Modeling the Choice Between Regulation and Liability in Terms of Social Welfare

Marcel Boyer and Donatella Porrini

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MODELING THE CHOICE BETWEEN REGULATION AND LIABILITY IN TERMS OF SOCIAL WELFARE[1]

by

MARCEL BOYER
Bell Canada Professor of industrial economics, Université de Montréal;
Fellow of CIREQ and CIRANO;
C.D. Howe Scholar in economic policy.
(marcel.boyer@umontreal.ca)

and

DONATELLA PORRINI
Istituto di Scienze Economiche e Statistiche,
Università degli Studi di Milano, Italy;
Facoltà di economia, Università di Lecce.
(donatella.porrini@unimib.it)

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Abstract

Using a formal political economy model with asymmetric information, we illustrate the conditions under which an environmental protection system based on extending liability to private financiers is welfare superior, inferior or equivalent to a system based on an incentive regulatory scheme subject to capture by the regulatees. We explicitly consider the following factors: the cost of care and its efficiency in reducing the probability of an environmental accident, the social cost of public funds, the net profitability of the risky activities, the level of damages, and the regulatory capture bias. We characterize in such a parameter space the regions where one system dominates the other.

Keywords: Environment, extended liability, capture, choice of instruments.

J.E.L. Classification numbers: D82, G32, K13, K32, L51.

1 Introduction

The increasing diffusion of risky activities in modern industrial societies, the necessity to properly compensate the victims of accidents, the need to induce an efficient level of care by the potential injurers in contexts characterized by asymmetric information, and the increasingly stringent budgetary limits of cash-constrained governments call for a better understanding of the relative efficiency of policy instruments in a political economy context.[1] More specifically, we consider environmental risks in the light of the challenging attempt by EC countries to design and implement a common environmental protection system,[2] of the experience and jurisprudence under CERCLA,[3] and of the new regulation approach adopted by the US Environmental Protection Agency (EPA website).

We compare two broad policy instruments: first, an assignment of strict liability on the responsible parties and second, an incentive regulation system. We consider that liability is extended to the financial partners of the firm if and when the firm goes bankrupt following an environmental accident,[4] and that the environmental protection agency may be captured by the regulated firms. Our model integrates the following variables and features: limited liability, the cost of low and high levels of care; the unobservability of care; the social cost of public funds; the (net) profitability of the firm; the level of damages if an accident occurs; and finally a regulatory capture factor. In this incomplete information political economy environment, we characterize the conditions under which incentive regulation is superior to extended liability in terms of social welfare. We consider three institutional contexts. First, a benevolent regulator who maximizes the proper social welfare function (the benchmark case). Second, a private financier, insurer or banker, who maximizes her own profit but is subject to extended liability. Third, a captured regulator who, benefiting from the firm's informational rent or profit, maximizes a biased social welfare function. The regulator or financier can determine whether or not the firm

[1] See for instance Menell (1991), Hahn (1993), Lewis (1996) and Segerson (1996). See also Boyer, Lewis and Liu (2000) for a model where standards are set to induce proper behavior by injurers and enforcers.

[2] See *The White Paper on Environmental Liability*, COM 66 final, Bruxelles, 9 February 2000. See also Arcuri (2002).

[3] The US *Comprehensive Environmental Response, Compensation and Liability Act* of 1980, 1985, 1996.

[4] See Summers (1983) and Shavell (1986) for early discussions of judgment proofness and De Geest and Dari Mattiacci (2002) for a discussion of the relationship between regulation, judgment proofness and tort law.

will be allowed or not to operate (be financed) and if it is, the level of accident preventing care implemented through a properly designed incentive contract. The present paper extends Boyer and Porrini (2001) by deriving and discussing comparative statics results which clearly show the power and policy relevance of the formal analysis.

The choice of instruments, such as ex ante regulation and ex post liability, has been regularly addressed in the law and economics literature. A first set of non formalized contributions addresses the general problem of finding the best policy to achieve given environmental policy targets. These contributions consider complete information frameworks where the choice between instruments reflects their relative imperfections.[5] A second set deals with the characterization of the relationship between the two instruments, as complements or substitutes in providing incentives to reduce the level of risk. Among those, Shavell (1984b) shows that neither regulation nor liability leads the parties to exercise the socially desirable level of care because regulatory authorities typically suffer from information problems and courts may impose significant costs on plaintiffs and allow parties to shun responsibility. He concludes that it is in general socially advantageous to use both liability and regulation. In addition to the inefficiencies considered by Shavell, namely the fact that suit may never be brought against the injurer, the limited resources of the injurer (limited liability), the imperfect knowledge of the regulator regarding the damage, and the setting of one single standard of care, Kolstad, Ulen and Johnson (1999) consider the difficulty in defining legal standards which may lead the firms to choose an improper level of care. They conclude also that the joint use of liability and regulation may be the best alternative. Schmitz (2000) criticize those analyses and questions the use of liability given that regulation by itself can always implement socially optimal behavior. In Shavell (1984b), the joint use of liability and regulation as complementary instruments follows from the limited efficiency of liability due to enforcement errors and the shunning of liability. Schmitz shows that if injurers cannot escape suit and if the magnitude of liability is set at the optimal level, it can never be socially advantageous to employ both liability and regulation as complementary instruments unless wealth differs between injurers.

[5] Calabresi (1970); Weitzman (1974); Wittman (1977).

Many authors have considered the specific topic of extended liability for environmental accidents.[6] Two recent papers on extended liability are of special interest in the context of the present paper. Hiriart and Martimort (2003) consider the optimal regulation of a risky project where a buyer (principal) has a contract with a seller (agent). The information on the level of safety care exerted by the agent is private to the agent (moral hazard). The authors derive conditions under which extending liability to the principal (buyer) improves social welfare. They show that if the principal has all the bargaining power, then extended liability favors the internalization of environmental damage and so improves welfare. However, when principals are competitive, extending liability has no value under complete contracting. But if the buyer-seller relation is plagued by adverse selection problems, then extending liability can again contribute to raising welfare. Hutchison and van't Veld (2003) consider a context where some care activities (unobservable) reduce the probability of accident while others (observable) reduce the level of damage if an accident occurs. In such a context, extended liability improves welfare but does not induce the first-best levels of care. With free entry and exit in the industry, extended liability generates too much exit (although second-best optimal given the levels of care). The authors show that if the regulator is constrained to one instrument only, then direct regulation of the observable type of care strictly welfare dominates extended liability.

The specific purpose of the present paper is to pursue the comparison between those instruments through a formal model of the way their (unavoidable) imperfections affect the outcome: the extension of liability to private financiers is imperfect insofar as the private financiers maximize their own profit rather than social welfare; the regulation system is inefficient insofar as the authorities may be captured by the regulated parties. Both instruments rest on the same asymmetric information framework, namely the level of precautionary activities is private information of the firm. The paper is organized as follows. Section 2 is devoted to the presentation and justification of the model, Section 3 to the characterization of the three solutions we want to compare, Section 4 to the comparative statics results. We conclude with a capsule of the main results and some general remarks.

[6] See among others Pitchford (1995 and 2001), Heyes (1996), Boyer and Laffont (1996 and 1997), Boyd and Ingberman (1997), Boyer and Porrini (2001 and 2002), Lewis and Sappington (1999 and 2001), Balkenberg (2001), Porrini (2001).

2 Modeling and characterizing the choice of instruments

The model is designed to compare two regimes. In the first regime, the firm interacts with a private financier who, under an extended liability regime, is the residual liable party for the environmental damages above the value of the firm's assets. The financier is assumed to be a deep pocket institution with a non-binding limited liability. She maximizes her own profit when dealing with the firm. In the second regime, the firm interacts with a regulator who is responsible for implementing environmental protection policies regarding both the accident preventing effort level and whether the firm should be allowed to operate or not.[7] The regulator maximizes welfare but is subject to capture by the regulated firm. Under this regulatory regime, the regulator takes into account the fact that the latter must be financially viable and that financial contracts have significant impacts on the firm's incentives to exert a high level of accident preventing activities.[8]

We want to concentrate here on the difficulty for regulators and financiers to directly observe the accident preventing activities chosen by firms to prevent the occurrence of catastrophic accidents is a significant and realistic characteristic of the design of efficient environmental policies. Even if the prevention and contingency plans are observable by concerned parties, their daily implementation is not. If this asymmetry is not adequately taken into account, the policies will likely be socially too costly and/or inefficient. In this vein, we consider, as in Boyer and Porrini (2001), the following information structure: the realized profit level is assumed to be observable by everyone while the level of accident prevention care is assumed to be a private information of the firm and therefore observable neither by the regulator nor by the private financier. The relationships between the regulator and the firm and between the private financier and the firm are modeled in a principal-agent framework. The timing of the interplay between the principal (either the public regulator or the private financier) and the agent (the

[7] For simplicity, we assume a direct financial link between the regulator and the firm, as a reduced form representation of the structural relationships between the regulator, the firm and the financial markets. See among others Hahn (1990), Laffont (1995), Boyer and Laffont (1997).

[8] Assuming that the private financier is a deep pocket institution may be seen as tilting the balance in favor of the extended liability regime given the imperfections such a regime would generate if the financier regime were subject to binding limited liability constraint. On the other hand, given that the captured regulator will favor the firm's rent, one may expect that the firms will put pressure on governments to opt for a regulation regime over the extended liability regime, thereby impairing the extended liability regime itself. We do not consider those factors in the present paper.

firm) is modeled as follows in both regimes considered. The principal offers the firm a financial contract that explicitly identifies the payments to be made if the firm is financed; since the level of profit is observable but the level of accident preventing activities is not, the payments made by the firm will optimally depend on the level of profits[9] but not on the level of accident preventing activities. The firm then chooses its level of care and produces. Profits are then observed and an environmental accident occurs or not. We assume that in each regime the principal has all the bargaining power and can extract all profits from the firm subject to participation and incentive constraints.[10]

The firm needs to borrow I to operate. The firm's operations are assumed to generate either a low level of net income $\underline{\pi}$ or a high one $\overline{\pi}$ with probability p and $1-p$ respectively, the expected net income (before accounting for the expected cost of an accident and the cost of care) being $\Pi = p\underline{\pi} + (1-p)\overline{\pi}$. The firm's operations are risky and can cause an accident with damage d which would make the firm bankrupt, $d > \overline{\pi}$. The probability of such an accident depends on the firm's unobservable accident preventing activities. For matter of simplicity, we assume that the probability of an accident is equal to $1-a$ where a is the level of accident preventing activities which can be chosen to be high, generating a probability of accident $1-\overline{a}$, or low, generating a probability of accident $1-\underline{a}$. The efficiency of effort in reducing the probability of accident is therefore $(1-\underline{a}) - (1-\overline{a}) = (\overline{a}-\underline{a})$. We denote the differential cost between the high and low levels as Δ and normalize the cost of the low level $\underline{a}$ at 0. We assume that Δ and $(\overline{a}-\underline{a})$ are such that it is socially optimal in a full information first best sense that a high level of care be exerted by the firm, that is $\Delta < (\overline{a}-\underline{a})d$.

The utilitarian social welfare function we use contains three terms: a first term corresponds to the expected net observable benefits of the firm's activities or project; a second term corresponds to the expected cost of an accident (probability of accident times the amount of damage); a third element corresponds to the informational rent or supra competitive profit that comes from the

[9] Hence the financial contract will not be a standard loan contract.

[10] The firm's negotiation power could be modeled through a more stringent participation constraint (increase in the reservation or best alternative project opened to the firm, which is assumed to be 0 here). An alternative interpretation of the model is that the principal wants to hire an agent/firm to realize a risky project at minimum cost to her.

assumption that the level of the firm's chosen precautionary activities is not observable. This rent is positive only if a high level of care is induced.

If the net social value of inducing a high level of care is low enough, then it may be better from a social point of view not to induce a high level of accident preventing activities, and therefore to tolerate a higher probability of accident, in order to avoid granting the firm an informational rent that may be socially costly. Indeed, we assume the existence of a social cost of public funds λ due to distortionary taxation in the economy.[11] Since the profit of the firm is observable, it could be used to reduce the general distortionary taxes. The profit thus enters the social welfare function with a weight of $(1 + \lambda)$ to explicitly represent its potential social value. Similarly, the expected cost of an accident enters the social welfare function with a weight of $(1 + \lambda)$ because the government will have to cover that cost one way or another, either directly or through the taxation rules (tax deductible expenses for cleaning up the polluted areas and/or for compensating the victims, for instance). The existence of a social cost of public funds is an important and realistic feature of regulatory frameworks and social welfare accounting: as we will see, it will lead under some conditions to distortions in the accident preventing effort levels and to distortions also in the decision to finance or not the firm's risky activities. Finally, the informational rent that the firm can capture or hide cannot be used to reduce distortionary taxation because it is not observed; it will thus enter the social welfare function with a weight of 1 to properly represent its utilitarian private value.

The model is a bare-bone model through which one can analyze the complex issues related to the comparison between extended liability and incentive regulation. The extension of liability to private financiers has a long tradition, especially in the US under CERCLA. Also, the possibility of capture of regulators by regulated firms is well documented. Regulators and financiers typically face similar information (moral hazard) asymmetries in their relationships with firms. Finally, distribution and efficiency issues are linked through the social cost of public funds, making it imperative to minimize the extra rents a firm can capture under asymmetric information.

[11] There is a large literature on this complex problem. Among others, Pigou (1947), Stiglitz and Dasgupta (1971), Kaplow (1996). Jones, Tandon and Vogelsang (1990) derive estimates indicating that λ is of the order of 0.3 in developed countries and higher in developing ones.

All these realistic features are embedded in our model of instrument choice.

3 Comparing the three institutional frameworks

We characterize and compare three solutions. The benchmark solution corresponds to the case where a *benevolent regulator*, not subject to capture, decides whether or not the firm should operate, that is be financed or not, and directly chooses the financial contract offered to the firm in order to maximize a utilitarian social welfare function in which the informational rent of the firm is properly accounted for.[12] The second solution is obtained when the decision whether the firm should operate or not is delegated to a *private financier* who, under an extended lender liability, decides to finance the firm or not and to offer a financial contract that maximizes her own expected profit function in which the informational rent of the firm is not present. The third solution is obtained when the *captured regulator* decides whether the firm should operate or not and chooses the financial contract offered to the firm; the captured regulator maximizes a distorted social welfare function in which the informational rent of the firm is overvalued.[13]

In a complete information context, the first best solution is feasible. It entails a high level of precautionary activities and the financing of the firm's risky activities under the condition that, given the high level of effort, the expected net income minus the fixed investment cost, the expected cost of the accident and the cost of accident preventing activities, is positive or at least non-negative, a condition that is met by assumption. This full information first best solution is achieved if we have a benevolent regulator or a captured regulator because they implement the same solution (since, even if the two regulators differ by their treatment of the firm's informational rent, the rent is zero under full information). For the same reason, the full information first best allocation is also achieved with the extended lender liability regime since it makes the financier internalize the full expected cost of an accident.

[12] As mentioned above, this is meant to be a reduced form representation of the complex relationships between the regulator, the firm and the financial markets.

[13] Given that the level of care can take only two values and that the firm is financed or not (investment financing is I or 0), there is no value, as we sill see below, in using jointly the captured regulator regime and the extended liability regime.

Under an asymmetric information structure and with limited liability of the firm, the internalization of externalities becomes a more difficult problem. The social optimum corresponds to the maximization of the social welfare function under the following conditions or constraints: the incentive compatibility constraint implying that, if the firm is induced to choose a high level of precautions, a costly rent is left to the firm; the limited liability of the firm requiring that the repayment levels not exceed the corresponding profit levels; the individual rationality constraint of the privately informed firm stating that the firm's expected profit cannot be negative. Under limited liability, if the accident occurs, the firm will be judgment-proof for damages above its profit level, so that the firm's behavior cannot simply and costlessly be controlled by imposing appropriate penalties.

Incentive compatibility requires that the firm gains in exerting a high level of care. Letting $\overline{P}$ [$\underline{P}$] be the payment to be made if profit is high [low] and EP be the expected payment, we must have[14] $(\overline{a})(\Pi - EP) - \Delta \geq (\underline{a})(\Pi - EP)$ implying that the expected payment be at most equal to $\Pi - \Delta/(\overline{a} - \underline{a})$. Substituting this value in the profit function under $\overline{a}$, we obtain $(\overline{a})(\Pi - EP) - \Delta = \overline{a}\Pi - \overline{a}\,(\Pi - \Delta/(\overline{a} - \underline{a})) - \Delta$. That is, to be induced to exert a high level of care, the firm must be granted a rent $\mathcal{R}$ equal to its expected (supra competitive) profit when it is induced to exert a high level of care:

$$\mathcal{R} = \frac{\underline{a}}{\overline{a} - \underline{a}}\Delta.$$

Because of the social cost of public funds, it will be welfare enhancing to make this rent as small as possible by adjusting the payments stipulated in the financial contract so that the rent is minimized under the condition that the contract induces a high level of care.

The regimes we consider differ in their treatment of the firm's information rent R: its weight is respectively 1, 0 and $K > 1$ in the function maximized by the benevolent regulator, the private financier and the captured regulator. The regimes differ also by the fact that the regulators value the observable benefits and costs of the firm's operations as well as the expected cost of an accident at their social value (factor $1 + \lambda$) while the private financier evaluate them at their

[14] Under $\overline{a}$, the firm incurs a care cost Δ and gets 0 with probability $(1 - \overline{a})$ and $(\Pi - EP)$ with probability $\overline{a}$. Under $\underline{a}$, the firm incurs no care cost and gets 0 with probability $(1 - \underline{a})$ and $(\Pi - EP)$ with probability $\underline{a}$.

private value 1.

The Benevolent Regulator Regime

Given the non-observability of precautionary activities, the social optimum, corresponding to the benevolent regulator solution, calls for a high level of accident preventing activities if and only if the sum of the net social cost of the firm's informational rent $[(1+\lambda)\mathcal{R} - \mathcal{R} = \lambda\mathcal{R}]$ plus the differential social cost of precautionary activities is less than or equal to the difference in the expected social cost of an accident under the high and the low levels of precautionary activities, that is, if and only if

$$\lambda\mathcal{R} + (1+\lambda)\Delta \leq (1+\lambda)(\overline{a} - \underline{a})d.$$

which can be rewritten as

$$\Delta \leq \frac{1+\lambda}{(1+\lambda)\overline{a} - \underline{a}}(\overline{a} - \underline{a})^2 d. \tag{1}$$

Hence, the benevolent regulator's willingness to reduce the probability of accident increases in the efficiency of effort in reducing the probability of accident and in the cost of an accident but decreases in the differential cost of effort and in the social cost of public funds. Financing occurs if the net social value of the firm's operations is larger than the net social cost of the firm's informational rent, that is, if

$$(1+\lambda)[\Pi - I - (1-\overline{a})d - \Delta] \geq \lambda\mathcal{R}$$

which can be rewritten as

$$\Delta \leq \frac{(1+\lambda)(\overline{a} - \underline{a})}{(1+\lambda)\overline{a} - \underline{a}}[\Pi - I - (1-\overline{a})d], \tag{2}$$

a condition which is more likely to be satisfied, the larger $\Pi - I$ and $\overline{a}$ are and the smaller Δ, d and λ are. Otherwise, it is best that the firm exerts a low care level (with no rent), in which case it should be allowed to operate if and only if

$$(1+\lambda)[\Pi - I - (1-\underline{a})d] \geq 0, \tag{3}$$

a condition which is more likely to be satisfied, the larger λ and $\Pi - I$ are, and the smaller the expected cost of an accident under low effort is.

This "social optimum under moral hazard" financing rule differs from the full information first best rule because of the presence of the informational rent.[15] The benevolent regulator cannot avoid giving up that rent to induce a high level of care and will therefore take into account the net social cost of that rent in deciding if the firm should be allowed to operate or not and in deciding what level of accident preventing activities should be implemented. If the net social cost of the rent is large, the benevolent regulator may prefer, in maximizing social welfare, to induce a low level of accident preventing activities, thereby generating a high probability of environmental accidents. It may even turn out that the benevolent regulator will prevent the firm from operating even if the firm's activities or projects are socially valuable under full information.

The Private Financier Regime

Under an extended lender liability regime, the principal is a private financier. As in the benevolent regulator case, the full expected cost of an accident is properly internalized given that the financier is the residual claimant of that cost. The difference is in the treatment of the firm's informational rent, which as before appears only when the high level of effort is induced. Hence, the comparison between the two regimes rests on their different evaluation of the firm's rent when a high level of care is induced. For the private financier, the cost of the rent is equal to the amount of the rent itself while for the benevolent regulator the net cost is smaller because she considers the private value of that rent in the social welfare function. The private financier, under extended liability, will induce the firm to exert a high level of accident preventing activities if and only if

$$\mathcal{R} + \Delta \leq (\overline{a} - \underline{a})d$$

which can be rewritten as

$$\Delta \leq \frac{(\overline{a} - \underline{a})^2}{\overline{a}}d, \tag{4}$$

a condition which is more likely to be satisfied, the larger the efficiency of effort in reducing the probability of accident and the cost of an accident are, and the smaller the differential cost of

[15] In the full information first best context, the condition for financing the firm would be: if the net social value of the firm's operations under full information is larger than 0.

effort is. She will then finance the firm if and only if

$$\Pi - I - (1 - \overline{a})d - \Delta \geq \mathcal{R}$$

which can be rewritten as

$$\Delta \leq \frac{\overline{a} - \underline{a}}{\overline{a}}[\Pi - I - (1 - \overline{a})d], \tag{5}$$

a condition which is more likely to be satisfied, the larger the efficiency of effort in reducing the probability of accident and the larger the value $(\Pi - I)$ of the project are, and the smaller the differential cost of effort and the cost of an accident are. Otherwise, she prefers that the firm exerts a low care level (with no rent) and will then finance the firm if and only if (3) is satisfied. This implies that the private financier is less willing than the benevolent regulator to lend and to induce a high level of accident preventing activities. Hence this undervaluation of the social value (overvaluation of its cost) of the firm's unavoidable informational rent leads to insufficient financing and too little care activities as compared with the solution a benevolent regulator would choose to implement. If the financier chooses to let the firm exert a low level of care in preventing accidents, there will be no rent and therefore the bank lends as often as the benevolent regulator would in that case. Hence, an extended lender liability regime will generate a welfare cost because of insufficient financing of risky business and because of less frequent inducement of high care levels.

The Captured Regulator Regime

The captured regulator overvalues the firm's informational rent in her version of the social welfare function, due to her indirect interests in the firm's informational rent or profit. Instead of evaluating the firm's rent at its face value $\mathcal{R}$, she values it at $K\mathcal{R}$ with $K > 1$. Because this informational rent is obtained by the firm only when it is induced to choose the high level of accident preventing activities, the captured regulator induces a high level of accident preventing activities more often than the benevolent regulator does. Indeed, the maximization of the biased social welfare function calls for a high level of accident preventing activities if and only if the biased net social cost of the firm's informational rent plus the differential cost of precautionary activities is less than or equal to the difference in the expected cost of an accident under the

high and the low levels of precautionary activities, that is if and only if

$$(1+\lambda)\mathcal{R} - K\mathcal{R} + (1+\lambda)\Delta \leq (1+\lambda)(\overline{a}-\underline{a})d$$

which can be rewritten as

$$\Delta \leq \frac{(1+\lambda)(\overline{a}-\underline{a})^2}{(1+\lambda)\overline{a}-K\underline{a}}\ d, \tag{6}$$

a condition which is more likely to be satisfied, the larger the capture factor K and the cost of an accident are, the smaller the differential cost of effort and the social cost of public funds are, and the larger the efficiency of effort in reducing the probability of accident is if and only if the capture factor is not too large, that is, $K < (1+\lambda)\frac{\overline{a}+\underline{a}}{2\underline{a}}$. When she induces a high level of care, thereby conceeding a rent to the firm, she also lends more often than called for by the second best optimal investment rule. Indeed, financing occurs then if the net social value of the firm's operations under full information is larger than the biased net social cost of the firm's informational rent, that is if

$$(1+\lambda)[\Pi - I - (1-\overline{a})d - \Delta] \geq [(1+\lambda)\mathcal{R} - K\mathcal{R}]$$

which can be rewritten as

$$\Delta \leq \frac{(1+\lambda)(\overline{a}-\underline{a})}{(1+\lambda)\overline{a}-K\underline{a}}[\Pi - I - (1-\overline{a})d], \tag{7}$$

a condition which is more likely to be satisfied, the larger the capture factor K is, the smaller the cost of an accident, the differential cost of effort and the social cost of public funds are, and the larger the efficiency of effort in reducing the probability of accident is if and only if

$$K \leq (1+\lambda)\frac{(\Pi - I)\underline{a} + (\overline{a}^2 - \underline{a})d}{(\Pi - I)\underline{a} + (2\overline{a} - \underline{a} - 1)\underline{a}d},$$

where the right-hand side is larger than $(1+\lambda)$. Otherwise, she prefers that the firm exert a low care level (with no rent) and will then let the firm operate if and only if (3) is satisfied. The net social cost of the firm's informational rent or supra competitive profit is undervalued by the captured regulator and therefore, the capture of the regulator leads to too much care and to overinvestment in the case of a high level of care as compared with the solution a benevolent regulator would choose to implement. When a low level of care is induced, then no rent is left to the firm and the investment rules of the captured regulator and the benevolent regulator are

the same. Hence, a regulation subject to capture regime will generate a welfare cost because it leads to excessive financing of risky activities and to too frequent inducement of high levels of accident preventing activities.

4 The impact of changes in parameter values on the choice of regimes

We can compare the two regimes considered, the extended liability regime and the incentive regulation subject to capture regime, by referring to five illustrative cases and figures. In the captions of those figures, BR stands for the solution (the investment rule, that is allowing the firm to operate or not, and the level of accident preventing activities) implemented by the "benevolent regulator", CR stands for the solution implemented by the "captured regulator" and PF stands for the solution implemented by the "private financier". We use " $\sim$ " to mean "is equivalent to" and " $\succ$ " to mean "is preferred to". The five graphs presented here are of course only some of the graphs that can be obtained by taking any two parameters as coordinates and giving numerical values to the other parameters of the model. The graphs are illustrative of the kind of results that can be derived from a formal analysis of the choice of instruments.

In each figure, the numbers associated with the different curves correspond to the equation numbers above; we use dotted curves to indicate that the condition is ineffective for the case considered. We indicate by Φ_1 the region, in the particular parameter space represented by the coordinates, where both the extended liability and the regulation subject to capture regime are equivalent to the benevolent regulator regime in the sense that they all induce a high level of accident preventing activities and implement the same investment or financing rule. Hence, in that region, both regimes are equivalent and generate no welfare loss. We indicate by Φ_2 the region where all regimes are equivalent but with a low level of accident preventing activities. In regions Ω and Γ, the two regimes differ. In region Ω, the regulation subject to capture regime and the benevolent regulator regime lead to the same care (high level) and financing choices while the the extended liability regime leads to a low level of accident preventing activities and therefore generates a welfare loss: there would be *too many* environment damaging accidents. In

region Γ, the extended liability regime and the benevolent regulator one lead to the same care (low level) and financing choices while the regulation subject to capture regime leads to a high level of accident preventing activities and therefore generates a welfare loss: there would be *too few* environment damaging accidents. In this region, it is better, from a social welfare point of view, to tolerate a higher probability of accident with no informational rent for the firm than to reduce the probability of accident together with abandoning a costly rent to the firm.

Let us consider Figure 1. The case depicted in this figure is such that the project is valuable even if the low level of accident preventing activities is exerted, that is condition (3) is satisfied. Hence the firm will always be financed or allowed to operate. Suppose that in Figure 1 the net social opportunity cost of public funds is $\lambda = 0.6$. Then, as the differential cost between the high and low levels of accident preventing activities Δ increases, we go from region Φ_1 where both regimes are equivalent and generate no welfare loss to region Ω where, once (4) is crossed, the private financier would find it unprofitable to induce the firm to exert a high level of care because with a higher Δ the rent (recall that $R = \underline{a}\Delta/(\overline{a} - \underline{a})$) that the firm can capture becomes too large. In spite of extended liability and therefore of the full internalization of the expected cost of an accident, the private financier finds it more profitable to let the probability of accident be relatively large. In that region, the regulation subject to capture is preferred. But for a larger value of Δ, we move into region Γ where the social optimum under moral hazard calls for a low level of accident preventing effort and no rent because the otherwise unavoidable rent increases with the differential cost of care. However, because the captured regulator has a vested interest in keeping the firm's rent or profit high, and since this rent is obtained only if a high level of effort is induced, she keeps inducing the firm to exert a high level of effort to reduce the probability of environmental accidents. But in so doing, she moves away from the social optimum which calls in this region Γ for the elimination of the rent at the expense of a higher probability of accident. As the differential cost Δ increases even more, we move into region Φ_2 where the rent level becomes so high that both the captured regulator and the private financier opt for letting the firm operate at a low level of effort but with no rent.

Let us now suppose that the differential cost between the high and low levels of accident pre-

venting activities Δ is fixed at the 0.5 level. As the social cost of public funds λ increases from 0 to 1, we move successively into regions Ω, Γ and Φ_2. When the value of λ becomes large enough to cross boundary (1) – note that this occurs earlier for larger values of Δ – the social cost of the rent becomes relatively high and it is then better to opt for the private financier extended liability regime which leaves no rent to the firm: the higher probability of accident that the private financier regime would imply is better, from a social welfare point of view, than the larger rent that the captured regulator regime would allow.

Hence, Figure 1 shows that larger values of the social opportunity cost of public funds – above (1) – favor the private financier extended liability regime as the preferred instrument, while smaller values of the differential cost of care – to the left of (1) – favor the regulation subject to capture regime as the preferred instrument.

Let us consider Figure 2. In the case depicted in this figure, we consider the same variable parameters (coordinates) as in Figure 1 and the same fixed values for the other parameters except for the probability of accident under a low level of care $\underline{a}$ which is now set at 0.3 rather than 0.1; this higher probability of accident when the firm exerts a low level of care implies that the firm's operations are not socially valuable when the low level of care is exerted, that is, (3) is not satisfied. We now find that in region $\hat{\Omega}$, the private financier solution calls for not financing the firm. But the social optimum under moral hazard calls for letting the firm operate and be induced to exert a high level of care. The captured regulator will implement such a solution and is therefore the preferred instrument. In spite of the fact that there will be more environment damaging accidents with the captured regulator regime than with the private financier regime, it is socially optimal to face the risk of such accidents. However, as we move into region $\hat{\Gamma}$, either because of a higher level of the social cost of public funds λ or because of a higher differential cost of care, the social optimum calls for preventing the firm from operating: the rent captured by the firm under a high level of effort is too large (higher Δ) or too costly (higher λ) compared to the social value of the firm's operations. In region $\hat{\Gamma}$, the captured regulator would rather let the firm operate with a high level of effort, thereby allowing a positive informational rent in which she has some interest. In this region, the private financier is the preferred instrument. As

in region $\hat{\Omega}$, there would be more environment damaging accidents with the captured regulator regime than with the private financier regime, but now the social cost of the unavoidable rent has become too large to make it socially profitable to face the risk of such accidents.[16] Figures 1 and 2 differ only by the probability of accident under a low level of effort $(1-\underline{a})$ equal to 10% in Figure 1 and 30% in Figure 2. The increase in the probability of accident under a low level of effort shows that the conditions under which the private financier extended liability regime is preferred or not to the captured regulator regime are now given by conditions (5), (2) and (7) rather than by (4), (1) and (6). For Δ less than the boundary (1), the benevolent regulator would prefer to induce the firm to exert a high rather than a low level of effort but she will not finance the firm if Δ is above the boundary (2). And similarly for the other conditions.

Let us now consider Figure 3 where the social cost of public funds is fixed at 0.3 and the variable parameters (coordinates) are now the differential cost between high and low levels of accident preventing activities as before and the cost of an accident d. The level of damages if an accident occurs remains known but we consider different levels of this known value between $\overline{\pi}$ and 50. The parameter values of this case are otherwise the same as in Figure 1; the firm's operations are valuable under a low level of care if $d \leq 25$. In Figure 3, we see that more costly (larger d) environmental accidents and more costly safety activities (larger Δ) interact in a complex way to determine the preferred regime. Let us now consider Figure 4 where the coordinates are now λ and K. As λ increases from 0 to 1, we move successively into regions Ω (it is socially preferable to induce the firm to choose a high level of care, the reason being that the social cost of the informational rent is rather small), Γ (the social optimum under moral hazard now calls for a low level of care with no rent for the firm; however, the level of λ is still not high enough, between boundaries (1) and (6), for the captured regulator to prefer inducing the firm to choose a high level of care), and finally Φ_2 (the social cost of the informational rent becomes

[16] In some cases, a partial liability system, as discussed by Boyer and Laffont (1997), may be better if there is some room to manoeuver between the need to induce the private financier to monitor the firm and provide it with the incentives to exert a high level of effort and the need to finance the firm whenever it is socially valuable to do so. In Figure 2, making the private financier partially liable would move (4) to the left and (5) to the right and lead to a welfare improvement. Similarly, under a negligence rule, as discussed by Pfaff and Sanchirico (2000), the 'integrated organization', that is the private financier together with the firm, may be fined too heavily for violations of the regulations as compared to an optimal fine level which could be a decreasing function of the organization's monitoring and disclosure rules and efforts.

too high and even the captured regulator prefers to let the firm operate with a low level of care). It is interesting to note that boundary (1), at which the preferred instrument switches from the regulation subject to capture to the private financier, is independent of the capture factor K whereas boundary (6), at which the captured regulator ceases to induce the firm to choose a high level of accident preventing activities and thus again implements the social optimum under moral hazard, is increasing with K. Let us now suppose that the social opportunity cost of public funds λ is fixed at the 0.3 level. Then, as the capture factor K increases from 1 to 2, we move successively into regions Φ_2 (both the captured regulator and the private financier are unwilling to induce the firm to choose a high level of care given that the social cost of the informational rent is large with $\lambda = 0.3$ and $\Delta = 0.6$) and Γ (the captured regulator moves away from the social optimum – this happens later for larger values of λ – but not the private financier).

Let us now consider Figure 5 where the coordinates are λ and the probability of a low level of profit p. The firm's operations are valuable under a low level of care if and only if the probability of the low level of profit p is below 0.6. In Ω and $\hat{\Omega}$, the regulation subject to capture regime is the preferred instrument because in those regions the private financier prefers, if $p \leq 0.6$, to finance the firm with a low level of accident preventing activities and, if $p > 0,6$, not to finance the firm at all. Let us suppose that $p = 0.5$. As the social opportunity cost of public funds λ increases from 0 to 1, we move successively into regions Ω, Γ and finally Φ_2, a case similar to the one discussed in Figure 4 except that in the present case, boundary (6) is constant for $p \in (0, 0.6]$. Let us now suppose that the probability of a low level of profit is fixed at the 0.63 level. As the social opportunity cost of public funds λ increases from 0 to 1, we move successively into regions $\hat{\Omega}$, $\hat{\Gamma}$ and finally $\hat{\Phi}_2$. When the value of λ crosses boundary (2), the firm's project ceases to be socially valuable. Under full information, the firm's operations would be socially valuable only if the firm exerts a high level of accident preventing activities but under moral hazard it ceases to be socially valuable even with a high level of care because of the social cost of the unavoidable informational rent: it is then better to prevent the firm from operating, which is what the private financier would do by refusing to finance the firm. However, because of her indirect interest in the firm's rent, the captured regulator would still, in region $\hat{\Gamma}$, finance the

firm and induce it to exert a high level of care, thereby *implementing the full information first best optimum but not the social optimum under moral hazard* which calls for shutting down the firm: because of the social opportunity cost of public funds, income distribution matters and it is no longer sufficient (or efficient) to attain the first best. As the social opportunity cost of public funds increases above boundary (7), the captured regulator then finds the social cost of the informational rent too high and ceases to allow the firm to operate, thereby implementing, as does the private financier regime, the social optimum under moral hazard. Let us now suppose that the social opportunity cost of public funds λ is fixed at the 0.03 level. Then, as the probability of a low level of profit p increases towards 1, we are successively in regions Ω, $\hat{\Omega}$, and $\hat{\Gamma}$. For low values of p, that is for a firm with a large expected profit level, it is socially preferable to let the firm operate and to induce it to choose a high level of accident preventing activities. This is the policy the captured regulator would implement contrary to the private financier who would prefer to finance the firm with a low level of care. As p increases, the profitability of the firm decreases, and we eventually move into region $\hat{\Omega}$ where the firm's operations are socially valuable only if a high level of care is induced. Since the private financier would not finance the firm in $\hat{\Omega}$, the captured regulator who implements the social optimum under moral hazard is the preferred regime. When the value of p crosses boundary (2), the firm ceases to be socially profitable whatever the level of care – this occurs later for smaller λ – and the social optimum calls for preventing the firm from operating. However, because of her interest in the firm's rent, the captured regulator keeps allowing the firm to operate and inducing a high level of effort.

5 Conclusion

To compare two major instruments to achieve environmental policy objectives, we followed a formal and structured analytical approach to model the interactions between governments, firms, regulators and financiers. We considered a stylized but explicit extended liability system and modeled the relationship between the financier as a residual liable party and the firms. The model recognizes asymmetric information and regulatory capture features and the instruments compared are in that regard "realistic" instruments. We illustrated our results through different

graphs allowing a more intuitive discussion of the implications of using different instruments. We showed how the cost of the accident preventing activities, the social opportunity cost of public funds, the size of the environmental damage, the bias factor in case of regulatory capture and the firm's profitability can influence the choice between *ex ante* policy instruments, such as a regulatory agency, and *ex post* policy instruments, such as a liability system.

The instruments we characterized are sophisticated versions of the statute-based regulatory schemes and tort law systems. We considered incentive regulation rather than command and control regulation to avoid giving an advantage to liability systems at the outset in terms of more adequate exploitation of the decentralized and asymmetric distribution of information. Similarly, we considered an extended liability system to avoid giving at the outset an advantage to the regulatory system which would otherwise be better able to internalize the judgment-proof limited liability constraints that all policy implementation instruments must face. The exercise is fruitful and useful given that more and more sophisticated instruments are likely to be implemented, whether they are related to environmental protection or not.[17] Moreover, the regulatory capture process is not modeled simply as a bribe system where the regulated firms would "buy" the decisions of the regulators but rather our captured regulator uses the proper social welfare function except for a larger weight given to the firms' rents or supra competitive profits. This overweighing of the firms' rents implies that the captured regulator will in some cases *overprotect* the environment in order to allow firms to capture larger informational rents. So, rather than letting the environment unprotected in order to allow firms to increase their profits, as the popular version of the capture argument suggests, our captured regulator tends to make the protection of the environment stricter.

We showed the following results. A relatively large differential cost of care favors the extended lender liability or private financier regime because, in this case, the regulator subject to capture regime would imply too much care, or too few environmental accidents, and too much financing of risky business, that is, an overdevelopment of environmentally risky industries: the social value of the informational rents so allowed is not large enough to compensate for the social cost

[17] See Boyer and Laffont (1999) for a theoretical model of the pros and cons of the emergence of incentive regulation in environmental policy.

of the extra care activities. A relatively low cost of public funds, that is a relatively efficient non-distortionary taxation system, favors the captured regulator regime because the extended lender liability regime would imply too little care and too little financing. The benefits of a reduced expected cost of environmental accidents are not large enough to compensate for the loss of profits (informational rents) whose social cost is small when the cost of public funds is low. More costly (larger d) environmental accidents and more costly safety activities (larger Δ) interact in a complex way to determine the preferred regime. A larger regulatory capture factor K favors the private financier regime: as K increases above a critical value which increases with the social cost of public funds, the captured regulator induces too much care prevention, hence too few accidents, allowing a costly informational rent for the firm.

Choosing between an ex ante regulation framework and an ex post liability framework to implement an environmental protection policy and drawing definitive conclusions about the determinants on that choice is not an easy matter. But we have shown in this paper how some important features or parameters of two particularly relevant frameworks affect that choice. We like to think that our analysis provides some preliminary formal steps in analyzing such a choice.

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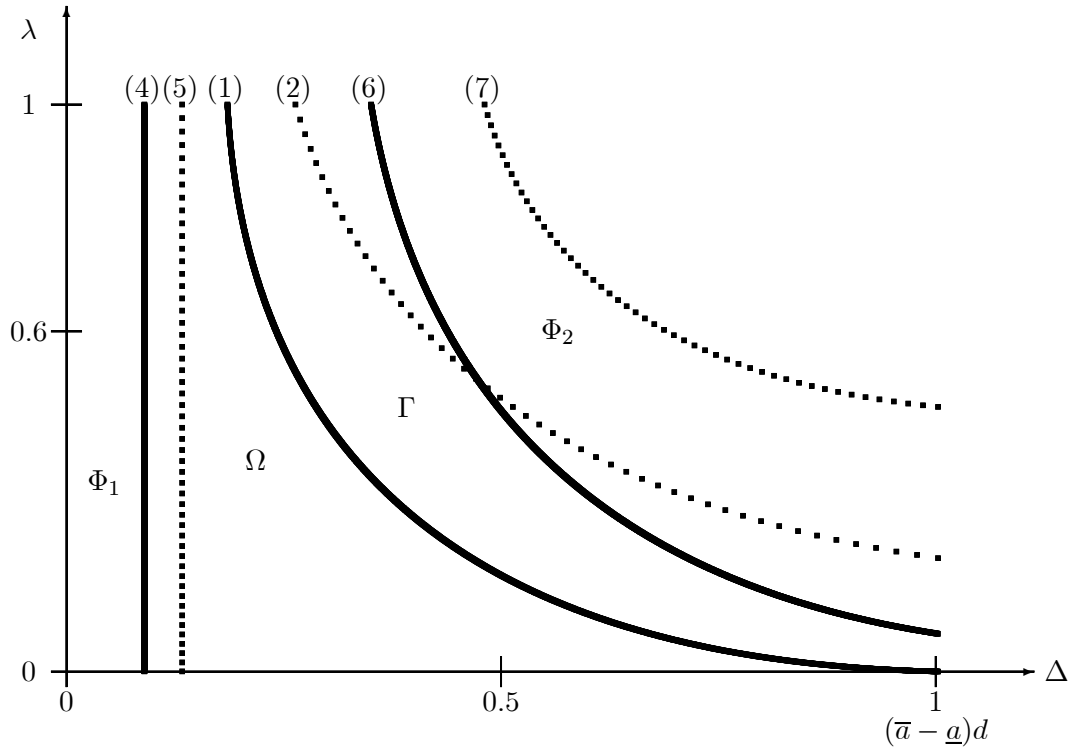
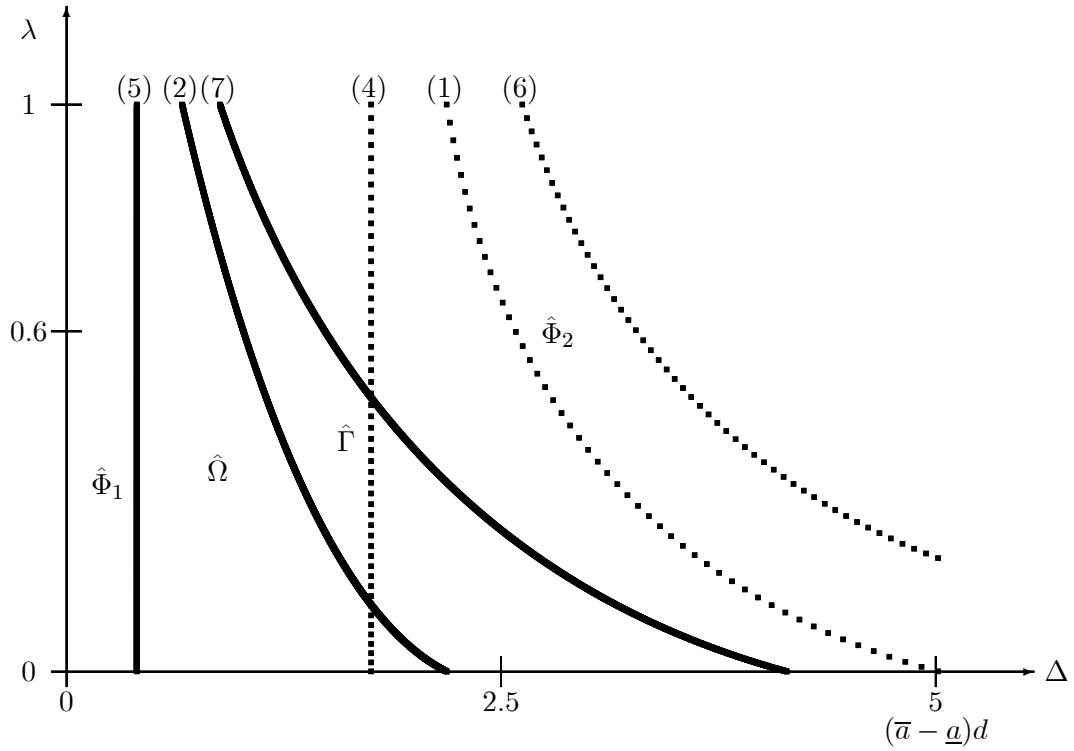
FIGURE 1 (The firm is profitable under $\overline{a}$ and $\underline{a}$)

$[\underline{\pi} = 5,\ \overline{\pi} = 10,\ p = 0.5,\ I = 5,\ (1 - \overline{a}) = 0.05,\ (1 - \underline{a}) = 0.1,\ d = 20,\ K = 1.2]$



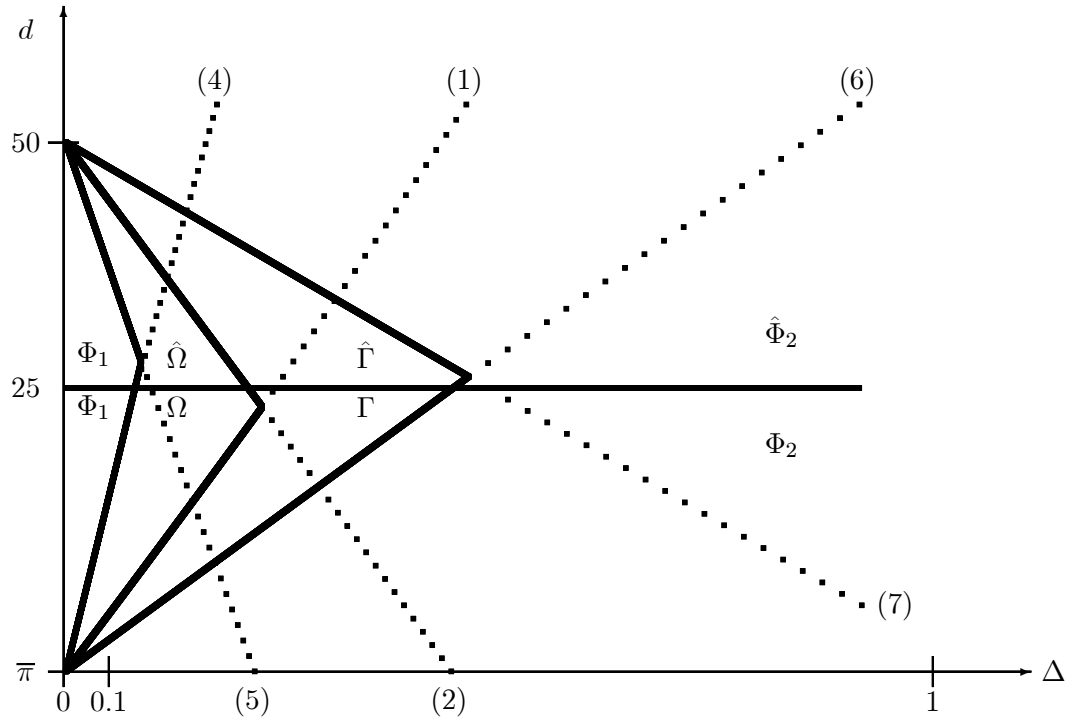
- In Φ_1, BR $\sim$ CR $\sim$ PF with financing and $\overline{a}$
- In Φ_2, BR $\sim$ CR $\sim$ PF with financing and $\underline{a}$
- In Ω, BR $\sim$ CR $\succ$ PF with financing and $\overline{a}$ under CR, financing and $\underline{a}$ under PF
- In Γ, BR $\sim$ PF $\succ$ CR with financing and $\underline{a}$ under PF, financing and $\overline{a}$ under CR

FIGURE 2 (The firm is profitable under $\overline{a}$ only)
$[\underline{\pi} = 5,\ \overline{\pi} = 10,\ p = 0.5,\ I = 5,\ (1 - \overline{a}) = 0.05,\ (1 - \underline{a}) = 0.3,\ d = 20,\ K = 1.2]$



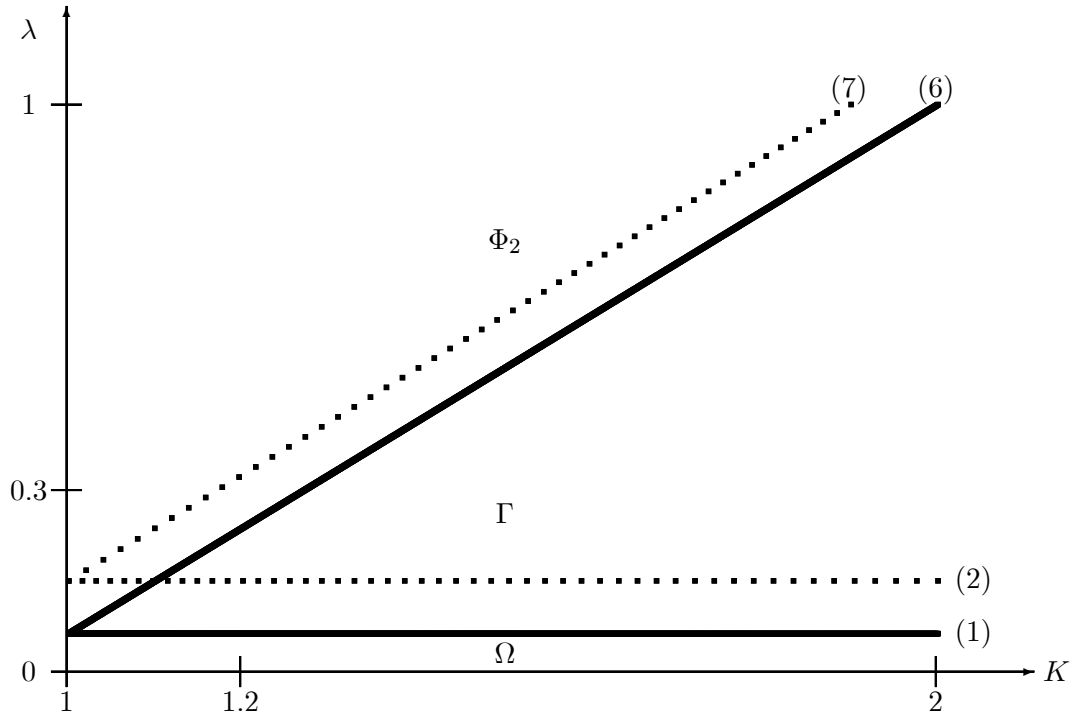
- In $\hat{\Phi}_1$, BR $\sim$ CR $\sim$ PF with financing and $\overline{a}$
- In $\hat{\Phi}_2$, BR $\sim$ CR $\sim$ PF with no financing
- In $\hat{\Omega}$, BR $\sim$ CR $\succ$ PF with financing and $\overline{a}$ under CR, no financing under PF
- In $\hat{\Gamma}$, BR $\sim$ PF $\succ$ CR with no financing under PF, financing with $\overline{a}$ under CR

FIGURE 3 (The firm is profitable under $\overline{a}$; and under $\underline{a}$ if $d < 25$)
$[\underline{\pi} = 5,\ \overline{\pi} = 10,\ p = 0.5,\ I = 5,\ (1-\overline{a}) = 0.05,\ (1-\underline{a}) = 0.1,\ K = 1.2,\ \lambda = 0.3]$



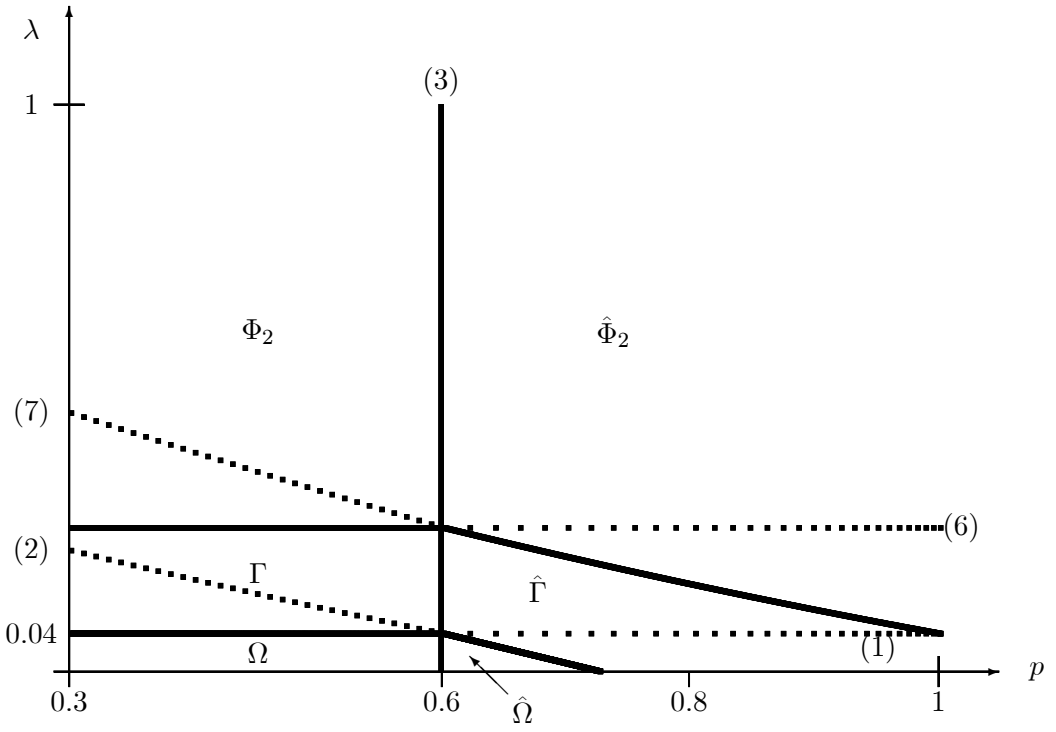
- In Φ_1, BR $\sim$ CR $\sim$ PF with financing and $\overline{a}$
- In $\hat{\Phi}_2$, BR $\sim$ CR $\sim$ PF with no financing.
- In Φ_2, BR $\sim$ CR $\sim$ PF with financing and $\underline{a}$
- In $\hat{\Omega}$, BR $\sim$ CR $\succ$ PF with financing and $\overline{a}$ under CR, no financing under PF
- In Ω, BR $\sim$ CR $\succ$ PF with financing and $\overline{a}$ under CR, financing and $\underline{a}$ under PF
- In $\hat{\Gamma}$, BR $\sim$ PF $\succ$ CR with no financing under PF, financing and $\overline{a}$ under CR
- In Γ, BR $\sim$ PF $\succ$ CR with financing and $\underline{a}$ under PF, financing and $\overline{a}$ under CR

FIGURE 4 (The firm is profitable under $\overline{a}$ and $\underline{a}$)
$[\underline{\pi} = 5,\ \overline{\pi} = 10,\ p = 0.5,\ I = 5,\ (1 - \overline{a}) = 0.05,\ (1 - \underline{a}) = 0.1,\ d = 20,\ \Delta = 0.6]$



- In Φ_2, BR $\sim$ CR $\sim$ PF with financing and $\underline{a}$
- In Ω, BR $\sim$ CR $\succ$ PF with financing and $\overline{a}$ under CR, financing and $\underline{a}$ under PF
- In Γ, BR $\sim$ PF $\succ$ CR with financing and $\underline{a}$ under PF, financing and $\overline{a}$ under CR

FIGURE 5 (The firm is profitable under $\overline{a}$, and under $\underline{a}$ iff $p < 0.6$)
$[\underline{\pi} = 5,\ \overline{\pi} = 10,\ I = 5,\ (1-\overline{a}) = 0.05,\ (1-\underline{a}) = 0.1,\ d = 20,\ K = 1.2,\ \Delta = 0.6]$



- In Φ_2, BR $\sim$ CR $\sim$ PF with financing and $\underline{a}$
- In Ω, BR $\sim$ CR $\succ$ PF with financing and $\overline{a}$ under CR, financing and $\underline{a}$ under PF
- In Γ, BR $\sim$ PF $\succ$ CR with financing and $\underline{a}$ under PF, financing and $\overline{a}$ under CR
- In $\hat{\Phi}_2$, BR $\sim$ CR $\sim$ PF with no financing
- In $\hat{\Omega}$, BR $\sim$ CR $\succ$ PF with financing and $\overline{a}$ under CR, no financing under PF
- In $\hat{\Gamma}$, BR $\sim$ PF $\succ$ CR with no financing under PF, financing with $\overline{a}$ under CR