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TOWARD A POLITICAL THEORY OF ENVIRONMENTAL POLICY

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RÉSUMÉ

Nous développons dans cet article quelques jalons d'une économie politique de la politique environnementale. Nous réexaminons le consensus des économistes en faveur de mécanismes sophistiqués de réglementation incitative. Nous insérons tout d'abord la question du choix des instruments dans le cadre général de la construction de mécanismes et nous développons une économie politique à partir d'une analyse de contrats incomplets. Ensuite, nous montrons dans divers contextes pourquoi des contraintes "constitutionnelles" sur le choix des instruments de politique environnementale peuvent être désirables malgré leur apparente inefficacité économique. Leur justification réside dans les limites qu'elles imposent à la capacité des politiciens de distribuer des rentes. Nos résultats permettent de mieux comprendre l'émergence récente de mécanismes incitatifs en réglementation environnementale.

Mots clés : environnement, économie politique, théorie politique, choix d'instruments

ABSTRACT

This paper makes some steps toward a formal political economy of environmental policy. Economists' quasi-unanimous preferences for sophisticated incentive regulation is reconsidered. First, we recast the question of instrument choice in the general mechanism literature and provide an incomplete contract approach to political economy. Then, in various settings, we show why "constitutional" constraints on the instruments of environmental policy may be desirable, even though they appear inefficient from a purely standard economic viewpoint. Their justification lies in the limitations they impose on the politicians' ability to distribute rents. Some insights are then provided into the question often raised regarding the recent emergence of incentive mechanisms in environmental regulation.

Key words : environment, political economy, political theory, choice of instruments

1 INTRODUCTION

A large number of instruments have been considered to regulate polluting activities - Pigouvian taxes, quotas, depollution subsidies, marketable emission permits,[1] deposit refund systems,[2] assignments of legal liabilities,[3] etc. As a result, the choice of policy instruments has become one of the major questions debated in environmental economics.[4] Most of the discussion has taken place within the benevolent social maximizer paradigm. But, starting with Buchanan and Tullock (1975), the necessity of looking for political economy explanations of the choice of instruments has been recognized.[5] However, dissatisfaction remains:

- "There is yet no satisfactory theory about the emergence of incentive based mechanisms." Hahn (1990)
- "The development of a positive theory of instrument choice in environmental regulation continues to elude researchers." Lewis (1995)

The purpose of this paper is to use and extend the methodology developed in Laffont (1995) to provide some preliminary steps in the construction of a formal political economy of environmental economics. Economists' general preferences for sophisticated incentive mechanisms is reconsidered. Our political economy approach characterizes those situations where finely tuned market based instruments are appropriate and situations where they are dominated by cruder instruments.

In section 2, we recast the question of instrument choice in the general mechanism design literature and we explain why the comparison of instruments requires an incomplete contract setting, that is, a framework where the constitutional design of policies is constrained by various imperfections. The inefficiencies of the political game will appear as just one particular constraint of the constitutional regulator.

[1] Crocker (1966) and Dales (1968a. 1968b) first proposed marketing emission permits.
[2] See Bohm (1981).
[3] See Boyer and Laffont (1995a, 1995b).
[4] Cropper and Oates (1992) devote a large part of their survey to this question. The recent survey by Lewis (1995) is entitled "Instruments of Choice for Environmental Protection."
[5] Beyond the debate about the Buchanan-Tullock paper (Yohe (1976), Dewees (1983), Coelho (1976)), see also Boyer (1979), Noll (1983), McCubbins. Noll and Weingast (1989), Hahn (1990), Hahn and McGartland (1989).

Section 3 develops models showing why constitutional constraints on the instruments of environmental policy may be desirable, even though they appear inefficient from a strict economic point of view. Their justification lies in the limitations they impose on the politicians' ability to distribute rents.[6] First, we consider, in a simple majority vote political game, the choice between two regulation approach: on the one hand, the (incentive) regulation of pollution delegated to the politicians (benefiting from their detailed information about the economy – here the social cost of public funds – but suffering from their private agendas) and, on the other hand, cruder mechanisms of regulation which can be imposed under a benevolent constitution. Second, we reconsider the same model where the choice of mechanisms must be delegated to politicians (again because it benefits from their information) but where the constitution can choose between requesting from politicians to select non-discriminatory quotas, that is, pooling mechanisms, or opening the possibility for politicians of selecting powerful incentive mechanisms. Third, we compare political discrimination with a (pooling) quota policy designed at the constitutional level. These models provide some insights into the question raised by Hahn (1990) of the recent emergence of sophisticated incentive mechanisms in environmental regulation.

Section 4 studies how the outcome of this constitutional design of constraints on instruments is affected by the dynamics of reelections. We assume that when a majority pursues excessively its private agenda, it generates a negative impact on its reelection probability.

Section 5 extends the model to a situation where two types of interest groups, producers and environmentalists, may benefit from the capture of the government through the size of informational rents that the regulation mechanisms leave them. The distortions due to the political process are studied in this more general model, as well as the impact of a dynamics of reelection based on campaign contributions and the comparison of instruments is extended to this case. Concluding comments are gathered in Section 6.

[6] Rents appear when the net benefits that an individual or a firm receives from participating to an activity are larger than the minimum level necessary to secure the participation of that individual or firm to the activity. Maloney and McCormick (1982) emphasized that input and output restrictions associated with environmental policy create rents for firms. A different but related argument is developed by Alesina and Rosenthal (1994) who claim that voters take advantage of the separation of powers in the U.S. government (a form of constitutional restrictions!) because they tend to dislike the somewhat extreme ideologies of the two major parties.

2 THE POSITIVE THEORY OF INSTRUMENT CHOICE: AN EXERCISE IN INCOMPLETE CONTRACTING

Incomplete information is by now well understood as being a major obstacle to first best efficient regulation. Starting with Loeb and Magat (1979), regulation of natural monopolies has been modeled as a principal-agent problem. When contracting is unconstrained, the Revelation Principle[7] then states that any type of regulation is equivalent to a revelation mechanism. In such a revelation mechanism, agents communicate truthfully their private information to the regulator who then recommends proper actions. The requirement of incentive compatibility puts constraints on the actions that can be implemented.

It is only recently that this framework has been extensively developed for environmental economics.[8] A revelation mechanism can be viewed as a command and control instrument and nevertheless it is clearly optimal here: once an optimal revelation mechanism has been obtained, the question of its implementation by various economic instruments or institutions, such as regulatory proceedings, taxes and markets, arises but by definition those institutions implement then the same allocations as the command and control approach. (See Laffont (1994) for an example).

In such a framework the question of instrument choice is empty. Such a question often arose in the literature because authors were not careful enough in defining their instruments. For example, Yohe (1976) correctly shows that the alleged difference between quotas and price controls in Buchanan and Tullock (1975) disappears when instruments are appropriately defined. He writes: "When the equivalent quantity control is properly specified, both the economist's general preference for taxation and the regulatee's general preference for quotas will disappear."

Two types of meaningful comparisons of instruments are then possible. Either one considers constraints on instruments (and the analysis should explain the origin of these constraints) and various constrained instruments can be compared. This is the essence of Weitzman's (1974) com-

[7] See Baron and Myerson (1982), Guesnerie and Laffont (1984).

[8] See Baron (1985a), Laffont (1994) and Lewis (1995). Early applications were essentially reinterpreting Groves mechanisms by treating environmental externalities like public goods (see for example Dasgupta, Hammond and Maskin (1980)).

parison of prices and quantities in a situation where asymmetric information calls for non-linear prices as optimal instruments, as Roberts and Spence (1976) pointed out. Another example is the case of non-convexities due to negative externalities (Starrett (1972), Baumol and Bradford (1972)). There, quotas are equivalent to non-linear taxes. Pigouvian (linear) taxes are then dominated by quotas. Similarly, taxes and subsidies which are equivalent when they are accompanied with appropriate lump sum transfers differ in their absence with respect to the long run, entry-exit decisions of firms (see Kamien, Schwartz and Dolbear (1966), Bramhall and Mills (1966), Kneese and Bower (1968), and Dewees and Sims (1976)).

Or, one considers instruments which could be equivalent in the complete contracting framework and one introduces imperfections elsewhere in the economy that cannot be corrected by the regulator (then a good explanation of this inability of the regulator must be given). This is the case in Buchanan's (1969) example of a polluting monopolist when the subsidies required to correct the monopolistic behavior are not available. Then, the Pigouvian tax is clearly dominated by a quota which implements the second best tax (devised for example by Lee (1975) and Barnett (1980)) and which depends on the firm's market power. A more sophisticated analysis would recognize that the control of the monopolist is conducted by a regulator different from the regulator of the environment and would cast the analysis in a multiprincipal framework.

A systematic analysis of instrument choice should then be conducted in well defined second best frameworks, which are all methodological shortcuts of an incomplete contract analysis. Constraints such as limited commitment, renegotiation-proof commitment, collusion, favoritism, multiprincipal structures[9] should be considered. Political economy constraints can be viewed also as a special case of this methodology. The lack of finely-tuned constitutional control of the politicians (the incomplete contract feature) who have then private agendas introduces inefficiencies in the regulatory decision process. It then may become desirable to impose constraints on politicians which favor particular instruments or to force the use of apparently crude instruments.

In the next sections we develop political economy models aimed at providing positive explanations of instrument choice under alternative constitutional controls.

[9] See Baron (1985b) for an early study of the distortions due to the uncoordinated activities of two regulators.

3 DISCRETION AND FLEXIBILITY: THE EMERGENCE OF INCENTIVE REGULATION

3.1 The Basic Model

We consider a natural monopoly which is delegated the realization of a public project which has social value S and costs $\beta(K - d)$ where K is a constant, β is a cost characteristic which is private information of the firm (with $\beta \in \{\underline{\beta}, \overline{\beta}\}$ and $\Delta\beta = \overline{\beta} - \underline{\beta}$) and d is the level of pollution accompanying the completion of the project. The lower the pollution, the higher the cost for the monopoly. The social disutility of pollution is $V(d)$ (with $V' > 0, V'' > 0$). Let t be the compensatory monetary transfer from the regulator to the firm which has a utility level

$$U = t - \beta(K - d).$$

If $1 + \lambda$, $\lambda > 0$, is the social cost of public funds due to the need for using distortionary taxation to raise public funds,[10] the consumers' welfare is

$$C = S - V(d) - (1 + \lambda)t.$$

The utilitarian social welfare is then

$$W = C + U = S - V(d) - (1 + \lambda)\beta(K - d) - \lambda U.$$

We assume that S is large enough to make the realization of the project always desirable. Under complete information, the benevolent regulation would set $V'(d) = (1 + \lambda)\beta$ for each value of β and $t = \beta(K - d)$ to nullify the socially costly rent of the firm.

3.2 Social Pooling versus Political Discrimination

Suppose now that there is incomplete information about β and that $\nu = Prob(\beta = \underline{\beta})$ is common knowledge. We consider first the situation where λ is a random variable whose distribution is common knowledge but whose value is observed by the government (the majority in power) only

[10] The value of λ is non-negligible and considered to be of the order of 0.3 in developed countries and higher in developing ones. See Jones, Tandon and Vogelsang (1990, chapter 3) for a recent review of the empirical evidence.

and cannot be made verifiable by a court. At the constitutional level, the choice is then between imposing a regulation mechanism which maximizes expected social welfare on the basis of $E\lambda$, the expected value of λ, or delegating to the political majority the choice of regulation which will then be a function of the value of λ in which case the choice of pollution regulation will reflect private agendas.

We have a continuum $[0,1]$ of agents in the economy. Let α be a random variable, drawn independently each period, taking the value $\alpha^* \in (\frac{1}{2}, 1)$ with probability $\frac{1}{2}$ and $1-\alpha^*$ with probability $\frac{1}{2}$; α represents each period the measure of consumers who do not share the firm's rent (type 1 agents) and $1-\alpha$ is the measure of those who share the rent (type 2 agents). When $\alpha = \alpha^*$, majority 1 is in power and this majority, of measure α^*, does not benefit from the firm's rent; when $\alpha = 1-\alpha^*$, majority 2 is in power in which case the measure of type 2 agents who share the firm's rent is α^*.

Accordingly, if $\alpha = \alpha^*$, we have majority 1 which maximizes the welfare of type 1 agents, namely

$$\alpha^* \left(S - V(d) - (1+\lambda)t\right) = \alpha^* \left(S - V(d) - (1+\lambda)\beta\left(K-d\right) - (1+\lambda)U\right),$$

thus overestimating the social cost of the firm's rent $(1+\lambda > \lambda)$. This formulation presumes that the funding of firms through indirect taxation is uniformly spread across all agents. Similarly, if $\alpha = 1-\alpha^*$, majority 2 maximizes

$$\alpha^* \left(S - V(d) - (1+\lambda)t\right) + U = \alpha^* \left(S - V(d) - (1+\lambda)\beta\left(K-d\right) - \left(1+\lambda-\frac{1}{\alpha^*}\right)U\right),$$

thus underestimating the social cost of the firm's rent $(1+\lambda - 1/\alpha* < \lambda)$.

Under incomplete information about β, the firm's individual rationality and incentive compatibility constraints must be taken into account. We know that only the type-$\underline{\beta}$ firm will receive a rent that is equal to

$$\underline{U} = \Delta\beta\left(K - \overline{d}\right),$$

where $\overline{d}$ is the pollution level requested by the discriminatory regulation mechanism $\left((\overline{t},\overline{d}),(\underline{t},\underline{d})\right)$ from the type-$\overline{\beta}$ firm.[11]

[11] See Laffont and Tirole (1993). The firm of type $\underline{\beta}$ can always pretend to be of type $\overline{\beta}$ and realize the project

Then, majority 1 (when $\alpha = \alpha^*$) solves:

$$\begin{aligned}\max_{(\underline{d},\bar{d})} W^{M1,D}(\underline{d},\bar{d}) &= \alpha^* \Big[\nu \Big(S - V(\underline{d}) - (1+\lambda)\underline{\beta}(K-\underline{d}) - (1+\lambda)\Delta\beta(K-\bar{d})\Big) \\ &\qquad +(1-\nu)\Big(S - V(\bar{d}) - (1+\lambda)\bar{\beta}(K-\bar{d})\Big)\Big] .\end{aligned}$$

Hence

$$\begin{gathered} V'(\underline{d}_1) = (1+\lambda)\underline{\beta}, \\ V'(\bar{d}_1) = (1+\lambda)\bar{\beta} + (1+\lambda)\frac{\nu}{1-\nu}\Delta\beta. \end{gathered} \tag{1}$$

The values of $\underline{d}_1$ and $\bar{d}_1$ thus depend on λ. Majority 2 (when $\alpha = 1-\alpha^*$), when it is in power, solves:

$$\begin{aligned}\max_{(\underline{d},\bar{d})} W^{M2,D}(\underline{d},\bar{d}) &= \alpha^* \Big[\nu \Big(S - V(\underline{d}) - (1+\lambda)\underline{\beta}(K-\underline{d}) - (1+\lambda-\frac{1}{\alpha^*})\Delta\beta(K-\bar{d})\Big) \\ &\qquad + (1-\nu)\Big(S - V(\bar{d}) - (1+\lambda)\bar{\beta}(K-\bar{d})\Big)\Big].\end{aligned}$$

Hence

$$\begin{gathered} V'(\underline{d}_2) = (1+\lambda)\underline{\beta} \\ V'(\bar{d}_2) = (1+\lambda)\bar{\beta} + (1+\lambda-\frac{1}{\alpha^*})\frac{\nu}{1-\nu}\Delta\beta. \end{gathered} \tag{2}$$

Again, the values of $\underline{d}_2$ and $\bar{d}_2$ depend on λ.

These results can be contrasted with the outcome of the maximization of expected social welfare

$$\begin{aligned}\max_{(\underline{d},\bar{d})} W^{D}(\underline{d},\bar{d}) &= \Big[\nu \Big(S - V(\underline{d}) - (1+\lambda)\underline{\beta}(K-\underline{d}) - \lambda\Delta\beta(K-\bar{d})\Big) \\ &\qquad + (1-\nu)\Big(S - V(\bar{d}) - (1+\lambda)\bar{\beta}(K-\bar{d})\Big)\Big].\end{aligned}$$

with the same informational constraints which yields:

$$\begin{gathered} V'(\underline{d}^*) = (1+\lambda)\underline{\beta} \\ V'(\bar{d}^*) = (1+\lambda)\bar{\beta} + \lambda\frac{\nu}{1-\nu}\Delta\beta. \end{gathered} \tag{3}$$

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with a pollution level of $\bar{d}$ at a cost of $\underline{\beta}(K-\bar{d})$; since it is entitled to a transfer $t(K-\bar{d} \geq \bar{\beta}(K-\bar{d})$, it realizes a profit (rent) of at least $(\bar{\beta}-\bar{\beta})(K-\bar{d})$ which must then be a lower bound on its profit when it acts according to its real type.

The pollution level assigned to or requested from the type-$\underline{\beta}$ firm is always optimal, but that of the $\overline{\beta}$-type firm is either too large (under a majority 1 government) or too low (under a majority 2 government): $\overline{d}_1 > \overline{d}^* > \overline{d}_2$. These apparently surprising distortions need some explanations. Since both majorities take into account the negative externality of pollution, they differ only in their treatment of the informational rent. Majority 1 overvalues the social cost of the firm's informational rent [it uses a weight of $(1+\lambda)$ instead of λ]. For that majority, the cost of inducing abatement is larger than its social cost because of the unavoidable informational rent and therefore majority 1's regulation leads to a larger than optimal level of pollution from the $\overline{\beta}$-type. Majority 2 undervalues the social cost of the firm's informational rent [it uses a weight of $(1+\lambda-1/\alpha^*) < \lambda$]. For that majority, the cost of inducing abatement is therefore smaller than its social cost because its members share the informational rent. Therefore majority 2's regulation leads to a smaller than optimal level of pollution from the $\overline{\beta}$-type.

The gain from political delegation comes through the dependence of $\overline{d}$ on λ. The cost of such delegation is the excessive fluctuation around $\overline{d}^*(\lambda)$. Alternatively, the constitutional regulator may impose the pooling mechanism $((\overline{t}^P,\overline{d}^P),(\underline{t}^P,\underline{d}^P))$ which depends on β and the expected value of λ but not on any particular value of λ and therefore not on the majority in power. Hence the maximization program:

$$\begin{aligned}\max_{(\underline{d},\overline{d})} W^{P\lambda}(\underline{d},\overline{d}) &= \Big[\nu\Big(S - V(\underline{d}) - (1+E\lambda)\underline{\beta}(K-\underline{d}) - (E\lambda)\Delta\beta(K-\overline{d})\Big) \\ &\quad + (1-\nu)\Big(S - V(\overline{d}) - (1+E\lambda)\overline{\beta}(K-\overline{d})\Big)\Big]\end{aligned}$$

yielding

$$V'(\underline{d}^P) = (1+E\lambda)\underline{\beta}$$
$$V'(\overline{d}^P) = (1+E\lambda)\overline{\beta} + (E\lambda)\frac{\nu}{1-\nu}\Delta\beta. \tag{4}$$

The pollution levels $\underline{d}^P$ and $\overline{d}^P$ now depend only on $E\lambda$.

The emergence of the rather sophisticated incentive mechanism which depends on λ hinges on its ex ante comparison with the "pooling" mechanism obtained above. We will carry out this comparison for small asymmetries of information represented by $\Delta\beta$. First, we observe that for $\underline{\beta} = \overline{\beta}$, the linearity of the problem in λ implies that both mechanisms implement the same pollution level d^0. We compare the two mechanisms by computing the second derivatives[12] of expected social welfare with respect to $\overline{\beta}$ at $\overline{\beta} = \underline{\beta}$. For the "pooling" mechanism (and $\nu = \frac{1}{2}$) we obtain in particular (see Appendix 1):

$$\left.\frac{d^2 W^{P\lambda}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = [\frac{1}{2} + 2E\lambda + 2(E\lambda)^2]\frac{1}{V''(d^0)}.$$

For the case of "political discrimination", we obtain (assuming that each majority is in power half the time) the expected social welfare $E_\lambda W^D$

$$E_\lambda W^D = \frac{1}{2}E_\lambda W_1^D(\underline{d}_1, \overline{d}_1) + \frac{1}{2}E_\lambda W_2^D(\underline{d}_2, \overline{d}_2)$$

where $W_m^D(\cdot,\cdot)$ is the social welfare when majority m decides, that is, simply $W^D(\underline{d}_m, \overline{d}_m)$. Therefore (assuming $\nu = \frac{1}{2}$)

$$\left.\frac{d^2 E_\lambda W^D}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = [\frac{1}{(2\alpha^*)^2}(2\alpha^* - 1) + 2E\lambda + 2(E\lambda)^2 + 2Var(\lambda)]\frac{1}{V''(d^0)}.$$

More generally, the comparison between $W^{P\lambda}$ and $E_\lambda W^D$ can be summarized in:

<u>Proposition 1</u>: *For $\overline{\beta}$ close to $\underline{\beta}$, there exists a function $v^*(\nu, \alpha^*)$,*

$$v^*(\nu, \alpha^*) = \nu^2\left(\frac{\alpha^{*2} - \alpha + \frac{1}{2}}{\alpha^{*2}}\right) > 0$$

increasing in ν and decreasing in α^*, such that for $Var(\lambda) > v^*(\nu, \alpha^*)$, $E_\lambda W^D$ is larger than $W^{P\lambda}$, that is, political discrimination [letting each majority choose a discriminatory mechanism with the pollution levels depending on λ] is better than social pooling [determining a unique discriminatory mechanism $(\underline{d}^P, \overline{d}^P)$ irrespective of the value of λ and therefore valid for both majorities].
(see Appendix 1 for a proof).

For $Var(\lambda) = 0$, social pooling is optimal and dominates political discrimination when $\overline{\beta}$ is close to $\underline{\beta}$. Indeed, discrimination on the basis of λ has then no value. But as $Var(\lambda)$ increases, the value of adjusting policies to the realized value of λ increases and therefore it becomes better to leave political majorities greater latitude in setting policies. A larger α^*

[12] The first derivatives with respect to $\overline{\beta}$ evaluated at $\overline{\beta} = \underline{\beta}$ are negative and equal.

(above $\frac{1}{2}$ by assumption) also favors political discrimination for a given $Var(\lambda)$. This is because as α^* increases, the difference between the objective functions of the majorities and the social welfare function decreases (the difference is maximal for $\alpha^* = \frac{1}{2}$). On the contrary, a larger ν favors pooling, because it makes more likely the existence of rents and the cost of political discrimination is related to excessive variations in those rents.

In this context, the emergence of sophisticated incentive mechanisms would arise from a greater variability of the social opportunity cost of public funds (larger variance of λ), stronger majorities (larger α^*) and a higher probability of type-$\overline{\beta}$ firms (smaller ν).

Finally, we may wonder if the constitutional reform of moving toward an incentive mechanism may emerge from unanimous *ex ante* consent and not simply by appealing to *ex ante* social welfare maximization. For this purpose we can compare *ex ante* the per capita welfare of the two types of agents. We obtain:

<u>Proposition 2</u> : *For $\overline{\beta}$ close to $\underline{\beta}$, type 1 agents prefer political discrimination [as defined in Proposition 1] over social pooling [as defined in Proposition 1] iff*

$$Var(\lambda) > v^{1*}(\nu,\alpha^*) \equiv \nu^2\left(\frac{\frac{1}{2}-\alpha^{*2}}{\alpha^{*2}}\right) < v^*(\nu,\alpha^*)$$

while type 2 agents prefer political discrimination iff

$$Var(\lambda) > v^{2*}(\nu,\alpha^*) \equiv \nu^2\left(\frac{2\alpha^* - \alpha^{*2} - \frac{1}{2}}{\alpha^{*2}}\right) > v^*(\nu,\alpha^*).$$

(see Appendix 1 for a proof).

In this context. environmentalists would be here more active proponents of incentive regulation than producers. If unanimous approval is needed for constitutional reform in favor of discriminatory mechanism, it will happen less often than socially desirable because $v^{1*}(\nu,\alpha^*) < v^*(\nu,\alpha) < v^{2*}(\nu,\alpha^*)$.

3.3 Simpler Constitutional Rules

We consider now the case of a pooling mechanism over β rather than over λ. Each majority can only select a single quota level (as a function of λ), not a menu of quotas. Accordingly, we will compare the large political discrimination allowed in section 3.2 (that we interpreted as a sophisticated incentive regulation) with the constitutional rule that lets the politicians choose the mechanism as a function of λ, but impose a pooling mechanism in β, typically a simple command and control mechanism.

If type 1 agents have the majority they solve

$$\max_d W^{M1,P\beta} = \alpha^*[S - V(d) - (1+\lambda)E\beta(K-d) - \nu(1+\lambda)\Delta\beta(K-d)]$$

yielding

$$V'(d_1) = (1+\lambda)\, E\beta + (1+\lambda)\, \nu\Delta\beta. \tag{5}$$

Similarly, majority 2 solves

$$\max_d W^{M2,P\beta} = \alpha^*[S - V(d) - (1+\lambda)E\beta(K-d) - \nu(1+\lambda - \frac{1}{\alpha^*})\Delta\beta(K-d)]$$

yielding

$$V'(d_2) = (1+\lambda)E\beta + (1+\lambda - \frac{1}{\alpha^*})\nu\Delta\beta. \tag{6}$$

Therefore, we obtain a social welfare level given by (assuming that each majority is in power half the time):

$$\begin{aligned} W^{P\beta} &= \tfrac{1}{2}W_1^{P\beta}(d_1) + \tfrac{1}{2}W_2^{P\beta}(d_2) \\ &= \tfrac{1}{2}\,[S - V(d_1) - (1+\lambda)E\beta(K-d_1)\nu\lambda\Delta\beta(K-d_1)] \\ &\quad + \tfrac{1}{2}\,[S - V(d_2) - (1+\lambda)E\beta(K-d_2)\nu\lambda\Delta\beta(K-d_2)] \end{aligned}$$

where $W_m^{P\beta}(\cdot)$ is the social welfare when majority $m \in \{1,2\}$ decides. Comparing $E_\lambda W^{P\beta}$ and $E_\lambda W^D$, we obtain:

Proposition 3: *For $\overline{\beta}$ close enough to $\underline{\beta}$, we have $E_\lambda W^{P\beta} > E_\lambda W^D$, that is, the pooling mechanism selected by majorities [a single non-discriminatory (valid for all β) pollution level chosen by the majorities as a function of λ and of their private agendas] dominates the incentive mechanism chosen by the majorities [letting each majority choose discriminatory (function of β) pollution levels as a function of λ and of their private agendas] iff*

$$H(\nu,\ \alpha^*,\ E\lambda,\ Var(\lambda)) \equiv \nu^2\left(\frac{\alpha^* - \frac{1}{2}}{\alpha^{*2}}\right) + 1 - 2\nu + 2(1-\nu)E\lambda + (E\lambda)^2 + \ Var(\lambda) < 0.$$

(See Appendix 2 for a proof).

For quadratic $V(\cdot)$ functions, the social welfare values are all quadratic in $\overline{\beta}$. We can derive then the global superiority of the pooling mechanism or the discriminatory mechanism from Proposition 3 and the fact that all welfare levels coincide at $\overline{\beta} = \underline{\beta}$. However, for more general $V(\cdot)$ functions, the increase in $\overline{\beta}$, which is favorable to the discriminatory mechanism, may lead to the superiority of the discriminatory mechanism when $H(\cdot) < 0$, that is when the pooling mechanism dominates for small $\overline{\beta}$. [See Figure 1A and 1B for examples].

[Figure 1A here]

[Figure 1B here]

In this context, the emergence of sophisticated incentive mechanisms would be associated with increases in $\Delta\beta$, the differential efficiency of the firms, that is the importance of the asymmetric information. From $H(\cdot)$, it is also associated with increases in $E\lambda$, in $Var(\lambda)$, in α^* and with decreases in ν.[13]

3.4 Quotas versus Discretion

We assume now that λ is commonly known and that the constitution may impose a single quota of pollution independent of the information about β and common to both majorities. Maximizing the *ex ante* social welfare, we obtain:

$$W^{P\beta}(d) = S - V(d) - (1+\lambda)E\beta(K-d) - \nu\lambda\Delta\beta(K-d)$$

yielding

$$V'(d^P) = (1+\lambda)E\beta + \lambda\nu\Delta\beta. \tag{7}$$

Proposition 4 : *For $\overline{\beta}$ close enough to $\underline{\beta}$, the pooling mechanism [a pollution level function of λ but independent of β and the majority in power] dominates political discrimination iff*

$$1 - \frac{1}{\nu}E_\lambda(1+\lambda-\nu)^2 > \frac{\alpha^* - \frac{1}{2}}{\alpha^{*2}}. \tag{8}$$

[See Appendix 2 for a proof]

[13] The function $H(\cdot)$ is increasing with $E\lambda$, $Var(\lambda)$ and α^* but decreasing with ν.

For small $\Delta\beta$, the lack of flexibility due to pooling may be less damaging than the excessive discrimination imposed by political majorities and the more so that α^* is close to $\frac{1}{2}$, $E\lambda$ is small, $Var(\lambda)$ is small and ν is large. We can expect that political discrimination will become more valuable as $\Delta\beta$ increases for parameter values such that pooling dominates when $\Delta\beta$ is small enough, that is, for which (8) is satisfied [See Figure 2 for an example].

[Figure 2 here]

In this context, the emergence of sophisticated incentive mechanisms would again be associated with increases in $\Delta\beta$, the differential efficiency of the firms, that is the importance of the asymmetric information. From (8), it is also associated with increases in $E\lambda$, in $Var(\lambda)$, in α^* and with decreases in ν.

4 THE EFFECT OF REELECTION CONSTRAINTS ON THE CONSTITUTIONAL CHOICE OF INSTRUMENTS

As a short cut to a full dynamic model, we will consider a two period model. Period 2 is analogous to the single period of the previous section and each majority exploits to the full extent possible its power to pursue its private agenda. However, in period 1, the majorities take account of the fact that an excessive pursuit of their private interests decreases their probability of reelection in period 2. In the case of political discrimination of section 3.2, we will assume that the probability of reelection of majority 1 depends on the difference between the impact of its policies $(\underline{d}, \overline{d})$ and those which would maximize social welfare $(\underline{d}^*, \overline{d}^*)$, that is[14]

$$\frac{1}{2} - \frac{k}{2}(\overline{d} - \overline{d}^*)^2$$

where $\overline{d}^*$ is given by (3). When in power, majority 1 ponders in period 1 the pursuit of its period 1 gain and the gains from being reelected next period. Therefore, it maximizes over $(\underline{d}, \overline{d})$ the following per capita welfare function of type 1 agents

$$W^{M1,D}(\underline{d}, \overline{d}) + \delta\left(\frac{1}{2} - \frac{k}{2}(\overline{d} - \overline{d}^*)^2\right) E^{M1}$$

[14] Note that $\underline{d}_1 = \underline{d}^*$.

where δ is the discount factor, k a parameter of sensitivity of the electorate to the majority's behavior in period 1 and E^{M1} is the stake of winning the election, that is, the difference between the welfare of a type 1 agent with majority 1 in power and his welfare with majority 2 in power.[15]

Assuming that $V(d) = \frac{1}{2}d^2$, we can solve for the choice of majority 1 in period 1. We obtain $\hat{\underline{d}}_1 = \underline{d}_1 = (1+\lambda)\underline{\beta} = \underline{d}^*$ and

$$\hat{\overline{d}}_1 = d^* + \frac{\overline{d}_1 - \overline{d}^*}{1+\delta k E^{M1}}$$

where $\overline{d}_1$ is given by (1) and $\overline{d}^*$ by (3). Similarly for majority 2, we obtain $\hat{\underline{d}}_2 = \underline{d}_2 = (1+\lambda)\underline{\beta} = \underline{d}^*$ and

$$\hat{\overline{d}}_2 = \overline{d}^* + \frac{\overline{d}_2 - \overline{d}^*}{1+\delta k E^{M2}}$$

where $\overline{d}_2$ is given by (2).

The expected first period social welfare under reelection considerations is given by

$$E_\lambda \widehat{W}^D = \frac{1}{2}E_\lambda W_1^D(\hat{\underline{d}}_1, \hat{\overline{d}}_1) + \frac{1}{2}E_\lambda W_2^D(\hat{\underline{d}}_2, \hat{\overline{d}}_2)$$

where $\hat{\underline{d}}_1 = \hat{\underline{d}}_2 = (1+\lambda)\underline{\beta}$ as before. In the case of social pooling of section (3.4), nothing is changed when reelection considerations are raised since politicians have no role and expected social welfare is given by

$$E_\lambda W^{P3}(d^p)$$

with d^p obtained from (7). We can now illustrate the fact that in a situation calling originally for pooling (condition (8) satisfied and δ or k equal to 0). the greater sensitivity of the electorate to excessive pursuit of private agendas and the greater desire of politicians to remain in power (positive δ and k and increasing δ or k) lead to the emergence of incentive mechanisms [See Figure 3 for an example]. Indeed, for δ or k large enough, the social welfare superiority of political discrimination over pooling appears.

[Figure 3 here]

In this context, the emergence of sophisticated incentive mechanisms would therefore be associated with increases in δ, the desire of politicians to remain in power over time, and increases in k, the greater dislike by the electorate of excessive pursuit of private agendas.

[15] $E^{M1} = W^{M1,D}(\underline{d}_1, \overline{d}_1) - W^{M1,D}(\underline{d}_2, \overline{d}_2)$ and $E^{M2} = W^{M2,D}(\underline{d}_2, \overline{d}_2) - W^{M2,D}(\underline{d}_1, \overline{d}_1)$ where $\underline{d}_1 = \underline{d}_2 = (1+\lambda)\underline{\beta}$. $\overline{d}_1$ is given by (1) and $\overline{d}_2$ is given by (2).

5 REELECTION CONSTRAINTS AND MULTIPLE PRIVATELY INFORMED INTEREST GROUPS

In the previous sections we have seen how the delegation to politicians of economic policy (here the choice of incentive mechanisms) enables them to distribute informational rents to interest groups. In this section we want to explore the extent to which competing interest groups may mitigate the distortions in the allocation of resources that politicians might find profitable. For this purpose, we extend the model by also introducing asymmetric information about the damages of pollution. In the same way as β is private information of producers, the disutility of pollution is now $\theta V(d)$ for $\theta \in \{\underline{\theta}, \overline{\theta}\}$, with $\Delta\theta = \overline{\theta} - \underline{\theta}$ and $\mu = Prob(\underline{\theta})$. The parameter θ is private information of the environmentalists. Environmentalists (type 1 agents) have now obtained to be compensated and their utility level is

$$U_1 = s - \theta V(d)$$

where s is the transfer from the government. The producers (type 2 agents) have now utility:

$$U_2 = t - \beta(K - d)$$

and taxpayers who are now distinct from producers and environmentalists have utility:

$$U_3 = S - (1 + \lambda)(t + s).$$

Utilitarian social welfare is

$$W = U_1 + U_2 + U_3 = S - (1 + \lambda)\left(\beta(K - d) + \theta V(d)\right) - \lambda(U_1 + U_2).$$

Under complete information the optimal pollution is characterized now[16] by $\theta V'(d) = \beta$. Under incomplete information a revelation mechanism is now a triple $\{d(\beta, \theta), t(\beta, \theta), s(\beta, \theta)\}$. The relevant incentive and individual rationality constraints are:

$$E_\theta\{t(\underline{\beta}, \theta) - \underline{\beta}(K - d(\underline{\beta}, \theta))\} \geq E_\theta\{t(\overline{\beta}, \theta) - \underline{\beta}(K - d(\overline{\beta}, \theta))\}$$
$$E_\theta\{t(\overline{\beta}, \theta) - \overline{\beta}(K - d(\overline{\beta}, \theta))\} \geq 0$$

[16] Having an individual rationality constraint for the environmentalists amounts to assuming that they are indemnified at a social cost of $(1 + \lambda)$. This is why we obtain now $\theta V'(d) = \beta$ instead of $\theta V'(d) = (1 + \lambda)\beta$.

$$E_\beta\{s(\beta,\underline{\theta}) - \underline{\theta}V(d(\beta,\underline{\theta}))\} \geq E_\beta\{s(\beta,\overline{\theta}) - \underline{\theta}V(d(\beta,\overline{\theta}))\}$$
$$E_\beta\{s(\beta,\overline{\theta}) - \overline{\theta}V(d(\beta,\overline{\theta}))\} \geq 0$$

Since the individual rationality constraints are binding, the expected rents for the type-$\underline{\beta}$ producer and type-$\underline{\theta}$ environmentalist are

$$\underline{U}_2 = E_\theta \Delta\beta(K - d(\overline{\beta},\theta))$$

$$\underline{U}_1 = E_\beta \Delta\theta V(d(\beta,\overline{\theta})).$$

Substituting in the social welfare function we obtain:

$$\begin{aligned} W^D(\vec{d}) = E_{\mu,\nu}W \;&=\; \nu\mu[S - (1+\lambda)(\underline{\beta}(K - d(\underline{\beta},\underline{\theta})) + \underline{\theta}V(d(\underline{\beta},\underline{\theta})))] \\ &+\nu(1-\mu)[S - (1+\lambda)(\underline{\beta}(K - d(\underline{\beta},\overline{\theta})) + \overline{\theta}V(d(\underline{\beta},\overline{\theta})))] \\ &+(1-\nu)\mu[S - (1+\lambda)(\overline{\beta}(K - d(\overline{\beta},\underline{\theta})) + \underline{\theta}V(d(\overline{\beta},\underline{\theta})))] \\ &+(1-\nu)(1-\mu)[S - (1+\lambda)(\overline{\beta}(K - d(\overline{\beta},\overline{\theta})) + \overline{\theta}V(d(\overline{\beta},\overline{\theta})))] \\ &-\lambda\nu\Delta\beta[\mu(K - d(\overline{\beta},\underline{\theta})) + (1-\mu)(K - d(\overline{\beta},\overline{\theta}))] \\ &-\lambda\mu\Delta\theta[\nu V(d(\underline{\beta},\overline{\theta})) + (1-\nu)V(d(\overline{\beta},\overline{\theta}))] \end{aligned}$$

with $\vec{d} = \left(d(\underline{\beta},\underline{\theta}),\ d(\underline{\beta},\overline{\theta}),\ d(\overline{\beta},\underline{\theta}),\ d(\overline{\beta},\overline{\theta})\right)$.

Assuming Bayesian Nash behavior of producers and environmentalists, the revelation mechanism which maximizes social welfare under incentive and individual rationality constraints is characterized by

$$\begin{aligned}
\underline{\theta} V'(d(\underline{\beta},\underline{\theta})) &= \underline{\beta} \\
\left(\overline{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta\right) V'(d(\underline{\beta},\overline{\theta})) &= \underline{\beta} \\
\underline{\theta} V'(d(\overline{\beta},\underline{\theta})) &= \overline{\beta} + \frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\Delta\beta \\
\left(\overline{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta\right) V'(d(\overline{\beta},\overline{\theta})) &= \overline{\beta} + \frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\Delta\beta.
\end{aligned}$$

That is, with $V(d) = \frac{1}{2}d^2$,

$$\begin{aligned}
d(\underline{\beta},\underline{\theta}) &= \underline{\beta}\underline{\theta}^{-1} \\
d(\underline{\beta},\overline{\theta}) &= \underline{\beta}\left(\overline{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta\right)^{-1} \\
d(\overline{\beta},\underline{\theta}) &= \left(\overline{\beta} + \frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\Delta\beta\right)\underline{\theta}^{-1} \\
d(\overline{\beta},\overline{\theta}) &= \left(\overline{\beta} + \frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\Delta\beta\right)\left(\overline{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta\right)^{-1}
\end{aligned}$$

Let us assume that the two interest groups use a share of their informational rent as campaign contributions to influence politicians. We consider as in section 4 a two period model. In period 2, the majority 1 is able to favor the interests of environmentalists by maximizing, with $\overrightarrow{d_1} = \left(d_1(\underline{\beta},\underline{\theta}),\ d_1(\underline{\beta},\overline{\theta}),\ d_1(\overline{\beta},\underline{\theta}),\ d_1(\overline{\beta},\overline{\theta})\right)$,

$$W^{M1,D}(\overrightarrow{d_1}) = E_{\mu,\nu}[S - (1+\lambda)(\beta(K-d) + \theta V(d))] - \lambda\mu\underline{U}_1 - (1+\lambda)\nu\underline{U}_2,$$

that is, by not including in its objective function the rent of the producers. This results in a second period regulation characterized by:

$$\begin{aligned}
\underline{\theta} V'(d_1(\underline{\beta},\underline{\theta})) &= \underline{\beta} \\
\left(\overline{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta\right) V'(d_1(\underline{\beta},\overline{\theta})) &= \underline{\beta} \\
\underline{\theta} V'(d_1(\overline{\beta},\underline{\theta})) &= \overline{\beta} + \frac{\nu}{1-\nu}\Delta\beta \\
\left(\overline{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta\right) V'(d_1(\overline{\beta},\overline{\theta})) &= \overline{\beta} + \frac{\nu}{1-\nu}\Delta\beta.
\end{aligned}$$

Similarly, if elected, majority 2 maximizes, with $\overrightarrow{d_2} = \left(d_2(\underline{\beta},\underline{\theta}), d_2(\underline{\beta},\overline{\theta}), d_2(\overline{\beta},\underline{\theta}), d_2(\overline{\beta},\overline{\theta})\right)$,

$$W^{M2,D}(\overrightarrow{d_2}) = E_{\mu,\nu}[S - (1+\lambda)(\beta(K-d) + \theta V(d))] - (1+\lambda)\mu\underline{U}_1 - \lambda\nu\underline{U}_2$$

yielding a second period regulation characterized by:

$$\begin{aligned}
\underline{\theta} V'(d_2(\underline{\beta},\underline{\theta})) &= \underline{\beta} \\
\left(\overline{\theta}+\frac{\mu}{1-\mu}\Delta\theta\right) V'(d_2(\underline{\beta},\overline{\theta})) &= \underline{\beta} \\
\underline{\theta} V'(d_2(\overline{\beta},\underline{\theta})) &= \overline{\beta}+\frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\Delta\beta \\
\left(\overline{\theta}+\frac{\mu}{1-\mu}\Delta\theta\right) V'(d_2(\overline{\beta},\overline{\theta})) &= \overline{\beta}+\frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\Delta\beta.
\end{aligned}$$

The stake of winning the election for period 2 is now, for majority 1,

$$E^{M1} = W^{M1,D}(\overrightarrow{d_1}) - W^{M1,D}(\overrightarrow{d_2})$$

and, for majority 2,

$$E^{M2} = W^{M2,D}(\overrightarrow{d_2}) - W^{M2,D}(\overrightarrow{d_1})$$

where

$$W^{M1,D}(\cdot) = W^D(\cdot) - \nu\underline{U}_2$$

$$W^{M2,D}(\cdot) = W^D(\cdot) - \mu\underline{U}_1$$

with obvious notations.

Let us assume that each majority makes campaign contributions C_1 and C_2 which are fixed proportions ζ, assumed equal for both majorities, of their average rents, that is,

$$\begin{aligned}
C_1 &= \zeta\mu\underline{U}_1 \\
C_2 &= \zeta\nu\underline{U}_2
\end{aligned}$$

with

$$\begin{aligned}
\underline{U}_1 &= \Delta\theta[\nu V(d(\underline{\beta},\overline{\theta})) + (1-\nu)V(d(\overline{\beta},\overline{\theta}))] \\
\underline{U}_2 &= \Delta\beta[\mu(K - d(\overline{\beta},\underline{\theta})) + (1-\mu)(K - d(\overline{\beta},\overline{\theta}))]
\end{aligned}$$

These campaign contributions affect the probability of winning the election that follows.For majority 1, the probability of winning is assumed to be:

$$\Psi = \frac{1}{2} + \frac{1}{2}g\zeta(\mu\underline{U}_1 - \nu\underline{U}_2)$$

where g is a parameter representing the importance of campaign contributions in the electoral process. Majority 1 maximizes

$$W^{M1,D}(\overrightarrow{\hat{d}_1}) + \delta\Psi E^{M1}(\overrightarrow{\hat{d}_1})$$

leading to

$$\begin{aligned}
\underline{\theta} V'(\hat{d}_1(\underline{\beta},\underline{\theta})) &= \underline{\beta} \\
\left(\bar{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta - \frac{1}{2}\frac{\delta E^{M1} g\zeta\Delta\theta\mu}{(1+\lambda)(1-\mu)}\right) V'(\hat{d}_1(\underline{\beta},\bar{\theta})) &= \underline{\beta} \\
\underline{\theta} V'(\hat{d}_1(\bar{\beta},\underline{\theta})) &= \bar{\beta} + \frac{\nu}{1-\nu}\Delta\beta + \frac{1}{2}\frac{\delta E^{M1} g\zeta\Delta\beta\nu}{(1+\lambda)(1-\nu)} \\
\left(\bar{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta - \frac{1}{2}\frac{\delta E^{M1} g\zeta\Delta\theta\mu}{(1+\lambda)(1-\mu)}\right) V'(\hat{d}_1(\bar{\beta},\bar{\theta})) &= \bar{\beta} + \frac{\nu}{1-\nu}\Delta\beta + \frac{1}{2}\frac{\delta E^{M1} g\zeta\Delta\beta\nu}{(1+\lambda)(1-\nu)}.
\end{aligned}$$

Let $\overrightarrow{\hat{d}_1} = \left(\hat{d}_1(\underline{\beta},\underline{\theta}),\ \hat{d}_1(\underline{\beta},\bar{\theta}),\ \hat{d}_1(\bar{\beta},\underline{\theta}),\ \hat{d}_1(\bar{\beta},\bar{\theta})\right)$. In comparison with the static case, the environmentalists majority increases the pollution levels in all cases, except in the case $(\underline{\beta},\underline{\theta})$. The reason is that it was before only interested in decreasing the producers' rent (with respect to the social optimum) because it undervalued this rent in its objective function. Now, in addition, it wishes to increase further its own rent in order to increase its probability of winning the election through its campaign contributions and furthermore it wishes to decrease even further the producers' rent for the same reason.

We obtain symmetric results for the producers' majority:

$$\begin{aligned}
\underline{\theta} V'(\hat{d}_2(\underline{\beta},\underline{\theta})) &= \underline{\beta} \\
\left(\bar{\theta} + \frac{\mu}{1-\mu}\Delta\theta + \frac{1}{2}\frac{\delta E^{M2} g\zeta\Delta\theta\mu}{(1+\lambda)(1-\mu)}\right) V'(\hat{d}_2(\underline{\beta},\bar{\theta})) &= \underline{\beta} \\
\underline{\theta} V'(\hat{d}_2(\bar{\beta},\underline{\theta})) &= \bar{\beta} + \frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\Delta\beta - \frac{1}{2}\frac{\delta E^{M2} g\zeta\Delta\beta\nu}{(1+\lambda)(1-\nu)} \\
\left(\bar{\theta} + \frac{\lambda}{1+\lambda}\frac{\mu}{1-\mu}\Delta\theta + \frac{1}{2}\frac{\delta E^{M2} g\zeta\Delta\theta\mu}{(1+\lambda)(1-\mu)}\right) V'(\hat{d}_2(\bar{\beta},\bar{\theta})) &= \bar{\beta} + \frac{\nu}{1-\nu}\Delta\beta - \frac{1}{2}\frac{\delta E^{M2} g\zeta\Delta\beta\nu}{(1+\lambda)(1-\nu)}.
\end{aligned}$$

Let $\overrightarrow{\hat{d}_2} = \left(\hat{d}_2(\underline{\beta},\underline{\theta}),\ \hat{d}_2(\underline{\beta},\bar{\theta}),\ \hat{d}_2(\bar{\beta},\underline{\theta}),\ \hat{d}_2(\bar{\beta},\bar{\theta})\right)$. In comparison with the static case, the producers majority decreases the pollution levels in all cases, except in the case $(\underline{\beta},\underline{\theta})$. The reason is similar that for which the environmentalists were increasing the pollution levels. Recalling the social welfare function $W = U_1 + U_2 + U_3$, let

$$E_\lambda \widehat{\widehat{W}}^D = \frac{1}{2}E_\lambda W^D(\vec{\vec{d}}_1) + \frac{1}{2}E_\lambda W^D(\vec{\vec{d}}_2).$$

The above discriminatory mechanism is to be compared with a pooling mechanism which restrict the choice of each majority to a unique pollution level (varying with λ) irrespective of the particular values of β and θ. We have:

$$\begin{aligned} W^{P\beta\theta}(d) &= S - (1+\lambda)\Big((\nu\underline{\beta} + (1-\nu)\overline{\beta})(K-d) + (\mu\underline{\theta} + (1-\mu)\overline{\theta})V(d)\Big) \\ &\quad -\lambda\mu\Delta\theta V(d) - \lambda\nu\Delta\beta(K-d) \end{aligned}$$

yielding, with $V(d) = \frac{1}{2}d^2$,

$$d^p = \frac{\nu\underline{\beta} + (1-\nu)\overline{\beta} + \frac{\lambda}{1+\lambda}\nu\Delta\beta}{\mu\underline{\theta} + (1-\mu)\overline{\theta} + \frac{\lambda}{1+\lambda}\mu\Delta\theta}$$

The desire to use powerful incentive schemes leads now to two types of additional distortions. First, campaign contributions are losses from a welfare point of view and second, efficiency distortions are reinforced. In a situation where pooling is dominated in the static case, we may expect for g, ζ or δ large enough the domination of pooling [See Figure 4A, 4B and 4C for an example].

[Figure 4A here]

[Figure 4B here]

[Figure 4C here]

In this context, the emergence of sophisticated incentive mechanisms would therefore be associated with decreases in δ, the desire of politicians to remain in power over time, decreases in g, the importance of campaign contributions in the electoral process and decreases in ζ, the willingness of agents to make campaign contributions out of their informational rents. The presence of multiple interest groups may transform valuable reforms towards incentive mechanisms into undesirable reforms: these mechanisms raise the stake of political conflicts generating other distortions.[17]

[17]This negative effect should be combined with the positive reputation effect of section 4.

6 CONCLUSION

We have interpreted the political economy of environmental policy as an analysis of the economic implications of politicians' discretion in pursuing the private agendas of their electoral base: some voters are more concerned than others by pollution, some voters have stakes in the rents of the polluting firms.

Sophisticated environmental policy is dependent on non verifiable variables which cannot be contracted upon in the constitution. Consequently it must be delegated to politicians, creating an incentive problem when politicians' motivations are to stay in power by pleasing a majority of voters and not to maximize social welfare. We have studied in this paper the severity of this incentive problem. We have shown that the larger the social cost of public funds is (larger $E\lambda$) and the greater the variability of economic variables ($Var(\lambda)$, $\Delta\beta$, $\Delta\theta$) is, the more valuable flexibility is and therefore the greater the delegation of authority to politicians should be. However, the thinner majorities are (the lower α^* is) or the larger the informational rents are (the larger ν and/or the larger μ are), the more the politicians' objectives are biased away from social welfare, providing a justification of cruder environmental policies which leave them less discretion.

Reelection considerations lead to conflicting influences on this basic trade-off. If, through reputation effects and a better social control (a larger k), pursuing excessively private agendas today is costly for the next election, more sophisticated environmental policies may emerge as socially optimal. On the contrary, if the campaign contributions favoring reelection are important (larger g) and significantly related (larger ζ) to the informational rents of the various interest groups, politicians are led to greater distortions to favor even more the interest groups supporting them. When this is added to the waste of campaign contributions themselves, it favors giving up sophisticated policies which become costly political stakes. Depending on the relative importance of these conflicting effects of reelection considerations, a longer term view in politics (larger δ) favors (if the k-effect dominates the combined g-effect and ζ-effect) or not (otherwise) the emergence of sophisticated market based or incentive mechanisms.

A APPENDIX 1

A.1 Proof of Proposition 1

Consider first the case of social pooling. From the envelop theorem,

$$\frac{dW^{P\lambda}}{d\overline{\beta}} = -[\nu E\lambda + (1-\nu)(1+E\lambda)](K - \overline{d}^P) < 0 \tag{9}$$

From the definition of $\overline{d}^P$ in (4),

$$\left.\frac{d\overline{d}^P}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}} = \frac{1+E\lambda-\nu}{(1-\nu)V''(d^0)}. \tag{10}$$

We have

$$\begin{aligned}
\left.\frac{d^2W^{P\lambda}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} &= (1+E\lambda-\nu)\left.\frac{d\overline{d}^P}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}} \\
&= \frac{(E\lambda+(1-\nu))^2}{(1-\nu)V''(d^0)} \\
&= \frac{\nu^2+1-2\nu+2(1-\nu)E\lambda+(E\lambda)^2}{(1-\nu)V''(d^0)}.
\end{aligned} \tag{11}$$

Consider now the case of discrimination. Social welfare when majority 1 decides, W_1^D, can be written as

$$W_1^D = \frac{W^{M1,D}}{\alpha^*} + \nu\Delta\beta(K - \overline{d}_1) \tag{12}$$

where W^{M1} is the objective function of majority 1. Using the envelope theorem for W^{M1} we have

$$\frac{dW_1^D}{d\overline{\beta}} = -(1+\lambda-\nu)(K-\overline{d}) - \nu\Delta\beta\frac{d\overline{d}_1}{d\overline{\beta}} \tag{13}$$

where from (1),

$$\left.\frac{d\overline{d}_1}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}} = \frac{1+\lambda}{(1-\nu)V''(d^0)} \tag{14}$$

and therefore

$$\left.\frac{d^2 W_1^D}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = \frac{(1+\lambda-2\nu)(1+\lambda)}{(1-\nu)V''(d^0)} \tag{15}$$

Similarly, when majority 2 decides, we have

$$W_2^D = \frac{W^{M2,D}}{\alpha^*} + (1-\frac{1}{\alpha^*})\nu\Delta\beta(K-\overline{d}_2)$$

yielding

$$\frac{dW_2^D}{d\overline{\beta}} = -(1+\lambda-\nu)(K-\overline{d}_2) - (1-\frac{1}{\alpha^*})\nu\Delta\beta\frac{d\overline{d}_2}{d\overline{\beta}}$$

where from (2)

$$\left.\frac{d\overline{d}_2}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}} = \frac{1+\lambda-\nu/\alpha^*}{(1-\nu)V''(d^0)} \tag{16}$$

and therefore

$$\left.\frac{d^2 W_2^D}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = \frac{(1+\lambda-\nu/\alpha^*)}{(1-\nu)V''(d^0)}(1+\lambda+\frac{\nu}{\alpha^*}-2\nu). \tag{17}$$

Hence the expected second derivative at $\overline{\beta}=\underline{\beta}$ in case of discrimination (assuming that each majority is in power half the time) is given by

$$\left.\frac{d^2 E_\lambda W^D}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = \frac{\nu^2\left(\frac{\alpha^*-\frac{1}{2}}{\alpha^{*2}}\right)+1-2\nu+2(1-\nu)E\lambda+(E\lambda)^2+Var(\lambda)}{(1-\nu)V''(d^0)}. \tag{18}$$

The comparison of second derivatives at $\overline{\beta}=\underline{\beta}$ as given by (11) and (18) shows the domination of political discrimination (through a larger second derivative at $\overline{\beta}=\underline{\beta}$) iff

$$\left[Var(\lambda)+\nu^2\left(\frac{\alpha^*-\frac{1}{2}}{\alpha^{*2}}\right)\right] > \nu^2$$

that is, iff

$$Var(\lambda) > v^*(\nu,\alpha^*) \equiv \nu^2\left(\frac{\alpha^{*2}-\alpha^*+\frac{1}{2}}{\alpha^{*2}}\right) > 0.$$

A.2 Proof of Proposition 2

We study now the constitutional choice from the point of view of each majority. Consider first majority 1. Its welfare under the current pooling mechanism is:

$$\begin{aligned} W^{M1,P\lambda}(\underline{d}^P,\overline{d}^P) &= \alpha^* \Big[\nu[S - V(\underline{d}^P) - (1+E\lambda)\underline{\beta}(K-\underline{d}^P) - (1+E\lambda)\Delta\beta(K-\overline{d}^P)] \\ &\quad + (1-\nu)[S-(1+E\lambda)\overline{\beta}(K-\overline{d}^P) - V(\overline{d}^P)]\Big] \\ &= \alpha^* W^{P\lambda}(\underline{d}^P,\overline{d}^P) - \alpha^*\nu\Delta\beta\left(K-\overline{d}^P\right) \end{aligned}$$

Hence, using the envelop theorem,

$$\begin{aligned} \frac{dW^{M1,P\lambda}}{d\overline{\beta}} &= \alpha^*\frac{\partial W^{P\lambda}}{\partial\overline{\beta}} - \alpha^*\nu\left(K-\overline{d}^P\right) + \alpha^*\nu\Delta\beta\frac{d\overline{d}^P}{d\overline{\beta}} \\ \left.\frac{d^2W^{M1,P\lambda}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} &= \alpha^* \left.\frac{d^2W^{P\lambda}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} + 2\alpha^*\nu\left.\frac{d\overline{d}^P}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}} \end{aligned}$$

that is, using (10) and (11),

$$\begin{aligned} \left.\frac{d^2W^{M1,P\lambda}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} &= \frac{\alpha^*}{V''(d^0)}\left[\frac{(1-\nu+E\lambda)^2}{1-\nu} + \frac{2\nu(1+E\lambda-\nu)}{1-\nu}\right] \\ &= \frac{\alpha^*}{V''(d^0)}\left[\frac{(1+E\lambda)^2-\nu^2}{1-\nu}\right] \end{aligned}$$

Its welfare under the discriminatory mechanism if it has the majority is :

$$\begin{aligned} W^{M1,D}\left(\underline{d}_1,\overline{d}_1\right) &= \alpha^*\Big[\nu[S - V(\underline{d}_1) - (1+\lambda)\underline{\beta}(K-\underline{d}_1) - (1+\lambda)\Delta\beta(K-\overline{d}_1)] \\ &\quad + (1-\nu)[S - V\left(\overline{d}_1\right) - (1+\lambda)\overline{\beta}(K-\overline{d}_1)]\Big]. \end{aligned}$$

From the envelop theorem,

$$\begin{aligned} \frac{dW^{M1,D}\left(\underline{d}_1,\overline{d}_1\right)}{d\overline{\beta}} &= -\alpha^*\left[(1+\lambda)\nu\left(K-\overline{d}_1\right) + (1-\nu)(1+\lambda)\left(K-\overline{d}_1\right)\right] \\ &= -\alpha^*(1+\lambda)(K-\overline{d}_1) \end{aligned}$$

and therefore, using (14),

$$\left.\frac{d^2W^{M1,D}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = \alpha^*(1+\lambda)\left.\frac{d\overline{d}_1}{d\beta}\right|_{\overline{\beta}=\underline{\beta}} = \alpha^*\frac{(1+\lambda)^2}{(1-\nu)V''(d^0)}.$$

Its welfare if majority 2 holds is

$$W^{M1,D}\left(\underline{d}_2,\overline{d}_2\right) = (1-\alpha^*)\left[\frac{W^{M2}\left(\underline{d}_2,\overline{d}_2\right)}{\alpha^*} - \frac{\nu}{\alpha^*}\Delta\beta\left(K-\overline{d}_2\right)\right]$$

Using the envelop theorem, we obtain

$$\begin{aligned}\left.\frac{dW^{M1,D}}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}} &= \frac{1-\alpha^*}{\alpha^*}\left.\left(\frac{dW^{M2,D}}{d\overline{\beta}}\right)\right|_{\overline{\beta}=\underline{\beta}} + (1-\alpha^*)\left[\frac{\nu}{\alpha^*}\frac{d\overline{d}_2}{d\beta}\Delta\beta - \frac{\nu}{\alpha^*}\left(K-\overline{d}_2\right)\right] \\ &= (1-\alpha^*)\left[-\nu\left(1+\lambda-\frac{1}{\alpha^*}\right)-(1-\nu)(1+\lambda)\right]\left(K-\overline{d}_2\right) \\ &\quad + \left(\frac{1-\alpha^*}{\alpha^*}\right)\left[\nu\Delta\beta\frac{d\overline{d}_2}{d\beta} - \nu\left(K-\overline{d}_2\right)\right]\end{aligned}$$

$$\begin{aligned}\left.\frac{d^2W^{M1,D}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} &= (1-\alpha^*)\left[1+\lambda+\frac{\nu}{\alpha^*}\right]\left.\frac{d\overline{d}_2}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}} \\ &= (1-\alpha^*)\frac{\left(1+\lambda+\frac{\nu}{\alpha^*}\right)\left(1+\lambda-\frac{\nu}{\alpha^*}\right)}{(1-\nu)V''(d^0)} = \frac{(1-\alpha^*)\left[(1+\lambda)^2-\left(\frac{\nu}{\alpha^*}\right)^2\right]}{(1-\nu)V''(d^0)}\end{aligned}$$

by making use of (16). Comparing the two institutions *ex ante* on a per capita basis, majority 1 prefers the discriminatory mechanism iff

$$\frac{1}{2}\frac{1}{\alpha^*}\left.\frac{d^2E_\lambda W^{M1,D}\left(\underline{d}_1,\overline{d}_1\right)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} + \frac{1}{2}\frac{1}{1-\alpha^*}\left.\frac{d^2E_\lambda W^{M1,D}\left(\underline{d}_2,\overline{d}_2\right)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} > \left.\frac{d^2W^{M1,P\lambda}\left(\underline{d}^P,\overline{d}^P\right)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}}$$

that is, iff

$$(1+E\lambda)^2-\nu^2 < \frac{1}{2}E(1+\lambda)^2 + \frac{1}{2}\left[E(1+\lambda)^2-\left(\frac{\nu}{\alpha^*}\right)^2\right]$$

that is, iff

$$Var(\lambda) > v^{1*}(\nu,\alpha^*) = \nu^2\left(\frac{\frac{1}{2}-\alpha^{*2}}{\alpha^{*2}}\right)$$

which may be positive or negative.

Consider now majority 2. We obtain in a similar way the following expressions under the pooling mechanism:

$$
\begin{aligned}
W^{M2,P\lambda}\left(\underline{d}^P,\overline{d}^P\right) &= \alpha^*\left[W^{P\lambda}\left(\underline{d}^P,\overline{d}^P\right)-\left(1-\tfrac{1}{\alpha^*}\right)\nu\Delta\beta\left(K-\overline{d}^P\right)\right]\\
\frac{dW^{M2,P\lambda}}{d\overline{\beta}} &= \alpha^*\frac{\partial W^{P\lambda}}{\partial\beta}+(1-\alpha^*)\nu[(K-\overline{d}^P)+\Delta\beta\frac{d\overline{d}^P}{d\beta}]\\
\left.\frac{d^2W^{M2,P\lambda}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} &= \alpha^*\frac{(1-\nu+E\lambda)^2}{(1-\nu)V''(d^0)}-2(1-\alpha^*)\nu\frac{d\overline{d}^P}{d\beta}\\
&= \frac{\alpha^*}{(1-\nu)V''(d^0)}\left[(1-\nu+E\lambda)^2-2\frac{(1-\alpha^*)}{\alpha^*}\nu(1+E\lambda-\nu)\right]\\
&= \frac{\alpha^*}{(1-\nu)V''(d^0)}(1-\nu+E\lambda)\left[1+E\lambda-\nu\left(1+\frac{2(1-\alpha^*)}{\alpha^*}\right)\right].
\end{aligned}
$$

Its welfare under the discriminatory mechanism when it has the majority is:

$$
\begin{aligned}
W^{M2,D}\left(\underline{d}_2,\overline{d}_2\right) &= \alpha^*\left[\nu[S-V(\underline{d}_2)-(1+\lambda)\underline{\beta}(K-\underline{d}_2)-\left(1+\lambda-\tfrac{1}{\alpha^*}\right)\Delta\beta\left(K-\overline{d}_2\right)]\right.\\
&\quad\left.+(1-\nu)[S-V\left(\overline{d}_2\right)-(1+\lambda)\overline{\beta}\left(K-\overline{d}_2\right)]\right]
\end{aligned}
$$

Using the envelop theorem, we obtain

$$
\begin{aligned}
\frac{dW^{M2,D}}{d\overline{\beta}} &= \alpha^*\left[-\nu\left(1+\lambda-\frac{1}{\alpha^*}\right)\left(K-\overline{d}_2\right)-(1-\nu)(1+\lambda)\left(K-\overline{d}_2\right)\right]\\
\left.\frac{d^2W^{M2,D}}{d\overline{\beta}_2}\right|_{\overline{\beta}=\underline{\beta}} &= \alpha^*\left[1+\lambda-\frac{\nu}{\alpha^*}\right]\left.\frac{d\overline{d}_2}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}}\\
&= \alpha^*\frac{\left(1+\lambda-\frac{\nu}{\alpha^*}\right)^2}{(1-\nu)V''(d^0)}
\end{aligned}
$$

by using (14). Its welfare if majority 1 holds is

$$W^{M2,D}\left(\underline{d}_1,\overline{d}_1\right) = (1-\alpha^*)\left[\frac{W^{M1,D}\left(\underline{d}_1,\overline{d}_1\right)}{\alpha^*} + \frac{\nu}{\alpha^*}\Delta\beta\left(K-\overline{d}_1\right)\right]$$

$$\frac{dW^{M2,D}\left(\underline{d}_1,\overline{d}_1\right)}{d\overline{\beta}} = (1-\alpha^*)\left[-\nu(1+\lambda)-(1-\nu)(1+\lambda)\right]\left(K-\overline{d}_1\right)$$

$$+\nu\frac{(1-\alpha^*)}{\alpha^*}\left[\left(K-\overline{d}_1\right)-\Delta\beta\frac{d\overline{d}_1}{d\overline{\beta}}\right]$$

$$\frac{d^2W^{M2,D}\left(\underline{d}_1,\overline{d}_1\right)}{d\overline{\beta}^2} = (1-\alpha^*)\left[1+\lambda-2\frac{\nu}{\alpha^*}\right]\left.\frac{d\overline{d}_1}{d\overline{\beta}}\right|_{\overline{\beta}=\underline{\beta}}$$

$$= \frac{1-\alpha^*}{(1-\nu)V''(d^0)}\left[1+\lambda-2\frac{\nu}{\alpha^*}\right](1+\lambda)$$

by using the envelop theorem and (14). Comparing the two institutions *ex ante* on a per capita basis, majority 2 prefers the discriminatory mechanism iff

$$\frac{1}{2}\frac{1}{\alpha^*}\left.\frac{d^2E_\lambda W^{M2,D}\left(\underline{d}_2,\overline{d}_2\right)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} + \frac{1}{2}\frac{1}{1-\alpha^*}\left.\frac{d^2E_\lambda W^{M2,D}\left(\underline{d}_1,\overline{d}_1\right)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} > \left.\frac{d^2W^{M2,P\lambda}\left(\underline{d}^P,\overline{d}^P\right)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}}$$

that is, iff

$$\frac{1}{2}E\left(1+\lambda-\frac{\nu}{\alpha^*}\right)^2+\frac{1}{2}E\left(1+\lambda-2\frac{\nu}{\alpha^*}\right)(1+\lambda) > (1+E\lambda-\nu)\left(1+E\lambda-\nu\left(1+2\frac{1-\alpha^*}{\alpha^*}\right)\right)$$

that is, iff

$$Var(\lambda) > v^{2*}(\nu,\alpha^*) = \nu^2\left(\frac{2\alpha^*-\alpha^{*2}-\frac{1}{2}}{\alpha^{*2}}\right) > 0.$$

B APPENDIX 2

B.1 Proof of Proposition 3

In the case of majority 1 we obtain from (5) and (6)

$$\left.\frac{dd_1}{d\bar{\beta}}\right|_{\bar{\beta}=\underline{\beta}} = \frac{1+\lambda}{V''(d^0)} \tag{19}$$

and

$$\left.\frac{dd_2}{d\bar{\beta}}\right|_{\bar{\beta}=\underline{\beta}} = \frac{1+\lambda-\frac{\nu}{\alpha^*}}{V''(d^0)}. \tag{20}$$

The social welfare, when majority 1 is in power, is given by

$$W_1^{P\beta} = \frac{W^{M1,P\beta}}{\alpha^*} + \nu\Delta\beta(K-d_1)$$

and similarly, the social welfare, when majority 2 is in power, is given by

$$W_2^{P\beta} = \frac{W^{M2,P\beta}}{\alpha^*} + \nu\left(1-\frac{1}{\alpha^*}\right)\Delta\beta(K-d_2).$$

Hence,

$$\left.\frac{dW_1^{P\beta}(d_1)}{d\bar{\beta}}\right|_{\bar{\beta}=\underline{\beta}} = -(1+\lambda-\nu)(K-d_1) - \nu\Delta\beta\frac{dd_1}{d\bar{\beta}}$$

and

$$\left.\frac{dW_2^{P\beta}(d_2)}{d\bar{\beta}}\right|_{\bar{\beta}=\underline{\beta}} = -(1+\lambda-\nu)(K-d_2) - \nu\left(1-\frac{1}{\alpha^*}\right)\Delta\beta\frac{dd_2}{d\bar{\beta}}.$$

Using (19), we obtain

$$\left.\frac{d^2W_1^{P\beta}(d_1)}{d\bar{\beta}^2}\right|_{\bar{\beta}=\underline{\beta}} = (1+\lambda-2\nu)\frac{(1+\lambda)}{V''(d^0)}.$$

And similarly, using (20), we obtain

$$\left.\frac{d^2W_2^{P\beta}(d_2)}{d\bar{\beta}^2}\right|_{\bar{\beta}=\underline{\beta}} = (1+\lambda+\frac{\nu}{\alpha^*}-2\nu)\frac{(1+\lambda-\frac{\nu}{\alpha^*})}{V''(d_0)}.$$

Hence the expected second derivative at $\overline{\beta} = \underline{\beta}$ in the above case of pooling mechanism (assuming again that each majority is in power half the time) is given by

$$\left.\frac{d^2 E_\lambda W^{P\beta}}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = \frac{\nu^2\left(\frac{\alpha^* - \frac{1}{2}}{\alpha^{*2}}\right) + 1 - 2\nu + 2(1-\nu)E\lambda + (E\lambda)^2 + Var(\lambda)}{V''(d^0)}. \tag{21}$$

Therefore, the second derivative of the expected social welfare under the pooling mechanism is $(1-\nu)$ times the second derivative of the expected social welfare under the discriminatory mechanism as given by (18). Those derivatives are of the same sign but may be positive or negative. If $H(\cdot)$ is negative [positive], those derivatives are negative [positive] and therefore the pooling mechanism [the discriminatory mechanism] dominates for $\overline{\beta}$ close to $\underline{\beta}$.

B.2 Proof of Proposition 4

The second derivative of the expected social welfare under the full discriminatory mechanism is given by (18). For the social pooling mechanism considered here, we have

$$\left.\frac{d^2 W^{P\beta}(d^p)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = \frac{(1+\lambda-\nu)^2}{V''(d^0)}$$

and therefore

$$\left.\frac{d^2 E_\lambda W^{P\beta}(d^p)}{d\overline{\beta}^2}\right|_{\overline{\beta}=\underline{\beta}} = \frac{(1-\nu)^2 + (E\lambda)^2 + Var(\lambda) + 2(1-\nu)E\lambda}{V''(d^0)} > 0. \tag{22}$$

Comparing (18) and (22), we obtain that the current pooling mechanism dominates for $\overline{\beta}$ small enough iff

$$1 - \frac{1}{\nu}E_\lambda(1+\lambda-\nu)^2 > \frac{\alpha^* - \frac{1}{2}}{(\alpha^*)^2}.$$

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FIGURE 1A

THE DIFFERENTIAL EXPECTED WELFARE ($E_\lambda W^{P\beta} - E_\lambda W^D$)

AS A FUNCTION OF $\overline{\beta}$ when $V(d) = \frac{1}{4}d^4$

(for $\lambda = 0.3$ [$E\lambda = 0.3$, $Var(\lambda) = 0$], $\alpha^* = 0.6$, $K = 30$, $\underline{\beta} = 1$, $\nu = 0.75$,

that is, when $H(\cdot) < 0$)

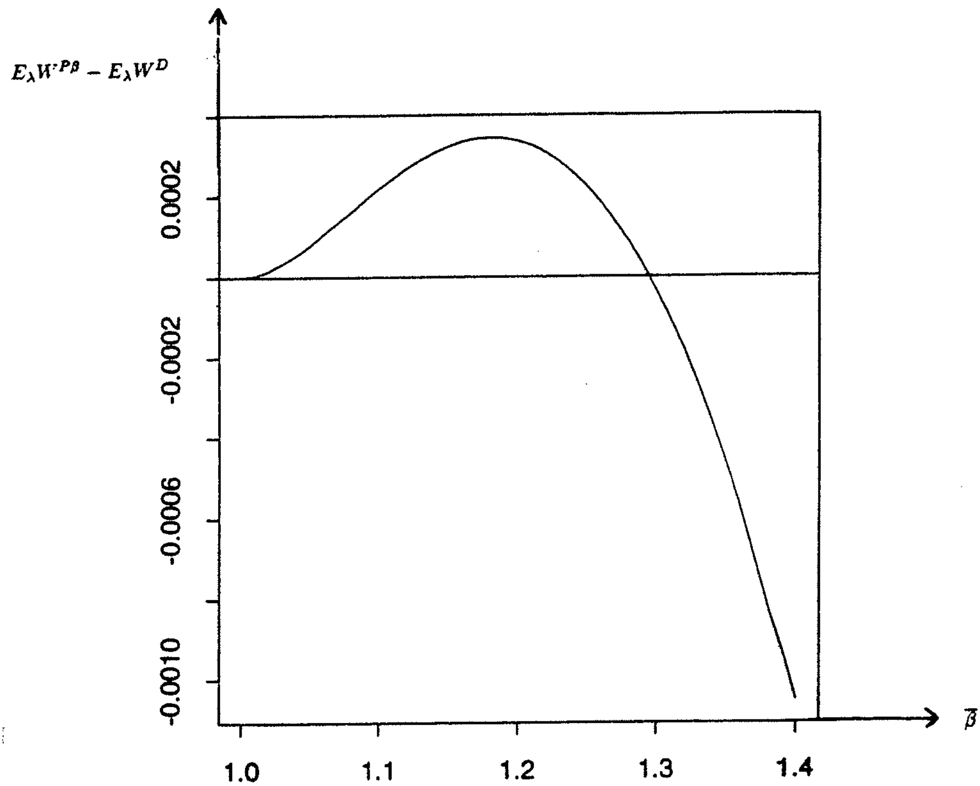


FIGURE 1B

THE DIFFERENTIAL EXPECTED WELFARE ($E_\lambda W^{P\beta} - E_\lambda W^D$)

AS A FUNCTION OF $\overline{\beta}$ when $V(d) = \frac{1}{4}d^4$

(for $\lambda = 0.5$ [$E\lambda = 0.5$, $Var(\lambda) = 0$], $\alpha^* = 0.6$, $K = 30$, $\underline{\beta} = 1$, $\nu = 0.75$,

that is, when $H(\cdot) > 0$)

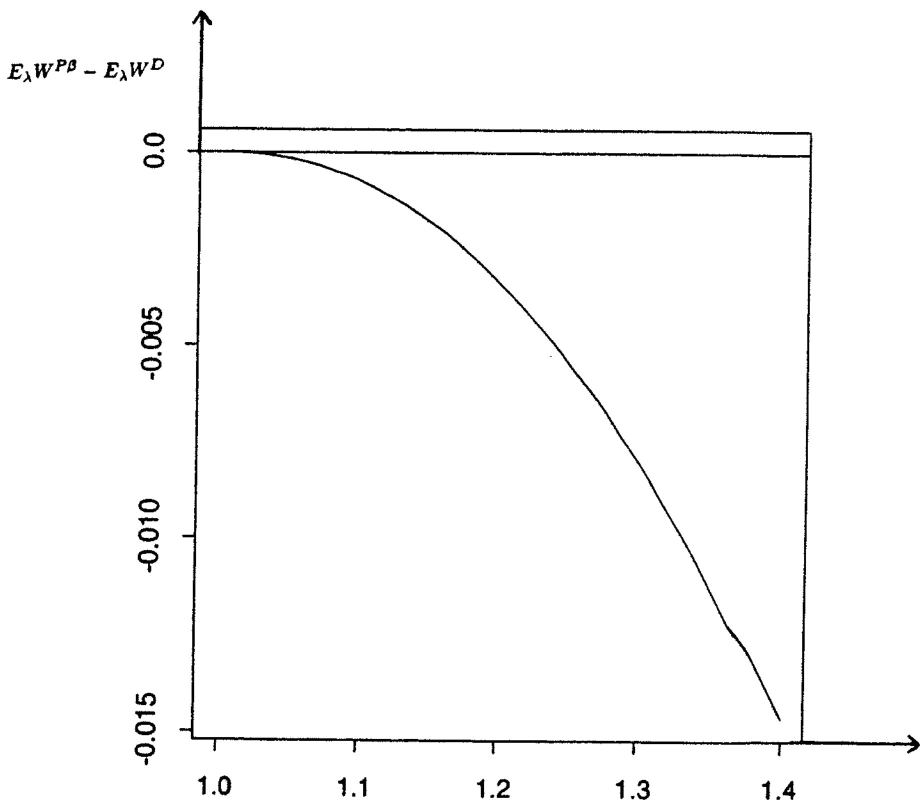


FIGURE 2

THE DIFFERENTIAL EXPECTED WELFARE ($E_\lambda W^{P\beta} - E_\lambda W^D$)

AS A FUNCTION OF $\overline{\beta}$ when $V(d) = \frac{1}{2}d^2$

(for $\lambda = 0.3$ [$E\lambda = 0.3$, $Var(\lambda) = 0$], $a^* = 0.7$, $K = 30$, $\underline{\beta} = 1$, $\nu = 0.75$,

that is when (8) is satisfied)

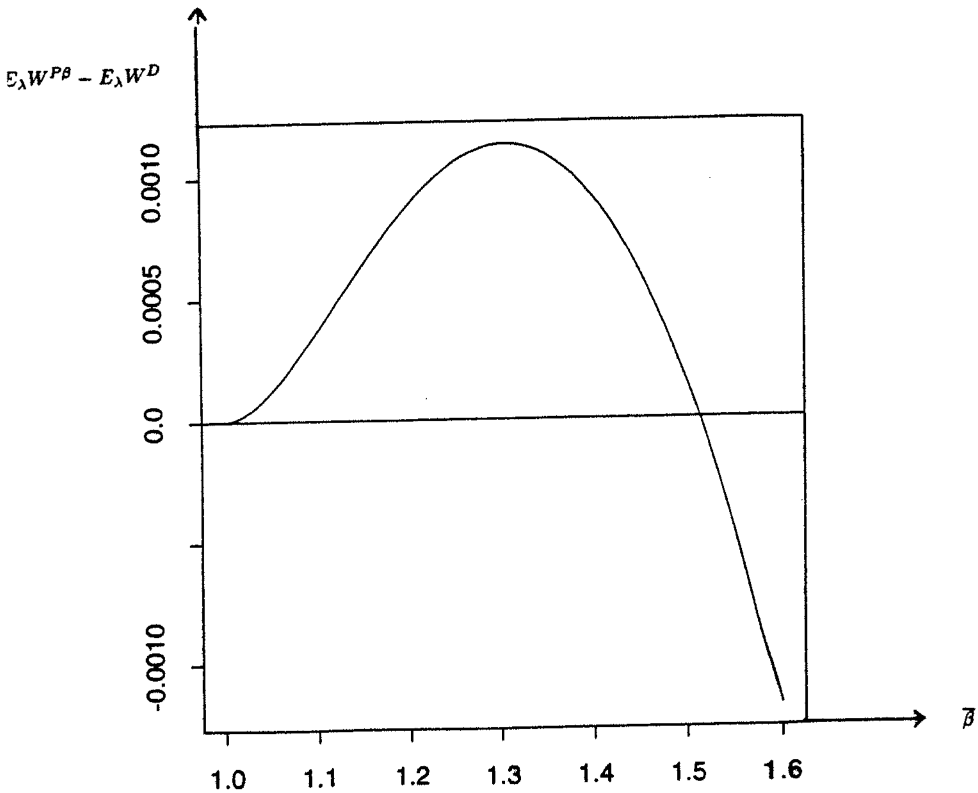


FIGURE 3

THE DIFFERENTIAL EXPECTED WELFARE ($W^{P\beta} - E\widehat{W}^D$)

AS A FUNCTION OF δ (or k) when $V(d) = \frac{1}{2}d^2$

(for $\lambda = 0.3$ [$E\lambda = 0.3$, $Var(\lambda) = 0$], $\alpha^* = 0.8$, $K = 30$, $\nu = 0.75$, $\underline{\beta} = 1$, $\overline{\beta} = 3$)

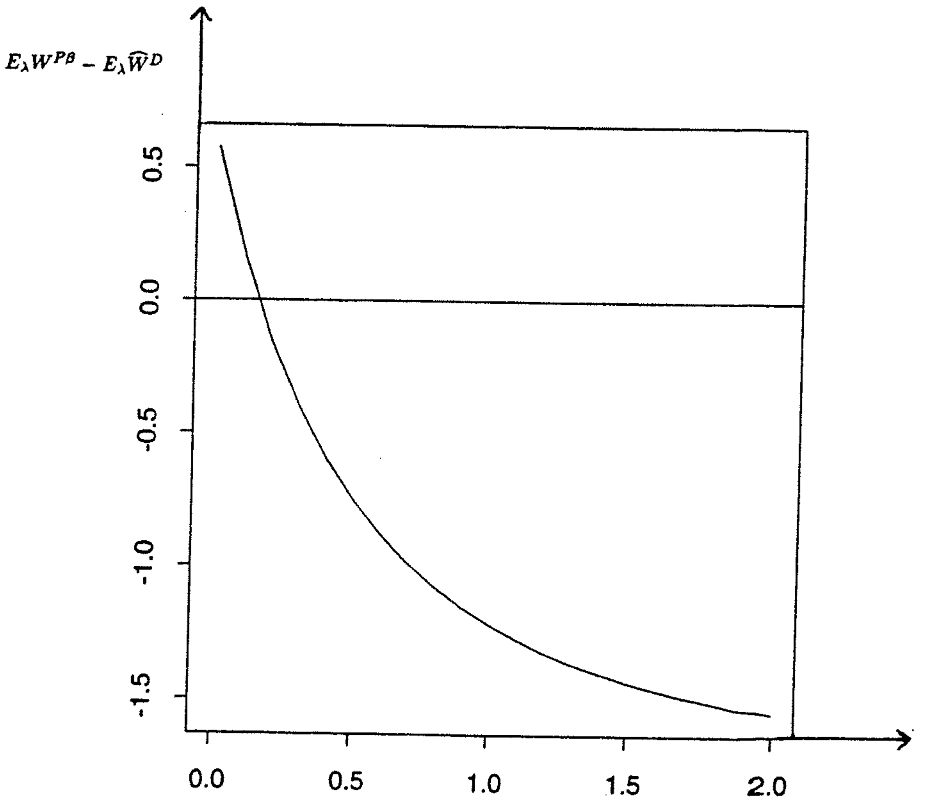


FIGURE 4A

THE DIFFERENTIAL EXPECTED WELFARE ($E_\lambda W^{P\beta\theta} - E_\lambda \widehat{\widehat{W}}^D$)

AS A FUNCTION OF δ when $V(d) = \frac{1}{2}d^2$

(for $\lambda = 1$ [$E\lambda = 1$, $Var(\lambda) = 0$], $\alpha^* = 0.8$, $\nu = 0.5$, $\mu = 0.7$, $K = 5$, $g = 1$, $\zeta = 0.5$

and $\underline{\beta} = 1$, $\overline{\beta} = 2$, $\underline{\theta} = 1$, $\overline{\theta} = 2$)

{the base case}

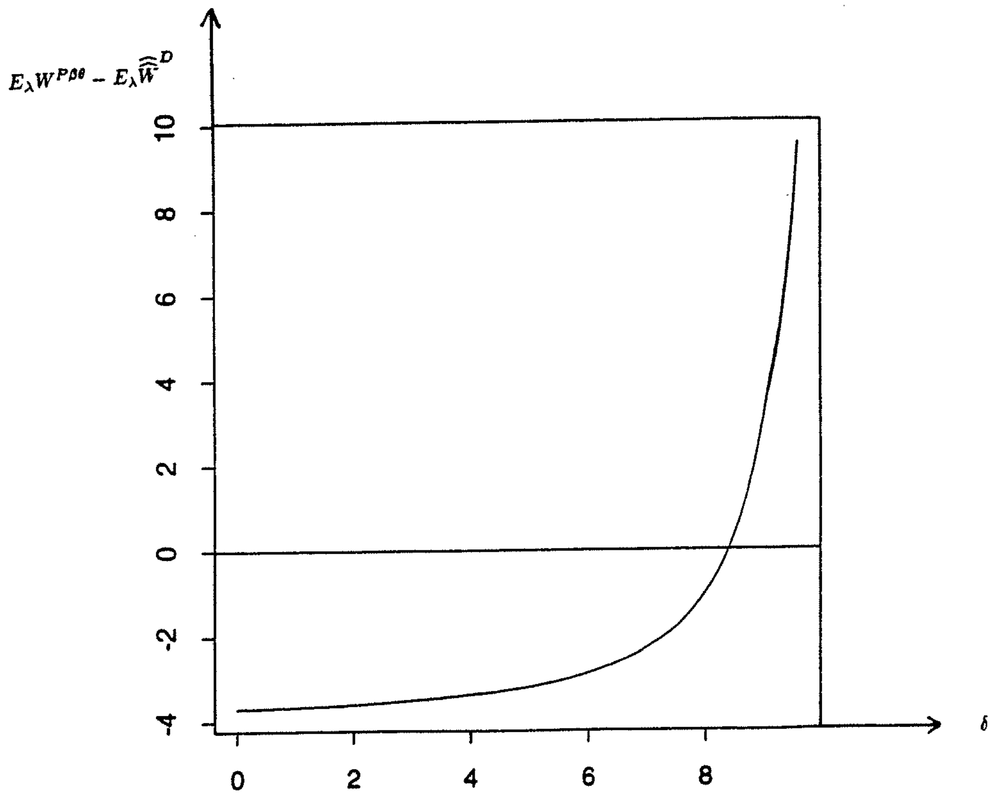


FIGURE 4B

THE DIFFERENTIAL EXPECTED WELFARE ($W^{P\beta\theta} - E\widehat{\widehat{W}}^D$)

AS A FUNCTION OF δ

(for $\lambda = 1$ [$E\lambda = 1$, $Var(\lambda) = 0$], $\alpha^* = 0.8$, $\nu = 0.5$, $\mu = 0.7$, $K = 5$, $g = 1$, $\zeta = 0.5$

and $\underline{\beta} = 1$, $\overline{\beta} = 1$, $\underline{\theta} = 1$, $\overline{\theta} = 2$)

{this case illustrates that as informational asymmetries are reduced ($\Delta\beta = 0$ here), the domination of the pooling mechanism occurs for larger values of δ}

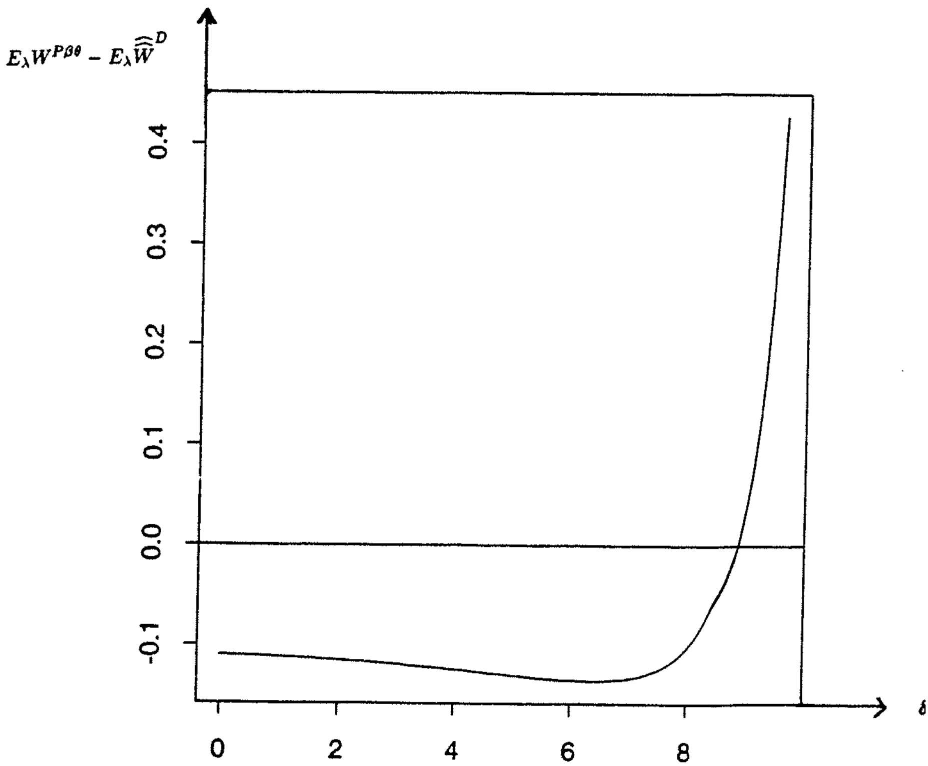


FIGURE 4C

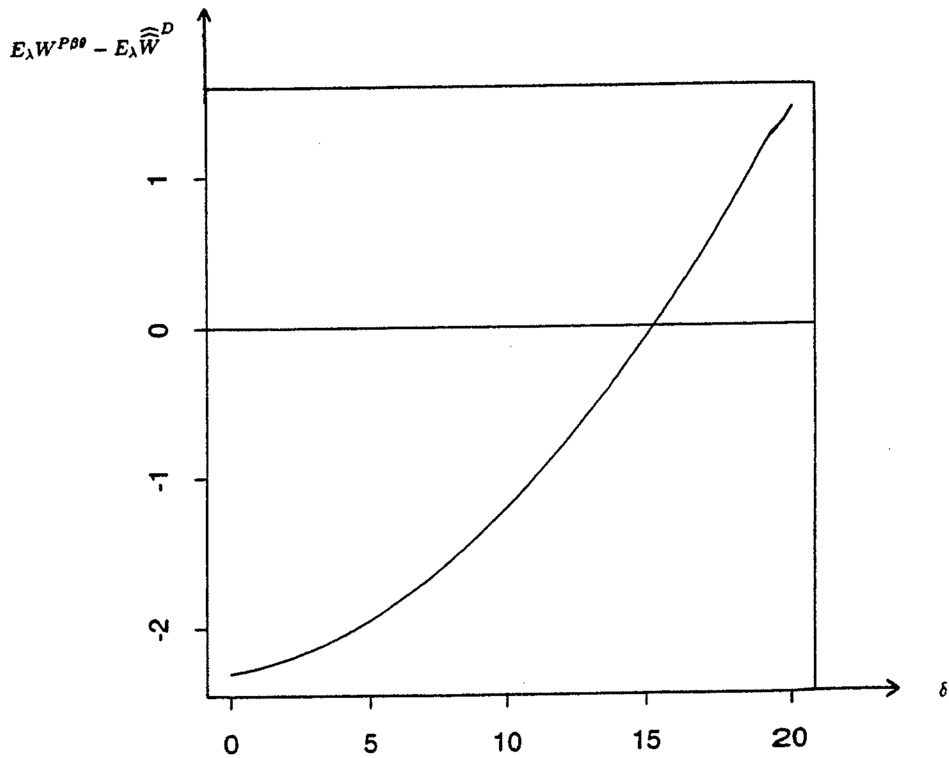
THE DIFFERENTIAL EXPECTED WELFARE ($E_\lambda W^{P\beta\theta} - E_\lambda \widehat{\widehat{W}}^D$)

AS A FUNCTION OF δ

(for $\lambda = 1$ [$E\lambda = 1$, $Var(\lambda) = 0$], $\alpha^* = 0.8$, $\nu = 0.5$, $\mu = 0.7$, $K = 5$, $g = 1$, $\zeta = 0.5$

and $\underline{\beta} = 1$, $\overline{\beta} = 2$, $\underline{\theta} = 1$, $\overline{\theta} = 1$)

{this case illustrates that as informational asymmetries are reduced ($\Delta\theta = 0$ here), the domination of the pooling mechanism occurs for larger values of δ}



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