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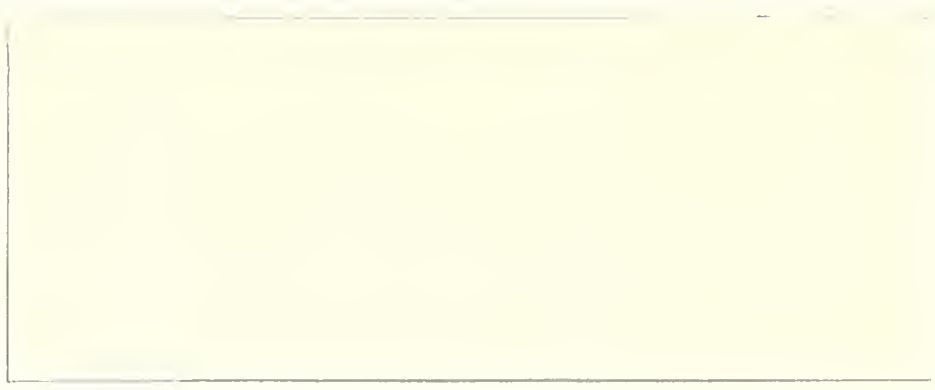

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by

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Abstract

We develop an agency-theoretic approach to interest-group politics. We study the potential identification of a regulatory agency with the interests of a regulated firm and of non-industry groups. We show that: (1) The organizational response to the possibility of agency politics is to reduce the stakes the interest groups have in regulation. (2) The threat of producer protection leads to low-powered incentive schemes for the regulated firm. (3) Consumer politics may induce uniform pricing by a multi-product firm. (4) The power of interest groups is not determined by a supply-and-demand theory, in which regulation is captured by the interest group with the highest willingness to pay. First, the regulatory inefficiencies associated with the pressures of several interest groups may compound rather than cancel. Second, the power of an interest group does not depend only on its willingness to pay, i.e., on the combination of its stake in the regulatory decision and of its cost of organizing and of influencing government, but also on the kind of influence it wants to exert. The group has more power when its interest lies in inefficient rather than efficient regulation, where inefficiency is measured by the degree of informational asymmetry between the regulated industry and the external monitor (Congress).

Key words: Regulation, asymmetric information, interest groups, capture theory, incentives.

JEL Numbers: 026, 613.

1. Introduction.

A major task of economics and political science is to explain the pattern of government intervention in industries. Two main theories have been proposed to this effect. The "public interest" theory emphasizes the government's role in correcting market imperfections such as monopoly pricing and environmental externalities. While regulatory agencies may face informational constraints, they are viewed as benevolent maximizers of social welfare. Almost all the theoretical work on the regulation of natural monopolies[1] for instance has embraced the public interest paradigm. The "capture" or "interest group" theory emphasizes the role of interest groups in the formation of public policy. Its origin can be traced back to Marx's view that big business controls institutions and to the early 20th century political scientists. Stigler's work [1971] considerably extended the paradigm by noting that the regulatory process can be captured by small business industries as well, and by using Olson's theory of collective action[2] as a building block to explain how "regulation is acquired by the industry and is designed and operated primarily for its benefit" (p. 3).[3] Olson's logic of collective action implies that, for a given issue, the smaller the group, the higher the *per capita* stake, and therefore the incentive of its members to affect the regulatory outcomes. Stigler infered that members of an industry

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[1]See the literatures on Ramsey pricing (e.g., Boiteux [1956], Baumol-Bradford [1970]), on contestable markets (e.g., Baumol-Panzar-Willig [1982]) and on the agency approach to regulation (e.g., Baron-Myerson [1982] and Laffont-Tirole [1986]). An exception in the agency approach in the Demski-Sappington [1987] paper, in which an agency must be given incentives to exert effort to acquire information about the industry. Yet the Demski-Sappington contribution is in the vein of the public interest literature in that social welfare is maximized conditionally on the agency's information--there is no regulatory capture.

[2]See also Buchanan [1965].

[3]Stigler also offered the view that there is a market for regulation, in which outcomes are determined by supply and demand. See Peltzman [1976] and Becker [1983,1985] for complete information voting models of regulatory behavior.

have more incentives than dispersed consumers with a low *per capita* stake to organize to exercise political influence. The emergence of some powerful consumer groups and the regulatory experience of the seventies led Peltzman [1976] and the academic profession to take a broader view of Stigler's contribution, that allows government officials to arbitrate among competing interests and not always in favor of business.[4]

Interest groups try to capture government decision making because it affects the industry and the consumers' welfare. Conversely, interest groups have means to influence public decision makers: a) Monetary bribes are feasible, although not common.[5] b) More pervasive are the hoped-for future employment for commissioners and agency staff with the regulated firms or their law firms or with public-interest law firms.[6] c) Personal

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[4]For reviews of the capture argument, see the second part of Moe [1986], Noll [1983, 1985], Posner [1974] and Wilson [1980].

[5]Note that some monetary bribes are legal however. For instance, the U.S. Defense Department directive 55007 allows gratuities when they are a part of a "customary exchange of social amenities between personal friends and relatives when motivated by such relationships and extended on a personal basis" (Adams [1981 p. 177]).

[6]Breyer and Steward [1979, pp. 141-142] and Adams [1981] contain extensive descriptions of the "revolving door" phenomenon. Two quotations from Adams [pp. 82-83] illustrate the point nicely:

> The availability of jobs in industry can have a subtle, but debilitating effect on an officer's performance during his tour of duty in procurement management assignment. If he takes too strong a hand in controlling contractor activity, he might be damaging his opportunity for a second career following retirement. Positions are offered to those officers who have demonstrated their appreciation for industry's particular problems and commitments.

(former Assistant Secretary of Defense J. Ronald Fox) and

> The greatest public risks arising from post-employment conduct may well occur during the period of Government employment, through the dampening of aggressive administration of Government policies.

(New York Bar).

Post-employment restrictions are costly because of the tight market for managerial expertise in industries (Breyer-Steward, pp. 142-144).

relationships provide incentives for government officials to treat their industry partners kindly.[7] d) The industry may cater to the agency's concern for tranquility by refraining from criticizing publicly the agency's management. e) Last, but not least, the industry can also operate indirect transfers through a few key elected officials who have influence over the agency. These include monetary contributions to political campaigns (Political Action Committees),[8] as well as the votes and lobbying of the "Grass Roots" (employees, shareholders, suppliers, citizens of communities where plants are located).

Such attempts at capturing the supervisory decision-making through collusive activities are likely to be only the "tip of the iceberg" (Tirole [1986]). That is, the hidden and bigger part of the iceberg is the organizational response to prevent collusion, in this case the rules and policies whose *raison d'être* is the potential for regulatory capture, and their effect on industry performance.

In spite of its importance to the economics of regulation and political science, the behavior of regulatory agencies and interest groups has not yet been modelled in an agency-theoretic framework. This paper is a modest attempt at formally analyzing the phenomenon of regulatory capture. The model

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[7]The full circle revolving door between government and industry is obviously conducive to the development of such relationships. The 1978 U.S. Ethics in Government Act aimed at restricting post-employment contacts between former top-level administrators and their former agencies. But as Warren [1982, p. 205] notes: "Conflicts of interest laws are virtually impossible to enforce unless governmental employees flagrantly violate them." (On this, see also Adams [1981, p. 79]). Contacts occur in various manners, including committees between government and private sector representatives; for instance, there were 820--mainly closed doors--committees in the defense sector in 1979 (Adams [1981, p. 165]).

[8]See, e.g., Adams [1981, pp. 8, 9] for a list of political contributions by defense contractors to the members of the Senate and House Defense Appropriations and Armed Services Committees.

depicts the regulation of a natural monopoly (or alternatively a cohesive industry). The regulatory structure regulates the firm's rate of return and price. The firm (the "agent") has private information about a technological parameter and chooses an unobserved level of cost reduction. Its private knowledge of technology allows it to enjoy an informational rent. The regulatory structure is two-tiered: agency (the "supervisor") and Congress (the "principal" or "external monitor"). In contrast to Congress, the agency has the time, resources and expertise to obtain information about the firm's technology.[9] Congress relies on information supplied by the agency. The agency's expertise allows it to hide information away from Congress in order to identify either with the industry or with the group of consumers affected by the price (output) decision. That is, these two interest groups can bribe the agency to retain specific kinds of information. To keep the model tractable, we assume that a monetary equivalent of $1 received by the agency costs $(1+\lambda_f)$ to the firm and $(1+\lambda_e)$ to the consumer group (in our example, the consumers are "environmentalists). The (shadow prices of) transfer costs

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[9]For instance, Bake and Riker [1982, p. 77] note that:

> Administrators within a particular system are, however, full-time employees, devoting all their professional attention to the rules and cases before them. Their role renders them better informed than legislators and at the same time wholly identifies their interests with the condition of the regulatory scheme.

This view is shared by Warren [1982, p. 51]:

> Bureaucracy, as Max Weber and other organizational theorists have recognized, is able to maintain its power position, despite challenges, because the bureaucrats are able to make themselves the real experts by keeping and controlling virtually all of the information...

and by Breyer and Stewart [1979, p. 144]:

> At present, Congress usually gets only an agency's official view of its activities--a view which may filter out unfavorable, though potentially important, information.

λ_f and λ_e have two facets: First they reflect the fact that transfers to an agency are not fully efficient. (A monetary bribe exposes the parties to the possibility of legal sanctions, government officials would prefer to receive the monetary equivalent of entertainment expenses, catering to specific interests goes against the agency's concern for "public service," etc.). Second, they embody the organizational costs. While the latter are likely to be small for the firm, they may be substantial for the consumers; following Olson, one would expect small consumer groups with a high per capita stake to have a smaller cost of organizing than the group of all taxpayers for instance. The legal environment (Ethics Acts, appropriations for intervenors programs) and other "exogenous" variables (rise of consumerism or of environmental awareness) affect the transfer costs and the relative influence of the interest group. Most of our results still hold when, more generally, the maximum amount of resources that can be channelled to the agency by interest groups i when the latter has stake Δ_i in the agency's decision, can be written $R^i(\lambda_i,\Delta_i)$ with $R^i_{\lambda_i} < 0$, $R^i_{\Delta_i} > 0$ and $R^i_{\lambda_i\Delta_i} \leq 0$.[10]

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[10]Here $R^i(\lambda_i,\Delta_i) = \Delta_i/(1+\lambda_i)$. But one can think of other functions. For instance, if there are n members in the interest group, and there is a fixed *per capita* cost f of collecting funds, the resource function might be: $R^i = \Delta_i - nf$. Defining $\lambda_i = n$ yields a function that satisfies the assumptions in the text.

Congress has the means to reward or punish the agency.[11] It maximizes a social welfare function that adds consumer, agency and producer surpluses. The existence of a shadow cost of public funds implies that Congress faces a trade-off between capturing the firm's rent and giving the firm incentives to reduce costs through "high powered schemes."[12] The assumption that Congress is a benevolent maximizer of a social welfare function is clearly an oversimplification, as its members are themselves subject to interest group influence. There are three justifications for making this assumption. First, ignoring the politics of Congress and focusing on the politics of the agency is a first step toward a more general theory of regulatory politics; yet it allows the derivation of a rich set of insights. Second, the model may admit alternative interpretations (for instance, the "agency" in the model might represent the coalition of a government agency and the members of the relevant congressional oversight committee, and "Congress" the rest of the legislature). Third, our methodology can be straightforwardly applied to cases in which Congress does not maximize social welfare but tries to control the regulatory outcome. It cannot, however, explain rules that constrain the regulatory process and decision-making (such as the definition of the scope of

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[11] In the U.S., Congress can abolish or reorganize an agency, change its jurisdiction, cut its appropriations and conduct embarassing investigations. Weingast (1984) and Weingast and Moran (1983) have shown in specific instances that Congress has a substantial influence on agencies.

The focus on Congress as the external monitor may be a good first approximation in the U.S. The President has theoretical, but small actual control over the bureaucracy (Fiorina [1981]), and Courts are often limited to the punishment of clear deviations from vague legislative mandates and are also constrained to taking universalistic decisions (Warren [1982]).

Note that there is no conflict between the observations that "monitoring and sanctions do not comprise a perfect solution to the problem of bureaucratic compliance" (McCubbins *et al.* [1987, p. 253]), and studies showing that agencies tend to be obedient to Congress (e.g., Barke-Riker [1982], Joskow [1972] and McFadden [1976]). In our model, Congress can dictate regulatory policy, but is dependent on the agency for information.

[12] As in Laffont-Tirole (1986).

regulation, the limitations on transfers to the industry, etc.). Restraining the choice set of a benevolent Congress can only reduce welfare in our set up. In contrast, in the absence of any benevolent party, it may pay to design regulatory institutions so as to limit the regulatory structure's scope of authority. We will investigate this idea in a companion paper.

Both the firm and the consumers have a stake in the agency's behavior. Congressional oversight of the agency and the industry must thus respond to the potential for collusion between the agency and the interest groups.

This simple model permits the study of several central issues in the theory of regulation: a) the determinants of interest group power (an interest group has power if its potential for organizing triggers a regulatory response. Note that, because of the later response, an interest group may be hurt by its own power), b) the effect of regulatory politics on the agency's incentive structure and discretion (in this model, discretion is measured by the sensitivity of regulatory decisions to agency reports), c) their effect on the regulated firm's incentives and rent, and on pricing, d) the dependency of these effects on the power of interest groups and on the amount of resources appropriated to the agency, e) whether interest groups' pressures offset or add up, and how interest groups affect each other's welfare (does an improved organization of consumers hurt or benefit the industry?).

Section 2 introduces the model. Sections 3 through 5 consider the case in which production is essential (the firm cannot be shut down), and solve the model in an increasing order of generality: Section 3 considers the benchmark in which interest groups are powerless (λ_f and λ_e infinite), Section 4 studies "producer protection" (λ_f finite, λ_e infinite) and Section 5 allows multiple interest groups (λ_f and λ_e finite). Section 6 discusses the case in which the firm can be shut down when it has an inefficient technology. Section 7 proposes a political theory of cross-subsidization in the spirit of the

previous sections, and section 8 summarizes the main economic insights.

2. The model.

We consider a three-tier hierarchy: firm/agency/Congress.[13] All parties are risk neutral.

a) Firm: The firm produces output q at cost

$$C = (\beta - e)q. \tag{2.1}$$

The cost or technology parameter β can take one of two values: "low" or "efficient" ($\underline{\beta}$) with probability ν and "high" or "inefficient" ($\bar{\beta}$) with probability $(1-\nu)$. The firm knows the realization of β. Let $\Delta\beta \equiv \bar{\beta} - \underline{\beta} > 0$. The firm's managers incur an increasing and convex (monetary) disutility $\psi(e)$ ($\psi' > 0$, $\psi'' > 0$) by exerting effort e to reduce cost. For technical reasons, we assume that $\psi''' \geq 0$.[14]

The gross consumer surplus is denoted by $S(q)$, an increasing and concave function. Let $P(q) \equiv S'(q)$ be the inverse demand function. The revenue is thus $R(q) \equiv P(q)q$. Our accounting convention is that Congress pays the firm's cost and receives the revenue. Letting t denote the (net) transfer from Congress to the firm, the firm's utility or rent is

$$U = t - \psi(e). \tag{2.2}$$

We normalize the firm's reservation utility at 0, so that the firm's participation or individual rationality constraint is:

$$U \geq 0. \tag{2.3}$$

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[13] The model builds on Laffont-Tirole [1986] and Tirole [1986].

[14] This assumption implies that the optimal incentive schemes are nonstochastic.

b) Agency. The agency receives income s from Congress and derives utility from its relationship with Congress: $V(s) = s-s^*$. That is, its reservation income is s^*. For simplicity, we assume that the agency is indispensable (that is, Congress needs the agency to regulate the firm's price and cost). Thus Congress must pay at least s^* to the agency in each state of nature:

$$(2.4) \qquad V(s) = s-s^* \geq 0.$$

The agency obtains information (a signal σ) about the firm's technology. With probability p, the agency learns the true β ($\sigma = \beta$); with probability (1-p), the agency learns "nothing" ($\sigma = \emptyset$). There are thus four states of nature: With probability $p\nu$, the technology and the signal are $\underline{\beta}$; with probability $(1-p)\nu$, the technology is $\underline{\beta}$, but the agency does not know it, and therefore still puts probability ν on the firm's being efficient; etc. The signal is hard evidence in the sense that the agency is able to reveal the true technology to Congress if $\sigma = \beta$. For simplicity, we assume that the interest groups (firm, consumer groups) learn what signal the agency receives.[15] Note also that p is exogenous (so in particular we take the agency's effort to discover the technology as given); p can be thought of as entirely determined by the agency's budget for investigation.

The agency reports $r \in \{\sigma,\emptyset\}$ to Congress. That is, if it has learned nothing ($\sigma = \emptyset$), it can only say so ($r = \emptyset$). If it has learned the truth ($\sigma = \beta$), it can either tell the truth ($r = \beta$) or claim its search for information was unfruitful ($r = \emptyset$).

c) Congress. As discussed in the introduction, Congress's utility is the sum

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[15]Alternatively, one could assume that, when the agency has an incentive to collude with an interest group, it can go to this interest group and disclose the signal it has received.

of producer, agency and consumer surpluses:

$$(2.5) \qquad W = U+V+[S(q)-P(q)q-(1+\lambda)(s+t+(\beta-e)q-P(q)q)],$$

where λ is the shadow cost of raising public funds through distortionary taxation. Using (2.2) and (2.4) to eliminate t and s in (2.5) yields:

$$(2.6) \qquad W = [S(q)+\lambda P(q)q]-(1+\lambda)(s^*+(\beta-e)q+\psi(e))-\lambda U-\lambda V.$$

That is, from the "generalized consumer surplus" $(S(q)+\lambda P(q)q)$ must be subtracted $(1+\lambda)$ times the total cost of the project $(s^*+(\beta-e)q+\psi(e))$ and λ times the rents left to the firm and the agency. The important property of (2.6) for our analysis is that Congress dislikes leaving a rent to the firm and to the agency.

Congress observes neither β nor σ. It observes the cost C, the output q (or the price $p = P(q)$) and receives the agency's report r. Congress designs incentive schemes $s(C,q,r)$ and $t(C,q,r)$ for the agency and the firm so as to maximize expected social welfare EW (where expectations are taken over the four states of nature).[16]

The timing is as follows: At date 0, all parties learn their information simultaneously. That is, they all learn the nature of the project; Congress learns that β belongs to $\{\underline{\beta},\bar{\beta}\}$, the agency learns σ and the firm learns β. The probability distributions are common knowledge. Then Congress designs incentives schemes for the agency and the firm. The agency can then sign side contracts (see below) with the interest groups. Next, the agency makes its report and the firm chooses its effort and price (the exact timing in this stage turns out to be irrelevant). Last, transfers are operated as specified in the contracts.

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[16] More complex mechanisms (including, e.g., announcements by the firm and the agency) would not raise welfare in this model with collusion. See Appendix 1.

Remark: The formulation implicitly assumes that the project is too ill-defined before date 0 for the parties to be able to sign relevant contracts before that date. Alternatively, we could assume that the project is well-defined before date 0 so that the parties can sign complete contracts before obtaining their information, as in Tirole [1986]. Most results (on the effect of collusion on incentive schemes, on pricing, and on the circumstances under which an interest group has power) are qualitatively unaffected if the firm and the agency are risk averse and attention is restricted to deterministic contracts; the difference is that the agency and the firm then have no *ex-ante* rent, unless an *ex-post* no slavery or limited-liability constraint is imposed. The analysis is a bit more cumbersome than in the case in which there is no contract prior to date 0, except when the agency and the firm are infinitely risk-averse (see Section 4).

d) Consumer groups. When consumers cannot organize (sections 3 and 4), it does not matter how the net surplus $(S(q)-P(q)q)$ and the taxes $((1+\lambda)(s+t+C-P(q)q))$ are allocated among consumers. In contrast, when they can influence policy decisions (section 5), the distribution of costs and benefits among consumers becomes important, as consumers have different marginal rates of substitution between consumption of the good and taxes. To simplify computations without losing insights, we will assume in section 5 that there are two groups of consumers: one which pays all taxes and another which receives the entire net surplus. Let us give three examples: (1) q is the output of an intermediate good used by another industry, or else the output of a final good consumed by a small group of consumers; taxes are paid by the general taxpayer. (2) q is the level of welfare benefits enjoyed by the poor; taxes are paid by the rich. (3) q is the level of pollution or pollution abatement that affects local residents; taxes are paid by the

federal taxpayers. [In these last two examples, the objective functions must be changed slightly as the good is non-marketed, but this is inconsequential.]

3. Collusion-free regulation.

In this section, we analyze the benchmark in which interest groups have no influence on the agency (their transfer costs are infinite). We sketch the solution, and summarize the relevant points for subsequent analysis.

Congress optimally offers the agency a constant income equal to its reservation income: $s = s^*$. The agency then has no incentive to misreport the signal. Hence, at social cost $(1+\lambda)s^*$, Congress has the same information structure as the agency.

Next we consider optimal regulation of the firm when Congress has full information (FI) and asymmetric information (AI).

a) Full information ($\sigma = \beta$). Congress, who knows the firm's technology parameter can deprive it of its rent (we index variables by a star to indicate the socially optimal policy under full information): For all β:

$$U(\beta) = U^*(\beta) = 0. \tag{3.1}$$

The effort $e^*(\beta)$ and output $q^*(\beta)$ or price $p^*(\beta)$ (which we will write $(\underline{e}^*,\underline{q}^*,\underline{p}^*)$ for the efficient type and $(\bar{e}^*,\bar{q}^*,\bar{p}^*)$ for the inefficient type) are set so as to maximize the full information welfare $((S(q)+\lambda P(q)q)-(1+\lambda)(s^*+(\beta-e)q+\psi(e)))$. Hence, for all β, $(e^*(\beta),p^*(\beta))$ solves:[17]

$$\psi'(e) = q \tag{3.2}$$

and

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[17] In the whole paper, we will assume that optimization programs have interior solutions.

(3.3) $$\frac{p-(\beta-e)}{p} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(p)}, \text{ or } p = R(\beta-e),$$

where $\eta \equiv -\frac{dq}{dp}\Big/\frac{q}{p}$ is the elasticity of demand.

Equation (3.2) states that the marginal cost and benefit of effort are equal. Equation (3.3) shows that price is given by a simple Ramsey formula. The Lerner index (price-marginal cost margin) is inversely proportional to the elasticity of demand (because public funds are costly, revenue is socially valuable, so pricing is intermediate between marginal cost and monopoly pricing). The formula giving the price as a function of marginal cost turns out to be independent of informational asymmetries (see b) below).[18] We let $\underline{q}^*(e)$ and $\bar{q}^*(e)$ denote the Ramsey outputs given by (3.3) contingent on marginal cost being β-e or $\bar{\beta}$-e. It is easy to show that $q^*(\cdot)$ and $\bar{q}^*(\cdot)$ are non-decreasing functions of e.[19]

Below we show that, under asymmetric information, the efficient type's allocation is unchanged relative to symmetric information (it is equal to $(\underline{e}^*,\underline{q}^*)$). The inefficient type's output $\bar{q}$ is still conditionally optimal given the inefficient type's effort $\bar{e}$ (i.e., $\bar{q} = \bar{q}^*(\bar{e})$). The focus of the analysis will thus be how $\bar{e}$ differs from the full information level $\bar{e}^*$. This suggests singling out the inefficient type's effort for the purpose of the analysis. Let $W^{FI}(\bar{e})$ denote the expected social welfare (that is, social welfare when Congress has not yet learned β, but knows that it will) given that the efficient type's allocation is at its full information level, the inefficient type's output is conditionally (Ramsey) optimal, but the inefficient type's effort is an arbitrary $\bar{e}$:

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[18] This is a special instance of the pricing-incentives dichotomy (see Laffont-Tirole [1988]).

[19] The proof of this is the same as the proof showing that a monopoly price is a non-decreasing function of a monopolist's marginal cost.

$$(3.4)\qquad W^{FI}(\bar{e}) \equiv \nu[(S(\underline{q}^*)+\lambda P(\underline{q}^*)\underline{q}^*)-(1+\lambda)(s^*+(\underline{\beta}-\underline{e}^*)\underline{q}^*+\psi(\underline{e}^*)]$$

$$+ (1-\nu)[(S(\bar{q}^*(\bar{e}))+\lambda P(\bar{q}^*(\bar{e}))\bar{q}^*(\bar{e}))-(1+\lambda)(s^*+(\bar{\beta}-\bar{e})\bar{q}^*(\bar{e})+\psi(\bar{e}))].$$

We assume that $W^{FI}(\cdot)$ is concave.[20] The expected social welfare W^{FI} is:

$$(3.5)\qquad W^{FI} \equiv W^{FI}(\bar{e}^*).$$

b) Asymmetric information ($\sigma = \emptyset$). We let $(\underline{e},\underline{q},\underline{t})$ and $(\bar{e},\bar{q},\bar{t})$ denote the efforts, output levels and transfers for types $\underline{\beta}$ and $\bar{\beta}$ under the optimal incentive scheme when the firm has an informational advantage over Congress. As is easily seen, the regulatory issue is to prevent the efficient type from claiming it is inefficient. That is, we must add an incentive constraint to the full information program:

$$(3.6)\qquad \underline{t}-\psi(\underline{e}) \geq \bar{t}-\psi(\bar{e}-\Delta\beta).$$

[The efficient type can produce at cost $\bar{\beta}-\bar{e}$ by exerting effort $\bar{e}-\Delta\beta$ and obtain transfer $\bar{t}$.]

The inefficient type obtains no rent ($\bar{t} = \psi(\bar{e})$). The efficient type's rent under asymmetric information will be denoted by $\underline{U}$. Because (3.6) is binding at the optimum, we have:

$$(3.7)\qquad \underline{U} \equiv \underline{t}-\psi(\underline{e}) = \bar{t}-\psi(\bar{e}-\Delta\beta) = \psi(\bar{e})-\psi(\bar{e}-\Delta\beta)$$

or

$$(3.8)\qquad \underline{U} = \Phi(\bar{e})$$

where

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[20] Sufficient conditions are λ small or decreasing marginal revenue.

(3.9) $\Phi(e) \equiv \psi(e)-\psi(e-\Delta\beta)$.

Under our assumptions, the function Φ (which will play a crucial role below) is increasing and convex. Note that when $\bar{e}$ increases (i.e., when the inefficient type is given "more incentives"), the efficient type's rent increases.

Congress maximizes expected social welfare:

$$(3.10)\qquad \max_{\{\underline{q},\underline{e},\bar{q},\bar{e}\}} \Big\{\nu[(S(\underline{q})+\lambda P(\underline{q})\underline{q})-(1+\lambda)(s^*+(\underline{\beta}-\underline{e})\underline{q}+\psi(\underline{e}))-\lambda\Phi(\underline{e})]$$
$$+ (1-\nu)[(S(\bar{q})+\lambda P(\bar{q})\bar{q})-(1+\lambda)(s^*+(\bar{\beta}-\bar{e})\bar{q}+\psi(\bar{e}))]\Big\}.$$

A simple inspection reveals that $\underline{q} = \underline{q}^*$, $\underline{e} = \underline{e}^*$ and $\bar{q} = \bar{q}^*(\bar{e})$ as announced. The absence of distortion of $(\underline{q},\underline{e})$ and of conditional distortion of $\bar{q}$ is not surprising: the incentive constraint (3.8) tells us that only $\bar{e}$ should be distorted:

$$(3.11)\qquad \psi'(\bar{e}) = \bar{q}^*(\bar{e}) - \frac{\lambda}{1+\lambda}\Phi'(\bar{e}),$$

which implies

$$(3.12)\qquad \bar{e} < \bar{e}^*.$$

Thus the inefficient type's effort $\bar{e}$ is distorted downwards in order to reduce the efficient type's rent (intuitively, if the inefficient type were given a cost-plus contract, the efficient type would not get any rent by mimicking the inefficient type).

Because the Ramsey output $\bar{q}^*(\cdot)$ is increasing, (3.12) implies

$$(3.13)\qquad \bar{q} < \bar{q}^*.$$

Let $W^{AI}(e)$ denote the expected welfare under asymmetric information when the inefficient type's effort is exogenously fixed at e (and (3.10) is

maximized with respect to the other variables). Note that:

$$(3.14) \qquad W^{AI}(e) = W^{FI}(e) - \lambda\nu\Phi(e).$$

$W^{AI}(\cdot)$ is concave when $W^{FI}(\cdot)$ is concave.

The expected social welfare under asymmetric information can be rewritten:

$$(3.15) \qquad W^{AI} = \max_{e}\{W^{FI}(e) - \lambda\nu\Phi(e)\} = W^{FI}(\bar{e}) - \lambda\nu\Phi(\bar{e}).$$

Let us summarize the relevant points for what follows. Congress obtains the agency's information by giving it a constant income s*. The expected social welfare under full and asymmetric information can be written as concave functions of the inefficient type's effort e: $W^{FI}(e)$ and $W^{AI}(e) = W^{FI}(e) - \lambda\nu\Phi(e)$, where $\Phi(e)$ is the efficient type's rent under asymmetric information and is an increasing function. The optimization with respect to e therefore implies that the inefficient type is given a less powerful incentive scheme under asymmetric information ($\bar{e} < \bar{e}^*$) in order to extract some of the efficient firm's rent. The corresponding market price is higher than under full information.

4. Producer protection.

In this section, we allow the firm to collude with the agency. More precisely, the firm can give a transfer $\bar{s}$ to the agency (so that the agency's income equivalent becomes $s+\bar{s}$) at cost $(1+\lambda_f)\bar{s}$, where $\lambda_f \geq 0$ denotes the shadow cost of transfers for the firm (equivalently the agency attributes monetary value $1/(1+\lambda_f)$ per dollar of the firm's collusive activity): see the introduction for a general discussion of transfer costs. We here content ourselves with a heuristic derivation of the equilibrium outcome under collusion with the firm. Appendix 1 offers a complete proof. In particular, it shows that a) Congress can without loss of generality restrict attention

to "collusion-proof" schemes, i.e., schemes that do not induce the agency and the firm to collude and lead the agency to report truthfully. Hence, there is no loss is welfare in requiring that there be no equilibrium bribes; b) the agency's income depends only on its report. We let $\underline{s}_1$, $\bar{s}_1$ and s_0 denote the agency's income when $r = \underline{\beta}$, $r = \bar{\beta}$ and $r = \emptyset$ respectively.

Collusion occurs when the agency has an incentive to hide information from Congress. The analysis in section 3 suggests the following intuition: Collusion can arise only if the retention of information benefits the firm. If the signal is $\bar{\beta}$, the firm has no stake in the agency's report as it obtains no rent under either full information or asymmetric information. In contrast, when the signal is $\underline{\beta}$, the firm has a stake, as the revelation of the truth lowers its rent from $\Phi(e)$ (where e is the inefficient type's effort under asymmetric information) to 0. To prevent the firm from bribing the agency, the cost to the firm of compensating the agency by the income $(\underline{s}_1 - s_0)$ lost by not reporting must exceed its stake:

$$(4.1) \qquad (1+\lambda_f)(\underline{s}_1 - s_0) \geq \Phi(e).$$

From the agency's individual rationality constraint, we know that $\underline{s}_1$ $\bar{s}_1$, s_0 all exceed s^*. Because revelation is not an issue when $\sigma = \bar{\beta}$ or $\sigma = \emptyset$ and because income given to the agency is socially costly, we have $\bar{s}_1 = s_0 = s^*$. We can thus rewrite (4.1) as:

$$(4.2) \qquad (1+\lambda_f)(\underline{s}_1 - s^*) \geq \Phi(e).$$

Because income given to the agency is socially costly, (4.2) holds with equality at the optimal policy:

$$(4.3) \qquad \underline{s}_1 = s^* + \frac{\Phi(e)}{1+\lambda_f}.$$

Equation (4.3), which depends only on e and $\underline{s}_1$, suggests that Congress should give lower incentives to an inefficient firm under asymmetric information, but

that it should leave the other variables (except $\underline{s}_1$) unchanged: that is, the efficient type's allocations under full and asymmetric information and the inefficient type's allocation under symmetric information are still the socially optimal ones $(\underline{e}^*,\underline{q}^*)$ and $(\bar{e}^*,\bar{q}^*)$. Furthermore, under asymmetric information, the inefficient type's output is the Ramsey level $\bar{q}^*(e)$ relative to effort e. That these properties indeed hold is verified in Appendix 1.

Congress chooses e so as to maximize expected social welfare:

$$(4.4) \qquad EW = \max_{e} \left\{ pW^{FI} + (1-p)W^{AI}(e) - p\nu\lambda \frac{\Phi(e)}{1+\lambda_f} \right\},$$

where the last term reflects the fact that the agency's rent has social cost λ from (2.6).

Using the fact that the objective function in (4.4) is concave, the first-order condition in (4.4) yields:

Proposition 1: Under producer protection:

a) Collusion reduces social welfare $(\partial(EW)/\partial\lambda_f > 0)$.

b) The firm is given a low-powered incentive scheme $(e < \bar{e})$.

c) Output is still Ramsey-optimal, but is lowered from $\bar{q}^*(\bar{e})$ to $\bar{q}^*(e)$ under asymmetric information for the inefficient type.

d) The agency is given an incentive scheme $(\underline{s}_1 > \bar{s}_1 = s_0)$.

e) The efficient firm enjoys a lower rent than in the absence of collusion $(\Phi(e) < \Phi(\bar{e}))$.

f) e (and therefore $\Phi(e)$ and $\bar{q}^*(e)$) increase with λ_f.

To prevent collusion, Congress reduces the stakes, i.e., the efficient type's rent under asymmetric information. To this purpose, the inefficient type is given an incentive scheme under asymmetric information that is even

less powerful than the corresponding scheme in the absence of collusion. Because the other states of nature are unaffected, producer protection can only reduce incentives in the potential advocate regime. Note also that as $\tilde{q}^*(\cdot)$ is increasing, the price is higher, and the transfer to the firm is lower than in the absence of collusion, under asymmetric information and type $\tilde{\beta}$.

Remark: What happens if the project is sufficiently well-defined before date 0 so that contracts can be signed before date 0? As mentioned above, the results are quite similar if the agency and the firm are risk averse and attention is restricted to deterministic contracts. Suppose for instance that, before date 0, the firm and the agency have objective functions min U and min V (they are infinitely risk averse). Thus, U and V must be non-negative for any realization of uncertainty at date 0. The coalition incentive constraint is still (4.1). What is modified relative to our analysis is the expression of the social welfare function. At the optimum, min U = min V = 0. Furthermore, *ex-post* rents (U > 0, V > 0) have no *ex-ante* social value as they are not "enjoyed" by the parties. So (4.4) is replaced by

$$(4.5) \qquad EW = \max_{e} \left\{ pW^{FI} + (1-p)W^{AI}(e) - p\nu(1+\lambda)\frac{\Phi(e)}{1+\lambda_f} - (1-p)\nu\Phi(e) \right\}.$$

Clearly, the results are qualitatively similar. The main difference is that the agency and the firm may enjoy an *ex-post* rent, but do not have any *ex-ante* rent.[21]

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[21] If the agency is very risk-averse, and the firm is less risk-averse, it may pay for Congress to commit to leave an *ex-post* rent U > 0 when the agency announces $r = \beta$. The reason for this is that leaving such a rent relaxes the coalition incentive constraint, which becomes: $(1+\lambda_f)(s_1 - s_0) \geq \Phi(e) - U$, which allows Congress to reduce s_1. On the other hand, leaving a rent to the firm is costly. But this cost is small if the firm is not too risk averse, because

5. Multiple interest groups.

To illustrate the effects of multiple interest groups, we now consider a specification of our model in which the firm's output affects the environment. Suppose that the total gross surplus associated with a level of production q is equal to the gross consumer surplus $\tilde{S}(q)$, associated with consumption of the good, minus an increasing and convex pollution damage D(q) born by a fraction of the population called "environmentalists" or "local residents":

$$(5.1) \qquad S(q) = \tilde{S}(q) - D(q).$$

Suppose also that the environmentalists do not purchase the good and do not pay the taxes associated with the regulation of the industry (as discussed in section 2, this assumption simplifies computations and does not affect qualitative results; what matters for our theory is that the environmentalists' marginal rate of substitution between output and taxes exceeds that of the rest of the public). In a first step, we will assume that, among the non-industry groups, only the environmentalists can organize. They can transfer $\tilde{\tilde{s}}$ to the agency at cost $(1+\lambda_e)\tilde{\tilde{s}}$ (so that the agency's income equivalent becomes $s+\tilde{s}+\tilde{\tilde{s}}$, where $\tilde{s}$ is the firm's transfer to the agency). We assume that public collection of funds is more efficient than the private collection of funds (where the latter cost takes account of the inefficiency of transfers to the agency -- see the introduction): $\lambda_e \geq \lambda$. This assumption allows us to focus on collusion-proof incentive schemes. [The intuition for this property (which is proved in Appendix 2) is that if the optimal allocation involved actual transfers from the consumers to the agency, it

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Congress can reduce the firm's utility in other states of nature while keeping (2.3) satisfied. So it may pay for Congress to somewhat renounce the pursuit of the extraction of the firm's ex-post rent. In this case, the agency acts not only as a potential advocate for the firm, but also as an effective advocate.

would be socially cheaper to have Congress substitute for the environmentalists and give these transfers to the agency. If $\lambda_e < \lambda$, it may be optimal to let the agency be rewarded by bribes, as private collection is more efficient than public collection. We believe that the assumption $\lambda_e \geq \lambda$ is reasonable for developed economies, where λ is relatively small (of the order of .3 for the U.S. from econometric studies).]

Again, we give an informal treatment. Complete proofs are relegated to Appendix 2.

Congress must ensure that the agency colludes neither with the firm nor with the environmentalists. Because Congress's optimization program has more coalition incentive constraints than when $\lambda_e = +\infty$, social welfare cannot exceed the level obtained for $\lambda_e = +\infty$.[22] We show that environmentalists affect the regulatory outcome.

For intuition about which coalition-incentive constraints are binding, it is useful to go back to Proposition 1.

When $\sigma = \underline{\beta}$, the firm has a stake in regulation. To preserve its rent, it is willing to bribe the agency up to the level $\Phi(e)$, where e denotes the inefficient firm's effort if $r = \emptyset$. In contrast, the environmentalists have no stake in agency's report as output is the same for both reports. Thus the only coalition incentive constraint when $\sigma = \underline{\beta}$ is:

$$(5.2) \qquad (1+\lambda_f)(\underline{s}_1 - s_0) \geq \Phi(e).$$

When $\sigma = \bar{\beta}$, the firm enjoys no rent and has no stake in the agency's report. In contrast, the agency's hiding its information induces asymmetric

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[22] In our model, a reduction in λ_e -- through a better organization, the advent of consumer activism, or government subsidies -- always reduces welfare. If consumers play a substantial role as watchdogs, i.e., if they bring information about the industry and products and check the agency, a reduction in λ_e may improve social welfare.

information and reduces output (Proposition 1). Let (e,q) and $(\tilde{e},\tilde{q})$ denote the inefficient type's effort and output when $r = \emptyset$ and $r = \tilde{\beta}$ respectively. We must add a second coalition incentive constraint:

$$(5.3) \qquad (1+\lambda_e)(\tilde{s}_1 - s_0) \geq D(\tilde{q}) - D(q).^{23}$$

The optimal policy implies that $s_0 = s^*$. Therefore, (5.2) and (5.3) (which hold with equality at the optimum) can be rewritten:

$$(5.4) \qquad \underline{s}_1 = s^* + \frac{\Phi(e)}{1+\lambda_f}$$

and

$$(5.5) \qquad \tilde{s}_1 = s^* + \frac{D(\tilde{q}) - D(q)}{1+\lambda_e}.$$

This suggests (and it can be verified) that e, q and $\tilde{q}$ are distorted at the optimal allocation so as to reduce the agency costs. More precisely, let $W^{FI}(\tilde{q},\tilde{e})$ and $W^{AI}(q,e)$ denote the expected welfares under full information and under asymmetric information when the inefficient type's allocation is $(\tilde{q},\tilde{e})$ and (q,e), respectively, and when the efficient type's allocation is undistorted $(\underline{q} = q^*, \underline{e} = e^*)$. Using (5.4) and (5.5), Congress maximizes expected social welfare:

$$(5.6) \qquad EW = \max_{\{\tilde{q},\tilde{e},q,e\}} \left\{ pW^{FI}(\tilde{q},\tilde{e}) + (1-p)W^{AI}(q,e) - p\nu\lambda \frac{\Phi(e)}{1+\lambda_f} - p(1-\nu) \frac{D(\tilde{q}) - D(q)}{1+\lambda_e} \right\}.$$

We will assume that this maximand in (5.6) is concave (for this, it suffices that λ be small or that λ_e be large): A straightforward analysis of (5.6) yields:

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[23] Note that this constraint does not in general define a convex set.

Proposition 2: a) The environmentalists have an influence on regulation.

b) $\underline{s}_1$ and $\bar{s}_1$ strictly exceed $s_0 = s^*$.

c) A decrease in λ_e raises e, and therefore raises the firm's rent $\Phi(e)$. It lowers $\tilde{e}$. And it lowers $\tilde{q}$ and raises q, and therefore it reduces $(\tilde{q}-q)$ towards 0.[24]

d) A decrease in λ_f decreases q, and therefore raises the environmentalists' welfare.

The intuition behind Proposition 2 is simple. To relax constraint (5.3), Congress lowers $\tilde{q}$ and raises q, so that the environmentalists' stake $(D(\tilde{q})-D(q))$ in regulation is reduced. Because q increases, marginal cost reduction becomes more valuable when $\sigma = \emptyset$ and $\beta = \tilde{\beta}$. Hence, e increases. The striking conclusion is that the more powerful the environmentalists, the higher the firm's rent! This is not altogether surprising. In this economy, the firm and the environmentalists are "objective accomplices" in that they both have a stake in making regulation inefficient. The firm wants Congress to be uninformed to enjoy a rent. The environmentalists want Congress to be uninformed to reduce output and thus pollution. We will see in section 6 that this coincidence of interests heavily relies on the assumption that production is essential. An increase in the environmentalists' power may well hurt the firm if shut down is a relevant option.

As we mentioned, environmentalists are powerful here because their interest lies in inefficient regulation. Note also that the effects of multiple interest groups do not cancel, but rather add up.

Furthermore, as in section 4, the agency must be rewarded for cooperating with Congress.

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[24] For λ_e small enough, it may be the case that $q = \tilde{q}$ (a corner solution).

We have assumed that neither the consumers of the good nor the taxpayers can organize (presumably because their *per capita* stakes are too small). Let us now show that even if the consumers of the good (henceforth, the "consumers") could organize, they would have no influence on the regulatory outcome. Without loss of generality, we assume that the consumers enjoy net surplus $\tilde{S}^n(q) \equiv \tilde{S}(q)-P(q)q$ and that they do not pay the taxes or bear the pollution cost associated with the project. They have a cost of transfer $\lambda_c \geq \lambda$. We can now state:

Proposition 3. The consumers have no political power. That is, the regulatory outcome is the same as if λ_c were infinite (as given by Proposition 2).

The proof of Proposition 3 is straightforward. Introducing the possibility of collusion between consumers and the agency cannot raise welfare, as the number of constraints facing Congress increases. Conversely, suppose that Congress adopts the regulatory policy that is optimal when consumers cannot organize. When $\sigma = \underline{\beta}$, the output is at its socially efficient level $\underline{q}^*$, regardless of whether the agency reports the truth ($r = \underline{\beta}$) or not ($r = \emptyset$). Hence, the consumers have no stake in the report. When $\sigma = \bar{\beta}$, the consumers do have a stake. The output is $\bar{q}^*$ if the agency reports the truth ($r = \bar{\beta}$) and $\bar{q}^*(e) < \bar{q}^*$ if the agency lies ($r = \emptyset$). Hence, by bribing the agency to hide its information, the consumers can only raise the price. Therefore they have no incentive to bribe the agency.[25]

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[25] One might conjecture that the agency could extract a bribe from the consumers by threatening them to hide the information $\sigma = \bar{\beta}$. However, such a threat is not "subgame-perfect": When the day comes at which the agency must report to Congress, the agency has an incentive to tell the truth, as $\bar{s}_1 > \bar{s}_0$ from Proposition 3.

Only in the case in which the agency can develop a reputation for being tough (lose income to hurt consumers) can such a threat be effective. Such a

The intuition behind Proposition 3 is that consumers favor high outputs. Because asymmetric information between Congress and the firm leads to low-powered incentives and hence to low quantities (Section 3), a high output requires full information. But the potential power of consumers (as well as of other interest groups) lies in inducing the agency to hide information from Congress.

Last, we can consider what happens when taxpayers (who want to minimize taxes $(1+\lambda)(s+t+C-P(q)q)$) can organize, although their high cost of organization in many situations makes this analysis irrelevant. We were unable to give a general characterization of whether taxpayers have influence on regulation. However, there is a case of interest in which the answer is straightforward. Suppose that the taxpayers and the consumers are the same people so that they form a single group (with objective function $\tilde{S}^n(q)-(1+\lambda)(s+t+C-P(q)q)$). When $\sigma = \underline{\beta}$, this group's interest lies in rent extraction, i.e., in the truth being reported.[26] Hence the group has no incentive to bribe the agency to misreport. Similarly, when $\sigma = \bar{\beta}$, it can be shown that the group prefers that the agency report the truth.[27] Hence, the taxpayers-consumers group has no political power in this model.

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reputation might develop in organizations where the supervisor monitors a large number of subordinates.

[26]Consider the solution described in Proposition 2. As $\Phi(e) = (1+\lambda_f)(\underline{s}_1-s_0)$, $\underline{s}_1-s_0 < \Phi(e)$ so that the total wage bill (s+t) is lower when the report is $r = \underline{\beta}$ (the cost and the output are independent of the report).

[27]Again, consider the solution described in Proposition 2. Because Congress can always duplicate the outcome for $r = \emptyset$ and $\beta = \bar{\beta}$ when $r = \bar{\beta}$, social welfare is at least as high in the latter case as in the former. But the firm has no rent in either case and the environmentalists prefer the former case to the latter from Proposition 2. Hence, the remaining group (consumers plus taxpayers) strictly prefers the latter to the former.

c) Discussion: An important principle emerging from this section is that *the power of an interest group depends not only on its stake and its transfer cost, but also on what kind of influence it wants to exert. An interest group has more political power when its interest lies in inefficient rather than efficient regulation*, because the agency's discretion lies in hiding information from Congress.

This principle can be transposed to other examples:

■ Pollution abatement vs. production-embodied pollution. Proposition 2 shows that environmentalists are powerful when pollution is tied to production. We now show that they may have no power in other circumstances. Let the firm's output be fixed at some level q_0. The firm can reduce its pollution level by an amount q at abatement cost $C = (\beta - e)q$ (which comes on top of a given cost of producing q_0). C can be thought of as the cost of buying and installing a new pollution-reducing technology. β here denotes a technology parameter that affects the marginal cost of pollution abatement, and e the effort to reduce the abatement cost. The reduction in pollution yields benefits B(q) to the "environmentalists" (B(•) is assumed increasing and concave). Ignoring the constant cost of producing q_0 and the generalized consumer surplus $(S(q_0)+\lambda P(q_0)q_0)$, the social welfare function is:

$$(5.4) \qquad W = B(q) - (1+\lambda)(s+C+\psi(e)) - \lambda U.$$

Replacing $[S(q)+\lambda P(q)q]$ by B(q), the analysis of sections 3 and 4 can be directly transposed to the pollution abatement model. However, the environmentalists have no power here, as they resemble the "consumers" of the production-embodied pollution model: Their interest lies in high pollution abatements (high qs).

That the environmentalists have power in one case and not the other is not surprising. They favor inefficient regulation in the production-embodied pollution model and efficient regulation in the pollution-abatement model.

■ Welfare benefits: Consider a two-class economy (rich/poor) and suppose that the poor are the recipients of a quantity q of welfare benefits financed by taxes on the rich. The poor have an interest in efficient regulation, as the latter is conducive to higher benefits, and therefore have less power than the rich, who save on taxes when inefficient regulation limits the level of welfare benefits.

6. Shutdown of the regulated firm.

The analysis in sections 3 through 5 proceeded under the assumption that the firm is essential. That is, it must produce even if it is inefficient (has type $\tilde{\beta}$). This is the case if the consumer surplus is sufficiently large, so that Congress cannot run the risk of foregoing production (shutting the firm down when it has type $\tilde{\beta}$ and allowing production by type $\underline{\beta}$ only). This sounds a reasonable assumption for many regulated firms. In some instances however, shutdown is a relevant option.

Shutting down type $\tilde{\beta}$ is a simple policy in our two-type model. Type $\underline{\beta}$ has now no rent because mimicking type $\tilde{\beta}$ brings none. Congress has full information on the technology conditionally on the firm's choosing to produce. This implies that the optimal policy in the collusion-free environment in the shutdown option is still collusion-proof when the interest groups can organize.[28]

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[28] The optimal shutdown policy consists in requiring that the firm produce $q = q^*$ at cost $\underline{C}^* = (\underline{\beta}-\underline{e}^*)q^*$ and in giving transfer $\underline{t}^* = \psi(\underline{e}^*)$ (the efficient firm has no rent).

Note that the agency has no role in the two-type model under the shutdown policy. With more than two types, the agency would bring information that helps Congress to distinguish those types which are not shut down. The features discussed in this section would still be relevant in the many-type model as long as the shutdown option is a relevant one.

This, together with the results in sections 4 and 5, implies that the more powerful the interest groups (i.e., the lower their transfer costs), the more attractive the shutdown policy is relative to the no-shutdown policy.

The possibility of shutdown reinforces most of our insights. For instance, in our model, it corresponds to an extreme absence of agency discretion. Furthermore, the shutdown of the firm can be viewed as an extreme case of low-powered incentive scheme.

There is a result, however, that relies heavily on the essentiality of production. In section 5, we observed that, the better organized the environmentalists, the higher the firm's rent. This may not be so when shutdown is a relevant option. A decrease in the environmentalists' transfer cost reduces the welfare associated with the no-shutdown policy. So it may induce Congress to switch to the shutdown policy, which annihilates the firm's rent.

7. A political theory of cross-subsidization.

Our methodology can be applied to study whether interest groups may lead to cross-subsidization by a multiproduct firm. To this purpose, we consider a variant of the model of section 2, in which none of the types of cross-subsidizations listed in Laffont-Tirole [1988] applies. In this variant, cross-subsidization may emerge as an optimal response to the political activities of some customers of the regulated firm. [One may, for instance, think of the captive coal shippers' successful fight against unrestrained price discrimination by railroad monopolies.]

Suppose that there are two classes of consumers, $i = 1,2$, with identical demands. Let $S(q_i)$ and $S^n(q_i) \equiv S(q_i)-P(q_i)q_i$ denote the gross and net surpluses of class i, where $P(\cdot)$ is the inverse demand function. We let $\eta(p_i)$ denote the elasticity of demand at price p_i.

The regulated firm's cost is

(7.1) $\quad C = (\beta-e)(q_1+q_2)+d(q_2-q_1)\chi,$

where $\chi = 1$ or -1 with equal probabilities. The parameter χ indicates which category of consumers is cheaper to serve (that is, the marginal cost of serving one category is 2d lower than the marginal cost of serving the other category). The "cost-differential parameter" d is common knowledge.

To simplify the analysis, we assume that the agency does not learn χ and therefore has no role (this involves no loss in insight: see below). So Congress regulates the firm directly. To focus on cross-subsidization, we assume that β is known to Congress in this section.

If Congress knows that $\chi = 1$ (without loss of generality), from Section 3, the optimal regulation specifies Ramsey pricing:

$$(7.2) \qquad L_1 \equiv \frac{p_1-(\beta-e-d)}{p_1} = R_1 \equiv \frac{\lambda}{1+\lambda}\,\frac{1}{\eta(p_1)},$$

$$(7.3) \qquad L_2 \equiv \frac{p_2-(\beta-e+d)}{p_2} = R_2 \equiv \frac{\lambda}{1+\lambda}\,\frac{1}{\eta(p_2)}.$$

Furthermore, the marginal disutility of effort is equal to marginal cost savings:

$$(7.4) \qquad \psi'(e) = q_1+q_2.$$

R_1 and R_2 are the Ramsey terms. When we allow collusion, we will say that there is cross-subsidization of good 2 by good 1 if $L_1 > R_1$ and $L_2 < R_2$. Note that (7.2) and (7.3) imply that $p_1 < p_2$, $q_1 > q_2$ and $L_1 = R_1 < L_2 = R_2$.

From now on we assume that the firm, but not Congress, knows χ. Furthermore, χ is "soft information." That is, the firm cannot "prove" to Congress that χ is equal to 1 or -1, but only announce it ($\hat{\chi}$); in other words, Congress knows that the firm knows χ, but cannot subpoena the firm to supply

evidence that substantiates its announcement $\hat{\chi}$. As we will see in Proposition 5, the introduction of soft information introduces the possibility that actual bribes are desirable in equilibrium. Last, we will assume for simplicity that the consumers also know χ. Proposition 4 below is qualitatively the same when the consumers do not know χ; the main difference is that there is less incentive to collude, and therefore a lower likelihood of cross-subsidization when the consumers have incomplete information about χ.[29]

If χ is known to the firm only, and there is no collusion between the firm and any group of consumers, the solution is unchanged, as the firm has no incentive to misreport χ. Indeed, lying about $\hat{\chi}$ would only lead Congress to switch the roles of good 1 and good 2 and increase the firm's cost by $2(q_1-q_2)d$ and therefore the firm's effort by $\frac{2(q_1-q_2)d}{q_1+q_2}$ without any gain.

In contrast, suppose that type-2 consumers can organize and collude with the firm, when $\chi = 1$, to lead the firm to announce $\hat{\chi} = -1$. This in turn leads Congress to quote a low price for good 2 and a high price for good 1, which benefits type-2 consumers and hurts type-1 consumers. Let us assume for the moment that the two classes of consumers have transfer costs λ_{c_1} and λ_{c_2} with $\lambda_{c_1} = +\infty$ (the type-1 consumers cannot organize). To avoid collusion with type-2 consumers when $\chi = +1$, the gain for type-2 consumers of a misreport of χ, $S^n(q_1)-S^n(q_2)$, must be lower than the extra disutility of effort, $\psi\left[e + \frac{2(q_1-q_2)d}{q_1+q_2}\right]-\psi(e)$, valued at the transfer cost between the type-2 consumers and the firm; the coalition incentive constraint is thus:

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[29] We may assume that type-2 consumers make an offer which is successful only if $\chi = 1$. If the probability that $\chi = 1$ is 1/2, they are willing to offer $[S^n(q_1)-S^n(q_2)]/2$. This term replaces the right-hand side in (7.5) below. The analysis is then similar.

$$(7.5)\qquad (1+\lambda_{c_2})\left[\psi\left[e+\frac{2d(q_1-q_2)}{q_1+q_2}\right]-\psi(e)\right] \geq S^n(q_1)-S^n(q_2).$$

[This constraint does not define a convex set.]

It is easily seen that the firm, who has no private information about β, enjoys no rent. Using the symmetry of the model, Congress's optimization program is:

$$(7.6)\qquad \underset{\{q_1,q_2,e\}}{\text{Max}} \Big\{S(q_1)+S(q_2)-(1+\lambda)[(\beta-e)(q_1+q_2)+d(q_2-q_1)+\psi(e)] +\lambda[P(q_1)q_1+P(q_2)q_2]\Big\}$$

subject to (7.5).

We can now state:

Proposition 4: For the solution to program (7.6) (assuming $\chi = 1$; for $\chi = -1$, indices are permuted), there exist $d_1 > 0$ and $d_2 > d_1$ ($d_2 \leq +\infty$) such that:

a) If $d < d_1$, pricing is uniform ($p_1 = p_2 = p$; $q_1 = q_2 = q$. The values of p and q are intermediate between the ones that prevail under symmetric information about χ). Cross-subsidization occurs ($L_1 < R_1$ and $L_2 > R_2$).

b) If $d_1 < d < d_2$, price discrimination occurs and collusion is socially costly.

c) If $d \geq d_2$, collusion is socially costless (i.e., the solution is given by equations (7.2) through (7.4)).

The proof of Proposition 4 is relegated to Appendix 3. An interesting conclusion is that, for small d, the stakes in collusion ($S^n(q_1)-S^n(q_2)$) are not only reduced at the optimum, but totally disappear. Congress imposes uniform pricing, an extreme form of cross-subsidization. The intuition for

this result is as follows. The welfare loss due to collusion is at most of order d when d is small, because Congress can adopt uniform pricing, which is collusion proof and involves only a loss of order at most d. Hence, a policy in which (q_1-q_2) is not of order at most d is suboptimal, as it involves a distortion relative to the full-information case that does not converge to 0 at rate d or faster. Now, consider the collusion incentive constraint (7.5). As a first approximation, the left-hand side is proportional to $(q_1-q_2)d$ and the right-hand side is of order (q_1-q_2). Hence the constraint cannot be satisfied unless $q_1 = q_2$.

For a large d, the firm's cost of lying is very large and constraint (7.5) is satisfied by the solution to (7.2) through (7.4) in the case of $d_2 < +\infty$. For an intermediate d, the analysis is complex, and we were not able to get specific results. This is due to the fact that lowering the differential (q_1-q_2) reduces the consumers' stake $(S^n(q_1)-S^n(q_2))$, but also makes it more costly for the firm to lie.

We now investigate the possibility that the consumer group which is cheap to serve can organize $(\lambda_{c_1} < +\infty)$. The new feature is that the collusion incentive constraint becomes less binding, and that bribes may be socially optimal <u>in equilibrium</u>. [The following discussion has benefited from discussions with Bengt Holmström, who, in another context, suggested to us that it may be socially optimal to allow bribes between two members of an organization who share soft information.]

To see why bribes may be optimal, suppose that there is price discrimination: $q_1 > q_2$. The type-2 consumers are willing to pay $S^n(q_1)-S^n(q_2)$ to the firm. Let

$$(7.7) \qquad \Delta \equiv \frac{S^n(q_1)-S^n(q_2)}{1+\lambda_{c_2}} - \left[\psi\left(e + \frac{2d(q_1-q_2)}{q_1+q_2}\right)-\psi(e)\right]$$

denote the bribe that the firm must receive from type-1 consumers to tell the

truth if equation (7.5) is not satisfied ($\Delta > 0$). It is in the interest of type-1 consumers to bribe the firm to tell the truth if and only if

$$(7.8) \qquad S^n(q_1)-S^n(q_2) \geq (1+\lambda_{c_1})\Delta,$$

or

$$(7.9) \qquad \psi\left(e + \frac{2d(q_1-q_2)}{q_1+q_2}\right) - \psi(e) \geq \frac{\lambda_{c_1}-\lambda_{c_2}}{1+\lambda_{c_2}} (S^n(q_1)-S^n(q_2)).^{30}$$

Note that for $\lambda_{c_1} = \lambda_{c_2}$, for instance, the collusion constraint (7.9) is not binding. So, in particular, price discrimination is feasible even for a small d. But there is a cost of having type-1 consumers transfer Δ to the agency, equal to $(\lambda_{c_1}-\lambda)\Delta$. There is thus a trade-off between relaxing the collusion constraint by having the type-1 consumers bribe the firm and creating costly side transfers. To say more, we simplify the model by assuming that $\lambda_{c_1} = \lambda_{c_2} = \lambda_c \geq \lambda$.[31]

Congress must then choose between two regimes. The "no-side-transfer regime" corresponds to $\Delta \geq 0$, and has already been studied. The "side-transfer regime" corresponds to $\Delta < 0$. There is no collusion constraint, and the social welfare function is given by:

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[30] We are here envisioning an auction between the two groups of consumers. The firm announces the χ which is favorable to the highest bidder, where the bid of the expensive-to-serve consumers is deflated by the extra disutility of effort engendered by lying.

[31] As before, assuming $\lambda_c \geq \lambda$ is meant to rule out the possibility that side transfers occur only because an interest group is a better collector of funds than Congress.

$$(7.10) \qquad \underset{\{q_1,q_2,e\}}{\text{Max}} \Big\{ \{S(q_1)+S(q_2)-(1+\lambda)((\beta-e)(q_1+q_2)+d(q_2-q_1)+\psi(e)) + \lambda[P(q_1)q_1 + P(q_2)q_2] - (\lambda_c-\lambda)\left[\frac{S^n(q_1)-S^n(q_2)}{1+\lambda_c} - \psi\left[e + \frac{2d(q_1-q_2)}{q_1+q_2}\right] + \psi(e)\right]\Big\},$$

where the last term takes into account the reduction in Congress's transfer to the firm in amount equal to the bribe received.

When λ_c is close to λ, Congress can reach almost the collusion-free welfare in program (7.10), while it cannot in program (7.6). Hence the side-transfer regime is optimal.

Fixing $\lambda_c > \lambda$, when d tends to 0, the no-side transfer regime (which we know from Proposition 4, involves uniform pricing) is optimal. To show this, it suffices to take the derivations of (7.10) with respect to q_1 and q_2 and to note that the difference (q_1-q_2) does not converge to 0 with d.

Proposition 5. Assume $\lambda_{c_1} = \lambda_{c_2} = \lambda_c \geq \lambda$.

a) When λ_c is close to λ, it is socially optimal to practice price discrimination and to let the consumers that are cheap to serve bribe the firm.

b) When d is small, uniform pricing and the absence of side-transfers are optimal.

A striking conclusion is that equilibrium side transfers may arise. Type-1 consumers are then used as a countervailing force to type-2 consumers. Recall that the collusion proofness principle obtained for the hard information model of Sections 2 through 6. The interest groups could bribe the agency to report or misreport its piece of hard information; but Congress

could duplicate this bribe at a lower transfer cost. Here, Congress does not know whether $\hat{\chi} = 1$ is a true report because of the softness of information, while the consumers are able to base their transfers on both the announcement and the truth.[32]

Last, we have assumed that there was no agency. Alternatively one could assume that the agency colludes with the firm. Suppose for instance that the agency learns χ (soft information) and announces it. While the outcome is similar to the one obtained above, this more complex framework allows the possibility that the consumers' side transfers be directed to the agency rather than directly to the firm.

8. Conclusion.

This paper has shown that interest-group politics can be apprehended in a tractable agency framework. Its general insights are:

(1) The organizational response to the possibility of agency politics is to reduce the stakes interest groups have in regulation.

(2) The threat of producer protection leads to low-powered incentive schemes. That is, the theory predicts contracts that are somewhat closer to cost-plus contracts than a theory ignoring the possibility of producer protection.

(3) The agency's discretion to choose among price levels, pollution levels and more generally variables affecting the other interest groups than the regulated industry is reduced when the latter become better organized.

(4) Our approach refines the view that there is a market for regulatory decisions. First, the regulatory inefficiencies associated with the pressures of several interest groups may compound rather than cancel. For instance, an

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[32] This shows that the possibility of equilibrium bribes is linked with our assumption that consumers know the true value of χ. If consumers do not know χ, then the collusion-proofness principle holds as Congress can duplicate the consumers' side transfers.

industry (eager to extract a rent) and an environmental group (eager to limit production to curb pollution) may have a common interest in Congress's not being informed about the production technology. Second, the power of an interest group does not depend only on its willingness to pay, i.e., on the combination of its stake in the regulatory decision and of its cost of organizing and of influencing government, but also on the kind of influence it wants to exert. The group has more power when its interest lies in inefficient rather than efficient regulation, where inefficiency is measured by the degree of informational asymmetry between the regulated industry and Congress.

(5) In contrast with the conventional wisdom on interest-group politics, an interest group may be hurt by its own power.

(6) Congress must reward the agency for "cooperating," i.e., for supplying information.

The more specific insights are:

(7) In our production-embodied pollution model (Section 5), the better organized the environmentalists, the higher the firm's rent, if the firm's production is essential. In contrast, if production is not essential so that shutdown is a relevant policy, the environmentalists' pressure may hurt the firm.

(8) The methodology developed in this paper is extended to yield a political theory of cross-subsidization. Interest-group politics may yield uniform pricing by regulated multiproduct firms.

(9) We showed that the optimal allocation can be implemented without side transfers when the supervisory information is hard. Soft supervisory information may make equilibrium side-transfers desirable; that is, Congress may use one interest group as a countervailing force to another interest group. The generalization of these insights to more general frameworks is an important line of theoretical research.

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Appendix 1. Producer protection.

Let us index the four states of nature in the following way: State 1: $(\beta = \underline{\beta},\ \sigma = \underline{\beta})$; state 2: $(\beta = \underline{\beta},\ \sigma = \emptyset)$; state 3: $(\beta = \bar{\beta},\ \sigma = \emptyset)$; state 4: $(\beta = \bar{\beta},\ \sigma = \bar{\beta})$. We let x_i denote the probability of state i (for instance $x_1 = p\nu$). A pair of contracts offered by Congress leads to a side contract between the agency and the firm, and to some equilibrium allocation. We index the final incomes and utilities (which include the equilibrium bribes, if any) by a hat: $(\hat{t}_i, \hat{s}_i, \hat{U}_i, \hat{V}_i)_{i=1}^4$. The actual transfers from Congress to the agency and to the firm are denoted s_i and t_i in state i. Letting $\tilde{s}_i$ denote the firm's bribe to the agency, we have:[33]

(A.1) $\hat{s}_i = s_i + \tilde{s}_i$.

(A.2) $\hat{t}_i = t_i - (1+\lambda_f)\tilde{s}_i$.

(A.3) $\tilde{s}_i \geq 0$.

(A.4) $\hat{U}_i = \hat{t}_i - \psi(e_i)$.

(A.5) $\hat{V}_i = \hat{s}_i - s^*$.

[We will assume that the final allocation is deterministic. The reasoning is easily extended to random final allocations.]

We want to prove that there is no loss of generality in assuming that a) the agency reports σ truthfully; b) transfers are based on (q,C,r) only (in particular, more complex mechanisms, like announcement games, do not raise welfare); c) the agency's income depends only on its report; d) there is no

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[33] We allow only positive bribes for simplicity. Negative bribes (bribes $\tilde{t}_i$ from the agency to the firm, which would cost $(1+\lambda_a)\tilde{t}_i$) can be shown to be suboptimal as long as $\lambda_a \geq 0$. [The reasoning is the same as the reasoning below.]

side-transfer in equilibrium ($\tilde{s}_i = 0$ for all i). The strategy of proof is the following: First, we derive an upper bound on expected welfare. To do so, we derive a couple of necessary conditions that must be satisfied by the final allocation in any equilibrium. We then write welfare as a function of the final allocation and equilibrium bribes, and maximize it subject to this limited set of constraints. We find in particular that optimal bribes are equal to zero. Second, we show that this upper bound can indeed be reached by an incentive scheme that satisfies properties a) through d) (and in particular is collusion-proof). It is then straightforward to check that the optimization program is equivalent to (4.4).

First, we claim that for all i

(A.6) $\hat{s}_i \geq s^*$.

(A.7) $\hat{U}_i \geq 0$.

If either of these inequalities is violated, one of the parties refuses to participate in the regulatory process because it rationally anticipates that its final utility will be lower than its reservation utility. Next, we claim that

(A.8) $\hat{U}_2 \geq \hat{U}_3 + \Phi(e_3)$.

Because, in state 2, the firm is the only one to know that $\beta = \underline{\beta}$, it can mimic the behavior of type $\bar{\beta}$ and get utility $\hat{U}_3 + \Phi(e_3)$. Last,

(A.9) $(1+\lambda_f)(\hat{s}_1 - \hat{s}_2) \geq \hat{U}_2 - \hat{U}_1$.

If (A.9) were violated, the agency and the firm would be better off signing a different side-contract in state of nature 1. The crucial point here is that any messages m_2 that are sent by both parties in state of nature 2 can also be sent in state 1 (the converse is not true, as in state 2 the agency cannot

substantiate a report $\sigma = \beta$). So the two parties can agree to send the messages m_2, and specify a large side-transfer from a party that defects from these messages to the other party.[34]

The expected social welfare is:

$$(A.10) \qquad W = \sum_{i=1}^{4} x_i\Big\{[S(q_i)+\lambda P(q_i)q_i]-(1+\lambda)(s_i+t_i+(\beta_i-e_i)q_i)+\hat{U}_i+\hat{V}_i\Big\},$$

or, using (A-1), (A.2), (A.4), and (A.5):

$$(A.11) \qquad W = \sum_{i=1}^{4} x_i\Big\{[S(q_i)+\lambda P(q_i)q_i]-(1+\lambda)(s^*+\lambda_f\tilde{s}_i+\psi(e_i)$$

$$+ \ (\beta_i-e_i)q_i)-\lambda\hat{U}_i-\lambda(\hat{s}_i-s^*)\Big\}.$$

We now find an upper bound W^{max} for W when the constraints (A.3), and (A.6) through (A.9) are imposed on the control variables $\{q_i,e_i,\tilde{s}_i,\hat{s}_i,\hat{U}_i\}_{i=1}^{4}$. That is, we ignore other potential constraints for the moment.

Because rents are costly, the solution must satisfy:

$$(A.12) \qquad \hat{s}_i = s^* \qquad \text{for } i = 2,3,4,$$

$$(A.13) \qquad \hat{U}_3 = \hat{U}_4 = 0.$$

Furthermore, (A.8) and (A.9) are satisfied with equality. Next, because the problem is separable between bribes and other variables,

$$(A.14) \qquad \tilde{s}_i = 0 \qquad \text{for all } i.$$

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[34] We are here assuming that, to be enforceable, the transfers from Congress to the agency and the firm, the price level and the cost targets are based on observable messages. But the analysis can be extended to cases in which the messages are not observed by all parties (under risk neutrality, the parties can design side-transfers based on the observable transfers, price and cost target that deter any party from deviating from m_2).

Last, we must show that $\hat{U}_1 = 0$. To do so, note that (A.8) and (A.9) imply that:

$$(A.15) \qquad (1+\lambda_f)(\hat{s}_1 - s^*) = \Phi(e_3) - \hat{U}_1.$$

Thus, maximizing W with respect to $\hat{U}_1$ is equivalent to maximizing $\left\{-\lambda\hat{U}_1 - \lambda\left[-\frac{\hat{U}_1}{1+\lambda_f}\right]\right\}$ subject to $\hat{U}_1 \geq 0$. Thus, $\hat{U}_1 = 0$. The maximizations with respect to q_i and e_i are as announced in Section 4: Output q_i is Ramsey optimal given marginal cost $(\beta_i - e_i)$: $q_i = R(\beta - e_i)$. And effort is socially optimal ($\psi'(e_i) = q_i$) except in state 3, in which:

$$(A.16) \qquad \psi'(e_3) = q_3 - \frac{\lambda}{1+\lambda}\left[\frac{x_2}{x_3} + \frac{x_1}{x_3(1+\lambda_f)}\right]\Phi'(e_3).$$

using (A.8) and (A.9). [That is, e_3 is the arg max e of (4.4)].

The second step of the proof consists in showing that the upper bound can be reached (that is, in the notation of the text, $EW = W^{max}$). To do so, suppose that Congress offers the following incentive schemes: The agency makes a report r and the firm announces its type $\hat{\beta}$. Letting i = 1 denote the state in which $r = \underline{\beta}$ and $\hat{\beta} = \underline{\beta}$, etc., Congress gives transfers

$$(A.17) \qquad t_i = \hat{U}_i + \psi(e_i)$$

$$(A.18) \qquad s_i = \hat{s}_i$$

and imposes cost target

$$(A.19) \qquad C_i = (\hat{\beta} - e_i)q_i$$

and price

$$(A.20) \qquad p_i = R(\hat{\beta} - e_i),$$

where $\{q_i, e_i, \hat{s}_i, \hat{U}_i\}_{i=1}^4$ are the solutions to the maximization (A.10) and $p_i \equiv$

$P(q_i)$. [If the agency's report and the firm's announcement are inconsistent, or if the cost target is not reached, Congress imposes a large penalty on the other two parties.] Now, it is straightforward to check that in no state of nature do the agency and the firm have an incentive to collude against this scheme, or to individually misreport or lie. Thus the upper bound can be reached by a pair of contracts that satisfy a) through d), as claimed above.

Last, we say a few words about the case in which the parties can sign a contract before the agency and the firm (simultaneously) get their information. We assume that both the agency and the firm are infinitely risk averse, so that they care only about their worst payoff. It is clear that for the optimal contract, both the agency and the firm are put at their reservation utilities, s* and 0 (otherwise, transfers could be reduced uniformly for at least one party, without any incentive effect). We focus on deterministic contracts. The social welfare function is slightly different from W, as *ex-post* rents have no longer a social value:

$$(A.21) \qquad \tilde{W} = \sum_{i=1}^{4} x_i\{[S(q_i)+\lambda P(q_i)q_i]-(1+\lambda)(s_i+t_i+(\beta_i-e_i)q_i\}$$

or

$$(A.22) \qquad \tilde{W} = \sum_{i=1}^{4} x_i\{[S(q_i)+\lambda P(q_i)q_i]-(1+\lambda)(\hat{s}_i+\lambda_f\tilde{s}_i+\hat{U}_i+(\beta_i-e_i)q_i+\psi(e_i)\}.$$

To show that the analysis is (qualitatively) identical to that of the no-prior-contract case, it suffices to note that the minimal set of constraints {(A.3), (A.6) through (A.9)} is still a set of necessary conditions when the parties are infinitely risk averse and contracts are signed prior to the revelation of information.

§ § §

Appendix 2: Multiple interest groups.

The reasoning is the same as in Appendix 1, so we will skip the details. Let $\tilde{\tilde{s}}_i$ denote the environmentalists' transfer to the agency in state of nature i. To show that $\tilde{\tilde{s}}_i = 0$ for all i in equilibrium, one proceeds as in Appendix 1, by writing the social welfare function as a function of the final allocations and bribes, and showing that one has a corner solution for bribes. An intuitive argument is the following: a bribe $\tilde{\tilde{s}}_i$ allows Congress to reduce s_i by $\tilde{\tilde{s}}_i$ for a given final income $\hat{s}_i$ (as in Appendix 1, the optimization problem is separable between bribes and the final allocations; so we must hold the final allocation as fixed). The social gain is $(1+\lambda)\tilde{\tilde{s}}_i$. But, the environmentalists' welfare is reduced by $(1+\lambda_e)\tilde{\tilde{s}}_i$. So, the net welfare gain is equal to $(\lambda-\lambda_e)\tilde{\tilde{s}}_i \leq 0$ if $\lambda_e \geq \lambda$.

The social welfare function is (using the notation of Appendix 1):

$$(A.23) \qquad W = \sum_{i=1}^{4} x_i\{[S(q_i)+\lambda P(q_i)q_i]-(1+\lambda)(s_i+t_i+(\beta_i-e_i)q_i)+\hat{U}_i+\hat{V}_i\}.$$

Using (5.4), (5.5) and the fact that $\tilde{s}_i = \tilde{\tilde{s}}_i = 0$ for all i,

$$(A.24) \qquad W = \sum_{i=1}^{4} x_i\{[S(q_i)+\lambda P(q_i)q_i]-(1+\lambda)(s^*+\psi(e_i)+(\beta_i-e_i)q_i)\}$$

$$-\lambda\left[x_2\Phi(e_3)+x_1\frac{\Phi(e_3)}{1+\lambda_f}+x_4\frac{D(q_4)-D(q_3)}{1+\lambda_e}\right].$$

[In the notation of Section 5: $q_4 = \tilde{q}$, $e_4 = \tilde{e}$, $q_3 = q$, $e_3 = e$.] We thus obtain:

$$(A.25) \qquad (1+\lambda)(P(q_i)-(\beta_i-e_i))+\lambda q_i P'(q_i)) = 0 \qquad i = 1,2.$$

$$(A.26) \qquad (1+\lambda)(P(q_3)-(\tilde{\beta}-e_3))+\lambda q_3 P'(q_3)) = -\lambda\frac{x_4}{x_3}\frac{D'(q_3)}{1+\lambda_e}.$$

$$(A.27) \qquad (1+\lambda)(P(q_4)-(\tilde{\beta}-e_4))+\lambda q_4 P'(q_4) = \lambda\frac{D'(q_4)}{1+\lambda_e}.$$

(A.28) $\psi'(e_i) = q_i \qquad i = 1,2,4.$

(A.29) $$\psi'(e_3) = q_3 - \frac{\lambda}{1+\lambda}\left[\frac{x_2}{x_3} + \frac{x_1}{x_3(1+\lambda_f)}\right]\Phi'(e_3).$$

That is, the price is distorted away from the Ramsey price in states 3 and 4, and effort is distorted downward in state 3. Now, using our assumption that the program is concave (as we mentioned, a sufficient condition for this is that λ not be too big), (A.26) and (A.27) imply that

$$\frac{dq_3}{d\lambda_e} < 0, \quad \frac{dq_4}{d\lambda_e} > 0.$$

Note that it may happen that the solution above satisfies $q_4 < q_3$. In this case, the solution is a corner solution: $q_4 = q_3$.

§ § §

Appendix 3: Proof of Proposition 4.

Let ζ be the Kuhn-Tucker multiplier associated with (7.5). The first-order condition for program (7.6) for an interior solution is:

(A.30)
$$L_1 = \frac{p_1-(\beta-e-d)}{p_1} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(p_1)} + \frac{\zeta}{1+\lambda}\left[\frac{1}{\eta(p_1)} - \frac{1+\lambda}{p_1}c_2\frac{4dq_2}{(q_1+q_2)^2}\psi'\left[e+\frac{2d(q_1-q_2)}{q_1+q_2}\right]\right]$$

(A.31)
$$L_2 = \frac{p_2-(\beta-e+d)}{p_2} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(p_2)} - \frac{\zeta}{1+\lambda}\left[\frac{1}{\eta(p_2)} - \frac{1+\lambda}{p_2}c_2\frac{4dq_1}{(q_1+q_2)^2}\psi'\left[e+\frac{2d(q_1-q_2)}{q_1+q_2}\right]\right]$$

$$\text{(A.32)} \qquad \psi'(e) = q_1+q_2+ \frac{\zeta(1+\lambda_{c_2})}{1+\lambda} \left[\psi'\left(e+\frac{2d(q_1-q_2)}{q_1+q_2}\right)-\psi'(e)\right].$$

a) Let us first assume that d is small. We see that $\{q_1 = q_2 = q,\ p_1 = p_2 = p, e, \zeta\}$ satisfy (A.30) through (A.32) if:

$$\text{(A.32)} \qquad \frac{p-(\beta-e)}{p} = \frac{\lambda}{1+\lambda} \frac{1}{\eta(p)}$$

$$\text{(A.33)} \qquad \psi'(e) = 2q$$

$$\text{(A.35)} \qquad \zeta = \frac{(1+\lambda)d}{(-P'(q)q)-2(1+\lambda_{c_2})d}.$$

Note that p, q and e are independent of d. The proof that uniform pricing is optimal proceeds in two steps. First, $q_1 < q_2$ is dominated by uniform pricing from the concavity of the social welfare function in a collusion-free world. Second, the reasoning in the text shows that q_1-q_2 must be of order d, and that the collusion incentive constraint cannot be satisfied as the stake is of order d and the cost of lying is of order d^2. By continuity, uniform pricing must be optimal on at least some interval $[0,d_1]$.

b) Consider the case in which the solution to (7.2) through (7.4) does not satisfy (7.5) for any d (so that $d_2 = +\infty$). We want to show that uniform pricing is not optimal for a large d (note that large d's raise the possibility that marginal costs become negative. We will assume that β is large enough so that this does not occur).

To this purpose, suppose that optimal pricing at p, yielding demand q, is optimal. Consider a small deviation around uniform pricing: $q_1-q_2 = \epsilon > 0$. The left-hand side of (7.5) is equal to $(1+\lambda_{c_2})\psi'(e)\frac{2d\epsilon}{2q} = 2(1+\lambda_{c_2})d\epsilon$ to the first approximation, where use is made of (A.34). Similarly the right-hand

side of (7.5) is $[-P'(q)q]\epsilon$ and is independent of d from (A.33) and (A.34). Hence, for d large enough, (7.5) is satisfied for small amounts of price discrimination. From the concavity of the social welfare function in the collusion-free world, a small amount of price discrimination, which, we just saw, is feasible, is preferable to uniform pricing.

Next consider the case in which there exist d's such that (7.5) is not binding for the collusion-free solution (given by (7.2) through (7.5)). Let d_2 denote the smallest such d. We claim that for $d = d_2 - \epsilon$ (where ϵ is positive and small) pricing is discriminatory. We know that at d_2, (7.5) is just binding. Because ψ is convex, one can increase e to $e+\eta$ where η is small such that

$$\psi\left[(e + \eta + \frac{2(d_2-\epsilon)(q_1-q_2)}{q_1+q_2}\right] - \psi(e+\eta) = \psi\left[e + \frac{2d_2(q_1-q_2)}{q_1+q_2}\right] - \psi(e).$$

(7.5) is still satisfied for the collusion-free levels q_1 and q_2. This implies that Congress can obtain almost the collusion-free level of welfare when d is close to d_2, which obviously is impossible under uniform pricing.

Next, we observe that if (7.5) is satisfied for the collusion-free levels and parameter d, it is also satisfied for the collusion-free levels and parameter $d' > d$. This means that the set of parameters for which the collusion-free solution obtains is indeed the open interval $[d_2, +\infty)$.

Last, we want to show that there exists d_1 such that uniform pricing obtains on $[0, d_1]$ and not elsewhere. To this purpose, note that the welfare under uniform pricing is independent of d. More generally, the envelope theorem shows that the derivative of the social welfare function with respect to d is equal to:

$$-(1+\lambda)(q_2-q_1) + \varsigma(1+\lambda_{c_2})\psi'\left[e + \frac{2d(q_1-q_2)}{q_1+q_2}\right]\frac{2(q_1-q_2)}{q_1+q_2} > 0$$

for price discrimination ($q_1 > q_2$). Hence, the region with discriminatory pricing and binding collusion is exactly an interval (d_1, d_2).

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