Political and Legal Contests for Pricing Externalities
with Free Entry of Injurers and Victims

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Abstract
Two methods for pricing an externality--taxes and strict liability--are modeled as lobbying contests with endogenous numbers of participants. In the tax contest, a regulator is susceptible to lobbying by polluters and victims. Under liability, the court's view is affected by legal representation. The liability system tends to generate excessive emissions, and the distortion gets worse as the damage function gets steeper. By contrast, the tax-lobby contest is constrained to the vicinity of a well-defined optimum. Emissions are excessive when they are least harmful, and they are over-abated when it is least costly to do so.

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1. Introduction

Externalities related to product defects, workplace hazards, etc., have been addressed almost exclusively through liability regimes and/or command-and-control regulation. In the case of pollution, governments seem reluctant to use emission taxes, but most western countries have introduced (and continue to extend) forms of strict liability on individuals and firms for damaging the environment. Examples include: the US Offshore Continental Shelf Act (1974); the US Comprehensive Environmental Recovery, Compensation and Liability Act of 1986; the German Environmental Liability Act of 1990, the Danish Compensation for Environmental Damage Act of 1994; and The Council of Europe (Lugano) Convention of 1993 on Civil Liability, which covers environmental damage from dangerous activities. A recently-released European Union White Paper on Environmental Liability (European Commission 2000) proposes, among other things, liability for “damage to biodiversity” in the Natura 2000 network, which will cover about 10 per cent of EU territory.

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1 There are examples of so-called "environmental taxes", but their incidence is rarely on the targeted emissions, due to exemptions and dilutions of coverage (see, e.g., Fullerton 1995).
This paper contrasts the economic effects of pricing externalities through exposure to liability versus taxes on injurious activities. There is already a considerable literature on the matter. The contribution here is to outline a general model which treats both instruments as a contest in which injurers and victims have an incentive to expend resources lobbying over a price parameter. Differences in outcomes arise because courts may be less able than tax authorities to deal efficiently with externalities from multiple sources, and tax payments go to the government while liability payments go to the victim.

Since two competing principals lobby to influence the behaviour of a single agent, the model here has some similarities to the common agency framework of, for example, Grossman and Helpman (1994) and Fredriksson (1997). However, in that setting, the regulator is being asked to distort a competitive equilibrium (at the political cost of causing a welfare loss), whereas the regulator here is internalizing a social cost, so there is, presumably, a political gain. Also, in the common agency model lobbying takes the form of a transfer to the regulator, whereas here it is a pure resource cost and the regulator does not profit from it as such. Hence subgame commitment problems between principals and the agent do not arise, and the focus is on the static equilibrium. However, as will be apparent, the contest function employed in this paper is general enough that it shares some of the same intuition of the influence-peddling models in the common agency literature. The chief difference is that the regulator here maximizes a (social welfare) function in which lobbying efforts are a cost rather than a benefit.

One important difference between the tax and liability regimes concerns the outcome when there are multiple defendants (injurers), such as when a group of firms jointly pollute a river or watershed. In principle, a Pigovian tax can be implemented in such

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2 See, for example, Cooter and Ulen 1988, Miceli 1997, Meiners and Yandle 1998.
a way that each polluter is charged the value of marginal damages at the efficient aggregate emissions level (McKitrick and Collinge, 2000). But the courts, confronted with multiple defendants (or joint tortfeasors) are generally unable to price individual actions in a way which provides efficient incentives to internalize damages, especially in the presence of free entry and exit of polluting firms (Miceli and Segerson 1991). If several defendants are found jointly liable for damages, the court typically apportions responsibility, assigning each party a percentage of the bill for damages. It has been shown elsewhere, and will be reiterated below, that an apportionment rule provides an inaccurate signal to firms of their marginal external costs. Unfortunately, the distortions induced by the apportionment rule get worse, the steeper is the marginal damages function.

A second difference between liability and taxes is that liability payments are received as compensation by the victim(s), whereas pollution taxes are paid to the government, which in turn may or may not pay compensation to the victim. A well-known result in general equilibrium models of optimal pricing schemes for externalities (Baumol and Oates 1988) is that if the victim has some control over the level of damages experienced and the amount of compensation, his or her incentives to self-protect will be weakened and the equilibrium value of damages will be distorted upwards. The tax regime avoids this but since the liability system does not, it creates a tendency for excessive entry of victims and an upward bias to damage payments.

Attention is focused here on situations in which it is possible, in principle, to price an externality either with a Pigovian charge or with strict liability. Therefore we are interested in cases where it is feasible to estimate marginal damages, at least approximately, since these are the situations in which clear economic incentives can be created. If it is impossible to forecast damages then neither regime will efficiently internalize costs.
An important feature of the model presented below is that it allows for bilateral free entry, that is, an endogenous number of both firms and victims. Achieving the optimal level of aggregate emissions requires not only getting each firm to emit the correct amount, but ensuring the optimal number of firms is present. Other authors who have examined the joint tortfeasors issue seem to have sidestepped the latter problem by assuming a fixed number of injurers (e.g. Tietenberg 1989, Landes and Posner 1980) or assuming a linear damage function (e.g. Polinsky 1980).

At the level of generality maintained here, it is not possible to make a direct comparison of aggregate welfare under tort liability versus taxes. Nevertheless the analysis clearly demonstrates that there is a tendency for the liability approach (with apportionment) to generate excessive emissions, and the distortion gets worse as the damage function gets steeper. By contrast, the incentives created by the tax-lobby contest constrains the outcome to the vicinity of the optimum, such that emissions are excessive when they are least harmful, and they are over-abated when it is least costly for firms to do so.

The next section presents the model and the tax contest. Section 3 analyzes the liability contest model and Section 4 presents conclusions.

2. The Model and the Tax Contest

The economy is contained within a region in which there are firms, households and a regulator. There are \( n \) firms indexed by \( i \), and \( m \) households indexed by \( j \). Both \( n \) and \( m \) are endogenous. Each firm engages in an activity \( e_i \) (emissions) which cause damages experienced as a public bad by households, and which generate a private benefit defined as

\[
B_i(e_i) = -\beta_i + b_i(e_i)
\]
where $b_i$ is concave and $\beta$ is a positive constant. Damages from emissions are defined by the positive, convex function $D(E)$, where $E = \sum_{i=1}^{n} e_i$. It is occasionally convenient to denote the sum of the emissions of all firms except $i$ using $E_{-i} = E - e_i$.

Households which move to the region earn utility

$$U_j = y_j - D(E)$$

where $y_j$ is a household-specific benefit, and $D$ is the level of damages associated with current emissions $E$. It is assumed that $y_j$ declines as $j$ increases, because, for instance, the quality of housing locations decreases and work opportunities get marginally more limited. Note that a new entrant does not affect the benefit $y_j$ of any existing households, so it is not a pure congestion externality.

Households and firms can hire lobbyists (or, in a court case, lawyers) at a cost of $w$ per unit. The lobbyists hired by individual firms are denoted as $L_i$ and by households as $L_j$. The price represents the opportunity cost of lobbyist time. It is assumed that lobbyists are "outsiders" in the sense that their utility is not included in the regional social welfare function, and in the absence of the payment $w$ each lobbyist would be fully employed in another region at some reservation wage.

The regulator is assumed to maximize local social welfare, which is defined as the sum of private benefits to firms and households in the region, minus damages due to emissions, minus the resource costs of lobbying:

$$W = \sum_{i=1}^{n} B_i(e_i) + \sum_{j=1}^{m} y_j - mD(E) - w(\sum_{i=1}^{n} L_i + \sum_{j=1}^{m} L_j)$$

(1)
To the extent that a voting system translates average social welfare into political support, the above equation could be taken as a political utility function. The first-best social optimum values are denoted with *. The letters \( N \) and \( M \) will be used to denote the first-best numbers of households and firms respectively, rather than \( n^* \) and \( m^* \), to avoid the clutter of a superscripted * on a subscripted letter. The optimum is defined by the following first-order conditions:

\[
\frac{\partial W}{\partial e_i} = \frac{\partial B_i}{\partial e_i} - mD' = 0 \quad \Rightarrow \quad B'_i(e^*_i) = MD'(E^*) \tag{2}
\]

\[
\frac{\partial W}{\partial n} = B_n(e_n) - mD' \cdot e_n - wL_n = 0 \quad \Rightarrow \quad B_N(e^*_N) = MD'(E^*) \cdot e^*_N + wL^*_N \tag{3}
\]

\[
\frac{\partial W}{\partial m} = y_m - D(E) - wL_m = 0 \quad \Rightarrow \quad y_M = D(E^*) + wL^*_M \tag{4}
\]

Since lobbying serves no purpose in a first-best situation, the optimum of (1) with respect to \( L_i \) and \( L_j \) implies

\[
L'_i = L'_j = 0 \quad \text{for all } i, j \tag{5}
\]

Equation (2) implies that the optimal firm-specific emissions equate marginal benefits to marginal damages, which in turn depends on the optimal number of households and firms locating in the region. These are defined by (3) and (4). The \( N \)-th firm should be the one whose marginal benefits from emitting just equal the incremental damages, defined as the additional emissions priced at the marginal damages of aggregate emissions. The \( M \)-th household is the one which earns just enough by locating in the region to equal the externality associated with the firms’ activities. Both of these definitions apply (5).
2.1 The Contested Pricing Scheme

In the tax policy case, the regulator announces that emissions will be priced according to marginal damages. However, the function $D'$ is not known, so a consultant is hired at cost $C_T$ to estimate it. The consultant correctly calculates $D'(E^*)$ but the regulator is unsure whether to trust the report, and is susceptible to lobbying on the issue.\(^3\) Firms will make the case that the report overstates actual damages, while victims will argue that it understates them. In the end the regulator will set the tax at

$$t = \theta m D'(E^*) \quad (6)$$

where $\theta = \theta(\Sigma L_i, \Sigma L_j) > 0$ is a variable reflecting the distortions in the emissions price. $\theta(\Sigma L_i, \Sigma L_j)$ is increasing and concave in victim lobbying efforts $L_i$, and decreasing and convex in polluter lobbying efforts $L_j$. If the equilibrium value of $\theta$ is less than unity, the firms prevailed and the regulator scales down the estimated damages when setting the tax rate, while if it is greater than unity the households prevailed and the regulator scales up the damages estimate.

The regulator is assumed to distribute revenues from the emissions tax using lump sum transfers to a closed list of recipients, so as not to affect entry/exit behaviour. As a practical matter, pollution tax revenues are very small compared to, e.g., income and consumption taxes, so even if the revenues in some way affect provision of a local public good (or the local mix of taxes) the effect will be so small that we need not be concerned about a potential distortion on entry.

\(^3\) The qualitative results here are unaffected if we assume the consultant makes a zero-mean additive error on the estimate of $D'(E^*)$. 
The function $\theta(\sum L_i, \Sigma L_j)$ is an example of a Contest Success Function, which has applications in public choice models, analysis of armed conflict, etc. It is common to choose a particular form (either a ratio or difference specification), and there are analytical implications of each (Hirschliefer 1989). In the present model it will not be necessary to use a particular functional form to obtain detailed results.

The profit function for the firm in a tax rate contest is

$$\pi_i = B_i(e_i) - te_i - wL_i = B_i(e_i) - \theta(\sum L_i, \Sigma L_j) mD(E^*) \cdot e_i - wL_i$$

Note that the tax rate is multiplied by $m$, the actual number of victims, not $M$, the optimal number. Also note that lobbying efforts combine additively, so the effect of any one agent's lobbying is through the aggregate of that type of agent's lobbying. This means that there will be a potential problem of free-riding on others' lobbying efforts. We will not explore any particular measures agents might use to overcome this problem, instead the outcomes derived below simply assume this structure to lobbying efforts. Since an increment to lobbying has the same effect regardless of which firm undertakes it we will denote the change in $\theta$ resulting from a change in $L_i$ as $\theta_f$ for all $i=1,\ldots,n$ firms; and similarly $\partial \theta / \partial L_j = \theta_v$ for all $j=1,\ldots,m$ victims.

\[\text{\textsuperscript{4}}\text{ It is to the regulator's advantage to use } m \text{ rather than } M, \text{ even if the latter were known. Fixing } M \text{ in equation (6) would make the price unresponsive to victim entry, which would distort household decisions. But it will be shown below (Result 1) that when } m \text{ is free, in equilibrium } m=M.\]

\[\text{\textsuperscript{5}}\text{ See Hamilton (1999) for empirical evidence on the propensity for victims of environmental torts to initiate class actions, and its role in determining the incentives created by a liability regime.}\]
The utility function for a household is

\[ U_j = y_j - D(E) - wL_j \quad (8). \]

Denote the derivative of the tax rate with respect to firm \( i \)'s lobbying as \( t_i = \theta_i D'(E^*) m = t_f \), which is uniform across firms and is a function of the level of victim lobbying. In the same way \( t_j = \theta_v D'(E^*) m = t_v \) is common across all victims and is a function of the level of firm lobbying. Denote \( D'(E^*) \equiv D'(\cdot) \) for simplicity.

The values of endogenous variables in the tax equilibrium are denoted with \(^\wedge\). The optimality conditions for the firm with respect to emissions, lobbying and entry yield

\[ B_i'(\hat{e}_i) = \theta m D'(\cdot) \quad (9a) \]
\[ -\theta_i D'(\cdot) \hat{m} \hat{e}_i = w \quad (9b) \]
\[ B_n(\hat{e}_n) - \theta D'(\cdot) \hat{m} \hat{e}_n - w \hat{L}_n = 0 \quad (9c). \]

Add (9b) across \( n \) firms to yield

\[ -t_f \hat{E} = \hat{n} w \quad (9d). \]

The optimality conditions for the victim with respect to lobbying and entry yield:

\[ -n \hat{D} \frac{\partial E}{\partial t_v} = nw \quad (9e). \]
\[ y_m = \hat{D} + \bar{w}\hat{L}_m \]  

(9f)

where \( \hat{D} \equiv D(\hat{E}) \) and \( \hat{D}' \equiv D'(\hat{E}) \). For ease of presentation we may occasionally suppress the \(^\wedge\) notation where it is not needed. Combine (9d,e) and multiply through by \( t/E \) to get

\[ nD' \frac{\partial E}{\partial t} \frac{t}{E} t_v = t_f \frac{E}{E} t. \]

Denote the elasticity of emissions with respect to the tax rate as \( \varepsilon = \frac{\partial E}{\partial t} \frac{t}{E} \) (note this is a negative number). Also denote the ratio of marginal effects of lobbying of firms versus victims as \( \mu_{fv} = \frac{t_f}{t_v} \) (also a negative number). Then the above reduces to

\[ nD' \varepsilon = \eta \mu_{fv}. \]

Using (6), the definition of the tax rate, we can rearrange the above to get

\[ \hat{\theta} = \frac{\hat{n}}{\hat{m}} \frac{\varepsilon}{\mu_{fv}} \frac{\hat{D}'}{\hat{D}'(\ast)} \]  

(10).

The equilibrium value of the tax distortion coefficient \( \theta \) reduces to a reasonably simple expression, involving the relative numbers of agents, the variables \( \varepsilon \) and \( \mu_{fv} \), and the slope of the damage function at two points. The elasticity of the tax rate, \( \varepsilon \), is equal to the elasticity of the marginal abatement cost (MAC) function, since firms choose their optimal
emissions level where \( MAC = t \). If \( \varepsilon \) is very small, the \( MAC \) is very steep (abatement costs rise very rapidly as emissions fall), and vice-versa.

We begin interpreting (10) by examining the equilibrium number of victims, and the levels of emissions and the number of firms entering the region.

**Result 1.** Under the tax system described above the optimal number of victims enters the region.

**Proof.** Evaluate \( \frac{\partial W}{\partial m} \) at \( \hat{m}, L_m^*, E^* \) using (9f), to get \( \frac{\partial W}{\partial m} = y_m - D(E^*) - wL_m^* \)

\[
= D(E^*) + wL_m^* - D(E^*) - wL_m^* = 0.
\]

Hence \( \hat{m} = M \).

Crucial to this result is the assumption that the regulator is able to distribute the proceeds of the tax in such a way as not to affect the entry decision of victims.

**Result 2.** If the equilibrium level of \( \hat{q} \) is greater (less) than 1, then each firm emits too little (much).

**Proof.** Combining (9a) and (10) yields

\[
B_i'(\hat{e}_i) = \hat{n} \frac{e_i}{\mu_{f_i}} \hat{D}'.
\]

If \( \hat{\theta} > 1 \) then \( \hat{n} \frac{\varepsilon}{\hat{m}} \frac{\hat{D}'}{D'(\hat{q})} > 1 \) which implies \( \hat{n} \frac{\varepsilon}{\mu_{f_i}} \hat{D}' > \hat{m}D'(\hat{q}) \). This plus the above expression, and Result 1, gives \( B_i'(\hat{e}_i) > MD'(\hat{q}) = B_i'(e_i^*) \). Concavity of \( B_i \) implies \( \hat{e}_i < e_i^* \). Reverse the inequalities to get the opposite case.

**Result 3.** If the equilibrium level of \( \hat{q} \) is greater (less) than 1, then too few (many) firms enter the region \( (\hat{n} < N) \), and vice versa.

**Proof.** We will evaluate \( \frac{\partial W}{\partial n} \) at \( M, e_n^*, \hat{n}, L_n^* \). The notation \( e_n^* \) refers to the \( \hat{n} \)-th firm emitting the planner’s optimal level for that firm. Denote \( \hat{D}'(\hat{q}) \equiv D' \left( \sum_{i=1}^{\hat{n}} e_i^* \right) \), i.e. the
summation of firm-specific optimal emission levels across \( \hat{n} \) firms. We have

\[
\frac{\partial W}{\partial n} = B_\hat{\theta}(e^*_\hat{n}) - M\hat{D}'(e^*_\hat{n}) - wL^*_\hat{n}.
\]

Applying (6) and (9c) yields

\[
\frac{\partial W}{\partial n} = \theta\hat{D}'(e^*_\hat{n})Me^*_\hat{n} - M\hat{D}'(e^*_\hat{n})e^*_\hat{n} - wL^*_\hat{n} + wL^*_\hat{n} = M\hat{D}'(e^*_\hat{n})e^*_\hat{n}(\theta - 1).
\]

If \( \theta > 1 \) then the derivative is positive, indicating \( \hat{n} < N \), and vice versa.

Note that if \( \hat{\theta} = 1 \) then the optimal number of firms enters and each one emits the socially optimal level.

**Result 4.** If the equilibrium level of \( \hat{\theta} \) is greater than 1, then aggregate emissions \( \hat{E} \) are below the optimum, and vice-versa.

*Proof:* Combine Results 2 and 3.

These results are intuitively straightforward. If \( \hat{\theta} > 1 \) then the price on the externality is inflated above the efficient level, in which case one expects emissions to be over-abated. At this point it is helpful to develop some intuition about the relationship between \( \theta \) and the optimal control of the emissions. The social cost of emissions is summarized by a marginal damages curve \( D'(E) \) and the cost to polluters of reducing emissions is summarized by the Marginal Abatement Cost curve (MAC), which is also the marginal return to emissions added up across firms. Suppose for simplicity that \( n=m \) and that total damages \( D \) are linear, so \( \hat{D}' = D' \). Then \( \hat{\theta} = \epsilon / \mu_{\hat{f}_\theta} \). A large value of \( \epsilon \) (high elasticity) implies the MAC is flat, so that firms do not find it very costly to achieve lower emission targets. Hence they engage in relatively less lobbying efforts and victims will have relatively more impact on the tax rate, implying \( \mu_{\hat{f}_\theta} \) is small.\(^6\) These together imply that

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\(^6\) I am grateful to Mel McMillan for this point.
the tax rate will be inflated upwards ($\theta > 1$). Since the MAC is fairly flat, this will mean the actual price of emissions is not much above the optimum, but equilibrium emissions will be much lower than the optimum. Figure 1a shows that, the higher is $\epsilon$, the larger is the distortion via $\theta$, but at the same time, the flatter is the MAC: so there is relatively little "room" to bias the emissions tax upwards without pushing emissions to zero. So the situation that gives rise to potentially increasing distortions simultaneously gives rise to constraints on the way those distortions affect the emissions price.

When $\epsilon$ is low, the MAC is fairly steep. In this case it is very costly for firms to reduce emissions, and they will put relatively strong efforts into lobbying against a pollution tax. Also, victims gain relatively little from lobbying since the equilibrium emissions level is not very responsive to the level of the tax. Hence $\mu_{fe}$ will be small, and since $\epsilon$ is low, this implies $\theta < 1$. As is shown in Figure 1b, the emissions price is distorted downwards, but the level of emissions does not increase much above the optimum, because the increasing slope of the MAC constrains the growth of emissions, even as the price $t$ goes to zero.

So the interaction between the slope of the MAC and the relative effects of lobbying implies that the tax will always be within a definable neighbourhood of the optimum. Either the price is distorted upwards in a setting in which the price cannot go too far above the optimum anyway (flat MAC), or the price is distorted downwards in a setting in which emissions cannot go too far above the optimal level (steep MAC) anyway. Or, alternatively, emissions get distorted downwards when it is relatively inexpensive for firms to over-abate, and emissions get distorted upwards when firms tend not to over-emit. Either way the lobbying contest leads, in general, to an outcome which is distorted, but in relatively benign ways.
Some further results emerge when the damage curve is convex, hence $D'$ is not constant. In particular, except when $\hat{\theta} = 1$, the tax rate will differ from optimal and actual marginal damages. Result 5 is a lemma and Result 6 establishes this.

**Result 5.** Whether the equilibrium value of $\hat{\theta}$ is greater or less than unity depends only on $n, m, \varepsilon$ and $\mu_{fv}$, and not on aggregate emissions or the slope of the damages function.

**Proof:** We need to show that $\frac{n \varepsilon}{m \mu_{fv}} > 1 \iff \hat{\theta} > 1$. The $\Rightarrow$ direction is established as follows.

Suppose $\frac{n \varepsilon}{m \mu_{fv}} > 1$ and $\hat{\theta} < 1$. Then by Result 4, $\hat{E} > E^*$ and thus $\hat{D}'/D'(\ast) > 1$. But then $\hat{\theta} > 1$, a contradiction. The $\Leftarrow$ direction is established as follows. If $\hat{\theta} > 1$ but $\frac{n \varepsilon}{m \mu_{fv}} < 1$ then it must be true that $\hat{D}'/D'(\ast) > 1$, which implies $\hat{E} > E^*$, which by Result 4 is inconsistent with $\hat{\theta} > 1$. Therefore $\frac{n \varepsilon}{m \mu_{fv}} > 1 \iff \hat{\theta} > 1$. Reversing the inequalities establishes the opposite case.

**Result 6.** If $\hat{\theta} > 1$ then the emissions price $t$ exceeds both optimal marginal damages and actual (equilibrium) marginal damages.

**Proof:** Since $t = \theta \hat{m}D'(E^*)$ and, by Result 1, optimal marginal damages are $\hat{m}D'(E^*)$, then $\hat{\theta} > 1$ clearly implies $t$ is greater than optimal marginal damages. To show that $t$ exceeds actual marginal damages, note that, by Result 5, $\hat{\theta} > 1$ $\Rightarrow \frac{n \varepsilon}{m \mu_{fv}} > 1$. This implies that

$$\frac{n \varepsilon}{m \mu_{fv}} \hat{D}' \quad \frac{D'(\ast)}{D'(\ast)}$$

$$\Rightarrow \hat{\theta} > \frac{\hat{D}'}{D'(\ast)}$$

$$\Rightarrow \hat{\theta} D'(\ast) > \hat{D}'$$

Multiply through by $\hat{m}$ to establish the result.
The opposite result can also be established: if \( \hat{\theta} < 1 \) then the emissions price \( t \) is below both optimal marginal damages and actual (equilibrium) marginal damages. Figure 2a illustrates Result 6, and Figure 2b illustrates the opposite case.

We can conclude this section with some general observations about the likely outcome of a contest over the appropriate tax rate. Typically there are fewer polluters than individual victims, so \( m > n \). There is reason to suppose that, in equilibrium, \( \mu_{fv} \geq 1 \); that is, lobbying on the tax rate from the polluters' side will be as or somewhat more influential than lobbying from the victims' side.\(^7\) To have \( \frac{n}{m} \frac{\varepsilon}{\mu_{fv}} > 1 \) (which by Result 5 suffices for \( \hat{\theta} > 1 \)) requires \( \varepsilon > (\mu_{fv})(m/n) > 1 \). If both terms in brackets are greater than 1, \( \varepsilon \) must be quite large for the inequality to hold, indicating that the MAC is very flat. But in western countries which have already achieved significant emission reductions over the past three decades it is unlikely that the relevant portion of the marginal abatement cost function is highly elastic. A steep or inelastic MAC implies \( \varepsilon < (\mu_{fv})(m/n) \) which implies \( \hat{\theta} < 1 \). It is a reasonable conjecture that most tax contests would result in a sub-optimal tax rate and excess emissions, as shown in Figure 2b, but the emissions will not exceed the optimum by “much”.

3. The Legal Contest Over Externality Pricing

The firm is one of \( n \) agents which might be forced to pay for damages \( mD(E) \). Since there are multiple injurers (or “joint tortfeasors”) the court will not typically assign the

\(^7\) This is not to imply that industry is always more powerful than environmentalists in lobbying on pollution regulation in general. We are here looking only at the setting of a pollution tax rate, which in practice is a rare occurrence, but to date it appears firms have been successful in securing significant exemptions and reductions (see Stavins 1999).
entire liability to one firm, instead the firm will have to pay a share $s_i$ of the damages. It is a legal convention that the total amount of liability payments cannot exceed the value of the damages, so $\Sigma s_i = 1$, although the court may also impose punitive damages. A common approach is the "apportionment rule" which assigns liability according to each defendant's share in the injuring activity. We approximate this rule as $s_i = e_i / E$.

It is assumed that all households in the region are affected by the externality and hence petition the court for redress. The contest in court is over the probability that the judge or jury will find the defendant liable, and whether punitive damages will be awarded. The model is similar to the tax contest in the sense that the realized value of a non-negative parameter $\theta$ is the outcome of competitive lobbying (legal representation) in court. However in the present contest the firms and victims are working with expectations of outcomes rather than the outcomes themselves. The parameter $\theta$ represents the product of the probability of an award and the expected ratio of the award to actual damages. If $\theta = 0$, either the defendant is expected to completely prevail or no damage award is anticipated, or both. If $\theta = 1$, either the victim expects full compensation with perfect certainty or punitive damages with less than complete certainty. $0 < \theta < 1$ corresponds to a situation in which the court awards damages with less than complete certainty, or awards less than full damages with certainty, or some combination of these. $\theta > 1$ always implies that punitive damages will be added to an award. It is maintained that $\theta$ is the result of the aggregate of lobbying (legal) efforts by all plaintiffs and defendants. On the plaintiff side the relevant concept is class action, and on the defendant side the assumption is that joint tortfeasors will be tried together.

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8 Under joint and several liability one firm may pay the entire award, but usually will be allowed to seek contributions subsequently from other tortfeasors (see North 1996).
Empirical evidence regarding the influence of expected environmental liability costs on firm behaviour is not extensive. Hamilton (1999) finds that US firms whose emission levels were publicly revealed through the Toxics Release Inventory of the Environmental Protection Agency were more likely to reduce emissions, the more toxic their emissions were and the more inclined the affected population is to initiate a class action suit. Alberini and Austin (1999) find that US states are as likely or more likely to experience some types of hazardous waste spills under strict liability than under alternative regulatory regimes. This may be because the threat of litigation prompts large firms to contract out the handling of hazardous materials to small firms who, because of their modest assets, are judgement-proof, yet because of their size do not have the expertise or technology to prevent spills. These findings suggest that firms do form expectations about the outcome of litigation and may change their own emissions in response, though the response to any particular form of liability may be hard to predict. The model developed here does not allow for contracting out of emissions but does provide an explanation for why the threat of liability may not induce efficient behaviour, even when there is a priori certainty that a court will award damages to victims.

The firm's expected profits in the legal contest are

\[ \pi_i = B_i(e_i) - \theta(\Sigma L_i, \Sigma L_j)ms_iD(E) - wL_i \]  \hspace{1cm} (11).

An important difference between this expression and the one for profits under the tax regime (equation 7) is that marginal damages do not enter (11). The inability of courts to price damages due to multiple tortfeasors at the margin, and the consequences for
efficiency, has been noted in the literature already (e.g. Miceli and Segerson 1991). A sharing rule \((s, i)\) will be considered below which confronts firms with marginal damage costs.

The utility function for a victim is

\[
U_j = y_j - D(E) + \theta(\Sigma L_i, \Sigma L_j)D(E) - wL_j
\] (12).

An obvious difference between the above and the utility of household \(j\) under taxes (equation 8) is that victims receive compensation at the rate \(\theta\) under the legal liability regime. This has important implications for the decision to enter or not.

It is assumed in this set-up that a specific expectation of \(\theta\) is common across firms and victims. There are important implications if the subjective probabilities of victory differ between plaintiffs and defendants (see, e.g. Cooter and Rubinfeld 1989), though there are reasons to suppose that expectations would be convergent, since competent legal counsel should be able to provide objective advice about the likelihood of winning at trial. Nevertheless it is a strong assumption, and relaxing it has potentially important implications which will not be explored here.

Denote the outcome under the liability rule using \(\sim\). The firm’s optimal emissions, legal counsel and entry decision are summarized by

\[
B_i'(\tilde{c}_i) = \theta(\Sigma L_i, \Sigma L_j)\tilde{m}(s, \tilde{D}'+\tilde{D}s_i')
\] (13a)

\[-\theta_f\tilde{m}s_i\tilde{D} = w\] (13b)

\[B_{\tilde{D}}(\tilde{c}_{\tilde{D}}) = \tilde{m}\tilde{s}_{\tilde{D}}\tilde{D} + w\tilde{L}_{\tilde{D}}\] (13c)
where $\bar{D} \equiv D(\bar{E})$, $\bar{\theta} \equiv \theta(\Sigma \bar{L}_i, \Sigma \bar{L}_j)$, etc. Also, $s'_i \equiv \partial s_i / \partial \epsilon_i$. The household’s legal counsel and entry decision conditions are

\[(\bar{\theta} - 1)\bar{D} \bar{E}_0 \bar{\theta}_e + \bar{D} \bar{\theta}_v = w\]  \hspace{1cm} (13d)

\[y_m = (1 - \bar{\theta})\bar{D} + w\bar{L}_m\]  \hspace{1cm} (13e).

For ease of notation the ~’s are temporarily dropped. The equilibrium value of $\theta$ can be found by first summing (13b) across $n$ firms to obtain

\[-\theta mD = nw\]  \hspace{1cm} (14)

Multiply (13d) by $n$ and set equal to (14), then rearrange to get

\[\theta - 1 = \frac{-D \cdot (\theta m + \theta v \cdot n)}{D^\prime \cdot E_0 \theta_v n}\]  \hspace{1cm} (15)

Define $\epsilon = \frac{\partial D}{\partial E} \cdot E$ (the elasticity of total damages due to emissions), $\epsilon_0 = -\frac{\partial E}{\partial \theta} \cdot \frac{\theta}{E}$ (the elasticity of emissions with respect to $\theta$), and $\lambda_{f \nu} = \frac{\theta_f}{\theta_v}$ (the ratio of the marginal influence on the court of firms and victims respectively). The negative sign in front of $\epsilon_0$ is due to the fact that $E$ and $\theta$ are inversely related, allowing us to define the variable $\epsilon_0$ as an absolute value, which will be convenient below. Note that $\lambda_{f \nu}$ is a negative number.

**Result 7.** The equilibrium value of $\theta$ in the court contest is defined by
\[ \theta = \frac{\varepsilon_D \varepsilon_\theta}{\varepsilon_D \varepsilon_\theta - \lambda_{f_0} m / n - 1}. \]

**Proof:** Applying the parameter definitions to (15) and rearranging gives

\[ \theta = 1 - \frac{\theta}{-\varepsilon_D \varepsilon_\theta} \left( \lambda_{f_0} m / n + 1 \right). \]

Collecting terms yields

\[ \left[ 1 + \left( \frac{\lambda_{f_0} m / n + 1}{-\varepsilon_D \varepsilon_\theta} \right) \right] \Rightarrow \theta = \frac{-\varepsilon_D \varepsilon_\theta}{-\varepsilon_D \varepsilon_\theta + \lambda_{f_0} m / n + 1} = \frac{\varepsilon_D \varepsilon_\theta}{\varepsilon_D \varepsilon_\theta - \lambda_{f_0} m / n - 1}. \]

It is an interesting contrast with the previous section that the slope of the marginal damages function now plays an important role in determining \( \theta \), whereas under the tax contest it did not. The slope of the MAC enters through the influence of \( \theta \) on \( E \). The intuition developed in Figures 1a,b also applies here. A flat MAC implies \( \tilde{\theta} \) is distorted upward, but the flatness of the MAC imposes a limit on the extent of this distortion. Likewise a steep MAC implies \( \tilde{\theta} \) is distorted downward, but the steepness of the MAC limits the extent of over-emissions. However, there is a less benign effect working through the MD curve. For a given MAC curve and \( \lambda_{f_0} \), a decrease in \( \varepsilon_D \) will, ceteris paribus, cause \( \tilde{\theta} \) to fall. As shown in Figure 3a, the steeper the MD curve (and therefore the smaller the value of \( \varepsilon_D \)), the more likely we are to observe excess emissions. Figure 3b shows that the flatter the MD curve, the more likely we are to observe emissions below normal. A steep MD curve implies rapidly increasing total damages, precisely the situation where we would not want the outcome distorted in the direction of excess emissions.

Result 7 also suggests the existence of some polar cases.

**Result 8.** If either \( \varepsilon_D = 0 \) or \( \varepsilon_\theta = 0 \) then \( \tilde{\theta} = 0 \).
Result 9. If either $\varepsilon_D \to \infty$ or $\varepsilon_\theta \to \infty$ then (ceteris paribus) $\tilde{\theta} \to 1$.

(Proofs are omitted.) Result 8 refers to two degenerate cases which we will rule out: namely that total damages are fixed with respect to emissions and that emissions are fixed with respect to liability exposure. Result 9 refers to extreme cases, in which damages go to infinity with infinitesimal increases in emissions over some range, or that emissions go to zero with infinitesimally small increases in liability. We also ignore these cases.

It should be noted that the elasticities of emissions and damages affect the degree of the distortion on $\theta$. But whether $\tilde{\theta}$ is greater or less than 1 depends only on the sign of $(\lambda_{f_i} + 1)$, which is a result with a surprising implication.

Result 10. The decision to award punitive damages depends only on the relative influence of the legal representatives and not on the slope of the damage function. In particular, if the firms have less average influence on the trial outcome than the victims, i.e. $|\theta_f / m| < \theta_v / n$, then $\tilde{\theta} > 1$ regardless of the $\varepsilon_x$'s.

Proof: $\tilde{\theta} > 1 \iff \varepsilon_D \varepsilon_\theta > \varepsilon_D \varepsilon_\theta - \lambda_{f_i} m / n - 1$

$\iff \lambda_{f_i} m / n > -1$

$\iff \theta_f / n \theta_v / m > -1$

$\iff \left| \frac{\theta_f / n}{\theta_v / m} \right| < 1$. This step adjusts for the fact that $\theta_f$ is negative.

In the same way, if the average influence is equal between firms and victims, $\tilde{\theta} = 1$ regardless of the $\varepsilon_x$'s. The surprising implication here is that while the elasticities defined above influence the value of $\theta$, and the extent of its distortion away from unity, the determination of whether $\theta$ is above or below unity depends only on the relative influence of the litigants, and is therefore independent of, say the slope of the damage function. This
is an unexpected result: an award of punitive damages ($\tilde{\theta} > 1$) is not directly tied to the severity of damages or the steepness of the marginal damage curve, instead it results only from the relative lobbying power between firms and victims. But it should be noted that the severity of damages indirectly affects the outcome, because it affects the incentives for litigants to hire legal representation (see equations 13b,d).

The welfare implications of the liability outcome can be analyzed by looking at equilibrium emissions, the number of firms and the number of victims. Some of the following results are already established in the literature, and the proofs are moved to the Appendix.

**Result 11.** If the court apportions share $s_i$ of a liability award to firm $i$, and if $\hat{\theta} > \frac{1}{s_i}$, then $\bar{e}_i < e_i^*$ (equilibrium emissions are too low).

Result 11 implies, quite reasonably, that the apportionment rule a firm expects to face plays a role in determining the overall incentive effects of a liability regime. However it is not a very general result. For instance, if a firm expects to pay less than half of an award then $\tilde{\theta}$ must exceed 2 in order to obtain the result. But the proof only provides a sufficient condition, so if $\tilde{\theta} < 2$ it does not imply emissions are excessive. We can obtain a necessary and sufficient result if we restrict attention to the apportionment rule

$$s_i = e_i / E$$

(16).
**Result 12.** If courts use apportionment rule (12), then $\bar{e}_i > e_i^* \Rightarrow \bar{\theta} < k$ where 

$$k = \frac{E}{e_i + E_{-i}/\varepsilon_D}.$$ 

Notice that if the elasticity of damages with respect to emissions equals 1 (or if there is only one firm), then $k=1$, so firm-specific emissions under the apportionment rule follow the same pattern as that under the tax system, namely $\bar{e}_i > e_i^* \Rightarrow \bar{\theta} < 1$ (see Result 2). This aspect of the outcome under the tax rule is invariant to the elasticity of damages, but under the liability rule the shape of the damage function plays an important role. The victim’s compensation payment is tied to the level of damages, which affects a victim’s willingness to try to influence the probability and magnitude of an award. However, Result 12 implies that there will be a tendency for the liability system to yield excessive emissions, especially when the damage function is convex. The following two results establish this.

**Result 13.** If the elasticity of the damage curve equals 1, then the damage function is a ray out of the origin. If the damage curve is strictly convex, then $\varepsilon_D > 1$.

If $\varepsilon_D$ exceeds 1 then the cut-off value $k$ for $\bar{\theta}$ increases, since $(e_i + E_{-i}/\varepsilon_D) < E$ and therefore $k>1$. This implies $\bar{\theta}$ must meet a high cut-off (i.e. greater than unity) in order for emissions to be at or below the optimal level (see Figure 4). Surprisingly, $\bar{\theta} = 1$ (certainty of a victim winning a full damage claim) does not suffice to yield optimal emissions, instead the firm must be certain that punitive damages of $(k-1)\%$ will also be assessed in order to induce emissions at the optimal level. As $\varepsilon_D$ approaches infinity, $k$ approaches $E/e_i$, and if a firm is one of many emitters ($e_i / E$ is small) this may make it practically impossible for the court to provide an adequate incentive for the firm to attain efficient emissions. The
fact that \( k \) exceeds 1 under an apportionment rule, while \( \theta \) tends to be less than 1 (see discussion following Result 7), suggests that when there are multiple emitters, liability law under an apportionment rule will result in excess emissions, unless the courts will support very high punitive damage awards (and there is no possibility of bankruptcy providing effective judgement-proofness).

**Result 14.** Under an apportionment rule (16) there are too many firms in equilibrium if and only if \( \theta < D' / D \), which is greater than 1 if \( D \) is convex.

From this it is evident that there is a tendency for too many firms to operate in equilibrium, since even if \( \theta = 1 \), \( \partial W / \partial n < 0 \). The apportionment rule prices externalities at average damages rather than marginal damages. If there were no uncertainty over the court’s decision and there were a liability sharing rule such that \( s, D = D' e \) for all firms then an efficient entry condition would be obtained.

From Result 12 there is a tendency for each firm which operates in equilibrium to over-emit, and Result 14 states that there will tend to be too many firms. Hence unless the court supports very high punitive damages, the liability outcome leads to too many firms, each over-emitting, therefore aggregate emissions are too high. What is worse, the levels \( k \) and \( D' / D \) both rise as the damage curve gets more convex (and hence the marginal damages curve gets steeper). This implies that the more serious the pollutant, the more likely the value of \( \theta \) is to fall in a range in which a liability contest yields excessive aggregate emissions.

The next result concerns the equilibrium number of victims.
**Result 15.** In any liability equilibrium with \( \tilde{\theta} > 0 \), there are too many victims living in the region.

Result 15 arises because of the fact that victims receive (at least partial) compensation for damages under a liability regime. This makes them less inclined to self-protect, by locating themselves away from the damaging activity. Fortunately, the more likely it is for emissions to be excessive (\( \tilde{\theta} \to 0 \)) the smaller the tendency for victim over-exposure.

The problems with the liability regime arise because the court charges average, rather than marginal damages to firms, and the expectation of compensation reduces victims’ incentives for self-protection. The expression for \( \partial W/\partial e_i \) in the proof of Result 11 suggests that the following apportionment rule would be preferable:

\[
s_i = \frac{D'(\tilde{E}) \cdot \tilde{e}_i}{D(\tilde{E})}
\]

(17).

The *legal* difficulty with (17) is that the shares sum to more than 1 if the damage function is convex. But it has some desirable economic properties. Using \( s_i' = (D'/D) - (D'/D)^2 e_i \) it can be shown that (17) implies

\[
\frac{\partial W}{\partial e_i} = (\theta - 1) mD'.
\]

(18)

In this case the firm-specific emissions distortion corresponds with that under the tax rule: \( \tilde{\theta} > 1 \) implies suboptimal emissions from each firm and vice versa, and \( \tilde{\theta} = 1 \) implies firm-
specific optimal emissions. Also, using (17) and the expression for $\frac{\partial W}{\partial n}$ from the proof of Result 14 yields

$$\frac{\partial W}{\partial n} = m(\theta - 1)D' \cdot e_n$$

(19).

hence excess (insufficient) entry corresponds to $\tilde{\theta} < 1$ ($\tilde{\theta} > 1$). Combining these results implies aggregate emissions are excess (insufficient) corresponding to $\tilde{\theta} < 1$ ($\tilde{\theta} > 1$) as well.

Result 15 still holds even in the presence of the efficient sharing rule, so correcting the behaviour of firms does not correct the victim incentives. Indeed an interesting result of using the efficient sharing rule (17) is that either problem can be corrected, but not both.

**Result 16.** If the court uses (17), the efficient sharing rule, then either the optimal aggregate emissions level can be achieved, or the optimal number of victims enter the region, but not both.

While the above result is discouraging in terms of achieving a first-best optimum, it is also encouraging because it shows that achieving the optimal emissions level through a liability regime is possible even if an inefficient number of victims enters. By Results 7 and 10 the value of $\theta$ resulting from the legal contest is dependent on the relative average influence of victim and polluter legal representation. If these are equal then $\tilde{\theta} = 1$ and an efficient emissions level is attained, regardless of the slopes of the MD and MAC curves and the presence of excessive victims.
4. Conclusions
The political task of pricing externalities was modeled as a contest over a pricing coefficient. In the case of Pigovian taxes, the regulator can be lobbied to increase or decrease the emissions tax rate. In the case of liability law, the court can be lobbied over the product of the probability of awarding damages and the ratio of the award to the actual damages. The tax contest appears to be inherently constrained to be close to the optimum. In the case in which the emissions price is above the efficient pollution charge, it cannot be too far above, and firms find it relatively cheap to abate anyway. In the case in which the emissions price is too low, emissions tend not to increase much even as controls weaken. Because victims do not automatically receive compensation, there is no incentive for too many or too few to enter the region, and the efficient number is observed in the equilibrium.

In the liability contest under an apportionment rule, there is a general tendency to have too many firms, each emitting too much, even in cases where there is certainty of a plaintiff being awarded full damages in court. Moreover, this tendency towards overemissions is exacerbated by a high elasticity of damages, although this simultaneously reduces the incentive for an excess number of victims to live in the region. As long as there is a nonzero probability of a nonzero damage award, too many victims will locate themselves in the damaged region. If the court applies an efficient sharing rule, the aggregate level of emissions depends on the equilibrium value of $\theta$, which is sensitive to the relative average influence of firms’ and victims’ lobbying in court, as well as to the slopes of both the $MD$ and $MAC$ curves. By contrast, in the tax contest the slope of the $MD$ curve plays no role in the determination of $\theta$. Applying an efficient sharing rule makes it possible to attain the efficient emissions level but it does not correct the incentives for victim overexposure.
While a direct welfare comparison is not possible in this model, in situations where the price of an externality is subject to a lobbying contest and there is free entry of firms and victims, a Pigovian pricing scheme appears to have important advantages over the sorts of liability regimes observed in practice. Unless the courts replace the common apportionment rule with a marginal pricing rule such as the one proposed here, a tax regime, even when distorted by lobbying activity, is likely to yield an outcome which departs from efficiency in relatively benign ways.
References


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FIGURE 1a

Tax Contest: High elasticity of $MAC$ implies $\theta > 1$, sub-optimal emissions
FIGURE 1b
Tax Contest: Low elasticity of $MAC$ implies $\theta < 1$, excess emissions
FIGURE 2a
Tax exceeds optimal marginal damages and actual marginal damages when $\hat{\theta} > 1$
FIGURE 2b
Tax is below optimal marginal damages and actual marginal damages when $\theta < 1$
Figure 3a
Liability Contest: Steep $MD$ associated with $\theta < 1$, excess emissions

![Graph showing the relationship between price and emissions with the lines $MD$, $\theta MD$, and $MAC$.]
Figure 3b
Liability Contest: Flat $MD$ associated with $\theta > 1$, suboptimal emissions

![Graph showing the relationship between Price, Emissions, and Liability Contests.](image)

- $\theta MD$
- $MD$
- $MAC$

$E^*$ and $\bar{E}$ are points on the graph where the $MAC$ curve intersects with the $MD$ and $\theta MD$ lines, respectively.
Figure 4
Under Liability Rule if $\tilde{\theta} < k$ then aggregate emissions are excessive

Excess emissions

1 $k$ $\tilde{\theta}$
Appendix: Proofs of Results 11-16.

Proof of Result 11: Evaluate \( \frac{\partial W}{\partial e_i} = B'_i - mD' \) using (13a) to get

\[
\frac{\partial W}{\partial e_i} = \theta m s_i D' + \theta m D s'_i - m D' = (mD')[\theta s_i - 1] + (\theta m D s'_i).
\]

The terms in parentheses are positive, while the term in the square brackets is of indefinite sign. If \( \tilde{\theta} > \frac{1}{s_i} \) then the whole expression is positive, indicating sub-optimal emissions.

Proof of Result 12: Rearrange the equation derived in Result 11 to get

\[
\frac{\partial W}{\partial e_i} < 0 \iff \tilde{\theta} < \frac{\varepsilon_D}{\varepsilon_D s_i + E s'_i}.
\]

Apply (16), noting that \( s'_i = E_{-i}/E^2 \), to get

\[
\frac{\partial W}{\partial e_i} < 0 \iff \tilde{\theta} < \frac{\varepsilon_D E}{\varepsilon_D e_i + E_{-i}},
\]

from which the result follows.

Proof of Result 13: \( \varepsilon_D = \frac{\partial D}{\partial E} D = 1 \Rightarrow D' = \overline{D} \), where \( \overline{D} = D/E \) denotes average damages. The only function for which average damages equal marginal damages everywhere is of the form \( D = aE \). If \( D \) is strictly convex then \( D' > \overline{D} \Rightarrow D'E/D (= \varepsilon_D) > 1 \).

Proof of Result 14: Evaluate \( \frac{\partial W}{\partial n} \) using (13c) (ignoring most of the \( \sim \)'s and \( *'s), yielding

\[
\frac{\partial W}{\partial n} = \theta m s_n D(E) + \omega L_n - m D e_n - \omega L_n = m(\theta s_n D - D e_n).
\]

Under the apportionment rule we have

\[
\frac{\partial W}{\partial n} = (\theta D - D')me_n < 0 \iff \tilde{\theta} < D'/\overline{D}.
\]

Proof of Result 15: \( \frac{\partial W}{\partial m} = \tilde{\gamma}_m - D(E) - \omega L_m = (1 - \tilde{\theta})D(E) - D(E) \) (by equation 13e)

\[
= -\tilde{\theta} D(E) < 0.
\]

Proof of Result 16: Equations (18) and (19) show that if \( \tilde{\theta} = 1 \) then there is an efficient number of firms each emitting an efficient level of emissions. But Result (15) shows that too many victims enter. Having the efficient number of victims requires \( \tilde{\theta} = 0 \), in which case (18) and (19) show emissions are excessive.
List of Symbols in Order of Appearance

- $n$: firms; $N$ is socially optimal level
- $i$: index of firms
- $m$: households; $M$ is socially optimal level
- $j$: index of households
- $e_i$: emissions of firm $i$
- $B_i$: private benefit to firm $i$ from emissions
  - $-\beta$: fixed portion
  - $b_i$: variable portion
- $D(E)$: Total damages
- $E$: aggregate emissions
- $U_j$: utility of household $j$
  - $y_j$: benefit of living in region
- $w$: unit cost of lobbying effort
- $L_i$: firm $i$'s demand for lobbying effort
- $L_j$: household $j$'s demand for lobbying effort
- $W$: social welfare
- $C_T$: cost of consultant report
- $t$: emissions tax
- $\theta$: distortion variable
  - $\ast$: signifies socially optimal level
  - $\wedge$: signifies private optimum under tax
  - $\sim$: signifies private optimum under liability
- $\varepsilon$: elasticity of emissions with respect to the tax rate
- $\mu_{f/\theta}$: ratio of marginal influence on tax rate
- $\varepsilon_D$: elasticity of total damages with respect to emissions
- $\varepsilon_{\theta}$: elasticity of emissions with respect to $\theta$
- $\lambda_{fv}$: ratio of marginal influence on court decisions
- $k$: cut-off value of $\widetilde{\theta}$ below which emissions are excessive