \beta) \pi(k) \left( 1 - \frac{G\left(\frac{\chi(k)}{H}\right)}{G\left(\frac{\chi(k)}{S(k)}\right)} \right) < 0$ . Since  $G$  is a non-decreasing function,

$$1 - \frac{G\left(\frac{\chi(k)}{H}\right)}{G\left(\frac{\chi(k)}{S(k)}\right)} \begin{cases} > \\ = \\ < \end{cases} 0 \text{ for } H \begin{cases} > \\ = \\ < \end{cases} S(k)$$

Therefore, the regulator will shut down the project if and only if  $H > S(k)$ . ■

The following Remarks follow from equations (4) and (5).

**Remark 1** For  $\beta < 1$ , all carve-out schemes that induce efficient regulation require that the regulator's expected compensation equals the firm's lost profits  $\pi(k)$  when  $H = S(k)$

This result mirrors a general principle in enforcement economics: “[t]he optimal fine equals the harm, properly inflated for the chance of not being detected” (Polinsky and Shavell 1992, p.133). In our setting, the compensation rule (5) does not lead to full cost-internalization for *all* realized  $H$ . When  $H > S(k)$ , for example, the regulator's expected compensation payout is less than  $\pi(k)$ . This inequality makes shutting down the project more attractive to the regulator than to a social planner. However, because this *under*-internalization only occurs when  $H > S(k)$ —i.e. when the project should be shut down anyways—the regulator's actions are ex post efficient.<sup>15</sup>

**Remark 2** Define strict compensation as  $M(k, H\eta) = \pi(k) \forall \eta$  (i.e.  $\chi(k) = \infty$ ); strict compensation induces efficient regulation.

The language of NAFTA's Chapter 11 suggests there should be no carve-out even for bona fide environmental regulation; investors are always entitled to compensation equal to the market value of the “taken” firm

<sup>15</sup>Similarly, when  $H < S(k)$  the regulator's (second stage) expected payout is greater than  $\pi(k)$ , making regulation less attractive to the regulator than it would be to a social planner.

or property. This interpretation matches our definition of *strict compensation*. Remark 2 states that a strict compensation rule induces efficient regulation. Section 5.1 shows that it also induces over-investment.

**Remark 3** *The compensation scheme that induces ex post efficient regulation given carve-out  $\chi(k)$  is independent of  $\beta$  provided  $\beta < 1$ .*

The appropriate penalty for correcting the regulator's fiscal illusion does not depend on the magnitude of fiscal illusion. This conclusion follows from equation (4): the regulator's decision rule is identical to the social planner's at the pivotal damage level  $H = S(k)$  only when the expected penalty equals  $\pi(k)$ . Since the probability that the police powers defense is rejected is independent of  $\beta$ , so is the compensation rule necessary for ex post efficiency.<sup>16</sup>

The discussion above focuses on cases where  $\beta < 1$ , although the compensation rule in equation (5) also induces efficient regulation if  $\beta = 1$ . In this case, though, there are an infinite number of compensation schemes that induce efficient regulation, because the regulator views any outlays as mere transfers. With this in mind, from here forward we restrict our attention to cases with  $\beta < 1$ .

**Remark 4** *When there is noise in the court's damage signal (i.e. the support of  $\eta$  is not degenerate), any compensation scheme that involves a carve-out ( $\chi(k) < \infty$ ) requires  $\theta(k) > \pi(k)$ .<sup>17</sup> Moreover, there are*

<sup>16</sup>Remark 3 begs an interesting question. If the problem is that the regulator fails to internalize the fraction  $[1 - \beta]$  of the investor's costs, why isn't the appropriate solution a penalty with expected value  $[1 - \beta]\pi(k)$ , i.e. a penalty equal to the uninternalized externality from regulation? The answer lies with *revenue recycling*. The entire penalty is recycled to the investor, whose welfare receives weight  $\beta$  in the regulator's objective function. Thus, the fraction  $\beta$  of any penalty  $Y$  is viewed as a benefit from the regulator's perspective. When  $Y = [1 - \beta]\pi$  the regulator sees  $\beta[1 - \beta]\pi$  as a benefit from regulation and so will want to shut down the project too often (i.e. at some  $H$  less than  $S(k)$ ). Of course the mechanism designer could attempt to correct for this recycling effect by topping up the penalty, setting the penalty equal to  $Y_1 = [1 - \beta]\pi + \beta[1 - \beta]\pi$ , but as long as the full value of the penalty goes to the investor there will be the same feedback effect. Continuing ad infinitum suggests the appropriate penalty would equal  $Y_\infty = [1 - \beta]\pi + \beta[1 - \beta]\pi + \beta^2[1 - \beta]\pi + \dots$ . Using the property  $1 + \beta + \beta^2 + \dots = \frac{1}{1 - \beta}$  we see that the only penalty inducing full cost internalization at  $H = S(k)$  in the presence of revenue recycling and fiscal illusion is a penalty with expected value of  $\pi$ .

<sup>17</sup>This statement relies on the assumption that the support of  $\eta$  is unbounded above. Suppose instead that the least upper bound of the support of  $\eta$  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 regulator's ex ante expected savings relative to the strict carve-out is

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

*states of the world in which the court commits a type II error, i.e. the courts reject a valid police powers defense.*

For  $H > S(k)$ ,  $G\left(\frac{\chi(k)}{H}\right)$  measures the probability, conditional on  $H$ , that the court commits a type II error. Provided that  $\chi(k)/H$  is greater than the lower bound of the support of  $\eta$ , the probability of a type II error is positive. Thus, there are states of the world in which the regulator must compensate the investor even though the courts know that regulation is always socially efficient in equilibrium. Moreover, when compensation is paid it exceeds actual damages, unlike the rule in Miceli and Segerson (1994). Both their and our models predict efficient regulation; however because they assume that harm is perfectly observable, in their setting cases are never brought to tribunals and compensation is never paid. In fact, we observe that a large number of cases have been brought against host states for regulatory takings under bilateral investment treaties.<sup>18</sup> Consistent with Miceli and Segerson (1994)'s model, legal theory had suggested that there should not be any cases. Our model reflects current experience in international law by allowing courts charged with adjudicating takings cases to receive only noisy signals of the social benefits from takings.

**Remark 5** *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.*

If  $\chi(k) > S(k)$  the regulator pays compensation for  $H \in (S(k), \chi(k)]$  even though the court knows that regulation is socially optimal. This rule is a variant on Miceli and Segerson's Ex Post rule; our variant stipulates that, when the court observes  $H$  perfectly, any rule that renders the regulator liable for compensation whenever realized  $H$  is less than  $S(k)$  induces efficient regulation.

**Remark 6** *If the firm generates no externalities but there are non-pecuniary benefits  $B$  from shutting down the project, where  $B$  is a random variable with PDF  $f$  and CDF  $F$ , then regulation is ex post efficient whenever the carve-out/compensation scheme satisfies equation (5).*

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<sup>18</sup>At least 27 such cases—not all having to do with the environment—have been brought under the expropriation clause in NAFTA alone.

In much of the Takings literature, the continued operation of the firm does not cause damages, but precludes benefits  $B$  that would arise if the property were in public hands. At least with regards to expectations formed after the realization of  $H$  (or  $B$ ), this approach is mathematically equivalent to ours; eliminating the  $H$  term from  $V^N$  and adding a  $B$  term to  $V^R$  confirms this claim. Provided that the compensation scheme satisfies equation (5), the carve-out is ex post efficient regardless of whether regulation is defensive—as with environmental and other regulations designed to limit externalities—or proactive as with conventional takings and seizures.

#### 4.1 Compensation as a transfer to industry

Remark 4 identifies the regulator’s burden under a carve-out/compensation scheme given a realized harm level  $H$ . In this subsection we examine the relationship between carve-out breadth and the regulator’s burden *before* the level of harm has been realized (but after the firm has chosen  $k$ ). The size of the regulatory burden—and the corresponding implicit transfer to industry—is of obvious importance in equity considerations. As we argue in 5.2, the size of the transfer is also important for efficiency if industry size is endogenous.

Begin by defining

$$R(k, \chi(k)) = \int_{S(k)}^{\infty} G\left(\frac{\chi(k)}{H}\right) f(H) dH, \quad (6)$$

the ex ante probability that the regulator has to pay compensation, and

$$T(k, \chi(k), \theta(k)) = \theta(k)R(k, \chi(k)) = \int_{S(k)}^{\infty} \theta(k)G\left(\frac{\chi(k; \rho)}{H}\right) f(H) dH, \quad (7)$$

the regulator’s ex ante expected compensation outlay.

**Proposition 2** *Define  $T_s(k) = [1 - F(S(k))]\pi(k)$  as the transfer implicit in a strict compensation rule and  $T(k, \cdot)$  as the transfer implicit in any ex post efficient compensation scheme with a carve-out  $\chi(k)$ . If there*

exists  $H_o$  such that

$$G\left(\frac{\chi(k)}{S(k)}\right) > G\left(\frac{\chi(k)}{H_o}\right) \text{ and } f(H_o) > 0 \quad (8)$$

then  $T(k, \cdot) < T_s(k)$ .

**Proof.** By equation (5)

$$T(k, \cdot) = \frac{\pi(k)}{G\left(\frac{\chi(k)}{S(k)}\right)} \int_{S(k)}^{\infty} G\left(\frac{\chi(k)}{H}\right) f(H) dH = \pi(k) \underbrace{\int_{S(k)}^{\infty} \frac{G\left(\frac{\chi(k)}{H}\right)}{G\left(\frac{\chi(k)}{S(k)}\right)} f(H) dH}_{\Psi}.$$

Because  $\frac{G\left(\frac{\chi(k)}{H}\right)}{G\left(\frac{\chi(k)}{S(k)}\right)} \leq 1$  for all  $H \geq S(k)$  and by equation (8) there exists some  $H_o$  for which  $\frac{G\left(\frac{\chi(k)}{H_o}\right)}{G\left(\frac{\chi(k)}{S(k)}\right)} f(H_o) < f(H_o)$ , then  $\Psi < 1 - F(S(k))$ . ■

Proposition 2 confirms that some carve-out is cheaper for the regulator than no carve-out. Given that a carve-out offers the regulator a chance that takings will not be compensable, the outcome that a carve-out is cheaper in expectation for the regulator than no carve-out is not surprising. However we should point out this result is not a given, since the regulator pays more than lost profits whenever the court rejects the police powers defense. The key lies in the design of  $\theta(k)$ . As noted earlier,  $\theta(k)$  is chosen so that expected payout  $\theta(k)G\left(\frac{\chi(k)}{H}\right)$  exactly equals  $\pi(k)$  when realized  $H$  equals  $S(k)$ ; thus, when realized  $H$  is greater than  $S(k)$ —i.e. in all cases in which regulation actually occurs—the expected payout is less than  $\pi$ . Integrating over  $H > S(k)$  yields  $T(k, \cdot) < [1 - F(S(k))]\pi(k)$ .

Next, we ask how broadening an existing carve-out affects the regulator's expected payout. We answer this question in three steps. We begin by showing that broadening the carve-out raises the compensation level  $\theta(k)$  necessary for ex post efficient regulation. We then obtain a necessary and sufficient condition under which broadening the carve-out decreases the expected payout conditional on the realization of  $H$ . This condition depends on the curvature of the noise CDF. Our third step gives a necessary and sufficient



condition under which a broader carve-out reduces the unconditional expected payout,  $T$ . We show that for some distributions this condition is always satisfied, but for other distributions and parameter values a broader carve-out increases the expected payout.

**Step 1: the relationship between  $\theta(k)$  and  $\chi(k)$**

Broadening the carve-out lowers the conditional probability courts reject the PPCO defense. Ceteris paribus, this change lowers the regulator’s expected costs from regulation, causing the regulator to regulate more often. Thus, in order to maintain regulatory efficiency, a broader carve-out requires a higher  $\theta$  in order to satisfy equation (5). Define

$$\mu(\eta) \equiv g(\eta)\eta/G(\eta),$$

the elasticity of the noise CDF. We also introduce a parameter  $\rho$  in order to discuss a change that broadens 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  $\rho$  corresponds to a broader carve-out. Log differentiating equation (5) gives

$$\frac{\hat{\theta}}{\hat{\rho}} = -\mu \left( \frac{\chi(k; \rho)}{S(k)} \right) \frac{\chi_\rho(k; \rho)\rho}{\chi(k; \rho)} > 0 \tag{9}$$

where the hat “ $\hat{\cdot}$ ” indicates percentage change, e.g.  $\hat{\rho} = d\rho/\rho$ . Equation (9) confirms that broadening the carve-out requires higher compensation.

**Step 2: Second stage expected compensation payment**

The curvature of  $G(\cdot)$  (the CDF of the noise in the court’s signal) evaluated at  $\frac{\chi(k)}{S(k)}$  determines the relationship between  $\theta$  and the breadth of the carve-out. The relation between the breadth of the carve-out and the

second-stage expected compensation payment,  $\theta(k)G\left(\frac{\chi(k;\rho)}{H}\right)$ , also depends on the shape of  $G(\cdot)$  evaluated at  $\eta = \chi(k)/H$ . The following lemma and proposition use distributions with unbounded support, but it is straightforward to confirm that the results are unchanged when  $\eta$  or  $H$  have finite supports.

**Lemma 1** *For  $H > S(k)$ , broadening the PPCO lowers the regulator's (second stage) expected payout  $\theta(k)G(\chi(k)/H)$  if and only if  $\mu(\chi(k;\rho)/H) > \mu(\chi(k;\rho)/S(k))$ .*

**Proof.**

$$\begin{aligned} \frac{d}{d\rho}\theta(k)G\left(\frac{\chi(k;\rho)}{H}\right) &= \frac{\theta(k)G\left(\frac{\chi(k;\rho)}{H}\right)}{\rho} \left[ \mu\left(\frac{\chi(k;\rho)}{H}\right) \frac{\chi_\rho(k;\rho)\rho}{\chi(k;\rho)} + \hat{\theta} \right] \\ &= \frac{\theta(k)G\left(\frac{\chi(k;\rho)}{H}\right)}{\rho} \frac{\chi_\rho(k;\rho)\rho}{\chi(k;\rho)} \left[ \mu\left(\frac{\chi(k;\rho)}{H}\right) - \mu\left(\frac{\chi(k;\rho)}{S(k)}\right) \right]. \end{aligned}$$

■

### Step 3: The relationship between $T$ and $\chi(k)$

We now discuss the relation between the breadth of the carve-out and the ex ante expected payout,  $T$ , defined in equation (7). Broadening the carve-out makes compensation less likely but larger when it is paid. The effect of the carve-out on  $T$  depends both on how the elasticity of  $G$  varies along its support and on the distribution of  $H$ , as the following proposition describes:

**Proposition 3** (a) *Within the class of compensation schemes that induce efficient regulation, a necessary and sufficient condition for a broader carve-out to reduce the regulator's expected payment  $T(\chi(k;\rho))$  is*

$$\int_{S(k)}^{\infty} \left[ \mu\left(\frac{\chi(k;\rho)}{H}\right) - \mu\left(\frac{\chi(k;\rho)}{S(k)}\right) \right] G\left(\frac{\chi(k;\rho)}{H}\right) f(H) dH > 0 \quad (10)$$

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

**Proof.** (a) Differentiating  $T$  with respect to  $\rho$ , factoring out the  $\theta \frac{\chi_\rho}{\chi}$  terms (which are independent of  $H$ ), and converting to elasticities gives

$$\frac{dT(\chi(k; \rho))}{d\rho} = \theta(k) \frac{\chi_\rho}{\chi} \int_{S(k)}^{\infty} \left[ \mu \left( \frac{\chi(k; \rho)}{H} \right) - \mu \left( \frac{\chi(k; \rho)}{S(k)} \right) \right] G \left( \frac{\chi(k; \rho)}{H} \right) f(H) dH.$$

Because  $\theta \frac{\chi_\rho}{\chi}$  is negative, inequality (10) is a necessary and sufficient condition for  $dT/d\rho < 0$ .

(b) If  $\mu$  is a decreasing function of  $\eta$  then  $\mu \left( \frac{\chi}{H} \right) > \mu \left( \frac{\chi}{S(k)} \right)$  for all  $H > S(k)$ . ■

The function  $\mu$  decreasing in  $\eta$  is a sufficient condition for  $T$  to be decreasing in the breadth of the carve-out: when  $\mu'(\eta) < 0$ , the second-stage expected payout is decreasing in the breadth of the carve-out for all  $H$ , so the ex ante expected transfer must also be decreasing. However, as part (a) points out, even if  $\mu$  is not monotone decreasing in  $\eta$  it is still possible for  $dT/d\rho$  to be negative so long as any harm levels at which  $\mu(\chi/H) < \mu(\chi/S)$  are sufficiently unlikely.

We know from Proposition 2 that a carve-out leads to lower expected costs for the regulator, compared to no carve-out. Therefore, it is not possible—for any distribution of  $\eta$ —that broadening the carve-out *always* increases the regulator'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 (10) 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 (10) as

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

We assume that  $\chi > 0$ , so a broader carve-out increases the regulator's expected costs if and only if  $\Theta < 0$ . Define  $y$  as the probability that the court rejects the police powers defense when  $H = S$ . Suppose that  $b = 2 = \sigma$ . Figure 1 shows the graph of  $y$  as a function of the carve-out  $\chi$  (the solid curve) and the graph

of  $10\Theta$ . For this example,  $\Theta < 0$  iff  $\chi < 2.45$ , at which value  $y \approx 0.77$ . Thus, the regulator 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.

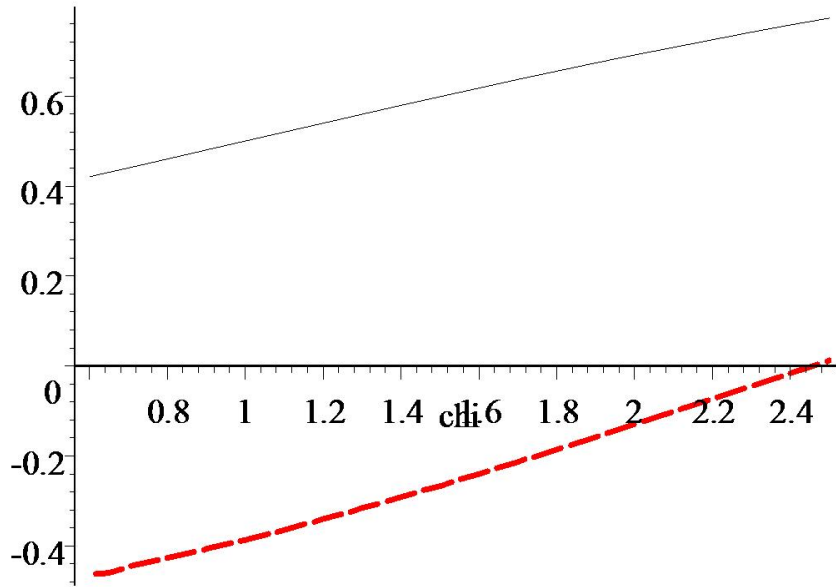


Figure 1: Solid curve: graph of probability that court rejects police powers defense when  $H = S$ . Dashed curve:  $10\Theta$

The sufficient condition for the regulator 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  $\eta$  or (b) decreasing for  $\eta$  sufficiently large. The sufficient condition that  $\mu(\eta)$  is decreasing for  $\eta \geq \frac{\chi(k;\rho)}{S(k)}$  is easier to satisfy if  $\chi(k)$  is large, i.e. if the carve-out is narrow. This observation is consistent with Proposition 2, which states that some carve-out is always better for the regulator 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 7** 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 distribution, a sufficient condition for  $\mu(\eta)$  to be decreasing is that  $\eta$  is greater than or equal to a constant that depends on the parameters of the distribution.<sup>19</sup> For the Normal distribution (with mean  $\bar{\eta}$  and variance  $\sigma^2$ ), 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  $\eta$  is Normal, Proposition 3 and Remark 7 imply that a broader carve-out (a smaller  $\chi(k)$ ) always benefits the regulator 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 regulator 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 regulator if  $\chi(k) \geq S(k)E(\eta)$ ; for the exponential, Weibull and (positive) Uniform distributions, a broader carve-out *always* benefits the regulator.

We summarize the results of this section as follows. It is possible to induce efficient regulation using a carve-out. Under any such scheme, the regulator's ex ante expected payout is less than it would be under a strict compensation rule. If the elasticity of the CDF of the court's observation error is a decreasing function of the realized error, then further broadening an already existing carve-out always decreases the regulator's expected payments. This condition always holds for some distributions, and it holds for sufficiently large observation shocks for other distributions.

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<sup>19</sup>The Beta density is  $\frac{\eta^{v-1}(1-\eta)^{w-1}}{B(v,w)}$ , where  $v$  and  $w$  are positive parameters, with  $E\eta = \frac{v}{v+w}$ . The constant mentioned in Remark 7 is  $\frac{v}{w+v} \frac{v+w}{w+v-1}$ .

## 5 Investment and Entry

A carve-out for seemingly bona fide regulation can solve the fiscal illusion problem even in the presence of asymmetric information. However, as we have already shown, the carve-out must be paired with a (punitive) compensation scheme. The prospect of compensation raises a concern voiced decades ago by BRS: a firm or land-owner promised compensation for takings may not internalize the full risk of that taking, investing too much as a result. Below, we show that a PPCO can be paired with a linear compensation scheme that solves the compensation-as-insurance problem at the firm level. However we point out that, even when compensation is effectively *lump-sum*, the fact that expected compensation is positive creates an *entry* problem that has been previously ignored in the Takings literature. We provide a simple extension of our basic model to illustrate that the entry problem is mitigated by reducing  $T$ , arguing for some PPCO (versus no carve-out) on efficiency grounds.

### 5.1 Firm level investment

In this subsection we show that a PPCO that induces efficient regulation (i.e. satisfied (5)) can be paired with a compensation rule that solves the compensation-as-insurance problem identified in BRS; as is common in the Takings literature we restrict attention to linear compensation schemes. Throughout this section we assume the investor is non-strategic, i.e. the investor takes the probabilities of regulation and compensation as exogenous; an Appendix offers a limited analysis of the efficient compensation scheme when the investor is strategic. In Section 5.2 we examine the implications of the carve-out/compensation scheme for entry.

Let  $1 - \tilde{F}$  and  $\tilde{R}$  denote the ex ante probabilities of regulation and compensation. The non-strategic investor views  $\tilde{F}$  and  $\tilde{R}$  as parameters. The firm's expected profits are

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

and the firm's first order condition for investment is

$$\tilde{F}\pi'(k) + \tilde{R}\theta'(k) = r. \quad (11)$$

The probability that the court rejects the police powers defense must be positive; otherwise, the regulator would shut down the project even when it is not socially optimal to do so. Therefore,  $\tilde{R} > 0$ . This inequality, and comparison of equations (1) and (11) shows that the latter generates  $k^*$  if and only if

$$\theta'(k^*) = 0. \quad (12)$$

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

$$\theta(k) = \delta\pi(k) + \gamma rk \quad (13)$$

where  $\gamma$  and  $\delta$  are constants. For the linear compensation

$$\theta'(k^*) = -\delta c_k(q(p(k^*)), k^*) + \gamma r = -\delta c_k - \gamma c_k F^* = -(\delta + \gamma F^*) c_k,$$

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

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

so the linear compensation scheme reduces to

$$\theta(k) = \frac{\delta}{F^*}(F^*\pi(k) - rk). \quad (14)$$

Taking into account the different notation, this result reproduces Theorem 2 in BRS. Under this linear scheme, the firm's expected profits (including compensation) are

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

In summary, we have

**Remark 8** *The only linear compensation scheme that induces efficient investment for the domestic firm is equivalent to an ad valorem subsidy of  $\frac{R^*\delta}{F^*}$  on expected profits.*

Using equations (5) and (14), the carve-out is

$$\hat{\chi}(k) = S(k)\phi(k; \delta) \text{ with } \phi(k; \delta) \equiv G^{-1}\left(\frac{F^*\pi}{\delta(F^*\pi - rk)}\right) = G^{-1}\left(\frac{\pi}{\theta}\right). \quad (15)$$

Thus, under the linear compensation scheme with carve-out, there is a one-parameter family of rules, indexed by  $\delta$ , that induces the efficient level of investment and regulation. (The condition  $\theta > \pi$  requires  $\delta > \frac{F^*\pi(k^*)}{F^*\pi(k^*) - rk^*}$ .) 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 international and domestic law? 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” (NAFTA Article 1110, paragraph 2). That is, NAFTA requires “strict” compensation that depends only on variable profits,  $\pi$ , and ignores sunk costs,  $rk$ . However (like BRS) we find that market compensation is distortionary: unless compensation is lump sum or proportional to the investor's objective function absent



compensation, it induces excessive investment.<sup>20,21</sup> Conversely, Miceli and Segerson's Ex Post rule mandates market compensation, a result that is sensitive to the information environment. In their model the court perfectly observes social benefits and costs from a taking, and it awards compensation only when a taking is inefficient. Anticipating this, the government regulates/takes a project only if it is socially efficient; in equilibrium *compensation is never paid*. Under Miceli and Segerson's Ex Post rule with perfect information, the firms' expected payoff is  $F^*\pi - rk$ , so investment is efficient. In our model with asymmetric information, the ex ante probability of compensation must be positive, i.e.  $R > 0$ , to prevent excessive regulation. Under market compensation with  $R > 0$ , the firm's ex ante expected profits equal  $[F^* + R]\pi(k) - rk$ ; that payoff would lead to over-investment.

## 5.2 Entry and the size of the transfer

This subsection considers the impact of a carve-out/compensation scheme on industry size. A compensation scheme that implicitly transfers rents to an industry facing regulatory risk raises a familiar concern: when the number of participants is endogenous, compensation induces inefficiently high entry. The entry problem is well known in both regulatory economics<sup>22</sup> and the literature on strict liability versus negligence.<sup>23</sup> However the possibility that compensation—even lump sum compensation—can lead to inefficiently high entry has been ignored in legal and economic research concerning takings.

In this section we extend the model to include a 0<sup>th</sup> stage in which a continuum of entrants with hetero-

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<sup>20</sup>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, investors ignore the investment externality 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 is independent of  $\beta$ .

<sup>21</sup>Unlike BRS, under our compensation rule there are states in which regulation (a taking) occurs but the investor receives no compensation.

<sup>22</sup>Spulber (1985) argues that emission standards effectively subsidize dirty industry because firms don't have to pay for damage inflicted by inframarginal emissions.

<sup>23</sup>Negligence rules require injurers to compensate victims only in cases where the injurer fails to take due care. This renders any injuries that result when due care is taken non-compensable. Shavell (1980) and Polinsky (1980) argue that this exemption leads to inefficiently high market entry because entrants do not internalize costs from engaging in careful (but not risk-free) activity in the first place.

geneous entry costs decide whether to enter the industry. Our goal here is to show that offering investors some chance of being compensated for regulatory takings raises their expected returns from entry. Compensation induces some firms to incur the fixed costs associated with entry even though the expected social return from their entry is negative. Compensation payments induce inefficiently large industries as a result; hence reducing  $T$  when  $T$  is positive unambiguously raises social welfare.

Suppose there is a continuum of potential entrants uniformly distributed over the unit interval and indexed by  $n$ . Let  $I(n)$  denote the fixed cost of entry for firm  $n$ ; to make things simple we assume  $I$  is continuously differentiable in  $n$  and order firms so that  $I'(n) > 0$ . Let  $\bar{n}$  identify the firm just indifferent between entering and not in equilibrium;  $\bar{n}$  also measures the fraction of potential entrants who actually enter the industry in equilibrium.

We continue to assume firms are atomistic in input and output markets and define  $q$  and  $k$  as per firm output and variable investment; we assume the variable cost function  $c(q, k)$  is identical across firms. We further assume marginal cost  $c_q$  is increasing in  $q$ . Thus, for all entrants variable investment and output supply decisions are identical and satisfy  $r = -c_k(q, k)F$  and  $p = c_q(q, k)$  where  $p$  is the equilibrium price which satisfies the goods market equilibrium condition  $Q(p) = nq$  in which  $Q(p)$  is aggregate demand. Although we take  $r$  as exogenous, we allow equilibrium price to depend on the level of entry. We write equilibrium values as functions of  $\bar{n}$ :  $p(\bar{n})$ ,  $q(\bar{n})$ ,  $k(\bar{n})$ .

Define

$$W(\bar{n}) = F(S(\bar{n}))S(\bar{n}) - \bar{n}rk(\bar{n}) + \int_0^{S(\bar{n})} Hf(H)dH - \int_0^{\bar{n}} I(n)dn$$

as aggregate social welfare, where

$$S(\bar{n}) \equiv \int_0^{q(\bar{n})\bar{n}} p(Q)dQ - \bar{n}c(q(\bar{n}), k(\bar{n})).$$

This welfare measure implicitly assumes harm  $H$  is independent of the number of entrants and that regula-

tion is ex post efficient and satisfies the rule “regulate if and only if  $H > S(\bar{n})$ .” Compensation payments and receipts do not appear in  $W(\bar{n})$  as they are transfers from a social welfare perspective.

Differentiating  $W$  with respect to  $\bar{n}$  gives

$$\frac{dW}{d\bar{n}} = F(S(\bar{n}))[pq - c] - rk - I(\bar{n}).$$

Thus the marginal effect of entry on social welfare is merely the difference between the marginal entrant’s expected variable costs and her investment costs. This is negative whenever  $T > 0$ , since the marginal entrant’s fixed costs satisfy  $I(\bar{n}) = F(S(\bar{n}))[pq - c] - rk + T$ . Because reducing  $T$  inhibits entry<sup>24</sup>, broadening the carve-out unambiguously raises welfare whenever equation (10) holds.

In sum, when the size of a risky industry is endogenous, there is an efficiency argument for reducing the transfer implicit in compensation requirements. In cases where  $T$  is monotonically decreasing in carve-out breadth, the entry problem creates a reason for infinitely broadening the carve-out. However even when  $T$  is not monotonic in the carve-out, from Proposition 2 we see that there is an efficiency argument for granting some carve-out instead of requiring strict compensation.

### 5.2.1 Transfer size and international investment

Subjecting different classes of investors to different compensation rules can lower welfare. This rather obvious point is important because rules in NAFTA (and the 2200 other international investment agreements containing expropriation clauses) entitle only foreign investors to use the treaties to claim compensation for *de facto* expropriation. This compensation tilts the playing field in favor of foreign firms. Fairness concerns

<sup>24</sup>To verify, examine the expected payoff of the marginal entrant:

$$\left[ F + \int_S^\infty \frac{G(\chi/H)}{G(\chi/S)} f(H) dH \right] [pq - c] - rk - I(\bar{n}),$$

which is zero in equilibrium. Now consider an increase in the breadth of the carve-out. Holding  $\bar{n}$  constant, when (10) holds then broadening the carve-out reduces  $\int_S^\infty \frac{G(\chi/H)}{G(\chi/S)} f(H) dH$ , rendering the marginal entrants expected payoff negative. She will choose not to enter.

aside, this asymmetric treatment is inefficient when entry is endogenous. Consider the following scenario. Firms of a particular nationality are heterogeneous, differentiated by their fixed costs of entry. Firms of all types are rival in that they are linked through the output market. Absent compensation and assuming ex post efficient regulation, the market sorts firms, inducing entry by only the low cost firms of either nationality. When only foreign firms are entitled to compensation, foreign firms that choose to enter the market receive a subsidy on their ex ante variable profits. This subsidy induces entry by some high fixed cost foreign firms that would otherwise stay out; their entry crowds out some relatively efficient domestic firms that would otherwise enter. This outcome exhibits both too much entry and *allocative inefficiency* in which some of the *wrong* firms enter.

Concern that governments will actively tilt domestic playing fields to disadvantage foreign investors/firms is the prime rationale for National Treatment rules. These rules prevent governments from treating foreign goods/investors/firms less favorably than their domestic counterparts *in like circumstances*. National Treatment rules appear in almost all modern trade and investment treaties. Our analysis suggests the National Treatment and Expropriation clauses are contradictory: the latter causes domestic and foreign investors to be in “unlike circumstances”, but the former does not recognize this induced difference. We do not advocate that National Treatment rules be dropped, nor do we advocate that all investors be entitled to compensation for regulatory takings. Instead, the modest goal of this paper is show that granting a PPCO for environmental and other public regulations can induce efficient regulation and firm level investment; a PPCO can also provide some relief from the entry and level playing field problems inherent in expropriation/compensation rules.<sup>25</sup>

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<sup>25</sup>Other solutions to the entry and level playing field problems are also imperfect. If entrants were charged an up front “right of establishment” fee equal to  $T$  then the compensation scheme would be self-financing in expectation and offer a net expected subsidy of zero. However, introducing up front taxes creates its own moral hazard problem. A regulator/host government that is free to set the tax has an incentive to choose a tax greater than  $T$  in order to capture rents for the state at the expense of investors. Moreover, up front access fees cannot be used as solution to the level playing field problem created by NAFTA and other IIAs: charging foreign (but not domestic) firms a fee for the right to establishment would violate National Treatment rules.

### 5.3 The magnitude of the transfer: an example

We close this section by addressing the *magnitude* of the implicit transfer  $T$ . We restrict attention to equilibrium behavior (thus dropping  $k$  as an argument) and to the family of carve-out/compensation schemes satisfying equations (14) and (15). We treat  $\theta$  as the policy parameter; equation (15) determines  $\chi$  as a function of  $\theta$ . For brevity we once again treat entry as exogenous.

Choose units so that  $\pi^* = 1$ , so the condition  $\theta > \pi^*$  (by Remark 2) implies  $\theta > 1$ . The transfer to an investor under compensation level  $\theta$  is

$$T(\theta) = \theta \int_S^\infty G\left(\frac{G^{-1}\left(\frac{1}{\theta}\right)S}{H}\right) f(H) dH. \quad (16)$$

We noted that when the observation error is exponentially distributed, a larger carve-out decreases the regulator's expected payment. In order to get an idea of the magnitude of this effect, we consider the case where both the damage parameter  $H$  and the observation errors are exponentially distributed. Let  $g(\eta) = e^{-\eta}$  (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

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

so

$$T = \theta \int_S^\infty \left(1 - \exp\left(\frac{S \ln\left(\frac{\theta-1}{\theta}\right)}{H}\right)\right) \lambda e^{-\lambda H} dH. \quad (17)$$

The model has two primitive parameters,  $S$ , the social surplus at the efficient level of investment, and  $\lambda$ , the hazard rate for damages, and one policy variable,  $\theta$ . From Proposition 3 and Remark 7 we know that  $T$  is a decreasing function of  $\theta$ . From equation (17) we know that as  $\theta \rightarrow 1^+$ ,  $R \rightarrow 1 - F^*$ , i.e. the court

never accepts the police powers defense, so the regulator 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  $F^* = 0.89974$ , i.e. there is approximately a 10% chance of regulation. From the comments above, the upper bound on  $T$  (as  $\theta \rightarrow 1^+$ ) is  $1 - 0.89974 = 0.10026$  and the minimum value (as  $\theta \rightarrow \infty$ ) is  $\int_S^\infty \left(\frac{S}{H}\lambda e^{-\lambda H}\right) dH = 0.0748$ .

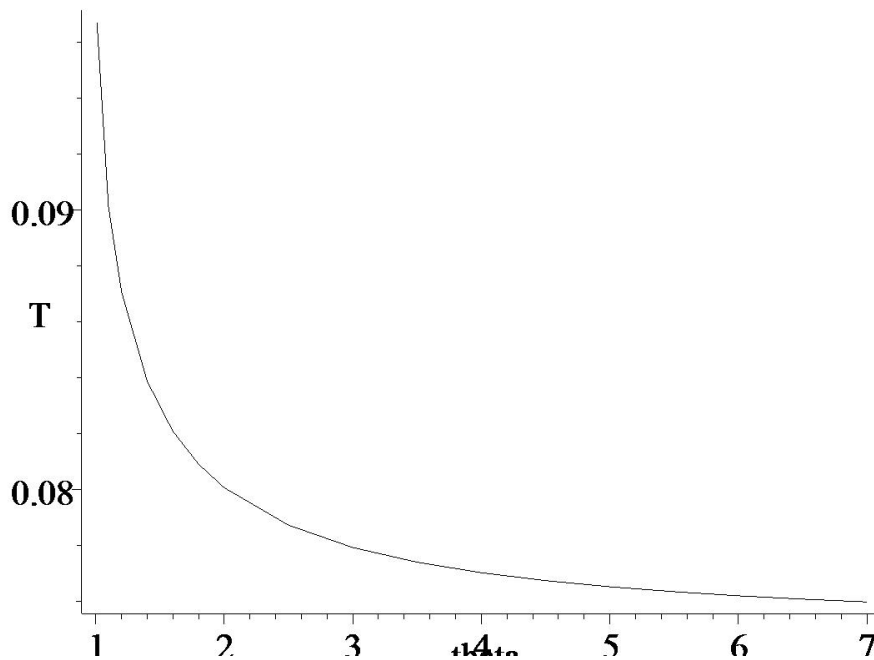


Figure 2: Expected transfer as a function of  $\theta$  for the exponential model with  $S = 1$  and  $\lambda = 1.15$ .

Figure 2 shows the expected transfer as  $\theta$  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 expected variable profits + compensation payments ( $F^*\pi + T$ ) range from 0.99999 to 0.97574. Expected consumer surplus less compensation payments ( $F^*(S - \pi) - T$ ) ranges from 0.7995 to 0.8237. Compare this to the case where

*regulation is efficient but there is no compensation paid (e.g. if  $\beta = 1$  and  $\theta = 0$ ), where the firm's expected variable profit is 0.9. Compensation reduces the value of consumer surplus minus compensation payments by 8.4% to 11% while the investor's profit rises by an equal percentage. These amounts bound the percentage chance of efficient regulation, 10%.*

Particularly worth noting is that  $T$  need not approach zero as the carve-out is infinitely broadened (i.e. as  $\theta \rightarrow \infty$ ). In this example at least, even the broadest carve-out scheme involves a positive expected transfer to the investor, implying that broadening the PPCO may mitigate the entry problem but will not solve it entirely.

## **6 Conclusion**

There is a valid efficiency argument for making regulatory takings compensable. When regulators suffer fiscal illusion, compensation requirements force them to internalize costs borne by investors and property owners. Compensation is a tool for inducing efficient regulation.

However compensation also distorts investment and entry decisions. As Blume et al. (1984) argue, basing compensation on market value insures investors against states of the world in which regulation is socially optimal. We point out that even when compensation packages are lump-sum, they serve as an implicit subsidy to industry facing regulatory risk, generating excessive entry.

This paper shows that a carve-out—a standing exclusion from compensation rules—for environmental and other public regulations can induce efficient regulation; when paired with an appropriate compensation package, the resulting carve-out/compensation scheme induces efficient firm level investment by non-strategic investors.

We explored the properties of such a carve-out/compensation scheme when the court has noisy information about the level of harm that regulation is designed to avoid. The court must be prepared to reject the

police powers defense in order to discourage excessive regulation. There are states of the world in which the court orders compensation even though it knows that in equilibrium regulation is socially efficient.

When the court rejects the police powers defense, the regulator pays damages exceeding investor losses. This compensation level reflects a standard result in the enforcement literature: if the probability a cheater goes unpunished is positive, then for a cheater who is caught the punishment must exceed the crime. In our model, the regulator has private information about the probability of being caught. Consequently, our carve-out/compensation scheme equates expected payouts and lost profits only at a particular margin; there, the harm equals the pecuniary benefit from the investment project, so social welfare is identical with and without regulation.

With this compensation structure, a broader carve-out (in general) has an ambiguous effect on the level of the expected transfer to firms. However, the expected transfer is lower under any carve-out, compared to under strict compensation (no carve-out). We obtained a sufficient condition under which a broader carve-out decreases the expected transfer. This condition always holds for a number of well-known distributions, and for other distributions it holds provided that the carve-out is not extremely broad. A lower expected transfer reduces the problem of excessive entry. It is also important to reduce the expected transfer if there is a deadweight cost of raising public funds (a feature that could easily be incorporated into our model).

Thus far Canadian and U.S. courts have accepted the police powers carve-out, but their status in international law is uncertain. When domestic courts accept a carve-out, but courts arbitrating disputes under International Investment Treaties Agreements (such as Chapter 11 of NAFTA) reject it, foreign investors obtain an advantage over national investors. In this case, there is tension between the Expropriation and the National Treatment clauses of International Investment Agreements.

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## Appendix: Strategic Investors

Our baseline models assumes investors are non-strategic. This assumption isn't problematic if industry contains many atomistic firms and regulation is industry wide. However in many instances only a subset of investors are subject to a takings—as when a tract of homes is seized to make way for a new road that will service homes remaining in the community—and so an investor may reasonably view the probability of regulation and compensation as a function of her own investment. Our goal in this section is to highlight obstacles to designing an efficient compensation scheme when investors are strategic. We note that the ex post efficiency of a carve-out satisfying equation (5) is unaffected by whether investors are strategic or not. In what follows we restrict attention to investors that have already chosen to enter the industry.

A strategic investor chooses  $k$  to

$$\max_k F(S(k))\pi(k) - rk + \theta(k)R(k)$$

where  $R(k)$  is defined in equation (6). Differentiating with respect to  $k$  and rearranging gives the first order condition

$$\underbrace{F(S(k))\pi'(k) - r}_{\text{“a”}} + \underbrace{\left[ \pi(k) - \theta(k)G\left(\frac{\chi(k)}{S(k)}\right) \right] f(S(k))S'(k)}_{\text{“b”}} + \underbrace{R(k)\theta'(k) + \int_{S(k)}^{\infty} G'\left(\frac{\chi(k)}{H}\right) \frac{\chi'(k)}{H} f(H)dH}_{\equiv \Delta(k)} = 0.$$

If regulation is ex post efficient, then by equation (5) the collection of terms denoted “b” equals zero. The collection of terms denoted “a” equals zero at the socially efficient level of investment  $k^*$ .

**Remark 9** Any scheme  $\{\theta(k), \chi(k)\}$  satisfying equation (5) and the following conditions induces efficient firm level investment:

C1.  $\Delta(k) = 0$  when evaluated at  $k^*$

C2.  $\Delta'(k) \leq 0$ ,

where C2 ensures the investor's objective function is concave.

If the court has a great deal of knowledge, for example if the court knows  $\pi(k^*)$  and  $S(k^*)$ , then fixing  $\chi(k) = \bar{\chi}$  for all  $k$  and offering lump sum compensation

$$\theta(k) = \frac{\pi(k^*)}{G\left(\frac{\bar{\chi}}{S(k^*)}\right)} \quad \forall k$$

induces efficient regulation and firm level investment. This solution requires that the court is able to calculate  $\pi$  and  $S$  at the efficient level of investment. A court that has this knowledge is able to deduce  $k^*$  and can use a much simpler mechanism: the rule “no compensation *unless*  $k = k^*$ ” as under Miceli and Segerson's (1994) Ex Ante Rule.

Our analytic framework is consistent with the assumption that the court has this level of knowledge. As a practical matter, though, it may be costly for the court to learn enough about the functions  $\pi(k)$  and  $S(k)$  to calculate  $k^*$ . We devote the remainder of this section to analyzing a PPCO-compensation scheme requiring the court only to observe the equilibrium values of  $\pi$  and  $S$ , i.e. a scheme that uses only market signals.

One seemingly obvious candidate is to set an absolute carve-out:  $\chi'(k) = 0$ , which by Remark 9 must be paired with  $\theta'(k^*) = 0$ . Differentiating  $\theta(k)$  under condition (5) gives  $\theta'(k) = \frac{-c_k}{G} \left[ 1 - \frac{\pi(k)}{S(k)} \mu \left( \frac{\bar{\chi}}{S(k)} \right) \right]$ , indicating  $\theta'(k) = 0$  at  $k^*$  if and only if  $\frac{\pi(k^*)}{S(k^*)} \mu \left( \frac{\bar{\chi}}{S(k^*)} \right) = 1$ . As this condition holds over a set of measure zero, we conclude that fixing the carve-out at a constant value and basing compensation on market information generally leads to inefficient firm level investment when investors are strategic. Having thus ruled out carve-out/compensation schemes exhibiting a fixed carve-out, we conclude that an efficient scheme must have a carve-out  $\chi$  and compensation scheme  $\theta$  that depend oppositely on  $k$ : if the “bar” for the police pow-

ers defense is increasing in investment, i.e.  $\chi'(k) > 0$  then compensation must be decreasing in investment.