How Much Discretion for Risk Regulators?[1]

Yolande Hiriart[2] and David Martimort[3]

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Abstract. We analyze the regulation of firms that undertake socially risky activities but can reduce the probability of an accident inflicted on third-parties by carrying out nonverifiable effort. Congress delegates regulation to an Agency, though these two bodies may have different preferences towards the industry. The optimal level of discretion left to the Agency results from the following trade-off: the Agency can tailor discretionary policies to its expert knowledge about potential harm, but it implements policies which are too "pro-industry". The Agency should be given full discretion when the firm is solvent; partial discretion is preferred otherwise. We then investigate how this trade-off changes as the political and economic landscapes are modified.

Keywords. Risk Regulation, Agencies, Rent/Efficiency Trade-Off, Rules versus Discretion, Organization of the Government.

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[2]Université de Franche-Comté (CRESE); yolande.hiriart@univ-fcomte.fr.

[3]Paris School of Economics-EHESS; david.martimort@parisschoolofeconomics.eu.

1 Introduction

Risk regulation differs significantly from one domain to another not only because of the economic costs and benefits at stake, but also in terms of the actual design of regulatory institutions, the mandate of agencies, and the kind of regulatory procedures they follow.[1] When Congress sets up a new agency or grants new responsibilities to an existing agency to deal with a particular area of concern, it defines its statutory mandate. In some fields, such mandates leave agencies with significant discretion in setting standards and fines for misconduct, authorizing new products, and granting licenses. In other circumstances, safety standards are mandatory, fines do not vary much, and strict norms apply uniformly across various domains and market conditions.

As an illustration, the statutory mandate of many agencies –especially in the areas of health, safety and the environment– is strikingly broad and nonspecific. Section 6 of the Toxic Substances Control Act stipulates that the U.S. Environmental Protection Agency (EPA) should control chemicals that pose *"unreasonable risk of injury to health or the environment"* without defining what is meant by *"unreasonable risk"*, thereby leaving considerable discretion to EPA to determine which risks are deemed reasonable and which are not.[2] More generally, Van Houtven and Cropper (1996) reported evidence that EPA enjoyed significant discretion in setting up regulatory standards to control chemical risks, taking into account in its decision process both costs and benefits based on its expertise. In a similar vein, and confirming the huge discretion left *de facto* to the EPA when controlling Superfund sites, Hird (1993, 1994) also reported that the relevant Congressional oversight committee had little or no impact on the pace of cleanups, even at sites located in districts of that committee's members. On the other hand, the Occupational Safety and Health Act has forced the corresponding agency to adopt safety standards as mandatory regulations, ignoring any cost-benefit analysis that could have exploited its expert information. Also, an often observed and controversial feature of liability regimes is that agencies face upper bounds in the damages that firms should cover for the harm inflicted on third-parties or on the environment. The Price-Anderson Act in the U.S. and the Nuclear Liability Act in Canada are examples of regulations that impose such limits for operators of nuclear power stations involved in off-site damage.[3] Similar limits are also found for oil pollution.[4]

Although delegation to administrative agencies has sometimes been viewed as a violation of the so-called *"Delegation Doctrine"*, arguing that legislative powers cannot be granted to administrative agencies, the number of administrative agencies has increased dramatically over

[1]Hood, Rothstein and Baldwin (2003) describe the variety of institutions found in risk regulation.

[2]As noticed by Applegate (1991): *"EPA is empowered to regulate the 'life cycle' of toxic chemicals through four major statutes: The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), The Toxic Substances Control Act (TSCA), the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, or Superfund). In each of these statutes, Congress has established regulatory standards only in the most general terms, leaving it to EPA to quantify them in rules of general applicability or through licensing proceedings. Although the statutes are phrased in different ways and use different regulatory structures, all adopt a standard that can generically be called unreasonable risk. "Unreasonable" describes an undefined, nonzero level of risk determined on an ad hoc basis by balancing both health considerations and non-health concerns such as technology, feasibility, and cost."*

[3]Heyes and Liston-Heyes (2000) stress the political economy aspect of such limits on fines and argue that those limits can be viewed as implicit subsidies for the operators.

[4]Jin and Kite-Powell (1999).

the years and agency decision-making has become the principal means of Federal regulation in the U.S.. According to Ashford and Caldart (2008), *"broad delegations of substantive authority to administrative agencies have become the rule rather than the exception."*[5] Hence, much delegation does take place and the issue of understanding why remains by and large unsettled. Changes in the nature of the regulated risk and the kind of political forces at play might certainly explain why agencies differ in terms of how much discretion they are left with. To understand these issues, we analyze the two-tier relationship between Congress, an Agency, and firms concerned by risk regulation. Such an analysis will help us to assess first, how much freedom should be left to risk regulators and, second, how economic and political forces shape this discretion.

The bottom line of our analysis is that restrictions on the Agency's discretion solve an *agency problem* between that Agency and Congress. This idea is not novel *per se* and has been a recurring theme of the political science literature over recent years.[6] For instance, Epstein and O'Halloran (1999) proved a version of the "Ally Principle" showing (and confirming through some empirical analysis) that more delegation should occur when Congress and the Agency are more aligned.[7] However, when studying the top-tier principal-agent problem between Congress and a regulatory Agency, the political science approach keeps it in isolation. It puts aside the analysis of the very reasons why regulation is needed in the first place and neglects the bottom-tier principal-agent problem that regulators face when dealing with regulated firms.

This article proposes an integrated approach that stresses how this downstream agency problem affects the optimal degree of discretion left to regulators. The novel insight of our article is that this conflict of interest between Congress and the Agency actually finds its roots in the informational constraints that limit the choice of regulatory instruments downstream and induce inefficient second-best regulations. This conflict only arises because asymmetric information, more precisely downstream moral hazard on the regulated firm's level of safety care, forces rents to be left to regulated firms and second-best regulations to be implemented.

Even though Congress and the Agency may have different "pro-firm" biases, possibly giving different weights to the firm's profit in their objectives, they certainly agree on what regulatory policies should be when downstream moral hazard is costless, and there is no need to leave any rent to implement an efficient regulation. In such an efficient regulatory environment, the Agency's expert information should be always used: leaving full discretion to the Agency is definitively optimal.

By contrast, when regulation is inefficient and firms can only be induced to exercise effort

[5] Similar trends can be found throughout Western Europe both for economic and social regulators, even though political scientists have expressed mixed feelings about the applicability of the Principal-Agent paradigm inherited from the study of American politics in that particular context (Gilardi, 2001, Thatcher and Stone Sweet, 2002).

[6] Although the so-called *Congressional Dominance Theory* (McCubbins and Schwartz, 1984, and Weingast and Moran, 1983) and the *Shift The Responsibility* approach (Fiorina, 1982) both pushed the view that Congress could perfectly control Agencies, McCubbins, Noll and Weingast (1987, 1989) already pointed out the role of congressional *ex ante* control in curbing bureaucratic drift. As convincingly argued by Epstein and O'Halloran (1999, p.74), the assumption of complete information between Congress and the Agency seems quite at odds with the mere observation that *not everything* is delegated.

[7] Bendor and Meirowitz (2004) and Huber and Shipan (2006) survey the political science literature built on that Principle. Importantly, this literature often comes up with the "Ally Principle" by restricting the kind of *ex ante* instruments that Congress can use to curb the Agency's behavior (for instance either leaving full discretion or no discretion at all). No such restrictions are made in our analysis as our mechanism design approach allows a full description of the set of incentive feasible allocations.

by means of moral hazard rent, Congress and the Agency may have different views on the optimal trade-off between efficiency and rent extraction in second-best environments. More delegation allows better use of the Agency's private information, but it might also induce regulatory policies which are too "pro-firm" oriented and leave excessive rents.

Remarkably, such differences in preferences can be endogenized as the outcome of a full-fledged political equilibrium. We show that regulated firms do indeed have incentives to exert enough pressure on their Agency to increase its "pro-firm" bias and secure moral hazard rent when regulation is inefficient. *A contrario*, had regulation been efficient and firms left with no rent, such pressure would be a pure waste of resources and would not arise at equilibrium. The preferences of Congress and the Agency would remain aligned.

Basic ingredients. To provide some intuition about our results, let us briefly give an overview of our model. Consider a firm involved in activities that put society or the environment at risk. The likelihood of an accident can be reduced if the firm exercises some level of safety care. This effort is nonverifiable and privately costly, although socially attractive. Moral hazard calls for corrective policies. An incentive regulation is designed to properly incentivize the firm to carry out prevention effort. Congress delegates to some extent the tasks of choosing and implementing the regulatory policy to an Agency. This delegation is justified by the fact that the Agency has some expertise that gives it an informational advantage vis-à-vis Congress in tailoring incentive payments to the potential realizations of harm. However, the Agency and Congress may have different objectives, giving different weights to the firm's profit, and the regulatory mandate can be constrained by Congress in response to these differences.

Limited discretion. Suppose that solving the firm's downstream moral hazard problem is costly. This happens when the firm has no assets to cover damages and is protected by limited liability. To induce effort, the firm must earn some liability rent. When the Agency and Congress give different weights to the firm's profit in their objective functions, they hold different views on the social cost of that rent. Leaving discretion to the better informed and more "pro-firm" regulator becomes costly from the point of view of Congress. More delegation allows a better use of the Agency's expert information, but it might also induce regulatory policies which are too "pro-firm" oriented and leave excessive rents.

Indeed, the "pro-firm" regulator may inflate possible harm in order to make it more attractive to induce the firm's effort, thereby leaving more rent. In other words, the downstream agency problem triggers an upstream agency problem between Congress and the regulatory Agency itself. Some *ex ante* control of the Agency might then be used to limit the scope for such manipulations: Congress imposes an upper bound on the possible rewards that the Agency could use to incentivize the firm. This establishes an information-based version of the *"Ally Principle"*: delegation is more pronounced when Congress and the Agency have more congruent preferences on what the optimal rent/efficiency trade-off under moral hazard should be.

Using the recent mechanism design literature on delegation in organizations,[8] we charac-

[8] Holmström (1984), Armstrong (1994), Baron (2000), Armstrong and Vickers (2010), Melumad and Shibano (1991), Martimort and Semenov (2006, 2008), Alonso and Matouscheck (2008), Kovac and Mylovanov (2009) among others.

terize the optimal trade-off between "fixing a rule" that applies whatever the level of harm that firms can cause, and "leaving discretion" to the Agency to set up an incentive regulation tailored to these losses. Indeed, Congress always gains by putting an upper bound on the rewards that the Agency might choose to incentivize firms. This limit is binding for the upper tail of the distribution of potential harm as risks are very high, rents huge, and conflicts between the pro-firm regulator and Congress most significant. Even worse, large-scale conflicts might call for no delegation at all and fully rigid rules based on *expected damages* alone.

This mechanism design approach characterizes the whole set of delegation policies without imposing any *ad hoc* restriction (such as restricting the choice to either full or no delegation). This illuminates the trade-off between rules and discretion in our context. It allows us to investigate how this trade-off changes as the political and economic landscapes are modified. This approach predicts the role that "uncertainty", be it politically or economically induced, plays on the degree of discretion.[9]

Comparative statics. A first set of results addresses how the upstream agency problem between Congress and the Agency affects discretion. The main value of these exercises is to help understand how changes in the distribution of losses on which the Agency has private information affect its discretion. It should be noticed that the fact that the misalignment between Agency and Congress endogenously arises from informational problems with regulated firms is not key to these results. Similar comparative statics could as well have been obtained by adopting a more *ad hoc* modeling that would short-cut the precise origin of this conflict and assume upfront that the Agency and Congress disagree about some policy dimension. However, we should also stress that our comparative statics results are obtained in environments where no exogenous restriction is imposed on the delegation mechanisms, an assumption that distinguishes our analysis from the cruder definition of delegation used in the political science literature. Novel and specific to this article is our second set of comparative statics exercises. They are related to the downstream moral hazard problem that, we argued above, is the very source of the conflict between Congress and the Agency. In this respect, we discuss how the optimal level of discretion changes with the information structure, the intensity of the Agency's monitoring of the firm's effort, and the risk of regulatory capture. Our main result here is that discretion is more valuable when moral hazard rents are more easily extracted.

Extensions. We then investigate how the trade-off between rules and discretion is modified in more complex political environments. Importantly, we consider the possibility that regulated firms exert pressure on the Agency to obtain more favorable policies. We show that the Agency's pro-firm bias can easily be rationalized by those means. Second, we analyze the case where the Agency has private information about its preferences at the time Congress enacts a regulation. This extra degree of asymmetric information restricts the Agency's discretion even further. Third, we turn to a more detailed analysis of the appointment process. The Executive may strategically appoint a regulator with less pronounced pro-firm preferences than its own in order to soften congressional control and ultimately increase the Agency's discretion.

[9] This theme echoes the important works of political scientists like Moe (1989) and Horn (1995).

Literature review. Our article belongs to and deepens several trends of the literature. The *New Economics of Regulation* (Baron and Myerson, 1982, Lewis and Sappington 1988, Laffont and Tirole, 1993, Laffont 1994) assumes that the regulator's preferences are exogenously given and, more often than not, that there is no conflict of interest between the Agency and Congress, both taken as a single entity. The main focus is on the design of optimal incentive regulations under informational constraints. These regulations generally use all information available to regulators and, as a result, the literature has sometimes been criticized for predicting policies which are too flexible.[10] Introducing, as we do hereafter, a difference in the preferences of Congress and the Agency over the rent/efficiency trade-off paves the way to a renewed analysis. Optimal regulations end up being quite rigid.

Laffont and Tirole (1993, Chapters 11 and following), among others, have opened the black-box of the relationship between Congress and agencies. They argue that regulatory capture is at the source of the conflict between different tiers of the government. We share with this approach the view that this conflict is better solved with optimal policies that are less sensitive to the regulator's expert information. However, in Laffont and Tirole (1993), reduced discretion never boils down to a completely rigid rule as in our analysis. A major difference between this line of research and ours is that the former relies on the possibility for Congress to incentivize regulators with some kind of performance pay;[11] our focus on "rules versus discretion" relies on no such possibility. This seems a more appropriate modeling of the crude control that Congress exerts over agencies through legislation and restrictions in procedures.

Other authors have analyzed how various political games influence the preferences of regulators. Using a median-voter theorem, Baron (1989) pointed out that preferences on the rent/efficiency trade-off are inherited from a political equilibrium within the legislature. Laffont (2000) argued that a constitutional commitment to fully rigid regulations may be preferred to a solution leaving more discretion to elected political principals when these principals differ in their preferences as to the rent/efficiency trade-off. Simple standards may be *ex ante* preferable to optimal incentive regulations because "on average" they come closer to the interim efficiency Pareto frontier.[12] Our results obviously share some flavor of this idea, though several noticeable differences remain. First, Laffont's framework does not distinguish between elected political principals and agencies.[13] Second, the "rule" to which more discretionary policies are compared is exogenously given, whereas it is endogenous in our setting.

As we argue below, the trade-off between imposing rules on agencies or leaving them with considerable discretion opens strategic possibilities for the Executive through the appointment process. The idea that the Executive can strategically choose an agent is reminiscent of several branches of economics ranging from industrial organization (Besanko and Spulber, 1993) to macroeconomics and public finance (Rogoff, 1985, Persson and Tabellini, 1993). Governments

[10]The literature on countervailing incentives (see for instance Lewis and Sappington, 1989) has nevertheless shown that optimal mechanisms may exhibit pooling, and appear quite rigid in specific environments where privately informed agents are torn between contradictory incentives.

[11]Sometimes this assumption is motivated as a short-cut to capture the regulator's career concerns.

[12]Boyer and Laffont (1999) applied this idea to environmental regulation.

[13]Faure-Grimaud and Martimort (2003) analyzed how the scope for regulatory capture depends on the relationships between short-term political principals and long-term independent agencies.

may solve a commitment problem by delegating control to agencies with different preferences from their own. Commitment *per se* is not an issue in our context. Instead, the compounding of the Agency's expertise and of conflicting interests between different branches of the government is the source of the incentive problem that partial delegation may solve.

Organization of the article. Section 2 presents the model. Section 3 shows that the conflict of interests between Congress and the Agency is irrelevant when the firm's moral hazard problem is costless. Full discretion should be left to the Agency. Section 4 demonstrates that such a conflict arises when downstream moral hazard induces a rent/efficiency trade-off. Partial discretion follows. Section 5 provides comparative statics exercices related either to the distribution of harm or to the importance of the firm's moral hazard problem. Section 6 investigates how the level of discretion is affected by various political factors such as the political pressure that the firm may exert on the Agency to secure more rent, asymmetric information on the regulator's ideological preferences, or the Executive's preferences in the appointment process. Section 7 briefly concludes by pointing out avenues for further work. Proofs are in an Appendix.

2 The Model

We consider the relationship between Congress, an Agency and a firm whose risky activities might be harmful for society.[14] Our framework has a broad appeal and applies equally well to all kinds of risk regulation (environmental regulation, product safety, medical malpractice, industrial or transportation safety, nuclear power plant regulation, etc...).

Moral hazard. By implementing some level of effort $e \in [0, 1]$, the firm reduces the probability $1 - e$ that third-parties will suffer losses of size D as a result of an accident. Carrying out effort entails a non-monetary cost $\psi(e)$ for the firm, with $\psi(\cdot)$ satisfying the Inada conditions ($\psi'(0) = 0$, $\psi'(1) = +\infty$, $\psi(0) = 0$).[15] The disutility function $\psi(\cdot)$ is common knowledge. It is increasing and convex ($\psi'(e) > 0$, $\psi''(e) > 0$) and satisfies $\psi'''(e) \geq 0$. The level of safety care is non-observable by either the Agency or any third-party, so that moral hazard might increase the risk of a potential harm occurring.

The firm is protected by limited liability and owns a stock of assets of insufficient value to fully compensate the victims for the harm done. To simplify exposition, we assume (unless specified otherwise) that the firm has no assets. Limited liability *cum* the non-verifiability of effort make it impossible for the firm to internalize the externality that its activities might inflict on third-parties. These assumptions are key to justifying the existing liability rent that accrues to the firm and to introducing a conflict of interests between Congress and the Agency.

[14]To fix ideas, one may think of a vessel shipping toxic products and whose leakages might create significant environmental losses. Another example could be firms involved in producing GMOs that are potentially harmful for existing species.

[15]The Inada conditions ensure interior optima under all circumstances below. Sometimes, it will be easier to get comparative statics results by using the quadratic form $\psi(e) = \frac{\lambda}{2}e^2$, in which case we will assume that λ is large enough to ensure that optimal efforts lie within the open interval $(0, 1)$.

Contracts. An Agency designs an incentive regulation in order to foster the firm's incentives to exercise care. Without loss of generality, such a regulation stipulates a base payment t from the rest of society to the firm as a reward for its activities but also a fine f in the event that a damage occurs. The assumption that the base payment t is controlled by the risk regulator is only made for simplicity. More generally, this base payment might reflect competition on the product market and be driven by market/supply considerations.[16]

Even though our analysis relies on the regulator's ability to use transfers in designing the firm's regulation, a broader interpretation of our modeling is available. On the one hand, baseline payments may account for lax standards on some other aspects of the firm's activities.[17] Baseline payments may also include any (implicit or explicit) subsidy that facilitates entry and avoids bankruptcy. In this respect, it is worth noticing that firms involved in the control of risky facilities may often be reluctant to incur the huge cost of safety care on the grounds that it would push them out of business and that public authorities may find it hard to enforce strict compliance with environmental standards, which amounts to an implicit subsidy for participation.[18] On the other hand, fines may be viewed not only as payments made by the firm to compensate victims, but they may also include reputational stigma incurred as a result of an accident[19] and more generally be considered as continuation values of the relationships with contractual partners, investors, lenders, etc... although the modeling of such extensions of our basic set-up would require a full-fledged repeated game approach. Along the same lines, the Agency's choice of incentive rewards and fines could be replaced by its ability to harden or soften future regulations when either banning or permitting the firm's new products and activities for instance. With these interpretations in mind, it becomes easier to map our findings with existing regulatory practices. For instance, an Agency that controls safety standards only and does not *a priori* directly affect the firm's financial incentives, may implement lax standards in the future as a substitute for monetary rewards.

Players' objectives. It is straightforward to write the firm's expected profit U as:

$$U = t - (1 - e)f - \psi(e). \tag{1}$$

Let S be the gross surplus generated by the firm's activities. Merging consumers and vic-

[16]This simple modeling device is standard in the literature and was already used in our earlier works (Hiriart and Martimort, 2006, Hiriart, Pouyet and Martimort, 2010) where we provided more motivation for the short-cut of using monetary transfers between the Agency and the regulated firm.

[17]For instance, an agency may put more emphasis on controlling safety for workers on the workplace and bear less attention to health issues for consumers of the relevant products.

[18]Although it cannot be *stricto sensu* easily mapped into our modeling, the case of Metaleurop Nord offers an interesting example that gives some background evidence for our analysis. This company, located in Northern France for more than one century was a limited liability subsidiary of Metaleurop S.A. which was specialized in heavy metals production (zinc, lead, etc...). Despite several industrial accidents over the nineties and repeated reports of a negative impact of the firm's activities on health, the company still ran its business up to the point it reached bankruptcy in 2003, without being subject to much compliance from French agencies in charge with the control of polluted water. See http://fr.wikipedia.org/wiki/Metaleurop.

[19]This reputation can ultimately affect the consumers' behavior or the stock market value of the firm.

tims as a single entity (the "rest of society"), its expected payoff V can be written:[20]

$$V = S - t + (1 - e)(f - D). \tag{2}$$

The Agency is appointed by the Executive branch of the government and its objective thus reflects the preferences of that branch.[21] It is a weighted sum of consumers/victims' payoff and the firm's profit:

$$W_R = V + \alpha_R U, \qquad \text{with } 0 \leq \alpha_R < 1. \tag{3}$$

The fact that the firm's profit receives a weight strictly less than one in the regulator's objective function captures the idea that the welfare of the "rest of society" is a greater concern for the regulator. As is already well-known from the incentive regulation literature (see Baron and Myerson, 1982), this assumption guarantees that the optimal regulation trades off efficiency and rent extraction.

Congress' preferences are slightly different and are written as:

$$W_C = V + \alpha_C U, \qquad \text{with } 0 \leq \alpha_C < \alpha_R < 1.$$

Congress gives less weight than the Agency to the firm's profit. This assumption reflects the possible capture of the Executive and Administrative branches of the government by private interests, and the greater influence that these interests may have on these branches.[22,23] It may also be viewed as a short-cut for the career concerns of the regulator who may want to please the industry so as to open "revolving doors". Last, and borrowing Baron (1989)'s view that enacted policies reflect the preferences of the median voter in Congress, this assumption may be relevant when this median voter comes from a district where the firm's business is not significant. This also makes sense when representatives who belong to the Committee in charge of overseeing the Agency are not from districts where the firm locates its activities. Finally, considering an extension of our basic model where the firm may face a random fixed cost of maintaining its activities, it is straightforward to observe that, as a consequence of the extra weight given to the firm's profit, a risk regulator might opt for a softer baseline regulation than what Congress would like as a mean to offer greater assurance that firms would participate in the market.

We denote by $\Delta\alpha = \alpha_R - \alpha_C > 0$ the measure of the conflict of interest between Congress and the Agency.

[20]This expression makes it clear that fines are transferred at no cost from the firm to victims. It would be straightforward to include a cost of public funds λ in our framework so that (2) would become:

$$V = S - (1 + \lambda)t + (1 - e)((1 + \lambda)f - D).$$

The lessons of our model would carry over by rescaling both damages and surplus as can be easily seen by dividing the latter expression by $1 + \lambda$.

[21]In Section 6, we analyze the case where the regulator is strategically appointed by the Executive when in conflict with Congress.

[22]Horn (1995) pointed out that firms whose costs can be affected by health or environmental regulations take a very active interest in the activities of agencies like OSHA and EPA in the U.S.

[23]In Section 6, we discuss the reverse assumption where Congress is more "pro-firm" than the Agency.

Information and Agency's discretion. To model the trade-off between discretion and bureaucratic rules in the design of risk regulation in a simple way, we assume that the Agency, because of its expertise, has private information about the loss D.[24] This informational advantage justifies using a regulator in the first place. To further simplify our modeling, we assume that the firm also knows D.[25]

The loss D is drawn from a common knowledge cumulative distribution $H(\cdot)$ over the support $\mathcal{D} = [\underline{D}, \bar{D}]$ ($0 \leq \underline{D} < \bar{D} \leq +\infty$) with an atomless and everywhere positive density $h(\cdot)$. For technical reasons, we assume that the monotone hazard rate property holds, $\frac{d}{dD}\left(\frac{1-H(D)}{h(D)}\right) < 0$. Let $E(\cdot|\cdot)$ be the conditional expectation operator.

3 The Optimality of Discretionary Policies

As a useful benchmark, let us first consider the case of a deep-pocket firm that can fully cover losses D. For simplicity, we first assume that potential damages are also known by Congress (we relax this assumption later on). In such contexts, the non-verifiability of the firm's effort does not preclude efficient regulation. A Pigovian fine just equal to the realized harm is enough to align private and social incentives to exercise effort. Raising its base payment sufficiently ensures the firm's participation. Another important point given our concerns in the rest of the article is that the resulting distribution of payoffs does not depend on the Agency's objectives.

To see why more formally, let us first write the firm's incentive constraint as:

$$e = \arg\max_{\tilde{e} \geq 0} \; t - (1-\tilde{e})f - \psi(\tilde{e}) \quad \text{or} \quad f = \psi'(e). \tag{4}$$

The firm is active when it gets more than its reservation payoff, normalized at zero:

$$U = t - (1-e)f - \psi(e) \geq 0. \tag{5}$$

Expressing the base payment t from the rest of society to the firm as a function of U, we may finally write the regulator's optimization problem as:

$$(\mathcal{P}_R): \quad \max_{\{U,e\}} \; S - (1-e)D - \psi(e) - (1-\alpha_R)U \;\; \text{subject to (5).}$$

The solution to this problem is summarized in the next proposition.

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[24]Alternatively, losses may remain to a large extent uncertain even to the regulator at the time of designing regulation. For instance, the Agency staff may not be fully aware of measurement technology or uncertain about the type, extent and timing of damage that could result. The term D should thus be viewed as the expected harm conditional on the regulator's expert information.

[25]Relaxing this assumption would not modify our results. Assuming that D is the regulator's private information would introduce an *informed principal* problem with the firm. However, because the loss D does not enter directly into the firm's payoff, this would be a *private values* context. We know from Maskin and Tirole (1990) that, with a risk-neutral principal, private information about D would not introduce any distortion with respect to the case where D is common knowledge. It should nevertheless be noticed that we are implicitly restricting the analysis to the case where revelation mechanisms that would use the separate reports of both the regulator and the firm on the value of the commonly observed loss D are not available. One standard justification for this assumption is that opening direct communication channels between Congress and the firm might be too costly.

Proposition 1. *Absent liability constraints on the firm's side, the optimal risk regulation*

- *Is independent of the Agency's preference parameter α_R;*
- *Implements the first-best level of effort $e^*(D)$ with a Pigovian fine equal to losses*

$$f^*(D) = D = \psi'(e^*(D)); \tag{6}$$

- *Extracts all possible rent from the firm (i.e. (5) is binding)*

$$U^*(D) = 0.$$

When the firm is wealthy enough to cover any harm its activities might inflict on the rest of society, downstream moral hazard is costless. The agency problem can be solved at no cost by making the firm the "residual claimant":[26] the deep-pocket firm should just pay a Pigovian fine equal to the harm done. In that case, even though Congress and the Agency may differ in their "pro-industry" biases, they do agree on the level of this fine.

Proposition 1 implies that the Agency's private information about D is not an issue as it does not add any agency problem between this Agency and Congress. Whatever the value of D, the Agency uses its expert knowledge to implement both the efficient level of effort $e^*(D)$ and induce the proper distribution of payoffs between the firm and the rest of society. This leads to the following important property.

Proposition 2. *When downstream moral hazard on the firm's side is costless, leaving full discretion to the Agency is always optimal.*

On top of the Pigovian fine $f^*(D) = D$ that induces the firm to properly internalize the impact of its safety care on the probability of damage, a base payment $t^*(D)$ such that $t^*(D) = (1 - e^*(D))D + \psi(e^*(D))$ ensures the firm's participation.

Let us now consider the more interesting case where the firm is protected by limited liability. As a first pass, suppose that the firm has some assets worth w that can be seized in the event of a poor environmental performance. Fines cannot exceed the firm's base payment plus the value of any asset holdings. This leads us to write the limited liability constraint as follows:

$$t - f \geq -w.$$

Observe first that the Pigovian fine $f^*(D) = D$ and the base payment $t^*(D) = (1 - e^*(D))D + \psi(e^*(D))$ altogether satisfy this liability constraint when the firm has "deep-pockets" and more precisely when

$$w \geq e^*(D)D - \psi(e^*(D)).$$

Corollary 1. *Assume that the firm has enough wealth. Then, leaving full discretion to the Agency is always optimal.*

[26] See the textbook treatment of moral hazard in Laffont and Martimort (2002, Chapter 4), for instance.

When damages are small compared with the firm's assets, no constraint on fines should be imposed on the Agency.

4 Liability Rent and Endogenous Conflict between the Agency and Congress

Turning now to the case where the firm is protected by limited liability, we focus on the situation where the firm has no assets.[27] The following limited liability constraint must be satisfied:

$$t - f \geq 0. \tag{7}$$

Had the efficient regulation $(t^*(D), f^*(D))$ been implemented, this constraint would be violated. Indeed, the firm's net payment in the event of an accident is negative with such a policy as $t^*(D) - f^*(D) = -e^*(D)\psi'(e^*(D)) + \psi(e^*(D)) < 0$ when $\psi(\cdot)$ is convex. Hence, this efficient policy is not feasible when the firm has no assets.

Using the definition of the firm's payoff and the moral hazard incentive constraint $\psi'(e) = f$, the limited liability constraint can be rewritten more compactly as:

$$U \geq R(e), \tag{8}$$

where $R(e) = e\psi'(e) - \psi(e)$. The term $R(e)$ will be referred to as the firm's *liability rent*. Note that $R(e) \geq 0$ with $R(0) = R'(0) = 0$, $R'(e) = e\psi''(e) > 0$ and $R''(e) = e\psi'''(e) + \psi''(e) \geq 0$. Due to the non-verifiability of effort and the potential insolvency of the firm, a rent $R(e)$ must be given up if one wants to induce a given level of effort e. The higher the effort one wants to implement, the higher the rent received by the firm. More precisely, a higher effort requires a higher fine f and, because the limited liability constraint is binding, an equal increase in the firm's base payment t. The latter being socially costly, this is the source of a rent/efficiency trade-off.[28]

■ **Full Discretion Again.** If the Agency had full discretion in choosing the regulatory policy, it would solve the following problem:

$$(\mathcal{P}_R^L): \quad \max_{\{U,e\}} \; S - (1-e)D - \psi(e) - (1-\alpha_R)U \; \text{ subject to (8).}$$

Optimizing $(\mathcal{P}_R^L)$ leads to the following proposition.

Proposition 3. *Under limited liability, the optimal regulation when the Agency has full discretion*

- *Depends on the Agency's preference parameter α_R;*

[27] We leave for subsequent investigation the case where $w \in (0, e^*(D)D - \psi(e^*(D)))$ which is such that the second-best problem is constrained by both the firm's liability and participation constraints. We focus in what follows on the case where only the liability constraint is binding.

[28] The firm's participation constraint (4) is implied by (8) and will thus be omitted in what follows.

- *Implements a second-best level of effort* $e^{SB}(\alpha_R, D)$ *which is increasing with* α_R *and* D *and such that*

$$D = \psi'(e^{SB}(\alpha_R, D)) + (1 - \alpha_R)R'(e^{SB}(\alpha_R, D)); \tag{9}$$

- *Leaves to the firm a positive rent which is also increasing with* α_R *and* D

$$U^{SB}(\alpha_R, D) = R(e^{SB}(\alpha_R, D)).$$

When protected by limited liability, the firm can no longer be the residual claimant for the harm caused. Under limited liability, the firm can no longer be punished for poor performances (the limited liability constraint (8) is binding). The only way to provide incentives is thus to increase the base payment t, and thus to leave a rent $R(e)$. As $\alpha_R < 1$, this rent is costly for the Agency. To reduce it, the firm's effort is distorted below the first-best, as shown in (9). Downstream moral hazard now entails agency costs in the optimal regulation. There is a trade-off between extracting the firm's liability rent and achieving efficiency. The first objective calls for distorting downward the firm's effort, thereby contradicting the second objective.

Because it gives a lower weight than the Agency to the firm's profit in its objective function ($\alpha_C < \alpha_R$), Congress would prefer more distortion of effort and a smaller rent. The "pro-firm" Agency tilts the rent/efficiency trade-off excessively towards efficiency, leaving more rent to the firm compared to what Congress would do.

Some readers may found it somewhat paradoxical that the pro-firm Agency increases the firm's rent by pushing up fines. However, remember that the Agency imposes higher fines to implement higher levels of safety care, which in turn increase the firm's rent.[29] The Agency also increases base payments so that the firm has enough wealth to cover large fines when an accident does occur. Baseline regulation is then significantly softer. For instance, when fines are boosted up, weaker standards might also be enforced on other aspects of the firm's activities, including maybe its future regulations.[30] Also, greater subsidies than what Congress would like might be offered by the Agency to facilitate entry or keep firms into business. Once this one-to-one relationship between fines and subsidies that arises when the limited liability constraint is binding is understood, the apparent paradox disappears. Indeed, Congress is tougher on participation than the Agency and does worry about excessive fines because it would require excessive subsidies or lax regulations on other aspects of the firm's activities to induce its participation.[31]

[29] More generally, the whole incentive regulation literature (Baron and Myerson, 1982, Laffont and Tirole, 1993, Armstrong and Sappington, 2007) makes the point that high-powered incentives also leave lots of information rent to privately informed firms.

[30] Rechtschaffen (2004, p.1336) reports some existing empirical evidence showing that non-statutory factors influence enforcement choices by agencies. For instance, he mentions that *"the Clean Water Act enforcement by the EPA is such that the higher the unemployment rate in a given state, the fewer violations the EPA referred for judicial enforcement. Another analysis of over 300 Clean Water Act, Clean Air Act (CAA), and RCRA penalty actions found that the EPA was less likely to criminally charge very large firms and government agencies than smaller or medium sized firms. As a result, small firms are more than twice as likely as large firms to face criminal sanctions, even after taking into account the harm from a violation."*

[31] Again, the case of Metaleurop referred to in Footnote 18 nicely illustrates those concerns. Agencies which were directly concerned with the firm's regulation like the DRIRE (Direction Régionale de l'Industrie, de la Recherche et de l'Environnement) and the DIREN (Direction Régionale de l'Environnement) were certainly less prone than the

The downstream agency problem introduces a trade-off between efficiency and rent extraction so that the most preferred policies of Congress and the Agency are no longer aligned in this second-best world. The downstream agency problem trickles up the hierarchy, creating an upstream agency problem between these two branches of government. The benefit of leaving more discretion to the Agency is that regulatory policies are tailored to its expertise on potential harm. The cost is that these policies give up excessive rent to the firm.

■ ***Ex ante* Optimal Constraints on Regulatory Agency.** To exercise greater control over the Agency in this second-best world, Congress can design *ex ante* legislation and rules that place constraints on the Agency's discretion. To understand this control, consider first the case where an exogenous constraint on the firm's possible reward t for good environmental performances is imposed by Congress.

A fully rigid rule. Suppose first that Congress forces the Agency to enforce a fixed reward/punishment $t_C = f_C$ (where the equality follows from the binding liability constraint (7)) such that

$$t_C = f_C = \psi'(e_C) \text{ with } E(D) = \psi'(e_C) + (1 - \alpha_C)R'(e_C), \tag{10}$$

where $E(D)$ is the average loss. This non-discretionary policy corresponds to the *ex ante* rule that would be chosen by Congress without any expert information.[32] The Agency has no choice but to implement that rule. The benefit of such a rigid rule is that the rent/efficiency trade-off is evaluated according to Congress' preferences. Its cost is that the Agency's expertise on potential harm is not used.

Mechanism design. Let us now take a more general perspective. We want to describe the whole set of *incentive mechanisms* that might limit the Agency's discretion and still make use of its expertise, at least over some range of possible realizations of D. In this respect, we follow the literature that models delegation in organizations as a mechanism design problem and derive the optimal *ex ante* limit on what the Agency can do without imposing any *ad hoc* restriction on the pattern of delegation.[33]

A direct mechanism is a menu of transfers $\{t(\hat{D})\}_{\hat{D}\in\mathcal{D}}$ contingent on the regulator's announcement $\hat{D}$ on the level of possible harm. From the Revelation Principle, there is no loss of generality in considering such direct and truthful mechanisms. Alternatively, such mechanisms stipulate a range of possible transfers from which the regulator can choose. This interpretation in terms of *delegation sets*, i.e. in terms of the range of mechanisms $\{t(\hat{D})\}_{\hat{D}\in\mathcal{D}}$,[34] stresses the role that Congress plays in restricting *ex ante* the possible options available to the Agency. We further focus on deterministic and continuous mechanisms, which have a quite tractable char-

rest of society to enforce compliance.

[32]This policy is similar to the *ex ante* policy based on average harm in Shavell (1984).

[33]For instance, the *ad hoc* restriction followed by most of the political science literature is to allow either always full discretion or no discretion at all.

[34]This interpretation is based on the so-called Taxation Principle that mirrors the Revelation Principle and replaces the direct revelation mechanism by an indirect one where the agent has to choose within the set of relevant options that the corresponding direct revelation mechanism was offering. See Rochet (1985).

acterization in terms of connected delegation sets.[35] Because $t = f$ from the binding limited liability constraint (7), any upper bound on rewards that would be imposed by such a mechanism can alternatively be viewed as an upper bound on fines.

Alternatively, given the one-to-one mapping between rewards and effort that arises from the firm's incentive constraint (4) (with again $t = f$), we may as well consider that these mechanisms stipulate the level of effort that the Agency implements in response to its private information. Although effort is non-verifiable and only indirectly controlled through fines, we will slightly abuse terminology and denote such mechanisms as $\{e(\hat{D})\}_{\hat{D}\in\mathcal{D}}$.

Given its expert knowledge of the potential harm D, implementing effort $e(\hat{D})$ yields the following payoff to the Agency:

$$W_R(\hat{D}, D) = S - (1 - e(\hat{D}))D - \psi(e(\hat{D})) - (1 - \alpha_R)R(e(\hat{D})).$$

The incentive compatibility constraints which are necessary to induce truthtelling by the Agency can thus be written as:

$$D \in \arg\max_{\hat{D}\in\mathcal{D}} W_R(\hat{D}, D). \tag{11}$$

From standard revealed preferences arguments, we obtain the following Lemma.

Lemma 1. *Any incentive compatible mechanism $\{e(\hat{D})\}_{\hat{D}\in\mathcal{D}}$ is such that $e(D)$ is weakly increasing in D and thus almost everywhere differentiable with, at any point of differentiability,*

$$\dot{e}(D) \geq 0, \tag{12}$$

$$\dot{e}(D) \left(D - \psi'(e(D)) - (1 - \alpha_R)R'(e(D))\right) = 0. \tag{13}$$

The monotonicity condition (12) implies that, as the level of harm increases, the firm's effort also increases. This quite natural condition is satisfied, for instance, by the outcome $e^{SB}(\alpha_R, D)$ obtained when the Agency has full discretion. The first-order condition (13) for truthtelling tells us that the optimal reward is either flat and independent of the harm level, or corresponds to the Agency's ideal policy. In this case, the Agency uses its discretion to tailor the firm's incentive reward to the level of harm.

The characterization of continuous mechanisms is then straightforward.

Lemma 2. *Any implementable policy $\{e(D)\}_{D\in\mathcal{D}}$ that is continuous is fully characterized by two thresholds D_* and D^* such that $\underline{D} \leq D_* \leq D^* \leq \bar{D}$ and:*

$$e(D) = \min\left\{\max\{e^{SB}(\alpha_R, D), e^{SB}(\alpha_R, D_*)\}, e^{SB}(\alpha_R, D^*)\}\right\}. \tag{14}$$

[35] Kovac and Mylovanov (2009) found conditions so that stochastic mechanisms are not optimal. Laffont and Martimort (2002) argued that stochastic mechanisms require the ability to commit to use a public randomizing device which could be manipulated, making those mechanisms less credible than deterministic ones. Melumad and Shibano (1991), Martimort and Semenov (2006), Alonso and Matouscheck (2008) and Kovac and Mylovanov (2009) have provided various conditions on distributions and utility functions ensuring continuity.

The amount of discretion left to the regulator is *a priori* bounded above by a cap on rewards, $t^{SB}(\alpha_R, D^*) = \psi'(e^{SB}(\alpha_R, D^*))$, and below by a floor, $t^{SB}(\alpha_R, D_*) = \psi'(e^{SB}(\alpha_R, D_*))$. Within this interval, the Agency has full discretion in setting up incentive rewards according to its own preferences. Our goal is essentially to find these bounds.

To provide more intuition on the limits to the Agency's discretion, we now investigate the kind of incentives it would have for manipulating its announcement $\hat{D}$ on potential harm if Congress's ideal policy $e^{SB}(\alpha_C, \hat{D})$ was implemented. We find:

$$\begin{aligned}\frac{\partial W_R}{\partial \hat{D}}(\hat{D}, D)\Big|_{\hat{D}=D} &= \frac{\partial e^{SB}}{\partial \hat{D}}(\alpha_C, \hat{D})\left(D - \psi'(e^{SB}(\alpha_C, \hat{D})) - (1-\alpha_R)R'(e^{SB}(\alpha_C, \hat{D}))\right)\Big|_{\hat{D}=D} \\ &= \Delta\alpha \frac{\partial e^{SB}}{\partial D}(\alpha_C, D)R'(e^{SB}(\alpha_C, D)) > 0.\end{aligned}$$

The mechanism $\{e^{SB}(\alpha_C, D)\}_{D\in\mathcal{D}}$ is not incentive compatible. The Agency finds it optimal to inflate potential harm. By doing so, the "pro-firm" regulator chooses higher levels of effort and increases the firm's rent. Hence, there is no reason to fix a floor on rewards because the Agency never has any incentive to understate losses. On the other hand, imposing a cap certainly helps in aligning the objectives of Congress and those of the Agency.[36] Therefore, the optimal mechanism is of the form $e(D) = \min\{e^{SB}(\alpha_R, D), e^{SB}(\alpha_R, D^*)\}$ where the level of damage D^* below which the Agency retains discretion is the optimization variable left to Congress.

Under asymmetric information on D, Congress' optimization problem becomes:

$$(\mathcal{P}_R^{SB}): \quad \max_{D^*\in\mathcal{D}} \; S - E((1-e(D))D + \psi(e(D)) + (1-\alpha_C)R(e(D)))$$

$$\text{where } e(D) = \min\{e^{SB}(\alpha_R, D), e^{SB}(\alpha_R, D^*)\}.$$

Optimizing $(\mathcal{P}_R^{SB})$ finally leads to the following proposition.

Proposition 4. *The optimal policy can be characterized as follows.*

- *If $e^{SB}(\alpha_R, \underline{D}) \geq e_C$, the Agency has no discretion and implements the effort e_C which is ex ante optimal from Congress' viewpoint (rigid rule).*
- *If $e^{SB}(\alpha_R, \underline{D}) < e_C$, the Agency has partial discretion but never full discretion. Congress imposes a cap $e^{SB}(\alpha_R, D^*(\alpha_R))$ on the firm's effort that the Agency may induce, where $D^*(\alpha_R) \in (\underline{D}, \bar{D})$ is the unique solution to*

$$E(D|D \geq D^*(\alpha_R)) = \psi'(e^{SB}(\alpha_R, D^*(\alpha_R))) + (1-\alpha_C)R'(e^{SB}(\alpha_R, D^*(\alpha_R))), \qquad (15)$$

  with $e^{SB}(\alpha_R, D^*(\alpha_R)) < e^{SB}(\alpha_C, \bar{D})$.

  The Agency induces an effort $e^{SB}(\alpha_R, D)$ when $D \in [\underline{D}, D^*(\alpha_R)]$ and is constrained by the cap otherwise.

Capping rewards and fines better aligns the regulator's choice with Congress' ideal policy. Once the cap is attained, i.e. when the level of harm is high enough and reaches $D^*(\alpha_R)$, the op-

[36] This is confirmed in the next proposition with a formal proof in the Appendix.

timal regulation is the Agency's ideal policy for harm equal to $D^*(\alpha_R)$, namely $e^{SB}(\alpha_R, D^*(\alpha_R))$ (see Figure 1 below). It is higher than the effort level $e^{SB}(\alpha_C, D^*(\alpha_R))$ that Congress would choose. However, when D increases, such an effort level comes closer to $e^{SB}(\alpha_C, D)$ up to the point where $e^{SB}(\alpha_R, D^*(\alpha_R))$ becomes too low compared to $e^{SB}(\alpha_C, D)$ for the most extreme values of D. Over the set of possible values of D where a rigid rule applies, the effort is either above or below Congress' ideal choice but *on average*, when $D^*(\alpha_R)$ is optimally chosen, these distortions compensate each other.

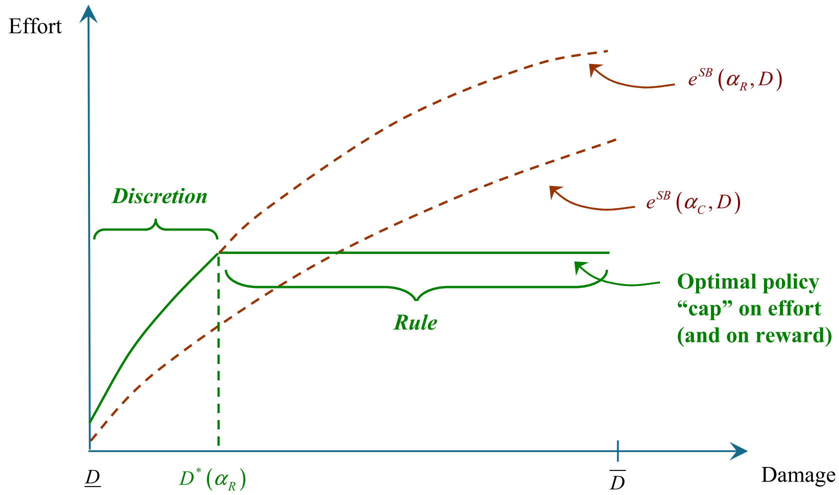

Figure 1

A rigid rule at e_C may be optimal when the objectives of the Agency and Congress differ sufficiently. More generally, leaving discretion to the Agency over the upper tail of the distribution of harm is never optimal. Indeed, given that $e^{SB}(\alpha_R, \bar{D}) > e^{SB}(\alpha_C, \bar{D})$, it is optimal to cap the level of effort in the neighborhood of $\bar{D}$ to bring it closer to Congress' preferences.

In the limiting case where $\alpha_R = \alpha_C$, the Agency should be left with full discretion and $D^*(\alpha_R)$ would converge towards $\bar{D}$.

Implementation. The optimal solution can be implemented by simply imposing a cap $t^{SB}(D^*(\alpha_R)) = f^{SB}(D^*(\alpha_R)) = \psi'(e^{SB}(\alpha_R, D^*(\alpha_R)))$ on the rewards/fines that the regulator can choose. Another possible implementation of the optimal mechanism consists in letting the Agency choose rewards from the interval $[\psi'(e^{SB}(\alpha_R, \underline{D})), \psi'(e^{SB}(\alpha_R, D^*(\alpha_R)))]$. This leads to a nice interpretation of how "vague" the Agency's mandate should be. Indeed, this model of delegation could be reinterpreted as an "incomplete contract" model where the delegation set specifies *a priori* the possible realizations of uncertainty where the Agency has real authority in setting up the regulation. A vague mandate corresponds to a lot of freedom for the Agency, which typically arises when $e^{SB}(\alpha_R, \underline{D})$ and $e^{SB}(\alpha_R, D^*(\alpha_R))$ are sufficiently far apart, i.e. when the distribution of D is spread enough. A stricter mandate corresponds to a smaller delegation set.[37]

[37]Note that the restriction made in the political science literature to a choice between leaving full discretion versus

5 Comparative Statics

We divide this section into two parts. First, we focus on the upstream agency problem and studies how changes in preferences and information structures affect discretion. The main take-away of these comparative statics is that more effective regulators, in the sense of being better aligned with Congress or having expertise on pieces of information which leave less scope for manipulation, should have more discretion. Second, we analyze how the intensity of the downstream agency problem with regulated firms affects the Agency's discretion. By definition, these results could not have been obtained with any *ad hoc* modeling of the upstream agency problem. Our analysis unveils that the very reason why some regulators are indeed more effective is that the economic or institutional environment calls for leaving few rents to regulated firms, thereby reducing the conflict between the Agency and Congress.

■ **Upstream Agency Problem.** To sharpen intuition and simplify the comparative statics exercises, consider the parametric case of a quadratic disutility function, $\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough so that effort remains in $(0, 1)$. Then, it is straightforward to check that

$$e^{SB}(\alpha_R, D) = \frac{D}{\lambda(2 - \alpha_R)}$$

and the first-order condition (15) yields

$$E(D|D \geq D^*(\alpha_R)) - D^*(\alpha_R) = \frac{\Delta\alpha}{2 - \alpha_R} D^*(\alpha_R). \tag{16}$$

□ **"Ally Principle".** From (16), we immediately recover the so-called *"Ally Principle"*, i.e. the Agency has more discretion when its objectives are closer to Congress.

Corollary 2. *Assume a quadratic disutility function ($\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough to avoid corner solutions). An increase in the conflict of interest between Congress and the Agency (i.e. $\Delta\alpha$ becoming larger) reduces the Agency's discretion (i.e. $D^*(\alpha_R)$ diminishes).*

This "Ally Principle" has received some pieces of evidence in the field of environmental regulation. For instance, Rechtschaffen (2004) reports that almost half of Clean Water Act enforcers from the EPA considered the state of economy when enforcing the law whereas, by contrast, *"more experienced inspectors from the Office of Surface Mining and Reclamation and inspectors with more critical views of the regulated industry issued more notices of violation."* In full accordance with our findings, these observations show that bureaucrats may exercise more of their discretionary power to enforce the law as the weight they give to the regulated sector in their objectives is lower. Beyond the case of risk regulation which motivated this article, this finding has more generally received significant empirical support in the political science literature (Wood and Bothe, 2004, Epstein and O'Halloran, 1994, Huber and Shipan, 2002). From a theoretical viewpoint, our model shows that this *"Ally Principle"* also holds when few restrictions are actually imposed on incentive mechanisms (beyond continuity and non-stochasticity). Moreover, we

no discretion to the Agency makes it impossible to discuss how vague an Agency's mandate should be.

should again stress that the political science literature specifies *a priori* the upstream conflict of interest rather than deriving it from informational limits on what the regulator can do.

□ **Comparisons of Information Structures.** Let us now investigate how changes in the distribution of damages affect the degree of discretion left to the Agency. An often-found argument in the political science literature (Epstein and O'Halloran, 1994, 1999, Bawn 1995) is that more *"uncertainty"* in the regulatory environment makes it more likely that discretionary power will be delegated to the Agency. This idea, although quite relevant for risk regulation as uncertainty plays a key role *de facto*, is now linked to properties of the distribution of losses. The restriction of the political science literature to the binary choice between leaving either full or no discretion to the Agency, together with the choice of quadratic utility functions, implies that the comparison between these organizational forms boils down to finding an upper bound on the variance of the Agent's expert information beyond which leaving no discretion is preferred by Congress. In our model where the optimal degree of discretion may be partial, the variance of the distribution no longer matters. Instead, the properties of the distribution on its upper tail, where a cap may be binding, now matter. This is exemplified by the analysis below.

Front-loading. A distribution $H_1(\cdot)$ is *more front-loaded* than a distribution $H_2(\cdot)$ if and only if:

$$\frac{1}{1-H_1(D)}\int_D^{\bar{D}} xh_1(x)dx \leq \frac{1}{1-H_2(D)}\int_D^{\bar{D}} xh_2(x)dx \text{ for all } D \in \mathcal{D}, \tag{17}$$

with equality at $\bar{D}$. This inequality simply means that the conditional expected harm over the upper tail $[D, \bar{D}]$ is always greater with $H_2(\cdot)$ than with $H_1(\cdot)$.[38] Intuitively, $H_1(\cdot)$ puts more mass around the lower tail than $H_2(\cdot)$.[39]

Corollary 3. *Assume a quadratic disutility function ($\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough to avoid corner solutions). The Agency has more discretion when D is drawn from the distribution $H_2(\cdot)$ than when it is drawn from the distribution $H_1(\cdot)$ (i.e. $D^*(\alpha_R)$ increases) if $H_1(\cdot)$ is more front-loaded than $H_2(\cdot)$.*

A more front-loaded distribution reduces the likelihood of serious damage. "Large" reports on potential losses can be interpreted by Congress as coming from a regulator who is very likely to have overstated their level. Stricter rules should be implemented and less discretion should be left to the Agency.

More uncertainty in the sense of Blackwell. We now investigate how the discretion left to the Agency evolves when the distribution of losses is better known, maybe thanks to the evolution of scientific knowledge. This question is particularly relevant in the case of GMOs for instance, where little is known about the consequences of authorizing some products at the time of enacting regulations, but knowledge of the distribution of potential losses will improve later on. We model the evolution of scientific knowledge as the arrival of some public information that

[38] In particular, the average damage is greater with distribution $H_2(\cdot)$ than with distribution $H_1(\cdot)$.

[39] Consider the exponential distributions on $\mathbb{R}_+$ such that $H_i(D) = 1 - exp\left(-\frac{D}{\mu_i}\right)$ for $i = 1, 2$ with $0 < \mu_1 \leq \mu_2$. It can be readily verified that (17) holds.

decreases uncertainty in the sense of Blackwell. Under weak assumptions, leaving more discretion to the Agency is preferable in more uncertain contexts. Contrariwise, risks which are better known require ”on average” more rigid rules.

Consider thus the case where one of K possible signals as to the possible distribution of harm becomes common knowledge. In response to this change in publicly available information, Congress devises new regulations. Denote by $H_k(\cdot)$ (resp. $h_k(\cdot)$) the cumulative distribution of D (resp. density) corresponding to signal $k \in \{1, .., K\}$ and let x_k be the positive probability that signal k is realized ($\sum_{k=1}^{K} x_k = 1$, $x_k > 0$). From an *ex ante* viewpoint, i.e. before the arrival of scientific knowledge, the cumulative distribution (resp. density) of losses is $H(D) = \sum_{k=1}^{K} x_k H_k(D)$ (resp. $h(D) = \sum_{k=1}^{K} x_k h_k(D)$). For the sake of tractability, we will only consider the case of exponential distributions each having mean $\mu_k > 0$, density $h_k(D) = \frac{1}{\mu_k} exp\left(-\frac{D}{\mu_k}\right)$ and cumulative distribution $H_k(D) = 1 - exp\left(-\frac{D}{\mu_k}\right)$ on $\mathbb{R}_+$. Let us then denote by $D_k^*(\alpha_R)$ and $D^*(\alpha_R)$ the levels of discretion left to the Agency either *ex post*, i.e. once the signal k is known, or *ex ante*, i.e. without having learned yet about the signal.

Corollary 4. *Assume a quadratic disutility function ($\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough to avoid corner solutions) and exponential distributions. More uncertainty in the sense of Blackwell increases the Agency's discretion in the following way:*

$$E_k\left(D_k^*(\alpha_R)\right) \leq D^*(\alpha_R). \tag{18}$$

The distribution $H(\cdot)$ has a conditional expectation on upper tails which is greater “on average” than conditional expectations obtained when signals have been revealed. The Agency's claim about high values of D in a more uncertain world is not so unlikely and cannot be interpreted too much as evidence for manipulating information to favor the firm. This calls for more discretion to be left.

More discretion should be left to the Agency at the inception of regulations but, as time goes on and knowledge about risk improves, more rigid regulations will be enforced “on average”. With such regulations, the firm gets “on average” less liability rent. This example suggests that firms might be net losers when scientific knowledge of potential harm increases. A rough example of such an evolution might be given by the regulation of genetically modified food and seeds. In that case, the U.S. has chosen to regulate both GM food and seeds under existing laws. This setting can be interpreted as the choice of an *ex ante* regulatory mandate. At the same time, the E.U. legislation has established a complex set of new regulations targeted to this technology. This setting can instead be interpreted as the choice of *ex post* regulatory mandates. Even though other considerations may affect this evolution, noticeably the different perceptions of risk over both sides of the Atlantic, it is remarkable that the E.U. did authorize only eighteen crops for import or cultivation by 2002, while the U.S.D.A. issued approvals for fifty and the EPA approved eight over the same time period (Vogel, 2003). This might point at to the decreased discretion of agencies with *ex post* mandates.

■ **Downstream Agency Problem.** We now provide some comparative statics with respect to the intensity of the downstream moral hazard problem. The bottom line is that the Agency's discretion decreases when the downstream moral hazard problem is modified so that Congress' and the Agency's views of the cost of the firm's liability rent depart from each other. This is the case when information structures harden rent extraction. Otherwise, the Agency's discretion increases.

□ **Noisy Performances.** Suppose that a "poor" performance, which still occurs with probability $1-e$, can only be observed with probability $(1-\theta)(1-e)$, where $\theta \in (0,1)$. Instead, a "good" performance is observed with probability $e + (1-e)\theta$. The firm's incentive constraint under limited liability (where $t = f$) can now be written as:

$$e = \arg\max_{\tilde{e} \geq 0} \;\; t - (1-\tilde{e})(1-\theta)f - \psi(\tilde{e}) \quad \text{or} \quad (1-\theta)f = \psi'(e). \tag{19}$$

This leads to the following expression of the firm's information rent:

$$U = R(e) + \eta\psi'(e). \tag{20}$$

The parameter $\eta = \frac{\theta}{1-\theta}$ captures the informativeness of a good performance on the firm's effort, η being greater when such performance is less informative about the firm's effort. Equation (20) shows that more noise increases the cost of inducing effort and the firm's information rent. It tilts the optimal regulation towards low-powered incentives. Assuming interior solutions, the level of effort $e^{SB}(\alpha_R, D)$ is more downward distorted than with $\eta = 0$:

$$D = \psi'(e^{SB}(\alpha_R, D)) + (1-\alpha_R)\psi''(e^{SB}(\alpha_R, D))(e^{SB}(\alpha_R, D) + \eta). \tag{21}$$

Corollary 5. *Assume a quadratic disutility function ($\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough) and that η is small enough to ensure a positive effort. Noisier performances reduce the Agency's discretion ($D^*(\alpha_R)$ decreases as η increases).*

When the downstream agency problem worsens because of less informative performances, the conflict between the Agency and Congress is exacerbated. The optimal institutional response is thus to leave less discretion to the Agency. Worse agency problems downstream imply worse agency problems upstream.

The noisy information structure studied in this section is particularly relevant in the case of environmental regulation. Poor environmental performances might indeed take time before being revealed because, for instance, pollution leakages are not immediate. Alternatively, we may interpret θ as reflecting the Agency's imperfect expertise in assessing the firm's performance. To the extent that this expertise may be linked to the size of the Agency's budget, our model predicts that the Agency's budget and its discretion should be positively correlated.

□ **Monitoring.** Suppose now that the Agency can increase the probability of a good performance by actively monitoring the production process. More precisely, assume that, with probability $1-e$, the Agency receives an interim signal that reveals future damage. With a monitoring effort θ of a fixed intensity, the probability of such an accident can be reduced to $(1-\theta)(1-e)$. For simplicity, let us assume that the Agency's monitoring effort is contractible and its cost is exogenous. A good performance (resp. damage) now occurs with probability $e + (1-e)\theta$ (resp. $(1-\theta)(1-e)$). Monitoring renders the firm's incentives costlier and its information rent is again given by (20).[40] This move towards low-powered incentives favors less discretion.

Corollary 6. *Assume a quadratic disutility function ($\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough) and that $\eta = \frac{\theta}{1-\theta}$ is small enough. More monitoring of the agent's effort decreases the Agency's discretion ($D^*(\alpha_R)$ decreases as θ increases).*

□ **Informative Signals.** Suppose that, maybe through on-site inspections, the Agency observes a signal $\sigma \in \{\underline{\sigma}, \bar{\sigma}\}$ which is informative as to the firm's effort even when there is no accident. More precisely, suppose that with probability $p_1(e) = \frac{1}{2}(e+\eta)$ (state 1), the accident does not occur but the signal $\underline{\sigma}$ informs the Agency that this is unlikely to be due to a high effort. This signal provides enough evidence against the firm to justify a fine, or at least the absence of any reward for a good precautionary behavior. Instead, with probability $p_2(e) = \frac{1}{2}(e-\eta)$ (state 2), there is still no accident but the signal $\bar{\sigma}$ informs the Agency that this is likely to be due to a high effort. To maintain positive probabilities, we assume η is positive but not too large. With complementary probability $p_3(e) = 1-e$, an accident occurs (state 3). Under limited liability, it is a standard result of the moral hazard literature (Laffont and Martimort, 2002, Chapter 4) that the optimal incentive scheme should reward the firm only in the state which has the highest likelihood ratio, i.e. in state 2, which is the most informative about the fact that the firm has exercised some effort.[41] As the fine f is inflicted in states 1 and 3, the firm's incentive constraint under limited liability (i.e. $t = f$) becomes:

$$e = \arg\max_{\tilde{e}\geq 0}\; t - \left(\frac{\tilde{e}+\eta}{2} + 1 - \tilde{e}\right) f - \psi(\tilde{e}) \quad \text{or} \quad \frac{f}{2} = \psi'(e). \tag{22}$$

This leads to the following expression of the firm's information rent:

$$U = R(e) - \eta\psi'(e). \tag{23}$$

Equation (23) is the flip side of (20). Using an informative signal helps reduce the firm's information rent and pushes towards higher-powered regulation. *Mutatis mutandis*, we obtain:

Corollary 7. *Assume a quadratic disutility function ($\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough), $\underline{D} > 0$, η is small enough so that state 2 arises with positive probability under all circumstances, and the firm's rent remains positive. A more informative signal as to the agent's effort increases the Agency's discretion ($D^*(\alpha_R)$ increases as η increases).*

The intuition here is the flip side of the intuition in Corollary 5. When η increases, state 2 becomes more informative about the firm's effort. Providing incentives is easier. The second-best effort comes closer to the first-best and the conflict between the Agency and Congress is

[40] See Aghion and Tirole (1997) for a similar mechanism.

[41] Note that the likelihood ratio $\frac{p_2'(e)}{p_2(e)} = \frac{1}{e-\eta}$ in state 2 increases with η whereas the likelihood ratio $\frac{p_1'(e)}{p_1(e)} = \frac{1}{e+\eta}$ in state 1 decreases with η. Moreover, we have $\frac{p_2'(e)}{p_2(e)} > \frac{p_1'(e)}{p_1(e)} > \frac{p_3'(e)}{p_3(e)}$.

less of a concern. Again, the Agency should have more discretion when its expertise to assess the firm's performance accurately is more pronounced and again, this factor is certainly linked to the size of its budget.

□ **Downstream Adverse Selection.** Let us now complexify the downstream agency problem by introducing asymmetric information, so that the disutility of effort is no longer common knowledge. More specifically, exercising effort e now costs the firm $\psi(e - \zeta(\theta))$. The latter has private information about the efficiency parameter θ. This parameter is drawn from $\Theta = [-\bar{\theta}, \bar{\theta}]$ according to some common knowledge density function symmetric around zero so that $E_\theta(\theta) = 0$. The function $\zeta(\cdot)$ is such that $\zeta(0) = 0$ and $\eta = E_\theta(\zeta(\theta))$. Moving from knowing for sure that $\theta = 0$ to the case of private information is thus akin to a mean-preserving spread.[42] For simplicity, we also adopt the quadratic specification $\psi(e) = \frac{\lambda e^2}{2}$ for some parameter λ large enough. These simple specifications will allow us to draw strong implications about the amount of conflict between Congress and the Agency by looking merely at the sign of η.

Because of limited liability, the regulatory policy is again reduced to a single instrument $t = f$. Under asymmetric information, this dimensionality constraint is such that there are not enough instruments to screen the different types of firm according to their efficiency parameter.

It is straightforward to derive the effort supplied by the firm with parameter θ when facing a base-payment/fine $t = f$ as:

$$e(\theta, t) = \arg\max_{\tilde{e}} \ \tilde{e}t - \psi(\tilde{e} - \zeta(\theta)) \Leftrightarrow e(\theta, t) = \frac{t}{\lambda} + \zeta(\theta).$$

Such a policy induces an expected rent for the firm worth

$$\mathcal{R}(t) = E_\theta \left[e(\theta, t)\psi'(e(\theta, t) - \zeta(\theta)) - \psi(e(\theta, t) - \zeta(\theta)) \right] = \frac{t^2}{2\lambda} + \eta t.$$

Observe that, when $\eta > 0$ (resp. < 0), the expected rent is greater (resp. less) than the rent of a firm known for sure having an efficiency parameter $\theta = 0$, as the higher realizations of θ contribute more (resp. less) to increasing the average probability of avoiding an accident than lower realizations contribute to decreasing it. From this finding, we show how private information downstream may or may not exacerbate the upstream conflict of interests, depending on the sign of η.

Corollary 8. *The Agency has less discretion when there is asymmetric information downstream if and only if $\eta > 0$.*

□ **Capture of the Agency's Staff.** Suppose now that members of the Agency's staff can perfectly observe the firm's effort and reveal hard evidence about its level with probability $\theta \in (0, 1)$ before any accident occurs. In that event, the optimal regulation can specify the first-best level of effort $e^*(D)$ and extract all rent from the firm. With complementary probability $1 - \theta$, the firm's effort cannot be observed and must be induced through an incentive regulation.

[42] Note then that $\zeta(\cdot)$ strictly convex (resp. strictly concave) implies, by Jensen inequality, $E_\theta(\zeta(\theta)) > 0$ (resp. $E_\theta(\zeta(\theta)) < 0$).

When staff members are captured by the firm, they hide valuable information against a share of the rent $R(e)$ that the firm can obtain. We follow Tirole (1992) and Laffont and Tirole (1993, Chapter 13 and following) in assuming that bureaucrats have all bargaining power in reaching collusive side-deals with the regulated firm, and transferring τ units of bribes entails some deadweight loss $(1-k)\tau$, where $k \in [0,1)$ is a measure of collusion efficiency.

Avoiding such collusive behavior requires giving resources to staff members, maybe in the form of extra wages, career opportunities or perquisites. Given that the stake of collusion is $R(e)$, leaving an extra wage $w = kR(e)$ to staff members in case they report valuable evidence ensures *collusion-proofness*. This comes at an extra cost for the Agency's budget, as well as for society. When staff members instead do not report any hard evidence about the firm's effort, they receive no extra wage beyond their reservation wage, which is normalized at zero.

Had the Agency been left with full discretion in setting fines, it would have induced an optimal effort e that maximizes the following expression of expected welfare:

$$\theta(S-(1-e^*(D))D-\psi(e^*(D)))+(1-\theta)(S-(1-e)D-\psi(e)-(1-\alpha_R)R(e))-\theta kR(e).$$

This expression takes into account the fact that, with probability θ, the efficient regulation is implemented and leaves no rent to the firm. However, extra resources are now spent to prevent collusion. This immediately leads to an optimal effort that solves:

$$D=\psi'(e^{SB}(\alpha_R,D))+(1-\alpha_R+\eta k)\,R'(e^{SB}(\alpha_R,D)) \text{ where again } \eta=\frac{\theta}{1-\theta}. \tag{24}$$

Preventing collusion moves the optimal regulation towards inefficient effort levels, both leaving low rent to the firm and decreasing the stake for capture.

Congress still considers this incentive regulation as excessively high-powered and must again limit the Agency's discretion. In full generality, the amount of discretion left to the Agency should be contingent on whether its staff members have reported hard evidence of the firm's effort or not. This contingent delegation scheme leads to full discretion when such evidence is available, and imposes a cap on the possible fines/base payments otherwise.

Corollary 9. *Assume a quadratic disutility function ($\psi(e)=\frac{\lambda e^2}{2}$ with λ large enough). The Agency has more discretion when collusion is more efficient (i.e., k greater).*

Preventing the petty collusion between staff members and the firm somewhat aligns the Agency's objectives with Congress, because it calls for low-powered incentives and less rent for the firm. As collusion becomes more efficient (the efficiency of side-contracting k increases), it becomes more attractive to prevent collusion by reducing rent: this common goal is shared by the head of the Agency and Congress. The conflict between Congress and the Agency being less acute, more discretion is left to the Agency.

One may argue that the "collusive technology" becomes less efficient when agencies have a larger staff. Indeed, a large staff reduces the probability of building a network of personal relationships that may facilitate collusion as a large staff may facilitate peer monitoring. Our model again predicts thus that Agencies with large budgets that can afford large staffs are also those with the greatest discretion.

6 Extensions

This section proposes several extensions of our basic framework to enrich the modeling of the political sphere and discuss how the optimal degree of discretion changes.

■ **Endogenizing the Upstream Conflict of Interest.** So far, our approach has consisted in fixing *a priori* differences in preferences over the rent-efficiency trade-off between Congress and the Agency, and deriving the latter's optimal amount of discretion from the existing frictions that second-best regulatory policies face under moral hazard. In this section, we go one step further and derive these differences in preferences explicitly from a political-economy equilibrium. We show that, again, downstream moral hazard is key to generating a *now fully endogenous conflict* between Congress and the Agency.

Suppose first that Congress can pick the head of an Agency having *a priori* the same preferences as to the rent-efficiency trade-off as its own, i.e. $\alpha_R = \alpha_C$.[43] Such a choice would justify granting full discretion to the Agency if the latter were to obey these induced preferences.

Following a now standard assumption in the political economy literature,[44] let us assume that the regulated firm can influence the Agency's preferences by spending resources. More specifically, by incurring a monetary cost $C(\alpha)$, the firm can induce the Agency to adopt preferences giving a weight α on the firm's profit.[45] This can be done either by spending those resources in lobbying the appointment process itself, or by influencing key members of the Agency when in office. We assume that $C(\alpha_C) = C'(\alpha_C) = 0$, i.e. the cost of leaving the Agency's preferences as specified by Congress is zero both in absolute terms and at the margin. The function $C(\cdot)$ is increasing and strictly convex for $\alpha \geq \alpha_C$ with $C(\alpha) = 0$ for $\alpha \leq \alpha_C$. In addition, it is prohibitively costly to induce $\alpha = 1$, $C(1) = +\infty$. Such lobbying takes place *ex ante*, i.e. before the choice of the level of discretion left to the Agency and before the realization of any potential harm.

Consider first the case where the downstream moral hazard problem is solved costlessly, as in Section 3. For any damage done $D \in [\underline{D}, \bar{D}]$, the regulated firm is left with no rent and there is no point in spending resources to influence the Agency's preferences. Henceforth, Congress' and the Agency's preferences remain perfectly aligned.

Suppose now that solving the downstream moral hazard problem means leaving some rent to the firm. More precisely, with limited liability, the regulated firm gets a rent equal to $R(\min\{e^{SB}(\alpha, D); e^{SB}(\alpha, D^*(\alpha))\})$ if the damage done is D and the Agency's preferences are $\alpha \geq \alpha_C$, which induces a cap at $D^*(\alpha)$. Assuming that lobbying activities take place before the firm knows the realization of D, the optimally induced preferences must maximize the firm's

[43] That the head of the Agency is appointed by Congress can be justified if the Executive (generally in charge with the appointment process) and Legislative branches of the government are aligned.

[44] See for instance Grossman and Helpman (1994) and references therein among other contributions.

[45] We leave for future research the analysis of a full-fledged model where the regulated firm can also influence the preferences of Congress. Implicit in the analysis below is the assumption that it is much more costly to influence Congress than to influence the Agency.

expected net payoff $\mathcal{U}(\alpha)$:

$$\alpha_R = \arg\max_{\alpha} \mathcal{U}(\alpha) \equiv E_D(R(\min\{e^{SB}(\alpha, D); e^{SB}(\alpha, D^*(\alpha))\})) - C(\alpha).$$

The firm now derives some gains from spending resources towards inducing more lenient behavior from the Agency. More precisely, the following result holds.

Proposition 5. *The Agency's induced preferences are more pro-firm than Congress would like, i.e. $\alpha_R > \alpha_C$, if and only if solving downstream moral hazard is costly.*

This important result first justifies our short-cut of taking as given the difference in preferences over the rent/efficiency trade-off between Congress and the Agency. On top of that, it shows that the existing conflict finds its roots in the very assumption, a costly downstream agency problem, that makes this conflict relevant to evaluating the Agency's discretion.

■ **Political Uncertainty and Asymmetric Information about the Agency's Preferences.** *Ex ante* constraints on agencies may be designed when there is still significant uncertainty about the preferences of the heads of these agencies. This uncertainty may be exogenous and linked to the intrinsic motivation of the bureaucrats in charge. It might also be endogenous to the political process. For instance, such uncertainty might be induced by random changes in the Agency's leadership (or significant changes in the composition of the Executive Committee). We characterize the optimal trade-off between rules and discretion in such an environment. The analysis is made complex because of the interplay between two pieces of private information that the Agency handles: first, its expertise on the level of harm and, second, its own bias towards the industry. We show that the Agency should be given less discretion as its preferences are more uncertain, although this effect is only of second-order magnitude.

To model such settings, we assume that, at the time of designing *ex ante* constraints on the Agency, the weight $\tilde{\alpha}_R$ that the firm receives in the Agency's objective is viewed as random by Congress, with $\tilde{\alpha}_R$ being uniformly distributed over an interval $[\alpha_R - \epsilon, \alpha_R + \epsilon]$. We assume that $\alpha_C < \alpha_R - \epsilon < \alpha_R + \epsilon < 1$ and that ϵ is small enough so that even the Agency which is the least eager to favor the firm has nevertheless more pronounced pro-firm preferences than Congress. Denote G_ϵ the corresponding cumulative distribution (such that $G_\epsilon(\alpha) = \frac{\alpha - \alpha_R + \epsilon}{2\epsilon}$ for $\alpha \in [\alpha_R - \epsilon, \alpha_R + \epsilon]$, $G_\epsilon(\alpha) = 1$ for $\alpha \geq \alpha_R + \epsilon$, $G_\epsilon(\alpha) = 0$ for $\alpha \in [\alpha_C, \alpha_R - \epsilon]$).

In full generality, a deterministic incentive mechanism must now induce the Agency to reveal truthfully all its private information, i.e. not only its expertise but also its own preferences. Such a mechanism is a menu of rewards for the firm $\{t(\hat{\alpha}, \hat{D})\}_{\{\hat{\alpha} \in [\underline{\alpha}, \bar{\alpha}], \hat{D} \in \mathcal{D}\}}$ as a function of the Agency's reports on the level of potential harm it privately observes and on its own preferences. Equivalently, and again using (4), such a mechanism can be viewed as a menu of effort levels $\{e(\hat{\alpha}, \hat{D})\}_{\{\hat{\alpha} \in [\underline{\alpha}, \bar{\alpha}], \hat{D} \in \mathcal{D}\}}$.

Incentive compatibility conditions again show that the Agency either chooses its most preferred policy $e^{SB}(\alpha, D)$ or is bound to an effort level independent of the level of damage and of its own preferences. It is thus straightforward to see that continuous incentive mechanisms still leave discretion when the effort level that the Agency would like to implement, $e^{SB}(\alpha, D)$, is below some threshold e^*. This is either because D is small enough or because α itself is low enough, i.e. because the Agency's preferences are close enough to those of Congress.

We want to understand how *"more uncertainty"* about the Agency's preferences affects the optimal degree of discretion. As ϵ increases, the distributions G_ϵ put mass on a greater interval around α_R. "More uncertainty" about the regulator's preferences can be modeled as an increase in ϵ. Denote by $e^*(\epsilon)$ the optimal cap corresponding to the distribution G_ϵ.[46] The following proposition gives an approximation of the optimal cap as ϵ becomes small.

Proposition 6. *Assume that damages are drawn from an exponential distribution on $\mathbb{R}_+$ (with mean $\mu > 0$) and a quadratic disutility function ($\psi(e) = \frac{\lambda e^2}{2}$ for λ large enough). More uncertainty as to the Agency's preferences decreases its discretion by a term of second-order magnitude.*

Everything happens as if more uncertainty about the regulator's preferences increases the conflict of interest between Congress and the Agency. The intuition can again be grasped from a careful analysis of the full consequences of downstream moral hazard. Indeed, downstream moral hazard implies that the frontier of the set of incentive feasible payoffs pairs (V, U) is strictly concave.[47] For each possible realization of the Agency's preferences, the optimal policy that this Agency would implement under full discretion lies on the boundary of that set. However, fluctuations in the Agency's preferences yield "average" payoffs that lie in the interior of this incentive-feasible set. With a uniform distribution of possible preferences for the Agency, the average effort induced is greater than the effort that would have been implemented by an Agency presenting "average" preferences. This is akin to an upward shift in the parameter α_R, and thus to an increased conflict of interest between Congress and the Agency. By an argument which is by now familiar, the Agency should have less discretion.

■ **Strategic Appointment.** The last section has shown how Congress may enact regulations when anticipating changes or at least some uncertainty as to the identity of future political principals in the Executive branch. Politics is often more of an ongoing process, with Congress and the Executive reacting each in turn to the other's move and jointly designing the regulatory environment. In this section, we take the alternative view and give the Executive the lead in the appointment process.[48] The Executive is now able to commit to choose the regulator before Congress decides the level of discretion, even though this choice in practice takes place only after Congress has enacted the regulation. This possibility can be viewed as a reduced form for the complex interactions between the Executive and Legislative branches at the inception of a new regulation. In other words, we no longer consider the Executive and the Agency as a single entity. Instead, we show how such appointments can be used strategically to affect

[46] In particular, we already know from Section 5 that $e^*(0) = \frac{D^*(\alpha_R)}{\lambda(2-\alpha_R)}$.

[47] Formally, in our quadratic case, this frontier admits the parametrization $V = S - (1-e)D - \lambda e^2$, $U = \lambda e^2/2$, or $V = S - (1 - \sqrt{2U/\lambda})D - 2U$, which is strictly concave.

[48] Though they are usually created by the Legislative branch, administrative agencies sit within the Executive branch. As a consequence, the Executive also exercises control over agency decision-making. Most of this influence is channeled through the appointment process as the President is permitted by most originating statutes to appoint the agency's top decision-makers (subject to the approval of the Senate). A typical example is given by nominations at the head of the EPA in the U.S. This Federal Agency is under the control of the Presidency, but it implements environmental regulations enacted by Congress. This process often entails a conflict due to non-congruent views of the administration and Congress, but it is *"an accepted part of the political process"* (Ashford and Caldart 2008, p. 267).

subsequent interactions between Congress and the Agency. More precisely, an Executive with a strong pro-firm bias strategically appoints a regulator whose preferences are closer to Congress. Accommodating Congress' preferences increases the Agency's discretion and favors the firm, in accordance with the Executive's prior objectives. At equilibrium, the Agency's preferences are chosen somewhere in between those of the Executive and Congress.

To make this point more formally, consider the case where the Executive's preferences α_E are more "pro-firm" than Congress, namely $\alpha_C < \alpha_E < 1$. Anticipating the choice of Congress on the level of discretion left to the Agency, the Executive acts as a Stackelberg leader when choosing the regulator.

Proposition 7. *Assume that the Executive's preferences α_E are more "pro-firm" oriented than those of Congress, i.e. $\alpha_C < \alpha_E < 1$. Then, the Executive chooses a regulator with preferences between those of Congress and its own: $\alpha_C < \alpha_R < \alpha_E$.*

We have taken an extreme view by leaving the lead in the political process to the Executive. A more symmetric and maybe more realistic standing of the two government bodies might be better captured by modeling the repeated relationship between the two branches, or by requiring top-level appointments to be subject to approval by Congress. Nevertheless, our result already predicts that regulation reflects, at equilibrium, a subtle compromise between the desires of the different public bodies involved.[49] Choosing a regulator who is a little bit less eager than the Executive to please the firm has only a second-order impact on the Executive's expected payoff when D is low, because the Agency has full discretion in setting up a regulatory policy over that range. Reducing α_R aligns somewhat the Agency with Congress' objectives and relaxes by a first-order term the cap on rewards that Congress imposes once D is large.

■ **Pro-Firm Congress.** Last, consider the case of an Agency which is less "pro-firm" than Congress. This might arise when the median voter in Congress comes from a district which is closely concerned by the firm's industrial activity. The problem is now to induce the Agency to adopt higher-powered incentive regulations that leave more rent to the firm. When Congress believes that an agency is pursuing regulatory policies that run counter to legislative intent, it can amend the corresponding statute. To illustrate, the Solid Waste Disposal Act (known as the Resource Conservation and Recovery Act) was modified in 1984 in response to a widespread perception in Congress that EPA was not moving swiftly enough to regulate the disposal of hazardous wastes. In a similar vein, Congress amended the Safe Drinking Water Act in 1986 and the Clean Air Act provisions for hazardous air pollutants in 1990 (Ashford and Caldart, 2008, p.258).

There is still a trade-off between rules and discretion, but it leads to putting a floor on the firm's rewards. Because it now has incentives to pretend that damages are low to induce low-powered regulations, the regulator should have discretion only on the upper tail of the distribution of these damages. On the lower tail instead, a rigid regulation is implemented.

[49] Warren (2012) also provides some evidence for such compromise in a model of the separation of powers but with a different mechanism than ours.

When $\alpha_R < \alpha_C$, it is straightforward to check that the optimal cut-off $D^*(\alpha_R)$ below which the rigid rule is binding solves:

$$E(D|D \leq D^*(\alpha_R)) = \psi'(e^{SB}(\alpha_R, D^*(\alpha_R))) + (1-\alpha_C)R'(e^{SB}(\alpha_R, D^*(\alpha_R)))$$

when $e^{SB}(\alpha_R, \underline{D}) \leq e_C \leq e^{SB}(\alpha_R, \bar{D})$.

With this change, we get results that mirror those we obtained above, *mutatis mutandis*.[50]

7 Conclusion

This article has shown how agency problems may propagate along the regulatory hierarchy. Downstream regulation of a limited liability firm in a moral hazard context requires giving up moral hazard rent to induce safety care. However, the "pro-firm" biased Agency and Congress may have conflicting preferences about the amount of this rent. This upstream conflict leads Congress to put *ex ante* constraints on the incentive rewards that the Agency can use, even though this Agency could tailor the optimal regulation to its expert information. The trade-off between rules and discretion which arises in such contexts depends on economic factors (most specifically the detailed properties of the distribution of risks and the intensity of the downstream moral hazard problem) as well as political factors. Optimal regulations may sometimes look like rigid rules making no use of the Agency's expert information. Moreover, uncertainty in the underlying environment, be it on the economic or political side, affects the Agency's optimal discretion. Importantly, any condition that worsens the downstream moral hazard problem with regulated firms exacerbates the conflict of interest between the Agency and Congress and, ultimately, leads to restricting the Agency's discretion.

These results could be extended along several lines. First, we could investigate how *e*x post devices help to solve the upstream agency problem between Congress and the Agency. The joint use of *ex post* monitoring devices and *ex ante* control is a recurring theme of the political science literature. Direct oversights by congressional committees, regulatory budget reviews, costly audits (Banks, 1989, Banks and Weingast, 1992) by specialized agencies such as the General Accounting Office, and fire-alarms by interest groups are all examples of such devices that may help relax the Agency's incentive constraints and improve the *ex ante* trade-off between rules and discretion.

It would be worth investigating the Agency's incentives to acquire information about potential damage in models where the information structure is endogenized. More complex delegation sets that favor discretion for "extreme" values of the damage might be useful to provide such incentives (Szalay, 2005). Congress should also be able to better discipline the Agency by

[50] For instance, the definition of "front-loading" is now replaced by: a distribution $H_1(\cdot)$ is *more "front-loaded"* than a distribution $H_2(\cdot)$ if and only if:

$$\frac{1}{H_1(D)}\int_{\underline{D}}^{D} xh_1(x)dx \geq \frac{1}{H_2(D)}\int_{\underline{D}}^{D} xh_2(x)dx \text{ for all } D \in \mathcal{D} \text{ (with equality at } \underline{D}).$$

This inequality means that the conditional expectation of the damages over the lower tail $[\underline{D}, D]$ is always greater with $H_1(\cdot)$ than with $H_2(\cdot)$. One can easily show that the Agency has more discretion with $H_2(\cdot)$ than with $H_1(\cdot)$.

allocating its budget in a way that increases its expertise along lines that reduce the bureaucratic drift.

Another important extension of our framework would be to consider other agency problems for the regulated sector. Most of the *New Economics of Regulation* has been developed in a framework where adverse selection generates the regulated firm's informational rent, an issue we have only briefly touched in this article. We conjecture that the lessons of this article would go through more general environments plagued with adverse selection. Any kind of asymmetric information downstream is bound to generate a rent/efficiency trade-off. Whenever this trade-off is appreciated differently by the Agency and Congress, the same kind of analysis as the one performed in this article would apply. Rules and limited discretion might be quite attractive.

Appendix

Proofs of Propositions 1, 2 and 3. These proofs are immediate and thus omitted. ■

Proof of Lemma 1. Fix a pair (D, D') such that $D > D'$. From (11), incentive compatibility constraints at D and D' respectively imply:

$$-D(1-e(D)) - \psi(e(D)) - (1-\alpha)R(e(D)) \geq -D(1-e(D')) - \psi(e(D')) - (1-\alpha)R(e(D')),$$

$$-D'(1-e(D')) - \psi(e(D')) - (1-\alpha)R(e(D')) \geq -D'(1-e(D)) - \psi(e(D)) - (1-\alpha)R(e(D)).$$

Summing these two inequalities yields:

$$(D-D')(e(D)-e(D')) \geq 0.$$

Hence, $e(\cdot)$ is weakly increasing and thus almost everywhere differentiable with (12) holding at any point of differentiability. At any such point, the first-order condition for (11) writes as (13). (12) is also the local second-order condition for (11). ■

Proof of Lemma 2. Lemma 1 shows that $e(\cdot)$ has either flat parts or is equal to $e^{SB}(\alpha_R, D)$. Observing that $e^{SB}(\alpha_R, D)$ is strictly increasing in D, continuous mechanisms are such that there exist necessarily two thresholds D_* and D^* such that (14) holds. ■

Proof of Proposition 4. Using the fact that the optimal mechanism has a cap on the level of effort that can be implemented by the regulator, we can rewrite the maximand in $(\mathcal{P}_R^{SB})$ as

$$W_C(D^*) = S - \int_{\underline{D}}^{D^*} (D(1-e^{SB}(\alpha_R, D)) + \psi(e^{SB}(\alpha_R, D)) + (1-\alpha_C)R(e^{SB}(\alpha_R, D)))h(D)dD$$

$$-\int_{D^*}^{\bar{D}} (D(1-e^{SB}(\alpha_R, D^*)) + \psi(e^{SB}(\alpha_R, D^*)) + (1-\alpha_C)R(e^{SB}(\alpha_R, D^*)))h(D)dD.$$

Note that

$$\dot{W}_C(D^*) = \frac{\partial e^{SB}}{\partial D^*}(\alpha_R, D^*)\int_{D^*}^{\bar{D}}(D - \psi'(e^{SB}(\alpha_R, D^*)) - (1-\alpha_C)R'(e^{SB}(\alpha_R, D^*)))h(D)dD$$

where $\frac{\partial e^{SB}}{\partial D^*}(\alpha_R, D^*) = \frac{1}{\psi''(e^{SB}(\alpha_R,D^*))+(1-\alpha_R)R''(e^{SB}(\alpha_R,D^*))} > 0$ with

$$\ddot{W}_C(D^*) = \frac{\partial e^{SB}}{\partial D^*}(\alpha_R, D^*)(\alpha_R - \alpha_C)R'(e^{SB}(\alpha_R, D^*))h(D^*)$$

$$+\frac{\partial^2 e^{SB}}{\partial D^{*2}}(\alpha_R, D^*)\int_{D^*}^{\bar{D}}(D - \psi'(e^{SB}(\alpha_R, D^*)) - (1-\alpha_C)R'(e^{SB}(\alpha_R, D^*)))h(D)dD$$

$$-\left(\frac{\partial e^{SB}}{\partial D^*}(\alpha_R, D^*)\right)^2(\psi''(e^{SB}(\alpha_R, D^*)) + (1-\alpha_C)R''(e^{SB}(\alpha_R, D^*))(1-H(D^*)).$$

Optimizing $(\mathcal{P}_R^{SB})$ with respect to D^* yields the following first-order condition for an interior solution $D^*(\alpha_R)$:

$$\dot{W}_C(D^*(\alpha_R)) = 0 \Leftrightarrow \int_{D^*(\alpha_R)}^{\bar{D}}(D-\psi'(e^{SB}(\alpha_R, D^*))-(1-\alpha_C)R'(e^{SB}(\alpha_R, D^*(\alpha_R))))h(D)dD = 0. \tag{A.1}$$

Therefore, an interior $D^*(\alpha_R) \in (\underline{D}, \bar{D})$ solves (15). Note that $\dot{W}_C(\underline{D}) \geq 0$ when $\int_{\underline{D}}^{\bar{D}}(D - \psi'(e^{SB}(\alpha_R, \underline{D})) - (1-\alpha_C)R'(e^{SB}(\alpha_R, \underline{D})))h(D)dD \geq 0$ or, taking into account the definition of e_C given in (10), when $e^{SB}(\alpha_R, \underline{D}) \leq e_C$. Moreover, $\dot{W}_C(\bar{D}) = 0$ so that $\bar{D}$ satisfies the first-order condition (A.1) but $\ddot{W}_C(\bar{D}) > 0$ (so that $\dot{W}_C(\bar{D}) < 0$ in a left-neighborhood of $\bar{D}$) and the second-order condition for optimality does not hold at that point. Putting together these two facts, there always exists an interior solution to (15) that satisfies the second-order condition.

In fact, this interior solution to (15) is unique. To see why, denote respectively the left- and right-hand sides of (15) as $A(D^*) = E(\tilde{D}|\tilde{D} \geq D^*) = D^* + \frac{1}{1-H(D^*)}\int_{D^*}^{\bar{D}}(1-H(x))dx$ and $B(D^*) = \psi'(e^{SB}(\alpha_R, D^*)) + (1-\alpha_C)R'(e^{SB}(\alpha_R, D^*))$.

First, observe that

$$\dot{A}(D^*) = \frac{h(D^*)}{(1-H(D^*))^2}\int_{D^*}^{\bar{D}}(1-H(x))dx \leq 1 \Leftrightarrow \varphi(D^*) \geq 0 \tag{A.2}$$

where $\varphi(D^*) = \frac{(1-H(D^*))^2}{h(D^*)} - \int_{D^*}^{\bar{D}}(1-H(x))dx$. Note that $\dot{\varphi}(D^*) = (1-H(D^*))\frac{d}{dD^*}\left(\frac{1-H(D^*)}{h(D^*)}\right) \leq 0$ and thus $\varphi(D^*) \geq \varphi(\bar{D}) = 0$ for all $D \in \mathcal{D}$.

Second, observe also that, as $\alpha_R > \alpha_C$,

$$\dot{B}(D^*) = \frac{\partial e^{SB}}{\partial D^*}(\alpha_R, D^*)(\psi''(e^{SB}(\alpha_R, D^*)) + (1-\alpha_C)R''(e^{SB}(\alpha_R, D^*))$$

$$= \frac{\psi''(e^{SB}(\alpha_R, D^*)) + (1-\alpha_C)R''(e^{SB}(\alpha_R, D^*))}{\psi''(e^{SB}(\alpha_R, D^*)) + (1-\alpha_R)R''(e^{SB}(\alpha_R, D^*))} > 1.$$

Hence, $\dot{A}(D^*) < \dot{B}(D^*)$ which in passing shows that $W_C(\cdot)$ is quasi-concave. As $A(\underline{D}) \geq B(\underline{D})$ when $e^{SB}(\alpha_R, \underline{D}) \leq e_C$ and $A(\bar{D}) < B(\bar{D})$ because $e^{SB}(\alpha_R, \bar{D}) > e^{SB}(\alpha_C, \bar{D})$, $D^*(\alpha_R)$

such that $A(D^*(\alpha_R)) = B(D^*(\alpha_R))$ is uniquely defined.

As $A(D^*) < \bar{D}$, we have $e^{SB}(\alpha_R, D^*(\alpha_R)) < e^{SB}(\alpha_C, \bar{D})$ as shown on Figure 1.

Rigid rule. When $e^{SB}(\alpha_R, \underline{D}) > e_C$, $\dot{W}_C(\underline{D}) < 0$, and a rigid rule at e_C is optimal.

Partial discretion. Full discretion never arises because $D^* = \bar{D}$, although it solves (A.1) never satisfies the second-order condition because $\ddot{W}_C(\bar{D}) > 0$.

Suboptimality of a floor. Suppose now that the Agency adds a floor at $e^{SB}(\alpha_R, D^{**})$ with $D^{**} < D^*$. We can now rewrite Congress's objective as:

$$W_C(D^{**}, D^*) = S - \int_{D^{**}}^{D^*} (D(1 - e^{SB}(\alpha_R, D)) + \psi(e^{SB}(\alpha_R, D)) + (1 - \alpha_C) R(e^{SB}(\alpha_R, D)))h(D)dD$$

$$- \int_{D^*}^{\bar{D}} (D(1 - e^{SB}(\alpha_R, D^*)) + \psi(e^{SB}(\alpha_R, D^*)) + (1 - \alpha_C) R(e^{SB}(\alpha_R, D^*)))h(D)dD$$

$$- \int_{\underline{D}}^{D^{**}} (D(1 - e^{SB}(\alpha_R, D^{**})) + \psi(e^{SB}(\alpha_R, D^{**})) + (1 - \alpha_C) R(e^{SB}(\alpha_R, D^{**})))h(D)dD.$$

Observe then that:

$$\frac{\partial W_C}{\partial D^{**}}(D^{**}, D^*) = \frac{\partial e^{SB}}{\partial D^{**}}(\alpha_R, D^{**}) \int_{\underline{D}}^{D^{**}} (D - \psi'(e^{SB}(\alpha_R, D^{**})) - (1 - \alpha_C) R'(e^{SB}(\alpha_R, D^{**})))h(D)dD$$

so that $\frac{\partial W_C}{\partial D^{**}}(\underline{D}, D^*) = 0$ and

$$\frac{\partial^2 W_C}{\partial (D^{**})^2}(\underline{D}, D^*) = \frac{\partial e^{SB}}{\partial D^{**}}(\alpha_R, \underline{D})(\alpha_C - \alpha_R) R'(e^{SB}(\alpha_R, \underline{D}))h(\underline{D}) \leq 0.$$

Hence, $D^{**} = \underline{D}$ is optimal. ■

Proof of Corollary 2. From (A.2), we deduce that $A(D) - D$ is decreasing. The solution $D^*(\alpha_R)$ to (16) writes as $A(D^*(\alpha_R)) - D^*(\alpha_R) = \frac{\Delta\alpha}{2 - \alpha_R} D^*(\alpha_R)$ and decreases with $\Delta\alpha$. ■

Proof of Corollary 3. Suppose that $H_1(\cdot)$ is more front-loaded than $H_2(\cdot)$, i.e. (17) holds. Denote by $D_i^*(\alpha_R)$ the optimal cap for distribution $H_i(\cdot)$. From (16), we have then:

$$\frac{1}{1 - H_2(D_1^*(\alpha_R))} \int_{D_1^*(\alpha_R)}^{\bar{D}} x h_2(x) dx \geq \psi'(e(\alpha_R, D_1^*(\alpha_R))) + (1 - \alpha_C) R'(e(\alpha_R, D_1^*(\alpha_R))).$$

Using the fact that $W_C(\cdot)$ (when expectations are computed with $H_2(\cdot)$) is quasi-concave, we have necessarily $D_1^*(\alpha_R) \geq D_2^*(\alpha_R)$. ■

Proof of Corollary 4. The amount of discretion $D_k^*(\alpha_R)$ left to the Agency *ex post* is obtained from (16) as:

$$\frac{1}{1 - H_k(D_k^*(\alpha_R))} \int_{D_k^*(\alpha_R)}^{\bar{D}} h_k(D) D dD - D_k^*(\alpha_R) = \frac{\Delta\alpha}{2 - \alpha_R} D_k^*(\alpha_R).$$

Instead, from an *ex ante* viewpoint, the optimal amount of discretion $D^*(\alpha_R)$ solves (with $E_k(\cdot)$

denoting the expectation operator conditional over signals):

$$\frac{1}{1 - E_k(H_k(D^*(\alpha_R)))} \int_{D^*(\alpha_R)}^{\bar{D}} E_k(h_k(D))DdD - D^*(\alpha_R) = \frac{\Delta\alpha}{2 - \alpha_R} D^*(\alpha_R).$$

With exponential distributions, $D_k^*(\alpha_R)$ and $D^*(\alpha_R)$ solve respectively

$$D_k^*(\alpha_R) = \mu_k \frac{2 - \alpha_R}{\Delta\alpha}$$

and

$$\frac{E_k\left(\mu_k exp\left(-\frac{D^*(\alpha_R)}{\mu_k}\right)\right)}{E_k\left(exp\left(-\frac{D^*(\alpha_R)}{\mu_k}\right)\right)} = \frac{\Delta\alpha}{2 - \alpha_R} D^*(\alpha_R).$$

Because $exp(-\frac{D^*}{\mu})$ and μ are both increasing in μ, they covary in the same direction which implies:

$$\frac{\Delta\alpha}{2 - \alpha_R} D^*(\alpha_R) = \frac{E_k\left(\mu_k exp\left(-\frac{D^*(\alpha_R)}{\mu_k}\right)\right)}{E_k\left(exp\left(-\frac{D^*(\alpha_R)}{\mu_k}\right)\right)} \geq E_k\left(\mu_k\right) = \frac{\Delta\alpha}{2 - \alpha_R} E_k\left(D_k^*(\alpha_R)\right).$$

This yields (18). ■

Proof of Corollary 5. For the case of a quadratic disutility function, $\psi(e) = \frac{\lambda e^2}{2}$ with λ large enough so that effort remains in $(0, 1)$, we obtain

$$e^{SB}(\alpha_R, D) = \frac{D - (1 - \alpha_R)\lambda\eta}{\lambda(2 - \alpha_R)}, \tag{A.3}$$

which remains positive when

$$\eta < \frac{\underline{D}}{\lambda(1 - \alpha_R)}. \tag{A.4}$$

The optimal level of discretion now satisfies:

$$E(D|D \geq D^*(\alpha_R)) - D^*(\alpha_R) = A(D^*(\alpha_R)) - D^*(\alpha_R) = \frac{\Delta\alpha}{2 - \alpha_R}\left(D^*(\alpha_R) + \lambda\eta\right). \tag{A.5}$$

Because $A(D) - D$ is decreasing, the solution $D^*(\alpha_R)$ to (A.5) decreases with η. ■

Proof of Corollary 6. Still in the quadratic case, the optimal effort with monitoring now solves:

$$D(1 - \theta) = \psi'(e^{SB}(\alpha_R, D)) + (1 - \alpha_R)\psi''(e^{SB}(\alpha_R, D))(e^{SB}(\alpha_R, D) + \eta).$$

The optimal level of discretion solves:

$$(1-\theta)E(D|D \geq D^*(\alpha_R)) = \psi'(e^{SB}(\alpha_R, D^*(\alpha_R)))+(1-\alpha_C)\psi''(e^{SB}(\alpha_R, D^*(\alpha_R)))(e^{SB}(\alpha_R, D^*(\alpha_R))+\eta).$$

In the quadratic case, this leads to

$$E(D|D \geq D^*(\alpha_R)) - D^*(\alpha_R) = \frac{\Delta\alpha}{2-\alpha_R}\left(D^*(\alpha_R) + \frac{\lambda\eta}{1-\theta}\right) \tag{A.6}$$

which is similar to (A.5) when damages have been scaled down by $1-\theta$, to take into account the fact that an accident only occurs when monitoring fails. Now effort remains positive when $\eta < \frac{D}{\lambda(1-\alpha_R)(1-\theta)}$. ■

Proof of Corollary 7. Everything happens as if the formula for the second-best effort and the optimal level of discretion were as in (A.3) and (A.5), with η being preceded by a sign $-$. Moreover, state 2 has a positive probability when η still satisfies (A.4). ■

Proof of Corollary 8. When the Agency has full discretion, it chooses a fine $t(\alpha_R, D) = f(\alpha_R, D)$ that, for any possible realization of the damage D, maximizes expected welfare taking into account expectations over the efficiency parameter θ, namely:

$$t(\alpha_R, D) = \arg\max_t \; S - (1 - E(e(\theta,t))D - E(\psi(e(\theta,t) - \zeta(\theta))) - (1-\alpha_R)\mathcal{R}(t).$$

Straightforward computations lead to the following expression of the optimal fine:

$$t(\alpha_R, D) = \frac{D - \lambda(1-\alpha_R)\eta}{2-\alpha_R}. \tag{A.7}$$

Of course, this base payment/fine exceeds the amount that would be chosen by Congress itself. A delegation mechanism is again of the form $\{t(\hat{D})\}_{\hat{D}\in\mathcal{D}}$, although uncertainty on the efficiency parameter θ now breaks the one-to-one relationship between fines and efforts. Proceeding as above, it is straightforward to check that continuous mechanisms stipulate a cap on fines which is defined as:

$$t(\alpha_R, D^*_\zeta(\alpha_R)) = \frac{E(D|D \geq D^*_\zeta(\alpha_R)) - \lambda(1-\alpha_C)\eta}{2-\alpha_C}. \tag{A.8}$$

Gathering (A.7) and (A.8), we finally obtain:

$$E(D|D \geq D^*_\zeta(\alpha_R)) - D^*_\zeta(\alpha_R) = \frac{\Delta\alpha}{2-\alpha_R}(D^*_\zeta(\alpha_R) + \lambda\eta). \tag{A.9}$$

From the fact that $A(D) - D$ is decreasing, we immediately deduce that $D^*_\zeta(\alpha_R)$ solving (A.9) is lower (resp. greater) than $D^*(\alpha_R)$ (that solves (A.9) under complete information and $\theta \equiv 0$) when $\eta > 0$ (resp. < 0). ■

Proof of Corollary 9. Mimicking our previous approach, we get the following expression of the discretion threshold $D^*(\alpha_R, k)$:

$$E(D|D \geq D^*(\alpha_R, k)) = \psi'(e^{SB}(\alpha_R, D^*(\alpha_R, k))) + (1 - \alpha_C + \eta k)\, R'(e^{SB}(\alpha_R, D^*(\alpha_R, k))).$$

In the quadratic case, the optimal level of discretion now solves:

$$E(D|D \geq D^*(\alpha_R, k)) - D^*(\alpha_R, k) = A(D^*(\alpha_R, k)) - D^*(\alpha_R, k) = \frac{\Delta\alpha}{2 - \alpha_R + \eta k} D^*(\alpha_R, k). \tag{A.10}$$

Because $A(D) - D$ is decreasing, $D^*(\alpha_R, k)$ increases with k. ■

Proof of Proposition 5. Observe that

$$\mathcal{U}'(\alpha) = \int_{\underline{D}}^{D^*(\alpha)} R'(e^{SB}(\alpha, D)) \frac{\partial e^{SB}}{\partial \alpha}(\alpha, D) h(D) dD$$

$$+ D^{*\prime}(\alpha) \int_{D^*(\alpha)}^{\bar{D}} R'(e^{SB}(\alpha, D^*(\alpha))) \frac{\partial e^{SB}}{\partial D}(\alpha, D^*(\alpha)) h(D) dD$$

$$+ \int_{D^*(\alpha)}^{\bar{D}} R'(e^{SB}(\alpha, D^*(\alpha))) \frac{\partial e^{SB}}{\partial \alpha}(\alpha, D^*(\alpha)) h(D) dD - C'(\alpha).$$

Evaluating this derivative at $\alpha = \alpha_C$ and taking into account that $D^*(\alpha_C) = \bar{D}$, the marginal benefit of increasing α is worth

$$\int_{\underline{D}}^{\bar{D}} R'(e^{SB}(\alpha_C, D)) \frac{\partial e^{SB}}{\partial \alpha}(\alpha_C, D) h(D) dD > 0$$

as $\frac{\partial e^{SB}}{\partial \alpha}(\alpha_C, D) > 0$ whereas the marginal cost is zero. This leads to $\mathcal{U}'(\alpha_C) > 0$ and necessarily $\alpha_R > \alpha_C$. ■

Proof of Proposition 6. In this context, incentive compatibility constraints necessary to induce truthtelling now become:

$$(\alpha, D) \in \arg\max_{(\hat{\alpha}, \hat{D})} \ S - (1 - e((\hat{\alpha}, \hat{D}))D - \psi(e(\hat{\alpha}, \hat{D})) - (1 - \alpha)R(e(\hat{\alpha}, \hat{D})).$$

Standard revealed preferences arguments lead to the following Lemma whose proof is similar to that of Lemma 1 and is thus omitted.

Lemma 3. *Any incentive compatible mechanism $\{e(\hat{\alpha}, \hat{D})\}_{\{\hat{\alpha} \in [\underline{\alpha}, \bar{\alpha}], \hat{D} \in [\underline{D}, \bar{D}]\}}$ is such that $e(\cdot)$ is monotonically increasing in α and D and is thus almost everywhere differentiable with, at any point of differentiability,*

$$\frac{\partial e}{\partial \alpha}(\alpha, D) \geq 0 \text{ and } \frac{\partial e}{\partial D}(\alpha, D) \geq 0, \tag{A.11}$$

$$\frac{\partial e}{\partial \alpha}(\alpha, D) \left(D - \psi'(e(\alpha, D)) - (1 - \alpha)R'(e(\alpha, D)) \right) = 0, \tag{A.12}$$

$$\frac{\partial e}{\partial D}(\alpha, D) \left(D - \psi'(e(\alpha, D)) - (1 - \alpha)R'(e(\alpha, D)) \right) = 0. \tag{A.13}$$

Hence, (A.12) and (A.13) when taken altogether again show that the Agency either chooses its most preferred policy $e^{SB}(\alpha, D)$ or is forced to choose an effort level independent of the level of damage and of its own preferences. Mechanisms with a cap on effort levels are thus of the form $e(\alpha, D) = \min\{e^{SB}(\alpha, D), e^*\}$.

Optimality condition. We can write Congress' problem of choosing an optimal cap e^* as:

$$(\mathcal{P}_R^{AI}): \quad \max_{e^*} \; W_C(e^*) \equiv S - E_{(D,\alpha)}((1-e(\alpha,D))D + \psi(e(\alpha,D)) + (1-\alpha_C)R(e(\alpha,D)))$$

$$\text{where } e(\alpha,D) = \min\{e^{SB}(\alpha,D), e^*\}.$$

We can rewrite the maximand $W_C(e^*)$ as

$$W_C(e^*) = S - \int_{\bar{\Omega}} D(1-e^{SB}(\alpha,D)) + \psi(e^{SB}(\alpha,D)) + (1-\alpha_C)R(e^{SB}(\alpha,D)))dH(D)dG_\epsilon(\alpha)$$

$$- \int_{\Omega} D(1-e^*) + \psi(e^*) + (1-\alpha_C)R(e^*))dH(D)dG_\epsilon(\alpha)$$

where

$$\Omega = \{(\alpha,D) \in [\alpha_C,1] \times \mathcal{D} \text{ such that } D - \psi'(e^*) - (1-\alpha)R'(e^*) \geq 0\}$$

is the set of pairs (α, D) where the regulatory cap on effort binds and

$$\bar{\Omega} = \{(\alpha,D) \in [\alpha_C,1] \times \mathcal{D} \text{ such that } D - \psi'(e^*) - (1-\alpha)R'(e^*) < 0\}$$

is the set of pairs (α, D) where this cap does not bind.

Using that $\psi(e) = \frac{\lambda e^2}{2}$, we get $e^{SB}(\alpha,D) = \frac{D}{\lambda(2-\alpha)}$ so that

$$\Omega = \left\{(\alpha,D) \in [\alpha_C,1] \times \mathcal{D} \text{ and } 2-\alpha \leq \frac{D}{\lambda e^*}\right\} \text{ and } \bar{\Omega} = \left\{(\alpha,D) \in [\alpha_C,1] \times \mathcal{D} \text{ and } 2-\alpha > \frac{D}{\lambda e^*}\right\}.$$

Observe then that:

$$W_C(e^*) = S + \int_{\bar{\Omega}} \left(-D + \frac{D^2}{\lambda(2-\alpha)}\left(1 - \frac{2-\alpha_C}{2(2-\alpha)}\right)\right) h(D)dDdG_\epsilon(\alpha)$$

$$+ \int_{\Omega} \left(-D(1-e^*) - \frac{\lambda(e^*)^2}{2}(2-\alpha_C)\right) h(D)dDdG_\epsilon(\alpha).$$

We can rewrite this expression as:

$$W_C(e^*) = S + \int_{\underline{D}}^{\bar{D}} \int_{\alpha_C}^{\min\left\{2-\frac{D}{\lambda e^*};1\right\}} \left(-D + \frac{D^2}{\lambda(2-\alpha)}\left(1 - \frac{2-\alpha_C}{2(2-\alpha)}\right)\right) dG_\epsilon(\alpha)h(D)dD$$

$$+ \int_{\underline{D}}^{\bar{D}} \int_{\min\left\{2-\frac{D}{\lambda e^*};1\right\}}^{1} \left(-D + De^* - \frac{\lambda(e^*)^2}{2}(2-\alpha_C)\right) dG_\epsilon(\alpha)h(D)dD.$$

Developing the first of these integrals (for the relevant case where $\bar{D} > \lambda e^*$) yields:

$$W_C(e^*) = S + \int_{\underline{D}}^{\lambda e^*} \left(\int_{\alpha_C}^{1} \left(-D + \frac{D^2}{\lambda(2-\alpha)}\left(1 - \frac{2-\alpha_C}{2(2-\alpha)}\right)\right) dG_\epsilon(\alpha)\right) h(D)dD$$

$$+ \int_{\lambda e^*}^{\bar{D}} \left(\int_{\alpha_C}^{2-\frac{D}{\lambda e^*}} \left(-D + \frac{D^2}{\lambda(2-\alpha)}\left(1 - \frac{2-\alpha_C}{2(2-\alpha)}\right)\right) dG_\epsilon(\alpha)\right) h(D)dD$$

$$+\int_{\lambda e^*}^{\bar{D}}\left(-D+De^*-\frac{\lambda(e^*)^2}{2}(2-\alpha_C)\right)\left(1-G_\epsilon\left(2-\frac{D}{\lambda e^*}\right)\right)h(D)dD.$$

We can now differentiate this expression with respect to e^* to obtain the optimal regulatory cap:[51]

$$\dot{W}_C(e^*)=0\Leftrightarrow\int_{\lambda e^*}^{\bar{D}}(D-(2-\alpha_C)\lambda e^*)\left(1-G_\epsilon\left(2-\frac{D}{\lambda e^*}\right)\right)h(D)dD=0. \tag{A.14}$$

Approximation. Using the expression of G_ϵ given in the text, we obtain that $e^*(\epsilon)$ solves the following equation:

$$f(e^*(\epsilon),\epsilon)=0$$

where

$$f(e^*,\epsilon)=\int_{(2-\alpha_R-\epsilon)\lambda e^*}^{(2-\alpha_R+\epsilon)\lambda e^*}(D-(2-\alpha_C)\lambda e^*)\left(1-\frac{2-\frac{D}{\lambda e^*}-\alpha_R+\epsilon}{2\epsilon}\right)h(D)dD$$

$$+\int_{(2-\alpha_R+\epsilon)\lambda e^*}^{\bar{D}}(D-(2-\alpha_C)\lambda e^*)h(D)dD. \tag{A.15}$$

For the quadratic disutility function $\psi(e)=\frac{\lambda e^2}{2}$, we have $e^*(0)=e^{SB}(\alpha_R,D^*(\alpha_R))=\frac{D^*(\alpha_R)}{\lambda(2-\alpha_R)}$ where $D^*(\alpha_R)$ solves (16). In particular, for an exponential distribution $1-H(D)=exp\left(-\frac{D}{\mu}\right)$ (with density $h(D)=\frac{1}{\mu}exp\left(-\frac{D}{\mu}\right)$) we have $D^*(\alpha_R)=\mu\frac{2-\alpha_R}{\Delta\alpha}$ and

$$e^*(0)=\frac{\mu}{\lambda\Delta\alpha}. \tag{A.16}$$

We look for a second-order approximation of $e^*(\epsilon)$ as:

$$e^*(\epsilon)=e^*(0)+\alpha\epsilon+\frac{\beta}{2}\epsilon^2+o(\epsilon^2).$$

Making second-order Taylor expansions of the condition $f(e^*(\epsilon),\epsilon)=0$, we can find (α,β) as solutions to the following system:

$$f_e(e^*(0),0)\alpha+f_\epsilon(e^*(0),0)=0 \tag{A.17}$$

and

$$f_e(e^*(0),0)\beta+f_{\epsilon\epsilon}(e^*(0),0)+f_{ee}(e^*(0),0)\alpha^2+2f_{e\epsilon}(e^*(0),0)\alpha=0. \tag{A.18}$$

After computations, we first get:

$$f_e(e^*,0)=-\lambda(2-\alpha_C)(1-H((2-\alpha_R)\lambda e^*))+\lambda(2-\alpha_R)exp\left(-\frac{(2-\alpha_R)\lambda e^*}{\mu}\right)$$

[51] Note that the quasi-concavity of the objective is guaranteed when ϵ is small enough by the fact that this property already holds at $\epsilon=0$. (See the Proof of Proposition 4 above).

or

$$f_e(e^*,0) = -\lambda\Delta\alpha exp\left(-\frac{(2-\alpha_R)\lambda e^*}{\mu}\right) \neq 0. \tag{A.19}$$

To compute the other derivatives, let us first consider the first integral on the right-hand side of (A.15):

$$g(e^*,\epsilon) = \int_{(2-\alpha_R-\epsilon)\lambda e^*}^{(2-\alpha_R+\epsilon)\lambda e^*} (D-(2-\alpha_C)\lambda e^*)\left(1-\frac{2-\frac{D}{\lambda e^*}-\alpha_R+\epsilon}{2\epsilon}\right) h(D)dD.$$

Introducing the change of variables $D = (2-\alpha_R+\epsilon x)\lambda e^*$ with $dD = \epsilon\lambda e^* dx$, we can rewrite

$$g(e^*,\epsilon) = (\lambda e^*)^2 \int_{-1}^{1} (-\Delta\alpha + \epsilon x)\epsilon \left(\frac{1+x}{2}\right) h((2-\alpha_R+\epsilon x)\lambda e^*)dx.$$

With this expression, it becomes easy to compute:

$$g_\epsilon(e^*,0) = -(\lambda e^*)^2 \Delta\alpha h((2-\alpha_R)\lambda e^*) \int_{-1}^{1}\left(\frac{1+x}{2}\right)dx = -(\lambda e^*)^2\Delta\alpha h((2-\alpha_R)\lambda e^*).$$

Also, we get:

$$g_{\epsilon\epsilon}(e^*,0) = (\lambda e^*)^2\left(-\lambda e^*\Delta\alpha h'((2-\alpha_R)\lambda e^*) + h((2-\alpha_R)\lambda e^*)\right)\left(\int_{-1}^{1} x(1+x)dx\right) \tag{A.20}$$

where $\int_{-1}^{1} x(1+x)dx = \frac{2}{3}$.

Consider now the second integral on the right-hand side of (A.15):

$$i(e^*,\epsilon) = \int_{(2-\alpha_R+\epsilon)\lambda e^*}^{\bar{D}} (D-(2-\alpha_C)\lambda e^*)h(D)dD.$$

Differentiating, we get

$$i_\epsilon(e^*,0) = (\lambda e^*)^2\Delta\alpha h((2-\alpha_R)\lambda e^*) = -g_\epsilon(e^*,0).$$

Therefore, $f_\epsilon(e^*,0) = g_\epsilon(e^*,0) + i_\epsilon(e^*,0) = 0$ and thus, inserting into (A.17), we get:

$$\alpha = 0. \tag{A.21}$$

Differentiating one more time

$$i_{\epsilon\epsilon}(e^*,0) = (\lambda e^*)^2\left(\lambda e^*\Delta\alpha h'((2-\alpha_R)\lambda e^*) - h((2-\alpha_R)\lambda e^*)\right). \tag{A.22}$$

This leads to

$$f_{\epsilon\epsilon}(e^*,0) = g_{\epsilon\epsilon}(e^*,0) + i_{\epsilon\epsilon}(e^*,0) = \frac{1}{3}(\lambda e^*)^2(\lambda e^*\Delta\alpha h'((2-\alpha_R)\lambda e^*) - h((2-\alpha_R)\lambda e^*)).$$

Using (A.18) and the result above in (A.21), we get:

$$\beta = -\frac{f_{\epsilon\epsilon}(e^*(0),0)}{f_e(e^*(0),0)} = \frac{(\lambda e^*(0))^2(\lambda e^*(0)\Delta\alpha h'((2-\alpha_R)\lambda e^*(0)) - h((2-\alpha_R)\lambda e^*(0)))}{3\lambda\Delta\alpha exp\left(-\frac{(2-\alpha_R)\lambda e^*(0)}{\mu}\right)}. \qquad \text{(A.23)}$$

Taking into account (A.16) and the fact that we have an exponential distribution $1-H(D) = exp\left(-\frac{D}{\mu}\right)$ with mean $\mu > 0$ (with density $h(D) = \frac{1}{\mu}exp\left(-\frac{D}{\mu}\right)$), we finally obtain the second-order approximation

$$e^*(\epsilon) = e^*(0) - \frac{2e^*(0)}{3\Delta\alpha}\epsilon^2 + o(\epsilon^2). \qquad \text{(A.24)}$$

■

Proof of Proposition 7. Formally, the Executive looks for an optimal preference parameter of the Agency α_R which solves the following problem:

$$(\mathcal{P}_R^{\alpha_R}): \quad \max_{\alpha_R} S - E_D(D(1-e(\alpha_R,D)) + \psi(e(\alpha_R,D)) + (1-\alpha_E)R(e(\alpha_R,D)))$$

$$\text{where } e(\alpha_R,D) = \min\{e^{SB}(\alpha_R,D), e^{SB}(\alpha_R,D^*(\alpha_R))\}.$$

Denoting by $W_E(\alpha_R)$ the maximand above, it is straightforward to check that:

$$\dot{W}_E(\alpha_R) = (\alpha_E - \alpha_R)\int_{\underline{D}}^{D^*(\alpha_R)} R'(e^{SB}(\alpha_R,D))\frac{\partial e^{SB}}{\partial \alpha_R}(\alpha_R,D)h(D)dD$$

$$+(\alpha_E-\alpha_C)(1-H(D^*(\alpha_R)))R'(e^{SB}(\alpha_R,D^*(\alpha_R)))\frac{\partial e^{SB}}{\partial D}(\alpha_R,D^*(\alpha_R))\dot{D}^*(\alpha_R).$$

When evaluating this derivative at $\alpha_R = \alpha_E$, i.e., at the point where the regulator's preferences are aligned with those of the Executive, we obtain:

$$\dot{W}_E(\alpha_E) = (\alpha_E-\alpha_C)(1-H(D^*(\alpha_E)))R'(e^{SB}(\alpha_E,D^*(\alpha_E)))\frac{\partial e^{SB}}{\partial D}(\alpha_E,D^*(\alpha_E))\dot{D}^*(\alpha_E).$$

Observe now that first, $\dot{D}^*(\alpha_E) < 0$ when $\alpha_E > \alpha_C$, i.e. the Agency has less discretion when its preferences further diverge from those of Congress; second, $\frac{\partial e^{SB}}{\partial D} > 0$, i.e. a higher harm calls for higher levels of prevention. Hence, we have $\dot{W}_E(\alpha_E) < 0$. Reducing α_R below α_E always improves the Executive's expected payoff.

Similarly, evaluating $\dot{W}_E(\alpha_R)$ at $\alpha_R = \alpha_C$ and taking into account that $D^*(\alpha_C) = \bar{D}$, we find $\dot{W}_E(\alpha_C) = (\alpha_E - \alpha_C)\int_{\underline{D}}^{\bar{D}} R'(e^{SB}(\alpha_C,D))\frac{\partial e^{SB}}{\partial\alpha_R}(\alpha_C,D)h(D)dD > 0$ as $\frac{\partial e^{SB}}{\partial\alpha_R} > 0$, i.e., a more "pro-firm" oriented regulator implements higher effort. Increasing α_R above α_C always improves the Executive's expected payoff. ■

References

AGHION, P. AND TIROLE, J. "Formal and Real Authority in Organizations." *Journal of Political Economy*, vol. 105 (1997), pp. 1-29.

ALONSO, R. AND MATOUSHECK, N. "Optimal Delegation." *Review of Economic Studies*, vol. 75 (2008), pp. 259-293.

APPLEGATE, J. "The Perils of Unreasonable Risk: Information, Regulatory Policy, and Toxic Substances Control." *Columbia Law Review*, vol. 91 (1991), pp. 261-333.

ARMSTRONG, M. "Delegation and Discretion." Discussion Papers in Economics and Econometrics no. 9421, University of Southampton, 1994.

ARMSTRONG, M. AND SAPPINGTON, D. "Recent Developments in the Theory of Regulation." In M. Armstrong and R. Porter, eds., *The Handbook of Industrial Organization*, Vol. 3, North-Holland, 2007.

ARMSTRONG, M. AND VICKERS, J. "A Model of Delegated Project Choice." *Econometrica*, vol. 78 (2010), pp. 213-240.

ASHFORD, N. AND CALDART, C. *Environmental Law, Policy, and Economics*. MIT Press, 2008.

BANKS, J. "Agency Budgets, Cost of Information, and Auditing." *American Journal of Political Science*, vol. 33 (1989), pp. 670-699.

BANKS, J. AND WEINGAST, B. "The Political Control of Bureaucracies under Asymmetric Information." *American Journal of Political Science*, vol. 36 (1992), pp. 509-524.

BARON, D. "Regulation and Legislative Choice." *The RAND Journal of Economics*, vol. 19 (1989), pp. 467-477.

BARON, D. "Legislative Organization with Informational Committees." *American Journal of Political Science*, vol. 44 (2000), pp. 485-505.

BARON, D. AND MYERSON, R. "Regulating a Monopolist with Unknown Costs." *Econometrica*, vol. 50 (1982), pp. 911-930.

BAWN, K. "Political Control versus Expertise: Congressional Choices about Administrative Procedures." *American Political Science Review*, vol. 89 (1995), pp. 62-73.

BENDOR, J. AND MEIROWITZ, A. "Spatial Models of Delegation." *American Political Science Review*, vol. 98 (2004), pp. 293-310.

BESANKO, D. AND SPULBER, D. "Contested Mergers and Equilibrium Antitrust Policy." *Journal of Law, Economics and Organization*, vol. 9 (1993), pp. 1-29.

BOYER, M. AND LAFFONT, J.J. "Towards a Political Theory of the Emergence of Environmental Incentive Regulation." *The RAND Journal of Economics*, vol. 30 (1999), pp. 137-157.

EPSTEIN, D. AND O'HALLORAN, S. "Administrative Procedures, Information and Agency Discretion." *American Journal of Political Science*, vol. 38 (1994), pp. 697-722.

EPSTEIN, D. AND O'HALLORAN, S. *Delegating Powers*. Cambridge University Press, 1999.

FAURE-GRIMAUD, A. AND MARTIMORT, D. "Regulatory Inertia." *The RAND Journal of Economics*, vol. 34 (2003), pp. 413-437.

FIORINA, M. "Legislative Choice of Regulatory Forms: Legal Process or Administrative Process." *Public Choice*, vol. 39 (1982), pp. 33-71.

GILARDI, F. "Principal-Agent Models Go to Europe: Independent Regulatory Agencies as Ultimate Step of Delegation." Paper presented at the ECPR General Conference, Canterbury, 6-8 September 2001.

GROSSMAN, G. AND HELPMAN, E. "Protection for Sale." *American Economic Review*, vol. 84 (1994), pp. 833-850.

HEYES, A. AND LISTON-HEYES, C. "Capping Environmental Liability: The Case of North American Nuclear Power." *The Geneva Papers in Risk and Insurance*, vol. 25 (2000), pp. 196-202.

HIRD, J. "Environmental Policy and Equity: The Case of Superfund." *Journal of Policy Analysis and Management*, vol. 12 (1993), pp. 323-343.

HIRD, J. *Superfund: The Political Economy of Environmental Risk*. Johns Hopkins University Press, 1994.

HIRIART, Y. AND MARTIMORT, D. "The Benefits of Extended Liability." *The RAND Journal of Economics*, vol. 37 (2006), pp. 562-582.

HIRIART, Y., MARTIMORT, D. AND POUYET, J. "The Public Management of Environmental Risk: Separating Ex Ante and Ex Post Monitors." *Journal of Public Economics*, vol. 94 (2010), pp. 1008-1019.

HOLMSTRÖM, B. "On the Theory of Delegation." In M. Boyer and R. Kihlstrom, eds., *Bayesian Models in Economic Theory*, Elsevier Science Publishers B.V, 1984.

HOOD, C., ROTHSTEIN, H. AND BALDWIN, R. *The Government of Risk*. Oxford University Press, 2003.

HORN, M. *The Political Economy of Public Administration*, Cambridge University Press, 1995.

HUBER, J. AND SHIPAN, C. *Deliberative Discretion: The Institutional Foundations of Bureaucratic Autonomy*. Cambridge University Press, 2002.

HUBER, J. AND SHIPAN, C. "Politics, Delegation, and Bureaucracy." In B. Weingast and D. Wittman, eds., *The Oxford Handbook of Political Economy*, Oxford University Press, 2006.

JIN, D. AND KITE-POWELL, H. "On the Optimal Environmental Liability Limit for Marine Oil Transport." *Transport Research*, vol. 35 (1999), pp. 77-100.

KOVAC, E. AND MYLOVANOV, T. "Stochastic Mechanisms in Settings without Monetary Transfers: The Regular Case." *Journal of Economic Theory*, vol. 144 (2009), pp. 1373-1395.

LAFFONT, J.J. "The New Economics of Regulation Ten Years After." *Econometrica*, vol. 62 (1994), pp. 507-537.

LAFFONT, J.J. *Incentives and Political Economy*. Oxford University Press, 2000.

LAFFONT, J.J. AND MARTIMORT, D. *The Theory of Incentives: The Principal-Agent Model*. Princeton University Press, 2002.

LAFFONT, J.J. AND TIROLE, J. *A Theory of Incentives in Procurement and Regulation*. MIT Press, 1993.

LEWIS, T. AND SAPPINGTON, D. "Regulating a Monopolist with Unknown Demand and Cost Functions." *The RAND Journal of Economics*, vol. 19 (1988), pp. 438-457.

LEWIS, T. AND SAPPINGTON, D. "Inflexible Rules in Incentive Problems." *American Economic Review*, vol. 79 (1989), pp. 69-84.

MARTIMORT, D. AND SEMENOV, A. "Continuity in Mechanism Design without Transfers." *Economics Letters*, vol. 93 (2006), pp. 182-189.

MARTIMORT, D. AND SEMENOV, A. "The Informational Effects of Competition and Collusion in Legislative Politics." *Journal of Public Economics*, vol. 92 (2008), pp. 1541-1563.

MASKIN, E. AND TIROLE, J. "The Principal-Agent Relationship with an Informed Principal: The Case of Private Values." *Econometrica*, vol. 58 (1990), pp. 379-409.

MELUMAD, N. AND SHIBANO, T. "Communication in Settings with no Transfers." *The RAND Journal of Economics*, vol. 22 (1991), pp. 173-198.

MCCUBBINS, M., NOLL, R. AND WEINGAST, B. "Administrative Procedures as Instruments of Political Control." *Journal of Law, Economics and Organization*, vol. 3 (1987), pp. 243-277.

MCCUBBINS, M., NOLL, R. AND WEINGAST, B. "Structure and Process, Politics and Policy: Administrative Arrangements and the Political Control of Agencies." *Virginia Law Review*, vol. 75 (1989), pp. 431-482.

MCCUBBINS, M. AND SCHWARTZ, T. "Congressional Oversight Overlooked: Police Patrol versus Fire Alarms." *American Journal of Political Science*, vol. 2 (1984), pp. 165-179.

MOE, T. "The Politics of Bureaucratic Structure." In J. Chubb and P. Peterson, eds., *Can the Government Govern?*, The Brooking Institution, 1989.

PERSSON, T. AND TABELLINI, G. "Designing Institutions for Monetary Stability." *Carnegie-Rochester Conferences Series on Public Policy*, vol. 39 (1993), pp. 53-84.

RECHTSCHAFFEN, C. "Promoting Pragmatic Risk Regulation: Is Enforcement Discretion the Answer?" *University Kansas Law Review*, vol. 52 (2004), pp. 1327-1375.

ROCHET, J.C. "The Taxation Principle and Multi-Time Hamilton-Jacobi Equations." *Journal of Mathematical Economics*, vol. 14 (1985), pp. 113-128.

ROGOFF, K. "The Optimal Degree of Commitment to an Intermediate Monetary Target." *Quarterly Journal of Economics*, vol. 100 (1985), pp. 1169-1190.

SHAVELL, S. "A Model of the Optimal Use of Liability and Safety Regulation." *The RAND Journal of Economics*, vol. 15 (1984), pp. 271-280.

SZALAY, D. "The Economics of Clear Advices and Extreme Opinions." *Review of Economic Studies*, vol. 72 (2005), pp. 1173-1198.

THATCHER, M. AND STONE SWEET, A. "Theory and Practice of Delegation to Non-Majoritarian Institutions." *Western European Politics*, Special Issue, vol. 25 (2002), pp. 1-22.

TIROLE, J. "Collusion and the Theory of Organizations." In J.J. Laffont, edr., *Advances in Economic Theory*, Cambridge University Press, Cambridge, vol. 2, 1992.

VAN HOUTVEN, G. AND CROPPER, M. "When is a Life too Costly to Save? The Evidence from U.S. Environmental Regulations." *Journal of Environmental Economics and Management*, vol. 30 (1996), pp. 348-368.

VOGEL, D. "The Politics of Risk Regulation in Europe and the United States." *The Yearbook of European Environmental Law*, 2003.

WARREN, P. "Allies and Adversaries: Appointees and Policymaking under Separation of Powers." *Journal of Law, Economics and Organization*, forthcoming, 2012.

WEINGAST, B. AND MORAN, M. "Bureaucratic Discretion or Congressional Control? Regulatory Policy-Making by the Federal Trade Commission." *Journal of Political Economy*, vol. 96 (1983), pp. 132-163.

WOOD, B. AND BOTHE, J. "Political Transaction Costs and the Politics of Administrative Design." *Journal of Politics*, vol. 66 (2004), pp. 176-202.