UNCERTAIN EXTERNALITIES, LIABILITY RULES AND RESOURCE ALLOCATION: A COMMENT

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I. INTRODUCTION

In a recent article in this Journal Greenwood and Ingene (G & I) examine the allocative consequences of liability rules in a world with uncertain externalities. In such a world G & I show that the assignment of liability can result in a different allocation of resources because of different risk preferences and imperfect options for risk spreading. They conclude, however, that "the government, by use of a tax/subsidy scheme, can intervene to create a Pareto optimal level of outputs" (p. 308). The Pigouvian prescription, most recently defended by Baumol (1972) and Baumol and Oates (1975) is thus retained, but made more complicated by the fact that the government must know the risk functions of the stochastically affected parties.

The purpose of this note is to take issue with the Pigouvian prescription in a world with uncertain externalities. While the assignment of liability may still affect the allocation of resources, it will be shown that no tax/subsidy scheme is needed, rather the extent of liability need only be defined for all possible externality states.

This result is derived in a contingent claims model, admittedly different than that employed by G & I. In many respects it is a more realistic model; one in which a decision made in period t may result in an externality in period t+1, but the level of externality, and thus the associated benefit or damage is not known at the time allocation and production decisions are made. The explicit time dimension of such a model is much better suited to the analysis of uncertain externalities and liability rules.

The problem of oil pollution, or more specifically oil spills would appear to be an important example of uncertain externality. A "spill" model is developed to explore the role of liability and also note other problem characteristics likely to be present when uncertainty is introduced.

II. UNCERTAIN EXTERNALITY: LIABILITY IN A CONTINGENT CLAIMS MODEL

Consider the following two-period, two-state model where:

$t = 0$ is the known present period

$t = 1$ is the uncertain future period

$i = a, b$ is an index for the two possible future states

q_o is the production decision of the potential externality generating activity

S_i is the spill level in the i^{th} future state

$q_i = q_o - S_i$ is the level of marketable output in the i^{th} future state

$R_i = R(q_i)$ is the present value of revenues from marketable output in the i^{th} state

$C_o = C(q_o)$ is the cost associated with the present period production decision

$D_i = D(S_i)$ is the present value of damage from the spill level in the i^{th} state

$P_i = P(S_i | q_o)$ is the probability of the i^{th} state conditional on the production decision q_o

The present value of net social benefits in the i^{th} state may be written

(1) $B_i = R(q_i) - C(q_o) - D(S_i)$

and maximization of the present value of expected net social benefits would involve

(2) $\underset{q_o}{\text{Max}}\ B = \sum_i P(S_i | q_o) \left[R(q_i) - C(q_o) - D(S_i)\right]$

Upon differentiating with respect to q_o one obtains:

$$(3)\quad \frac{dB}{dq_o} = \sum_i \left\{ \frac{dP(\cdot)}{dS_i} \frac{dS_i}{dq_o} B_i + P(\cdot)\left[\frac{dR}{dq_i} (1 - \frac{dS_i}{dq_o}) - \frac{dC}{dq_o} - \frac{dD}{dS_i} \frac{dS_i}{dq_o} \right] \right\} = 0$$

The optimal production decision involves not only a balancing of expected marginal revenues with marginal private and social costs, but also the possibility that variations in production, especially increases, may change the probability of certain states occurring. Suppose $S_a = 0$ and $S_b > 0$ and that $\frac{dP(\cdot)}{dS_a} \frac{dS_a}{dq_o} < 0$ while $\frac{dP(\cdot)}{dS_b} \frac{dS_b}{dq_o} > 0$ that is increases in q_o (production) make the probability of a spill more likely. Then it is entirely likely that past some point

$$(4)\quad \sum_i \frac{dP(\cdot)}{dS_i} \frac{dS_i}{dq_o} B_i < 0$$

and marginal increases in q_o result in incremental expected costs (private and social) which exceed expected incremental revenues.

Interestingly enough the private profit maximizing firm will set production so as to take into account the increased probability of (larger) spills associated with increases in q_o. If oil which is spilt cannot be marketed then rational private behavior will require a balancing of expected marketable output against expected production lost (spilt). With slower rates of extraction over a longer time horizon a larger volume may be marketed more profitably than a smaller volume over a shorter time horizon. As in the static externality analysis the private profit maximizing firm will not take into account the expected social cost of his production decision. No tax is needed, however, rather only a liability rule requiring that spill damages be paid in the event that they occur. By specifying $L_i = D(S_i)$ the profit maximizing firm can calculate the change in expected liability according to

$$(5) \quad \frac{dL}{dq_o} = \sum_i \left\{ \frac{dP(\cdot)}{dS_i} \; \frac{dS_i}{dq_o} \; L_i + P(\cdot) \frac{dD}{dS_i} \; \frac{dS_i}{dq_o} \right\}$$

No tax is collected. No spill may take place. The firm has been induced to modify its production decision by the prospect of expected liabilities.

I suspect that the assignment of liability could significantly alter the production decision q_o if one were to introduce explicit social and private risk functions and differential options for spreading risk. There is also a more obvious reason why the assignment of liability could be allocatively significant. With uncertainty as to what is the true conditional spill distrubition, $P_i = P(S_i|q_o)$, differences as to what is the optimal social level of production could arise. In a Bayesian learning situation individuals starting with different priors may or may not rapidly converge into agreement on $P(S_i|q_o)$. The "real world" further differs from both this and G & I's analysis in that an exhaustive partitioning of future damages is seldom possible.

In summary, the Pigouvian tax/subsidy scheme is replaced by a liability rule specifying damage claims in all possible future states. Factors such as risk preferences, risk spreading options, and prior subjective distributions are likely to differ with the assignment of liability resulting in a different allocation) of resources. It may further be the case, as in the spill model developed here, that the <u>probability</u> of future externality states is inturn conditional on the allocation of resources.

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