

Police Powers, Regulatory Takings and the Efficient Compensation of Domestic and Foreign Investors*

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Modern international investment agreements have challenged the customary exclusion of public good regulations from being considered government ‘takings’ subject to compensation rules. Full compensation for regulatory takings can, however, lead to over-investment and excessive entry in risky industries. An alternative is to ‘carve-out’ apparently efficient regulation from compensation requirements. We design a carve-out/compensation rule that induces efficient regulation and firm-level investment even when the regulator suffers fiscal illusion and has private information about the social benefit from regulation. We also show that a carve-out reduces the subsidy to risky industry implicit in compensation rules, and thus mitigates the entry problem.

I Introduction

Over the past 20 years a number of attempts have been made to make regulatory takings compensable in international law. The Organisation for Economic Co-operation and Development’s (OECD) proposed Multilateral Agreement on Investment (MAI) failed in 1989 largely because of intense debate over the clauses requiring host governments to compen-

sate foreign investors for losses arising from any measures *tantamount* to expropriation. Since then, essentially identical clauses have been successfully included in thousands of bilateral investment treaties as well as in the investment chapters of a growing number of bilateral or plurilateral free trade agreements. These agreements have been able to avoid the intense public debate that surrounded the MAI by typically involving at most one developed country signatory.

The first exception to this pattern was the North American Free Trade Agreement (NAFTA) which involved both the United States and Canada as well as Mexico. The experience with NAFTA in some ways confirmed the worst fears of critics of the expropriation clauses. Investors have used NAFTA

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to sue host governments for a number of environment-related regulations, including backfilling rules designed to protect native sacred sites, a municipality's refusal to grant operating permits for a hazardous waste facility, a ban on the import of one gasoline additive and the use of another.¹

Indeed, the cases brought under NAFTA have led prominent commentators to suggest that the definition of compensable expropriation may become the dominant issue in international investment law (see, e.g. OECD Directorate for Financial and Enterprise Affairs, 2004, and Fortier, 2003). The experience with NAFTA led the US and Canadian governments to modify their approach to subsequent international investment agreements and chapters by including a clause stating that 'Except in rare circumstances, non-discriminatory regulatory actions by a Party that are designed and applied to protect legitimate public welfare objectives, such as public health, safety, and the environment, do not constitute indirect expropriations' (Aus-US FTA, 2004, Annex 11B – Expropriation). This clause essentially re-instates a substantial but not total 'police powers carve-out' (PPCO) from the regulatory compensation requirements in international investment agreements. Notably for Australia, the Australia-US FTA investment chapter includes such a carve-out, but the Australia-China Investment Promotion and Protection Agreement (IPPA) does not. This article compares the efficiency of the original full compensation for regulatory takings to the alternative of an optimally designed PPCO.

Historically, the legal institutions in most industrialised countries have drawn a distinction between direct expropriation – such as taking of land and property for road construction – and indirect expropriation – such as loss of value of an investment owing to the banning of the company's product. Direct expropriation is generally subject to full and fair compensation, whereas

indirect or 'regulatory' takings are not. The push at the end of last century to expand compensation to cover regulatory takings is generally seen as a response to the ever-expanding use of regulation by governments, particularly with regard to environmental amenities. In the case of international investment agreements and chapters in FTAs, increased competition among nation states for foreign investment is an additional driver for stronger investor rights.

Although there exists a very large literature on the economics of takings and compensation, relatively little of it considers regulatory takings. This lack of direct consideration of regulatory takings may be inconsequential if, as some authors argue, they are logically equivalent to traditional takings (Hermalin, 1995). Traditional and regulatory takings are equivalent in a model with perfect information among government, investor and court. However, in practice the nature and extent of information asymmetries may vary considerably between direct and indirect expropriation cases. Accordingly, the appropriate model for studying the efficiency of paying compensation will also vary. For example, consider the taking of a family home for road construction compared with losses for a pesticide manufacturer when one of their products is banned. The private value of the pesticide firm is mostly economic, and relatively easy for a court to assess, but the private value of a family home has a large emotional component and is very difficult for a court to assess. Conversely, the social value of government road construction is mostly economic, and relatively easy for a court to assess, whereas the social value of a pesticide ban relates to environment and health and is much harder for a court to assess. In our model the firm's profits are public information, but the government has private information about the social harm avoided by implementing an environmental regulation.

The possibility that governments have 'fiscal illusion', that is, that they discount the costs that their actions impose on a group of private citizens, is the central efficiency argument for making takings compensable.² This is equally

¹ These cases are, respectively, *Glamis Gold Ltd. v. United States of America* (see US Department of State, 2005a), *Metalclad Corporation v. United Mexican States* (see US Department of State, 2005b), *Ethyl Corporation v. Canada* (see Canada Department of Foreign Affairs, 2002) and *Methanex Corporation v. United States of America* (see UNCITRAL Tribunal *Methanex Corp. v. United States of America*, 2005).

² There may also be fairness arguments favouring compensation. See, for example, Michelman (1967), Fischel and Shapiro (1989) and Niemann and Shapiro (2008). This article, however, examines only efficiency.

so with regulatory takings as with traditional takings: regulators with fiscal illusion tend to regulate too often. Although there has been much discussion in the literature about the potential causes of fiscal illusion in a domestic setting, the source in an international setting is obvious. National, state and municipal governments are elected to maximise local welfare, not the joint welfare of citizens and foreign investors; the 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 favour of the adoption of a regulatory takings doctrine in international investment law.

Also in common with outright takings, compensation for regulatory takings distorts investment decisions. Blume *et al.* (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 this problem of excessive (implicit) insurance. Nevertheless, 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.

We propose a mechanism that addresses both the fiscal illusion and insurance problems yet still allows governments to introduce bona fide public regulation without compensation. The mechanism is essentially what is legally known as a PPCO – a rule under which the regulator is exempt from paying compensation if and only if the court perceives that the social benefits from regulation are sufficiently high; otherwise, takings are compensable. We show that an appropriately designed PPCO induces efficient regulation despite fiscal illusion even when there is asymmetric information between the regulator and the court. We also show that for any PPCO there exists a linear compensation scheme that induces both efficient regulation and firm-level investment if investors are non-strategic.

Although often applied in legal practice, PPCOs have received little attention in economic analyses of takings. The exception is Miceli and Segerson (1994) who propose an

ex-post rule under which a regulator is exempt from paying compensation if and only if the taking is socially efficient. Their analysis assumes a full information environment in which courts can perfectly observe the social costs and benefits of a taking. Miceli and Segerson's (1994) PPCO does not lead to over-investment because in equilibrium the government does not over-regulate and compensation is never paid. The problem with this solution is that in practice compensation is paid. This fact is particularly obvious in international investment law where the large number of cases being brought against host states for regulatory takings under the conditions of international investment agreements has surprised and alarmed many of the legal architects of these agreements. As in Miceli and Segerson's (1994) 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 case to receive only noisy signals of the social benefits from takings.³

Unlike previous research on takings, we also examine the effect that the compensation and carve-out have on entry. Compensation rules transfer expected rents from society to investors, increasing entry above the efficient level. Broadening the carve-out tends to reduce the size of the implicit transfer to investors, so granting a PPCO can mitigate the entry problem. Broadening the carve-out does not eliminate this transfer, so our proposal does not induce efficient entry. This feature of our model is particularly relevant in the context of international investment agreements. As the agreements provide better compensation for regulatory takings than domestic laws, they promote entry by foreign firms at the expense

³ Hermalin (1995) similarly 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 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 extort payments from landowners, as this would generate its own moral hazard problem.

of domestic firms, that is, they create a non-level playing field. Moreover, national treatment rules in these agreements (which require that host governments treat foreigners no less favourably than domestic investors) prevent host governments from charging foreigners upfront taxes that would offset this implicit subsidy.

II Model

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

(i) 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 k taking the rental price for capital, r , as given. Here we treat the number of firms in the industry (normalised to 1) as given. Section (ii) analyses the entry decision. An investor whose project is not regulated earns variable profits $\pi(k)$, where

$$\pi(k) = \max_q \{pq - c(q, k)\}, \quad (1)$$

q is output and c is a cost function that is increasing in q and decreasing in k . The solution to the firm's optimisation problem is a function of price and capital, $q = Q(p, k)$. The equilibrium price and quantity are functions of k : $p = p(k)$ and $q = Q(p(k), k) \equiv q(k)$. Denote consumer surplus as $U(p(k))$ and denote pecuniary social surplus from the project as $S(k) = U + \pi$. Using the definition of S , the fact that firms are price-takers, and the envelope theorem applied to the problem in Equation (1), we have $S'(k) = -c_k(q(k), k)$.

The *regulator* decides whether to shut the project down. An unregulated project causes harm H , which for the sake of specificity we refer to as *environmental damage*.⁴ When the investor chooses k , H is a non-negative random variable with probability density function (PDF) $f(H)$ and (CDF) $F(H)$. The regulator knows the realised value of H when deciding whether to

shut down the project. Regulation causes a loss of surplus $S(k)$ and avoids the environmental cost H .⁵

Regulation leads to an investor claim for compensation. The *court* determines whether the regulator must compensate the investor and the size of the compensation payment. The court observes a noisy signal of harm, ηH . When the regulator decides whether to shut down the project, η is a random variable with PDF $g(\eta)$ and CDF $G(\eta)$.

The three stages of the model are as follows.

- First stage [investment]: the investor chooses investment level.
- <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 realised but before the noise in the court's signal is realised.

Ex-post efficiency: efficient given investment level k and realised harm H .

(ii) 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 maximises $V(k) - rk$, giving the first-order condition

⁵ Our model assumes symmetric 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.

⁴ In practice, the harm arising when the project is unregulated may be a function of k . In Footnote 12, we show that in such cases an additional policy tool – a capital tax – is appropriate.

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

which simplifies to

$$-c_k(q(p(k)), k)F(S(k)) = r. \quad (2)$$

We use $*$ to denote the optimal level of a variable or function, so k^* is the socially optimal level of investment and $F^* = F(S(k^*))$. We assume that firms have positive expected profits under optimal regulation and investment: $F^*\pi^* - rk^* > 0$.

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

III Arbitration

The court observes a noisy signal, $H\eta$, of damages where η is a random variable. 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 that 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 $G(1) = 0.5$.

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 $\theta(k)$. Thus, the court's decision rule depends on the two functions $\chi(k)$ and $\theta(k)$.

The function $\chi(k)$ is the minimum level of the damage signal necessary for the court to accept a *police powers* defence from the regulator; a court that observes damage $\eta H < \chi(k)$ rejects the police powers defence and requires that compensation $\theta(k)$ be paid. Thus, the function $\chi(k)$ is an inverse measure of the PPCO. 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 $M(k, H\eta)$:

$$M(k, H\eta) = \begin{cases} 0 & \text{if } H\eta > \chi(k) \\ \theta(k) & \text{if } H\eta \leq \chi(k) \end{cases}. \quad (3)$$

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 to induce efficient regulation and investment, conditional on previous entry.

IV 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 $\beta \in [0, 1]$. β is the weight that the regulator gives to a dollar of investor pay-offs, relative to a dollar of consumer welfare or environmental harm; $1 - \beta$ reflects the regulator's degree of fiscal illusion.⁶

When deciding whether to shut down the project, the regulator knows H but not η . In the absence of regulation, the regulator's pay-off is

$$\begin{aligned} V^N(k, H) &= U(k) + \beta\pi(k) - H \\ &= S(k) - (1 - \beta)\pi(k) - H \end{aligned} \quad (4)$$

and with regulation the expected pay-off is

$$\begin{aligned} V^R(k, H) &= -[1 - \beta]E_\eta(M(k, H\eta)) \\ &= -[1 - \beta]\theta(k)G\left(\frac{\chi(k)}{H}\right). \end{aligned} \quad (5)$$

The regulator shuts down the project (regulates) if and only if $V^N < V^R$. When the regulator shuts down the project, the difference between the firm's lost profits and the regulator's expected compensation payment is

$$\Sigma(H; k) = \pi(k) - \theta(k)G\left(\frac{\chi(k)}{H}\right). \quad (6)$$

Define the level of harm above which it is socially optimal to regulate as $H^* = S(k)$. The following proposition notes a general feature of *ex post* efficient schemes, and it identifies a particular efficient scheme that we then analyse.

Proposition 1. *We assume that $\beta < 1$ and consider only compensation schemes that are continuous in k at $k = S^{-1}(H^*)$, and are of the form of Equation (3). (i) Under these assumptions, expected compensation equals lost profits at the critical level of harm H^* . That*

⁶ Brennan and Boyd (2006) employ a political support model to endogenise fiscal illusion. They argue in favour of manipulating compensation levels so as to encourage participation by under-represented parties. We abstract from political economy concerns and treat β as exogenous.

is, $\Sigma(H^*; k) = 0$. (ii) *The particular compensation scheme*

$$\theta(k) = \frac{\pi(k)}{G\left(\frac{\chi(k)}{S(k)}\right)} \quad (7)$$

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

Proof. (i) Regulation is *ex post* efficient if and only if $S(k) - H < 0$. Regulation occurs if and only if $V^N < V^R$. Using the definitions of V^N and V^R in equations (4) and (5), and the definition of $\Sigma, V - V^R < 0$ if and only if

$$S(k) - H - (1 - \beta)\Sigma(H; k) < 0. \quad (8)$$

The necessary and sufficient condition for efficiency is that the left side of inequality (8) has the same sign as $S(k) - H$. Suppose, contrary to the proposition, that the regulation is efficient and $\Sigma(H^*; k) = \varepsilon \neq 0$. If $\varepsilon > 0$ then for H sufficiently close to but strictly less than H^* , $S(k) - H > 0$; however, the left side of inequality (8) is negative for H sufficiently close to H^* . In this case, regulation is not efficient. A parallel argument holds if $\varepsilon < 0$. This contradiction establishes that $\Sigma(H^*; k) = 0$.

(ii) For $\theta(k)$ given by Equation (7), $V^N - V^R < 0$ if and only if

$$\{S(k) - H\} + \left\{ (1 - \beta)\pi(k) \left[\frac{G\left(\frac{\chi(k)}{H}\right)}{G\left(\frac{\chi(k)}{S(k)}\right)} - 1 \right] \right\} < 0. \quad (9)$$

The fact that G is non-decreasing in its argument implies,

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

Therefore, the two bracketed terms on the left side of inequality (9) have the same sign. The inequality is therefore satisfied (i.e. regulation occurs) if and only if $H > S(k)$ (i.e. if it is optimal to regulate).

Proposition 1(i) mirrors a general principle in enforcement economics: '[t]he optimal fine equals the harm, properly inflated for the chance

of not being detected' (Polinsky & Shavell, 1992, p. 133). The compensation rule (7) does not lead to full cost-internalisation for *all* realised 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-internalisation* only occurs when $H > S(k)$ – that is, when the project should be shut down anyway – the regulator's actions are *ex post* efficient.

We note some features of efficient compensation schemes in the following remarks.

Remark 1. *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 many international investment agreements – including the NAFTA's chapter 11 and the Australia–China Investment Promotion and Protection Agreement 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 or property. This interpretation matches our definition of *strict compensation*. Remark 1 states that strict compensation rules induce efficient regulation. The next section shows that they also induce over-investment.

Remark 2. *The compensation scheme in Equation (7) is independent of β .*

The penalty for correcting the regulator's fiscal illusion does not necessarily depend on the magnitude of fiscal illusion. However, inequality (8) shows that it is possible to design compensation schemes that do depend on β . As noted in the proof of Proposition 1, the necessary and sufficient condition for efficiency is that the left side of inequality (8) has the same sign as $S(k) - H$. Fix $\chi(k)$ and for a given β choose a compensation scheme that satisfies the condition for efficiency. For a different value of β , this compensation scheme may not satisfy the condition for efficiency. In that case, the efficiency-inducing compensation scheme does depend on β . The independence, with respect to β , of the scheme in Equation (7) is an advantage, because it may be difficult to measure β .

This discussion focuses on cases where $\beta < 1$, although the compensation rule in Equation (7)

also induces efficient regulation if $\beta = 1$. In this case, although, 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 onwards we restrict our attention to cases with $\beta < 1$.

Remark 3. *When the court receives a noisy damage signal (i.e. the support of η is not degenerate), any ex-post compensation scheme that involves a carve-out ($\chi(k) < \infty$) requires $\theta(k) > \pi(k)$.⁷*

A regulator who is sometimes exempt from paying compensation, must on other occasions pay more than actual damages.

Remark 4. *There are states of the world in which the court commits a type II error, that is, the courts reject a valid police powers defence.*

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 η , 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.

Remark 5. *If the court observes H without noise, any ex-post efficient 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

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 regulator's ex-ante expected savings relative to the strict carve-out is

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

that regulation is socially optimal. This result is similar 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 (realised) benefits. Miceli and Segerson (1994) consider only the case in which the court perfectly observes the benefits (equivalent to avoided damages in our model) from a taking; our variant of this perfect information rule requires the regulator to pay compensation when the court observes H less than $\chi(k)$.

Remark 6. *Suppose that regulation of the firm would create non-pecuniary random benefits B with CDF F ; in this variation of the model there is no environmental harm. Regulation is ex-post efficient whenever the carve-out/compensation scheme satisfies Equation (7).*

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 realisation 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 (7), 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.

(i) *Compensation as a Transfer to Industry*

Remarks 3 and 4 relate to the regulator's burden under a carve-out/compensation scheme given a realised 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 realised (but after the firm has chosen k).

We want to show that under efficient regulation, a carve-out reduces the regulator's expected costs, relative to no carve-out. To this end, define the *ex-ante* probability that the regulator has to pay compensation

$$R(k, \chi(k)) = \int_{S(k)}^{\infty} G\left(\frac{\chi(k)}{H}\right) f(H) dH. \quad (10)$$

The regulator's *ex-ante* expected compensation under a carve-out is

$$T(k, \chi(k), \theta(k)) = \theta(k)R(k, \chi(k)) \\ = \int_{S(k)}^{\infty} \theta(k)G\left(\frac{\chi(k)}{H}\right)f(H) dH \quad (11)$$

and the expected compensation in the absence of a carve-out is

$$T_s(k) = [1 - F(S(k))]\pi(k). \quad (12)$$

We have the following.

Proposition 2. *Given efficient regulation, a carve-out lowers expected compensation, compared with the case without a carve-out.*

Proof. By Equations (7) and (11),

$$T(k, \cdot) = \pi(k)\Psi \quad (13)$$

with

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

The fact that

$$\frac{G\left(\frac{\chi(k)}{H}\right)}{G\left(\frac{\chi(k)}{S(k)}\right)} < 1 \quad \text{for } H > S(k)$$

implies $\Psi \leq 1 - F(S(k))$. This inequality, and Equations (12) and (13) imply that $T(k, \cdot) < T_s(k)$.

Given that a carve-out offers the regulator a chance that takings will not be compensable, Proposition 2 is not surprising. However, neither is it trivial, as the regulator pays more than lost profits whenever the court rejects the police powers defence. The key to the result lies in the design of $\theta(k)$. As noted earlier, $\theta(k)G\left(\frac{\chi(k)}{H}\right) = \pi(k)$ when $H = S(k)$; thus, when realised $H > S(k)$ – that is, in all cases in which regulation actually occurs – the expected payout is less than π . Distinguishing between *some* carve-out and none is not hair splitting. The text

of many international investment agreements explicitly states that takings resulting from regulation ‘for a public purpose’ (NAFTA, 1994, Article 1110, para. 1) are compensable.^{8,9}

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 realisation 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

⁸ Some courts have taken this new language to heart whereas others have not. When adjudicating a lawsuit between Mexico and Metalclad, a US waste disposal company, a tribunal ruled 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). Subsequently, when adjudicating the claim by Methanex, a Canadian producer of methanol, against the United States for California's ban on the use of methyl tertiary butyl ether (MTBE) – in which methanol is an input – a different tribunal concluded ‘...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 Methanex Corp. v. United States of America, 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 lawsuits under NAFTA or similar international investment agreements. See ‘Background and Institutional Context: Notes to accompany Police-Powers, Regulatory Takings and the Efficient Compensation of Domestic and Foreign Investors’ available online for summaries of this and other relevant NAFTA cases.

⁹ Other bills have acknowledged a PPCO for only a subset of regulations. Oregon State Legislature 197.352 (2007) explicitly acknowledges a PPCO for land-use regulation ‘for the protection of public health and safety’ (subsection 3) but not for other regulations, for example, those designed to provide new public goods at the expense of landowners.

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 defence. *Ceteris paribus*, this change lowers the regulator’s expected costs from regulation, causing the regulator to regulate more often. Thus, to maintain regulatory efficiency, a broader carve-out requires a higher θ to satisfy Equation (7). Define

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

the elasticity of the noise CDF. We also introduce a parameter ρ 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 ρ corresponds to a broader carve-out. Log-differentiating Equation (7) gives

$$\frac{\hat{\theta}}{\hat{\rho}} = -\mu\left(\frac{\chi(k;\rho)}{S(k)}\right) \frac{\chi_\rho(k;\rho)\rho}{\chi(k;\rho)} > 0, \quad (14)$$

where the hat ‘^’ indicates percentage change, for example, $\hat{\rho} = d\rho/\rho$. Equation (14) 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 θ 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 η 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.

$$\begin{aligned} \frac{d}{d\rho}\theta(k)G\left(\frac{\chi(k;\rho)}{H}\right) &= \frac{\theta(k)G\left(\frac{\chi(k;\rho)}{H}\right)}{\rho} \\ &\times \left[\mu\left(\frac{\chi(k;\rho)}{H}\right) \frac{\chi_\rho(k;\rho)\rho}{\chi(k;\rho)} + \hat{\theta} \right] \\ &= \frac{\theta(k)G\left(\frac{\chi(k;\rho)}{H}\right)}{\rho} \\ &\times \frac{\chi_\rho(k;\rho)\rho}{\chi(k;\rho)} \left[\mu\left(\frac{\chi(k;\rho)}{H}\right) - \mu\left(\frac{\chi(k;\rho)}{S(k)}\right) \right]. \quad (15) \end{aligned}$$

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 (11). 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 described by the following proposition.

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:*

$$\begin{aligned} &\int_{S(k)}^{\infty} \left[\mu\left(\frac{\chi(k;\rho)}{H}\right) - \mu\left(\frac{\chi(k;\rho)}{S(k)}\right) \right] \\ &\times G\left(\frac{\chi(k;\rho)}{H}\right) f(H) dH > 0. \quad (16) \end{aligned}$$

(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 ρ , factoring out the $\theta \frac{\chi_\rho}{\chi}$ terms (which are independent of H), and converting to elasticities gives

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

Because $\theta \frac{\chi_0}{\chi}$ is negative, inequality (16) is a necessary and sufficient condition for $dT/d\rho < 0$. (b) If μ is a decreasing function of η then $\mu\left(\frac{\chi}{H}\right) > \mu\left(\frac{\chi}{S(k)}\right)$ for all $H > S(k)$.

Not surprisingly, μ decreasing in η 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 μ is not monotone decreasing in η it is still possible for $dT/d\rho$ to be negative as 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 with no carve-out. Therefore, it is not possible – for any distribution of η – that broadening the carve-out *always* increases the regulator’s expected costs. To show that the expected pay-off can be non-monotonic in the breadth of the carve-out, it is sufficient to show that in some cases inequality (16) is violated. We demonstrate this possibility using the following example.

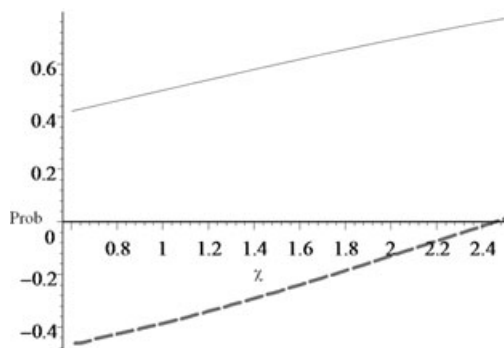
Example 1. Suppose that $\eta \sim N(1, \sigma^2)$ (so that the signal is unbiased) and let $H \sim U[0, b]$ with $b > 1$; let $S = 1$, so $\bar{z} = \chi$. Making a change of variables, we can write the integral in inequality (16) as $\frac{\chi}{b}\Theta$ with

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

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 defence when $H = S$. Suppose that $b = 2 = \sigma$. Figure 1 shows the graph of y 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 $y \approx 0.77$. 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 defence (when $H = S$) is greater than 0.77.

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-

FIGURE 1
Solid Curve: Graph of Probability that Court Rejects Police Powers Defence when $H = S$; Dashed Curve: 10Θ



known distributions, it is easy to confirm that $\mu(\eta)$ is either (i) decreasing for all η or (ii) decreasing for η sufficiently large. The sufficient condition that $\mu(\eta)$ is decreasing for $\eta \geq \frac{\chi(k;p)}{S(k)}$ is easier to satisfy if $\chi(k)$ is large, that is, 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.

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 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 η is greater than or equal to a constant that depends on the parameters of the distribution.¹⁰ For the normal distribution (with mean $\bar{\eta}$ and variance

¹⁰ 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

$$\frac{v}{w+v} \frac{v+w}{w+v-1}.$$

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 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 summarise 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 observation 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.

V Investment

The takings literature uses a compensation scheme that is linear in profits and investment costs. Here we adopt this linear compensation function and require it to satisfy condition (9), so that it induces efficient regulation. In this section we assume that the investor is non-strategic, that is, the investor takes the probabilities of regulation and compensation as exogenous. Section 6 offers a limited analysis of the efficient compensation scheme when the investor is strategic.

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

$$\tilde{F}\pi'(k) + \tilde{R}\theta'(k) = r. \tag{17}$$

The probability that the court rejects the police powers defence 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 (2) and (17) shows that the latter generates k^* if and only if

$$\theta'(k^*) = 0. \tag{18}$$

The linear compensation scheme (as in BRS) is

$$\theta(k) = \delta\pi(k) + \gamma rk. \tag{19}$$

For the linear compensation

$$\begin{aligned} \theta'(k^*) &= -\delta c_k(q(p(k^*)), k^*) + \gamma r \\ &= -\delta c_k - \gamma c_k F^* = -(\delta + \gamma F^*)c_k, \end{aligned}$$

where the second equality uses Equation (2). Setting this expression equal to 0 gives the condition

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

so the linear compensation scheme reduces to

$$\theta(k) = \frac{\delta}{F^*}(F^*\pi(k) - rk). \tag{20}$$

Note that this compensation formula involves the optimal probability of regulation under optimal investment, F^* . Society's ability to implement this formula therefore depends on the extent to which it knows both the optimal level of investment and the distribution of damages.

Taking into account the different notation, Equation (20) reproduces theorem 2 in BRS. Under this linear scheme, the firm's expected profits (including compensation) are:

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

In summary, we have the following remark.

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 (7) and (20), the carve-out is

$$\hat{\chi}(k) = S(k)\phi(k; \delta)$$

with

$$\phi(k; \delta) \equiv G^{-1}\left(\frac{F^*\pi}{\delta(F^*\pi - rk)}\right) = G^{-1}\left(\frac{\pi}{\theta}\right). \quad (21)$$

Thus, under the linear compensation scheme with carve-out, there is a one-parameter family of rules, indexed by δ , which 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 defence if and only if its estimate of harm, $H\eta$, is less than $\phi(k)S(k)$. If the court rejects the police powers defence, 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 with those proposed elsewhere in the takings literature and international and domestic law? Many international investment agreements stipulate that '[c]ompensation shall be equivalent to the fair market value of the expropriated investment immediately before the expropriation took place'.¹¹ That is, international investment agreements often require 'strict' compensation that depends only on variable profits and ignores sunk costs. However (like BRS) we find that strict compensation is distortional: unless compensation is lump sum or proportional to the investor's objective function absent compensation, it induces excessive investment.^{12,13} Miceli and Segerson's (1994) *ex-post* rule mandates strict 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 (1994) *ex-post* rule with perfect information, the firm's expected pay-off is $F^*\pi - rk$, so investment is efficient. In our model with asymmetric

information, the *ex-ante* probability of compensation must be positive, that is, $R > 0$, to prevent excessive regulation. Under strict compensation with $R > 0$, the firm's *ex-ante* expected profits equal $[F^* + R]\pi(k) - rk$, which would lead to over-investment.

(i) Size of the Transfer

Here we discuss the magnitude of the implicit transfer T . Remark 8 states that it is proportional to expected profits absent compensation. We use an example to show how T varies with the size of the carve-out. We restrict attention to equilibrium behaviour (thus dropping k as an argument) and to the family of carve-out/compensation schemes satisfying Equations (20) and (21). We treat θ as the policy parameter; Equation (21) determines χ as a function of θ .

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

$$T(\theta) = \theta \int_s^\infty G\left(\frac{G^{-1}\left(\frac{1}{\theta}\right)S}{H}\right) f(H) dH. \quad (22)$$

We noted that when the observation error is exponentially distributed, a larger carve-out decreases the regulator's expected payment. To

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, 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:

$$\begin{aligned} \theta(k) &= \frac{\delta}{F^*} [F^*\pi(k) - (r + \tau^*)k] \text{ and} \\ \hat{\chi}(k) &= S(k)\phi(k; \delta) \text{ with } \phi(k; \delta) \\ &\equiv G^{-1}\left(\frac{F^*\pi}{\delta(F^*\pi - [r + \tau^*]k)}\right) = G^{-1}\left(\frac{\pi}{\theta}\right). \end{aligned}$$

Notably, the efficient investment tax is independent of β .

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

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, para. 2.

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 $G^{-1}(\frac{1}{\theta}) = -\ln(\frac{\theta-1}{\theta})$. Using this relation, we have

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

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

so

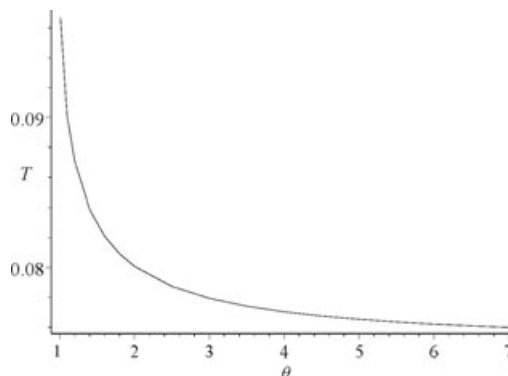
$$T = \theta \int_S^\infty \left(1 - \exp\left(\frac{S\ln\left(\frac{\theta-1}{\theta}\right)}{H}\right)\right)\lambda e^{-\lambda H} dH. \quad (23)$$

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 3 and Remark 7 we know that T is a decreasing function of θ . From Equation (23) we know that as $\theta \rightarrow 1^+$, $R \rightarrow 1 - F^*$, that is, the court never accepts the police powers defence, so the regulator compensates whenever it regulates. As $\theta \rightarrow \infty$, using l'Hôpital's Rule we have $T \rightarrow \int_S^\infty (\frac{S}{H} \lambda e^{-\lambda H}) dH$. 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 normalisation $\pi^* = 1$, 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 $F^* = 0.89974$, that is, there is approximately a 10 per cent chance of regulation. From these comments, the upper bound on T (as $\theta \rightarrow 1^+$) is $1 - 0.89974 = 0.10026$ and the minimum value (as $\theta \rightarrow \infty$) is $\int_S^\infty (\frac{S}{H} \lambda e^{-\lambda H}) dH = 0.0748$.

Figure 2 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 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

FIGURE 2
Expected Transfer as a Function of θ for the Exponential Model with $S = 1$ and $\lambda = 1.15$



from 0.7995 to 0.8237. Compare this with 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 8.4–11 per cent whereas the investor's profit rises by an equal percentage. These amounts bound the percentage chance of efficient regulation, 10 per cent.

Note that T does 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.

(ii) Entry Problem

A compensation scheme that implicitly transfers rents to an industry facing regulatory risk raises a familiar concern: when industry size is endogenous, compensation induces inefficiently high entry. In the appendix, we extend the model to include a zeroth stage in which a continuum of entrants with heterogeneous entry costs decide whether to enter the industry. We 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. Reducing T when T is positive unambiguously raises social welfare.

A first step towards solving the entry problem is to reduce the size of the transfer implicit in a compensation scheme. Although we cannot guarantee that broadening a carve-out always reduces T , Proposition 2 verifies that T is always smaller when there is *some* carve-out rather than none, and Remark 1 shows that a broader carve-out reduces the expected transfer for several different distributions.

A related point is that subjecting different classes of investors to different compensation rules can lower welfare. This rather obvious point is important because compensation rules in international investment agreements entitle only foreign investors to (possible) compensate for government actions 'tantamount' to expropriation. This compensation tilts the playing field in favour of foreign firms. With endogenous entry, this asymmetric treatment is inefficient, in addition to being 'unfair'. 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 favourably than their domestic counterparts *in like circumstances*. National treatment rules appear in almost all modern trade and investment agreements. 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 recognise 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 article is to 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 in international investment agreements.

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 to capture rents for the state at the expense of investors. Moreover, up-front access fees cannot be used to level the uneven playing field created by international investment agreements: charging foreign (but not domestic) firms a fee for the right to establishment would violate national treatment rules.

VI Strategic Investors

Our baseline model assumes investors are non-strategic. This assumption is reasonable if the industry contains many firms and regulation is industry-wide. However in many instances only a subset of investors are subject to a taking – 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 in designing an efficient compensation scheme when investors are strategic. We note that the *ex-post* efficiency of a carve-out satisfying Equation (7) is unaffected by whether investors are strategic. In what follows, we restrict attention to investors who 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 (10). Differentiating with respect to k and rearranging gives the first-order condition

$$\begin{aligned}
 & \overbrace{F(S(k))\pi'(k) - r}^{a'} \\
 & + \overbrace{\left[\pi(k) - \theta(k)G\left(\frac{\chi(k)}{S(k)}\right) \right] f(S(k))S'(k)}^{b'} \\
 & + \underbrace{R(k)\theta'(k) + \int_{S(k)}^{\infty} G'\left(\frac{\chi(k)}{H}\right) \frac{\chi'(k)}{H} f(H) dH}_{\equiv \Delta(k)} \\
 & = 0.
 \end{aligned} \tag{24}$$

If regulation is *ex-post* efficient, then by Equation (7) 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 (7) 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 π 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 analysing a PPCO compensation scheme requir-

ing the court only to observe the equilibrium values of π and S , that is, 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 (7) 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 χ and compensation scheme θ that depend oppositely on k : if the ‘bar’ for the police powers defence is increasing in investment, that is, $\chi'(k) > 0$ then compensation must be decreasing in investment.

VII Conclusion

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

However, compensation also distorts investment and entry decisions. Basing compensation on market value insures investors against states of the world in which regulation is socially optimal. Even when compensation packages are lump-sum, they serve as an implicit subsidy to industry facing regulatory risk, generating excessive entry.

This article 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 defence 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 defence, the regulator pays damages exceeding investor losses. This compensation level reflects a standard result in the enforcement literature: if the probability that 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 with 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. This result is important because 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). Finally, reducing the transfer helps in reducing the bias in favour of entry by foreign firms which is caused by the fact that international investment agreements provide better protection against regulatory takings than is provided to local firms by domestic law.

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Appendix

Here, we examine the relationship between T and social welfare when entry is endogenous. We endogenise entry by adding a zeroth ‘entry’ stage to the model in which compensation satisfies $\theta'(k^*) = 0$ (as detailed in Section V) and firms are non-strategic, that is, they take the probabilities of regulation, F , and compensation, R , as exogenous.

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; compensation payments and receipts do not appear in $W(\bar{n})$ as they are transfers from a social welfare perspective. Note that this rule reflects regulation

that is *ex-post* efficient and satisfies the rule ‘regulate if and only if $H > S(\bar{n})$ ’.

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 $T > 0$, as the marginal entrant’s fixed costs satisfy $I(\bar{n}) = F(S(\bar{n}))[pq - c] - rk + T$. Because reducing T inhibits entry,¹⁴ broadening the carve-out unambiguously raises welfare whenever Equation (16) holds.

¹⁴ To verify, examine the expected pay-off 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 Equation (16) 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 pay-off negative. She will choose not to enter.