NBER WORKING PAPER SERIES

THE CASE FOR A TWO-PART INSTRUMENT: PRESUMPTIVE TAX AND ENVIRONMENTAL SUBSIDY

Don Fullerton
Ann Wolverton

Working Paper 5993

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 1997

We are grateful for financial assistance provided by EPA grant R824740-01-0. A special thanks to Gunnar Eskeland, Bob Schwab, Hilary Sigman, Rob Stavins, Margaret Walls and Sarah West for helpful comments and suggestions. This paper is part of NBER's research program in Public Economics. Any opinions expressed are those of the authors and not those of the Environmental Protection Agency or the National Bureau of Economic Research.

The Case for a Two-Part Instrument: Presumptive
Tax and Environmental Subsidy
Don Fullerton and Ann Wolverton
NBER Working Paper No. 5993
April 1997
JEL Nos. Q21, H23
Public Economics

ABSTRACT

This paper builds two simple general equilibrium models to demonstrate the equivalence between the Pigovian tax and the combination of a presumptive tax and an environmental subsidy. A presumptive tax is a tax that is imposed under the presumption that all production uses a dirty technology or all consumption goods become waste. The environmental subsidy is then provided only to the extent that production uses a cleaner technology or that consumption goods are recycled. To analyze the usefulness of the tax-subsidy combination, we review conceptual considerations regarding its implementation and practical considerations regarding its actual use throughout the world. While the tax-subsidy combination is increasingly being used, in the form of a deposit-refund system, we argue that more flexible interpretations are important to explore. The two parts of such a policy do not have to apply to the same side of the market. The tax and subsidy do not have to equal one another, and they can apply to different goods altogether. Compared to the Pigovian tax, a two-part instrument may be easier to enforce, may be easier to enact, and can still force the market to recognize the social cost of disposal.

Don Fullerton
Department of Economics
University of Texas at Austin
Austin, TX 78712
and NBER
dfullert@eco.utexas.edu

Ann Wolverton
Department of Economics
University of Texas at Austin
Austin, TX 78712
mwolvert@eco.utexas.edu

I. INTRODUCTION

Economists have long noted that many types of pollution can be controlled efficiently by placing a price or tax directly on the polluting activity (Pigou, 1932). This incentive can induce the household or firm to find the cheapest possible way to reduce waste, whether by recycling, installing new equipment, switching fuels, using labor-intensive methods, or perhaps just reducing production of the offending good. Still, few such taxes are ever employed by policy makers. Most environmental policies in the U.S. and other countries are "command and control" regulations, and most "environmental taxes" are labeled as environmental only because the resulting revenues are spent on clean-up, not because the tax applies per unit of a polluting activity.[1]

Perhaps the major reason that taxes on polluting activities are rare is that wastes are hard to monitor and the taxes are difficult to enforce. Practical policy requires that the tax apply to an observable market transaction like the purchase of petroleum or chemical inputs, rather than to the "spilling of oil" or the "dumping of chemical wastes." These polluting activities can be prohibited by law, and controlled through the required use of certain technologies, but they are hard to measure for the application of a waste-end tax.

The point of this paper is that the desirable incentive effects of a waste-end tax can be matched exactly, without the measurement and enforcement problems, by the use of a "two-part instrument." To see this equivalence, one must first view the generation of waste as an input to production, with its own marginal product, just like labor, capital, and materials.[2] Then the tax does not need to apply directly to the

---

[1] The U.S. Internal Revenue Service identifies four "environmental taxes:" (1) petroleum, for the Oil Spill Liability Trust Fund and for Superfund; (2) chemical feedstocks, for Superfund; (3) ozone-depleting chemicals, for the general fund; and (4) motor fuels, for the Leaking Underground Storage Tank (LUST) fund. These taxes apply to useful petroleum and chemical inputs, not to waste by-products or emissions (Fullerton, 1996).

[2] One can think of labor, capital, and materials as inputs to the production of a good output and a bad output (such as waste). Then the production function can be

unobservable wastes. Identical changes in relative prices can be achieved with a tax on an observable transaction such as the purchase of the output, in combination with a subsidy to other observable transactions like the purchase of all other inputs to production *except* waste.

The intuition is fairly simple, and follows from the idea that the waste-end tax has two intended incentive effects. First, it raises production costs and makes the good more expensive, so the "output effect" reduces production and therefore consumption of the good. Second, it makes the waste more expensive relative to other inputs, so the "substitution effect" reduces waste per unit of the remaining amount of the output that still gets produced. By analogy, the two-part instrument accomplishes the same effects separately. The first part imposes a tax on the output, reducing production and consumption of the good. This tax on output is equivalent to a tax at the same rate on *all* inputs to production, including labor, capital, materials, and waste. The second part subsidizes all non-waste inputs, which makes waste *relatively* more expensive and reduces waste per unit of output.

We refer to the first part of the two-part instrument as a presumptive tax; it is imposed under the presumption that all production uses a dirty technology or that all consumption goods become waste. The second part is an environmental subsidy; it is provided only to the extent that production uses clean technology or that consumption goods are recycled. The obvious practical example of a two-part instrument is a deposit-refund system: the consumer pays a deposit under the presumption that the item will be discarded improperly, and gets a refund only with proper performance (when the item is recycled). When litter or other illegal disposal cannot be taxed directly, the deposit-refund system can accomplish the same goals (Bohm, 1981, Stavins, 1991, Cropper and Oates, 1992). A subsidy to the form of disposal with lower social costs provides the substitution effect, shifting disposal away from socially-costly dumping,

---

rearranged algebraically by moving waste to the other side of the equation, so that the good output is a function of capital, labor, materials, and waste.

but that subsidy implicitly makes consumption cheaper and *encourages* purchase of the good. An output tax corrects this latter effect.

The literature does not use the term presumptive tax to refer exclusively to the first part of a two-part instrument. Gunnar Eskeland (1994) defines it as a tax that exploits the presumed relationship between the good to be taxed and the pollution to be regulated, but he does not require that it be paired with a subsidy.[3] Using this definition, any indirect tax that acts as a proxy for the direct taxation of emissions can be called a presumptive tax. For example, a gasoline tax is a presumptive tax on emissions, because one presumes that gasoline use is related to emissions. The tax on gasoline is more practical than a tax on vehicle emissions, but it is not a perfect proxy because it does not provide incentives to fix a car's broken pollution control equipment or to buy a car with lower emissions per gallon of gasoline.

In this paper, to avoid categorizing any indirect tax as a presumptive tax, we will refer to a presumptive tax only in combination with an environmental subsidy. The above gasoline tax is an indirect tax on emissions, but we refer to it as a presumptive tax only if it is coupled with a subsidy to the repair of all vehicles' broken pollution control equipment, or a subsidy to the purchase of vehicles with lower emissions per gallon of gasoline. The two-part instrument thus improves the aim of policy at the desired behavioral targets.[4]

The main advantage of the two-part instrument is that both parts apply to market transactions with invoices to help ensure compliance. In contrast, a Pigovian tax may

---

[3] The presumptive tax-subsidy combination is not excluded from his analysis, but it is not his primary focus. Eskeland simply defines presumptive taxation more broadly to include taxes unaccompanied by subsidies. Eskeland and Devarajan (1996) show how different combinations of instruments can be used to approach the effect of an ideal Pigovian tax.

[4] Actually, the two-part instrument might be difficult to implement perfectly for vehicle emissions because driving is not a market commodity that can be taxed in a way that will mirror the subsidy for clean inputs to driving. Certain kinds of heterogeneity also can be a problem for the two-part instrument, as discussed below.

apply to the firm's own measure of an input that is not purchased on the market and therefore does not have an invoice. The two-part instrument puts the information requirements where they can be met most cheaply and efficiently. It shifts the burden of proof. The firm must measure its own clean inputs and provide the evidence necessary to receive the subsidy.

Discussions in the literature of the tax-subsidy combination largely have been limited to deposit-refund systems in which the deposit and the refund are explicitly linked, and in which the deposit and the refund are equal to one another.[5] No such restrictions are made here. The refund may be paid to an individual or firm other than the one who paid the deposit, and the optimal refund may be a different amount than the original deposit. The tax and subsidy may even apply to different commodities altogether.

Current deposits and refunds do apply to particular consumer items such as beverage containers, car hulks, oil, and batteries, but we wish to emphasize that this concept has much wider applicability and may provide a promising alternative to widely-used CAC policies.[6] In a broad sense, the United States income tax system

---

[5] Several papers compare this restricted deposit-refund system to other policies such as an advanced disposal fee or a virgin materials tax. Sigman (1995a) uses a partial equilibrium framework to analyze lead recycling, while Miedema (1983) uses a general equilibrium context to compare solid waste policy options. Dinan (1993) finds that, since a deposit-refund system is equivalent to a waste-end tax, it is more efficient than a virgin materials tax. Palmer et al (1996) build a partial equilibrium model and run simulations in which the deposit is assumed to equal the refund, but where the deposit is paid by producers while the refund is given to recyclers. Swierzbinski (1994) uses a partial equilibrium, game-theoretic approach that allows the deposit to differ from the refund, but he requires that they apply to the same firm.

[6] The two-part instrument may not be such a promising alternative, however, in cases where emissions are already being measured cheaply and effectively. Air emissions such as SO_2, for instance, are already monitored effectively by the EPA with installed continuous emissions monitoring (CEM) systems; firms are fined at the end of the year if actual emissions exceed the amount allowed. The two-part instrument may be more important in cases with many small polluters, where expensive emission monitoring equipment would be required for each.

operates on a deposit-refund principle. An individual pays a presumed amount of tax directly out of his or her paycheck each month, and a refund is given at the end of the fiscal year if the individual files a proper tax return with proof of overpayment. The same approach can be used in an environmental context. Thus, instead of limiting ourselves to a discussion of a deposit and refund, we want to think more generally about how a simple excise tax on a given consumption good can be coupled with a subsidy per ton of recycled material used in production. If markets work, this subsidy can be passed on to suppliers of recycled goods.

We begin in section II by outlining two simple general equilibrium models to demonstrate the equivalence between a Pigovian tax on emissions and a presumptive tax-environmental subsidy combination. This equivalence is shown to hold even when one agent pays the tax on a good or factor and a different agent receives the subsidy, possibly on a different good or factor. In the first model, the deposit always equals the refund. In the second model, however, this is not necessarily the case. Section III examines some practical advantages and disadvantages of using a presumptive tax-subsidy combination to elicit the optimal solution. Section IV provides a review of how this idea of a two-part instrument has been used in actual policy implementation. Finally, we conclude in section V that the presumptive tax coupled with a performance subsidy is a broader and more useful policy instrument than commonly thought.

II. THEORETICAL EQUIVALENCE TO A PIGOVIAN TAX

A. The Simplest Possible Model

To illustrate the equivalence between the Pigovian tax and the two-part instrument, we build a simple general equilibrium model in the tradition of Baumol and Oates (1988).[7] In the simplest possible model, the economy is a closed one with linear production and only one jurisdiction. We also assume perfect information, no transactions costs, and no pre-existing distortions.

In this simple model, the society consists of n identical households. Each household owns one unit of "resources," which may include a fixed amount of labor, capital, land or any other resource that can be sold in the market or used at home. The household sells some of this resource and uses the income to buy a clean good c and a dirty good d. It retains some of these resources to produce a household good h, which can be interpreted either as leisure or as household production. We define the units in our model such that the marginal rate of transformation is equal to 1. Thus, given these assumptions, the resource constraint is simply: $h+c+d=1$. Utility of the household u depends positively on each of these three goods and negatively on the total amount of the dirty good present in society, $D=nd$. Throughout this paper, lower case letters denote individual household amounts, while upper case letters denote aggregates for the society.

The social planner maximizes the utility of a representative household, subject to the resource constraint, recognizing the effect of each household's consumption of the dirty good d on the total amount of D. Thus, the optimization problem is:

$$\max \; u(c,d,h,nd) + \lambda(1-h-c-d) \tag{1}$$

with respect to c, d, and h. This yields the first order conditions:

---

[7] Another model, similar to this one, is applied to the specific problem of household disposal in Fullerton and Kinnaman (1995).

$$u_c = \lambda \qquad (2a)$$

$$u_d + nu_D = \lambda \qquad (2b)$$

$$u_h = \lambda \qquad (2c)$$

where a subscript denotes a partial derivative, and λ is the social marginal value of the resource. These first order conditions state that the marginal utility from an additional unit of c, d, or h equals the marginal social cost, λ.

In the private market with perfect competition, the individual household maximizes utility subject to its budget constraint:

$$\max\ u(c,d,h,D) + \gamma[(1-h)(1-t_r) - c(1+t_c) - d(1+t_d)] \qquad (3)$$

where prices are normalized to one, t_c is the tax per unit of c, t_d is the tax per unit of d, and t_r is the tax per unit of resources supplied in the market. A household does not take into account the effect of its own use of d on the total amount of the dirty good D in society. Thus, it maximizes utility with respect to c, d, and h but takes D as given. The first order conditions from the individual household's problem are:

$$u_c = \gamma(1+t_c) \qquad (4a)$$

$$u_d = \gamma(1+t_d) \qquad (4b)$$

$$u_h = \gamma(1-t_r) \qquad (4c).$$

The solution strategy is to find tax rate combinations where the market (equations 4a - 4c) is induced to match the social optimum (equations 2a - 2c). We first examine the case where $t_c = t_r = 0$. From (2a) and (4a), we then find that $\lambda = \gamma$; the social utility from one more unit of income (or time) is equal to its private utility. Using this relationship and combining (2b) with (4b) reveals that the optimal tax on d is:

$$t_d = -\frac{nu_D}{\gamma} \qquad (5)$$

This result is a simplified version of the Pigovian tax derived in Baumol and Oates (1988). It is the total, for all n households, of the marginal disutility from another unit of d, converted into dollars when divided by the marginal utility of income. Since n

and γ are positive, a negative externality u_D yields a positive tax t_d. The tax discourages consumption of d, inducing households to reach the social optimum.

Suppose, however, that t_d cannot be used as a policy instrument, either because it is difficult to enforce or because d is hard to measure. We can still obtain the same first-best outcome by using the two other instruments: t_c and t_r. With a non-zero tax on c, however, λ is no longer equal to γ. Using (2a) and (4a), we find that $\lambda = \gamma(1 + t_c)$. Also, from (2c) and (4c), we have $\lambda = \gamma(1 - t_r)$. Using these two expressions for λ, it must be the case that $t_c = -t_r$. As a consequence, one of these "taxes" will in fact be a subsidy.

Next, with $t_d = 0$, (4b) states that $\gamma = u_d$. If we substitute $\lambda = \gamma(1 - t_r)$ into (2b) and solve for t_r, we have:

$$t_r = -\frac{nu_D}{\gamma}. \tag{6}$$

Given that $\gamma \geq 0$ and $u_D \leq 0$, t_r is a positive tax. This tax applies to all earnings. As previously established, t_c is the negative of this result. This subsidy is a rebate on all spending *except* spending on the dirty good.

Thus, even a very simple model can be used to demonstrate the equivalence of the two-part instrument with the standard Pigovian tax. The deposit still equals the refund, but otherwise this tax-subsidy combination does not resemble the standard deposit-refund system because the tax applies to labor or capital income while the subsidy is on an entirely different commodity. This presumptive tax can be part of the income tax collected by the government each year, while a separate subsidy applies to c. As a practical matter, this subsidy can appear simply as a sales tax that is lower on c than on all other goods. Thus, the consumer may not even notice the connection between the tax and the subsidy, despite the fact that together they induce the optimal behavior.

B. A Model with Production and Emissions

A second general equilibrium model illustrates the usefulness of the two-part instrument for controlling a firm's emissions from production. As in the previous model, we make the standard assumptions of no transaction costs, perfect information, no pre-existing distortions, a closed economy, and perfectly competitive markets. Again, the society consists of n identical households. Each household's utility u is a function of one good d, household production h, and the total amount of waste in the society $W=nw$. Thus,

$$u = u(d, h, W) \tag{7}$$

where $u_d \geq 0$, $u_h \geq 0$, and $u_W \leq 0$.

The good d is produced using the following constant returns to scale production function:[8]

$$d = f(r_d, w). \tag{8}$$

where r_d is the direct use of resources r in the production of d. Production cannot occur without the generation of waste w. This waste requires the use of some private resources for removal and disposal r_w, in the amount $r_w = aw$. The household good h is produced using only one input r_h, the amount of the resource retained at home. Thus, $h = r_h$. With a fixed total resource r, the resource constraint for the model is $r = r_d + r_h + r_w$.

The social planner maximizes utility subject to production and resource constraints as well as $r_w = aw$. Substituting these constraints into the planner's problem yields:

$$\max \ u[f(r_d, w), r_h, nw] + \lambda[r - r_d - r_h - \alpha w]. \tag{9}$$

The planner maximizes utility by choosing r_d, w, and r_h, explicitly taking into account the effect of production waste on utility. This gives the following first order conditions:

---

[8] Because of constant returns to scale, all of these variables can be expressed in amounts per household.

$$u_d f_{r_d} = \lambda \tag{10a}$$

$$u_d f_w + n u_W = \alpha\lambda \tag{10b}$$

$$u_h = \lambda \tag{10c}$$

where f_{r_d} is the partial of f with respect to r_d, and f_w is the partial of f with respect to w. Intuitively, these first order conditions state that the marginal social benefit from a particular use of the resource is equal to the marginal social cost.

In the private market, the consumer maximizes utility with respect to d and r_h subject to a budget constraint:

$$\max \quad u(d, r_h, W) + \gamma[(r - r_h) - d(p_d + t_d)] \tag{11}$$

where t_d is a tax on the consumption of d, and the resource r is the numeraire. The individual consumers have no control over the total amount of waste being produced by firms. However, they are still affected by its generation; thus, $u_W \leq 0$. The first order conditions are:

$$u_d = \gamma(p_d + t_d) \tag{12a}$$

$$u_h = \gamma\,. \tag{12b}$$

Producers of d maximize profits by their choice of inputs r_d and w. Thus, the firm's problem is:

$$\max \quad p_d f(r_d, w) - (1 + t_r)\cdot r_d - (\alpha w + t_w w) \tag{13}$$

where t_r is a tax on the use of resources r_d, and t_w is a possible tax on waste emissions. The first order conditions yield two important relationships:

$$p_d = \frac{1 + t_r}{f_{r_d}} \tag{14a}$$

$$p_d = \frac{\alpha + t_w}{f_w}\,. \tag{14b}$$

In this model, from (12b) and (10c), we again have $\lambda = \gamma$. When both t_r and t_d are zero, the government has only t_w available to induce the private market to match the social optimum. We set (14a) equal to (14b) and use the result along with (10a) and (10b) to find the Pigovian tax:

$$t_w = -\frac{nu_W}{\gamma}. \tag{15}$$

However, this tax on emissions does not apply to a market transaction and may therefore be difficult to monitor. In the case where emissions cannot be taxed directly ($t_w = 0$), both t_r and t_d can be used to arrive at exactly the same first-best socially optimal solution. This combination may be easier to implement, since it involves a tax on the output of a market good *d,* and on the input of a market resource r.

We begin by solving for t_d. Substituting (14b) into (12a) and then into (10b), we find that:

$$t_d = -\frac{nu_W}{\gamma f_w} \tag{16}$$

Since consumers derive negative utility from *W,* and firms have a positive marginal product from w, t_d is a positive tax on consumer purchases of *d.* It can be rewritten as the marginal external damage from w (the Pigovian tax on firms in (15)) divided by the marginal product of w. Thus, intuitively, t_d can be interpreted as the increase in the price of d that would have occurred with a tax on waste.

Now we solve for t_r by substituting (10a), (14a) and (16) into (12a):

$$t_r = \frac{nu_W f_{r_d}}{\gamma f_w}. \tag{17}$$

Since $u_W \leq 0$, we know t_r is negative. This subsidy is the marginal external damage from w multiplied by the ratio of the marginal products. This latter ratio is the slope of the isoquant, the trade-off between units of the dirty input and the clean input. Thus, if the price of r_d is high, then t_r must also be high to generate the necessary substitution from w to r_d. The optimal subsidy per unit of clean input, t_r, can also be interpreted as the damage per unit of dirty input multiplied by the number of dirty inputs per clean input.

The use of t_d with t_r constitutes a two-part instrument that yields the same efficient results as the standard Pigovian tax on waste. Thus, the equivalence between the two tax systems still holds in a model where producers have a choice regarding emissions per unit of output. In this model, the equivalency between the Pigovian tax and the two-part system holds even though the Pigovian tax is placed on the firm, while the presumptive tax is placed on the purchases made by consumers. As in the previous model, the tax and subsidy are not explicitly linked; the tax is on the output while the subsidy is on the clean input. In addition, the deposit no longer is required to equal the refund.

The tax-subsidy combination is useful particularly when a tax directly on emissions is difficult to enforce. Because emissions are not observed in a market transaction, a presumptive tax is placed instead on the output, which is easily observed in the market. Given a presumed relationship between output and emissions, the tax on output is a proxy for a direct tax on emissions. However, if producers can change emissions per unit of output, then this presumptive tax might not be a good proxy by itself. The firm's purchase of clean inputs such as labor or capital are also observed in the market, and can be subsidized by a reduction in other taxes that are normally collected on those inputs. The combination of a tax on output with a subsidy on clean inputs is a perfect proxy for an unenforceable tax on the dirty input.

III. BEYOND THE MODEL: TWO-PART INSTRUMENT VS. PIGOVIAN TAX

The two models above are simple, and yet they demonstrate cases where the two-part instrument is equivalent to a Pigovian tax. The results cannot be used to choose one such policy over another, however. To make the case for the two-part instrument, we must look outside the models at considerations such as feasibility, administrative costs, policy enforcement, and political perceptions. We also examine the possible effects of relaxing some of our models' assumptions.

A. Practical Differences from a Pigovian Tax

First, consider feasibility. A Pigovian tax directly on the dirty input or emissions may not be possible, either because emissions cannot be measured or because the tax is not enforceable. For example, a tax on vehicle emissions is not yet technologically feasible (Harrington et al, 1994), and a tax on "midnight dumping" is not enforceable. When the Pigovian tax is not viable, the equivalent two-part instrument has an obvious advantage. It still discourages the illegal disposal that is so costly to clean up or that is so hazardous to health.

Second, even when the Pigovian tax is feasible, the two-part instrument will often have lower total social costs of administration. The Pigovian tax requires one party, the government, to collect data on emissions of a different party, the polluter. In contrast, the two-part instrument places the data requirements on those with information. The shift in the "burden of proof" leaves the individual consumer or firm to provide proof that proper disposal has taken place in order to obtain the subsidy. As argued by Russell (1988), these monitoring costs must be lower for the firm or consumer than for a government official who has less knowledge of the production or disposal process. Some of the reduced administrative cost of government may be offset by the increased compliance cost of firms and consumers, but the total is likely to be smaller since the firm's cost of monitoring its own amounts of each type of disposal is probably lower than the government's costs of monitoring those behaviors. The government only needs to set the deposit and the refund, and to check for the authenticity of a returned item or clean input (Stavins, 1991).

Third, consider enforcement problems. To enforce the Pigovian tax, the government must try to prevent illegal dumping by properly setting the rate of taxation, the rate of audit or inspection, and the rate of penalty. The Pigovian tax itself provides an incentive to hide taxable emissions. In contrast, the two-part instrument provides incentives to *reveal* data in order to qualify for the subsidy. In fact, the two-part instrument effectively taxes illegal dumping (by not returning the presumptive tax on amounts dumped), and so it can discourage dumping to the proper extent without any additional legal sanctions.[9]

The two-part instrument might provide doubled opportunities for cheating, since the presumptive tax on output is subject to evasion while the subsidies on clean inputs or on "proper" disposal are subject to overstatement. The potential for cheating is relatively low for these market transactions, however, since each transaction involves an invoice for payment, which is difficult to fabricate. In contrast, the single Pigovian tax on emissions or any less-desired type of disposal does not apply to a market transaction. The firm can make up its own records involving emissions, and it can dump illegally without records at all. No other party verifies the transaction. Two simple examples illustrate this risk. A tanker truck carrying liquid waste can enter a truck wash, start the washer sprays, and open the drain on the bottom of the truck, effectively rinsing away the waste without paying the tax. Another example is of waste oil, which can be discarded on roadbeds of railroad lines in order to escape detection and the waste-end tax (Fullerton, 1996). The alternative is a simple tax on all purchases of oil, plus a subsidy on its proper disposal.

Any cheating that does occur under incentive-based policies is often due to asymmetric information. The firm or consumer often has more and better information than the government. While this lends itself to the idea of shifting the burden of proof to the party that has better access to the information, it also allows for the danger of falsifying the "proof" (Russell, 1990). This proof does apply to a market transaction, as just discussed, but some degree of enforcement is necessary in order to ensure that this proof accurately reflects the true behavior of the consumer or firm. Thus, to optimize

[9] In fact, this argument suggests that any further legal sanctions on dumping are not only unnecessary, but also undesirable. If the firm pays a presumptive tax on all output that is equal to the social external cost of dumping, and then receives a subsidy on all activities except dumping, it already pays the marginal social cost of that dumping. Then the chosen amount of dumping is the socially optimal amount of dumping, and any additional legal sanction would overcorrect the externality and reduce social welfare!

compliance on the part of the individual firm or consumer, the government must implement the proper mix of penalties and audits -- not on emissions or dumping, but on properly reported output subject to a tax and on inputs eligible for a subsidy. Even this type of enforcement can be a difficult and rather inefficient task. Russell (1990) notes that auditing in the United States is infrequent and poorly performed, and thus does not act as sufficient inducement for accurate paperwork. Further complicating the ability of the government to audit a firm is the risk of infringing on the firm's constitutional protection against forced entry without reason. Under Pigovian taxation, audits often must be announced prior to arrival, allowing the firm to cover up any illegalities beforehand. Shifting the burden of proof to the firm under a tax-subsidy combination, on the other hand, means the government does not have to force entry. If the firm wishes to receive the subsidy, then it must open its own doors and provide proof to demonstrate eligibility.[10]

A fourth consideration is political appeal. The Pigovian tax may not be a popular action if it raises taxes on consumers or firms. At least in the case where the same individual or firm that pays the deposit has the opportunity to receive a refund, the deposit-refund system may be more popular with voters. If those who properly dispose of an item can receive a refund on the tax originally paid, then taxes increase only for those who refuse to participate. According to a GAO study (U.S. Government Accounting Office, 1990), the bottle bill faces, on average, an 87% approval rating in states with a bottle bill, and a national bottle bill has a 70% approval rating with American citizens. For more general two-part instruments, political feasibility may be greater in the case where consumers get the rebate and producers pay the tax than in the case where producers get a subsidy and consumers pay the tax.

---

[10] See Swierzbinski (1994) for a partial equilibrium game-theoretic approach to this problem. His model allows the firm the opportunity to request an audit, in order to get refunds, but such an audit still requires the government officials to measure the emissions.

A second reason for its potential political appeal, according to the literature, is that the deposit-refund system can be self-financing; the refund can be taken directly from funds generated by deposits (Russell, 1988). However, we wish to emphasize that the pairing of a presumptive tax with an environmental subsidy does not require that the funds gathered from the tax be set aside for the accompanying subsidy nor that the tax equal the subsidy. While this eliminates a potential political advantage, it can create another: flexibility in the use of funds. The two-part instrument can also provide the government with a possible source of revenue. This is not an advantage specific to the two-part instrument, however. As we have shown, the two-part instrument is equivalent to the Pigovian tax. Therefore the revenue from the presumptive tax must exceed the cost of the environmental subsidy by exactly the amount of revenue that would have been collected by the Pigovian tax.

Other attributes have been ascribed specifically to various incarnations of the deposit-refund system. For instance, the deposit on a beverage container does not need to be claimed by the original purchaser. In fact, the incentive to return the item is effectively transferred to anyone finding it (Bohm, 1981). Thus, while a busy person with a high time value might throw a bottle out the car window, another person with a low time value might pick up bottles along the roadside in order to collect the refunds. This combination is efficient, and it helps to prevent litter.[11] Other argued advantages include: health savings due to a decrease in litter-related injuries; a decrease in roadside damage to bicycle tires and farm equipment; job creation due to an increased demand for truck drivers, sorters, and recyclers; and energy savings from the use of recycled rather than virgin materials.[12]

---

[11] The waste-end tax might be just as efficient, if high-time-value individuals can get their trash sorted by paying low-time-value individuals, but the waste-end tax would not directly subsidize low-time-value individuals to pick up litter along the roadway. Also, the refund provides some incentive to clean up the existing stock of litter, while the waste-end tax applies only to new litter (Lee et al, 1992).

[12] These issues are discussed in the context of U.S. State bottle bills in the next section.

B. A Relaxation of the Models' Assumptions

With several simplifying assumptions, the tax-subsidy combination works perfectly in the context of our general equilibrium models. These simplifying assumptions include: no transaction costs, perfect information, no pre-existing distortions, a closed economy, and perfect competition. When each of these assumptions is relaxed, complications may arise. Any of these complications might reduce the effectiveness of the two-part instrument; however, most of these problems apply equally to the usual waste-end or Pigovian tax. Such considerations are important to discuss.

First, transaction costs can contribute to the cost of compliance for the firm or consumer. A two-part instrument requires two collection or payment points: one at the time of purchase and another at the time of return. Also, a firm accepting the returned item often faces additional storage and transportation costs as well as the cost of providing the promised refund. With a large number of small transactions, the act of paying out a refund can be expensive. In fact, many times these transaction costs are so high that other policy instruments can reach the same goal much more cost-effectively. For these reasons, we emphasize that the two-part instrument need not operate as a strict deposit-refund system. The two-part system does not need to collect and return five cents on each aluminum can. Approximately the same incentives can be provided with substantially lower transaction costs by a simple sales tax or excise tax on beverages and a subsidy paid to recycling firms per ton of recycled aluminum. Without making the individual consumer stand in line to get the five cent refund, the subsidy per ton of recycled aluminum will affect market prices in a way that still induces stores to offer efficient service or some other inducement to consumers who bring in aluminum cans.

A second potential complication is the lack of perfect information. With imperfect measures of social costs, the government might set the wrong rate for the presumptive tax or subsidy. If so, then the two-part instrument will not induce the socially efficient mix of "proper" disposal (such as recycling) and "improper" disposal (such as litter). This imperfection can mean costly clean-up of improperly disposed waste, if the refund is too low, or it can signify unwarranted social costs from too much proper disposal, if the refund is too high.[13] This complication equally affects the Pigovian waste-end tax, however, since the authorities are required to know *a priori* what size tax is needed to induce optimal behavior. For the Pigovian tax, Baumol and Oates (1971) describe a system of "standards and prices" that can be used to adjust the tax rate by trial and error, and the exact same argument applies to the two-part instrument. Once the authorities have set a target for quantities to be recycled, they can adjust the deposit and refund periodically until the desired quantity is reached. Thus, the element of trial-and-error is not particularly worse under a tax-subsidy combination.

A third potential pitfall relates to the theory of the second-best. Pre-existing distortions can affect the size of the tax or subsidy needed to balance two major objectives, namely, raising revenue and ensuring the desired amount of proper disposal. Bovenberg and De Mooij (1994) examine the case of a Pigovian tax with a pre-existing labor tax that distorts the consumer's choice between consumption and leisure. Thus, in the second-best world, neither the Pigovian tax nor the equivalent two-part instrument maximizes social welfare, because they exacerbate the labor-leisure distortion. As shown in Fullerton (1997), however, the two-part instrument and the Pigovian tax equally affect the labor-leisure choice. As a consequence, the same second-best correction applies. The properly modified rate of taxation on waste can still be replaced by equally modified rates for the presumptive tax and environmental subsidy.

Fourth, potential complications arise in relation to the assumption of a closed economy. If the two-part instrument operates as a presumptive tax on all output and a subsidy to all clean inputs, then it still serves as an effective tax on domestic pollution, even if the output is exported. For a deposit-refund system, however, the equivalence

---

[13] In the case where the refund level is too high, individuals may even try to bring in a stolen or substitute item in order to receive the refund.

can be broken if the deposit is paid on goods before export, and subsequent recycling is not re-imported to receive the refund. Conversely, if the foreign firm pays the deposit on goods shipped to the U.S., and is then responsible for receiving and recycling its own goods, the extra transportation and transaction costs can operate as a type of non-price trade barrier. It may be easier for the foreign firm to arrange with a domestic firm for the collection, storage, and transportation of its disposed products such as bottles or other forms of packaging. Also, it may be easier to offer a refund to the consumer for the proper return of the product through domestic facilities. Otherwise, the foreign firm may have to set up recycling facilities in the U.S. or transport its recycled products back to the originating country. If this is the case, the domestic firm may gain an advantage over the foreign producer. This argument may be important for products such as computers where many producers rely on a take-back system in order to re-use valuable components. However, in cases where the foreign producer is not responsible for recycling its own product, so that a domestic firm can collect the product for recycling, this advantage disappears.

Finally, imperfect competition or monopoly behavior in certain industries can complicate the model significantly. If a firm with market power has already restricted output below the socially optimal level, then a tax on output can induce a further restriction and decrease social welfare even more. In this case, even without the presumptive tax, a subsidy to proper disposal may reduce the overall cost of production and help offset the pre-existing market distortion (Baumol and Oates, 1988). In a simple monopoly model, the tax-subsidy combination is still equivalent to the emissions tax; it raises production costs and exacerbates the monopoly distortion. In a more complicated game-theoretic model of oligopoly, we hesitate to conjecture about this equivalence.

Though the models above are used to show where the two-part instrument is equivalent to the Pigovian tax, considerations beyond the model are reasons enough to give careful thought to the tax-subsidy combination. In many cases, the problems listed here are of a lesser degree for the two-part instrument than for the Pigovian tax, making the case even stronger for the pairing of a presumptive tax with a subsidy.

IV. POLICY EXPERIENCES

This section reviews actual experiences with two-part instruments in the United States as well as in other countries. Examples that are discussed include deposit-refund systems on bottles, waste oil, and car hulks. In many cases the relative success or failure of a deposit-refund system appears to be related to the ability of the government to set the appropriate deposit or refund to induce the desired behavior.

A. "Bottle Bills" for Beverage Containers

A two-part instrument has most often appeared as a deposit-refund system. A "bottle bill" is one of its most common forms. This policy combines a deposit paid by the consumer at the time of purchase and a refund when the beverage container is properly returned.[14] Ten states in the U.S. reportedly have bottle bills.[15] California's bottle bill differs from those in other states in that the distributors pay the deposit, while consumers receive the refund (Container Recycling Institute, 1992). Also, in most states the deposit does not equal the refund because of a handling fee.[16] Indications of the success of such policies are mixed. Evidence that suggests some degree of success

---

[14] A beverage container is usually defined as "any sealable bottle, can, jar, or carton which is primarily composed of glass, metal, plastic, or any combination of those materials and is produced for the purpose of containing a beverage" (Massachusetts Executive Office of Environmental Affairs, 1989).

[15] These ten states include California, Connecticut, Delaware, Iowa, Maine, Massachusetts, Michigan, New York, Oregon, and Vermont. The system in California is sometimes called a deposit-refund system and is sometimes referred to as an advanced disposal fee.

[16] According to Jenkins and Lamech (1992), the handling fee in most states is 20% of the deposit.

includes reports of a high response rate by consumers, a reduction in solid waste, a decrease in litter, and high-quality recyclable inputs. Evidence is somewhat less convincing with respect to energy savings, job creation, and administrative, production, and distributive costs.

Return rates for bottles appear to be high in the U.S. **Table 1** presents both the overall return rate and return rates by bottle type, if available, for each of the U.S. states with bottle bills. Overall return rates range from 76.5% in New York to 93% in Michigan.[17] For specific bottle types, the lowest return rate is 50% for plastic containers in California, while the highest return rate is 95% for aluminum containers in Iowa. Such high return rates stand in marked contrast to non-bottle-bill items. For instance, Oregon boasts an overall return rate on aluminum, plastic and glass containers of 92.3%, whereas the overall return rate for non-bottle-bill containers is less than 30% (Wahl, 1995).

Reports also indicate that solid waste has seen a slight decrease due to the bottle bill. The GAO (1990) cites a 6% reduction by weight, and an 8% reduction by volume of the amount of solid waste being landfilled. However, opponents cite these small figures as a reason for repeal of bottle bills; the benefits are too small to justify the cost of implementing such a system. Bottle bills seem to have had a significant impact on litter, however. A GAO study (1990) finds a decrease in litter between 79 and 83% for nine states with bottle bills (excluding California). Porter (1983) finds that Michigan's litter decreased 85%. In terms of cost, Maine saw a decrease in clean-up costs of almost 50% (Jenkins and Lamech, 1992).

Because the bottle bills are so effective at decreasing litter, these states have experienced a significant decrease in damages and injuries due to broken bottles and other discarded beverage containers. Injuries to children caused by broken bottles decreased 60% after the implementation of the bottle bill in Massachusetts (Friedland

---

[17] Porter (1983) finds a slightly higher return rate for Michigan of 95%.

TABLE 1: Return Rates for Containers in Bottle-Bill States

STATE	RETURN RATES	
California	Aluminum	88%
	Glass	76%
	Plastic	50%
	Overall	84%
Connecticut	Cans	88%
	Bottles	94%
	Plastic	70-90%
Delaware	Not Available	
Iowa	Aluminum	95%
	Glass	85%
	Plastic	70-90%
	Overall	91%
Maine	Beer/Soda	92%
	Wine/Spirits	80%
	Juice	75%
Massachusetts	Overall	85%
Michigan	Overall	93%
New York	Soda	66%
	Beer	79%
	Overall	76.5%
Oregon	Aluminum	86.6%
	Glass	94.1%
	Plastic	92.5%
	Overall	92.3%
Vermont	Overall	85%

Sources: Gupta (1996), NY Department of Environmental Conservation (1994), Wahl (1995), Iowa Department of Natural Resources (1996), and Container Recycling Institute (1992).

and Perry, 1995). Costs to farmers due to improperly discarded beverage containers include decreased productivity, injuries and death of livestock, and damage to equipment. These costs are estimated to lie between $1.2 million and $3.7 million annually in Virginia, and $37 million per year in Pennsylvania (Krogulski, 1994). No estimates are provided in the literature on the amount by which these costs to farmers have decreased in states that have implemented a bottle bill. Similarly, no data is available on savings to bicyclists as a result of the bottle bill; however, damages across the country to bicycle tires due to beverage containers is estimated at $200 million annually (Friedland and Perry, 1995). In addition, a significant amount of wildlife is injured or killed due to discarded broken bottles. It follows that a significant decrease in roadside litter due to bottle bills will result in a decrease in each of these damage costs.

Critics of the bottle bill often argue that it deprives curbside recycling programs of a large potential source of revenue. A GAO study (1990) found the two policies to be complementary, however. While some consumers will return a bottle in order to receive the refund, others will not be willing to take the time to do so; these individuals may still find it easy to throw the bottle in the recycling bin for curbside pick-up. A Rhode Island study demonstrates that, while having both programs in place is more costly, having a bottle bill in addition to a curbside recycling program will divert an additional 17 to 35% from the waste stream (Naughton et al, 1990).[18]

Also, bottle bills provide higher-quality material than curbside recycling programs. Containers are more homogenous because they have been sorted; glass is often unbroken and sorted by color. The monetary incentive guarantees a steady supply

---

18 A Massachusetts study also finds that the bottle bill actually helps the recycling programs in that state, since a bottle bill is often a cheaper option in locations where curbside collection is expensive to implement. Also, restaurants and businesses are usually excluded from curbside recycling and can use a bottle bill to recycle containers. This can mean a substantial increase in a state's total recycling; 80% of the beverage containers collected in Massachusetts come from commercial sources (Friedland and Perry, 1995).

of recycled beverage containers (Iowa Department of Natural Resources, 1996). For all of these reasons, firms that use recycled materials have demonstrated their preference for recycled glass and plastic from bottle-bill states. Two-thirds of glass and 98% of plastic recycled by firms are purchased from the nine bottle-bill states other than California (Friedland and Perry, 1995) whereas these states contain only 17% of the U.S. population.

The bottle bill also reportedly saves energy. In glass production, for instance, the use of 50% recycled glass means a 50% decrease in water pollution, a 79% decrease in mining waste, and a 14% reduction in air pollution (Krogulski, 1994). Energy use is reduced by 59% from using recycled polyethylene terephthalate (PET) bottles (Oregon Department of Environmental Quality, 1982). However, bottle bills may also increase fuel use due to the fact that re-usable bottles are often bulkier than non-returnable bottles and because trucks are often required to pick up items on a more frequent basis. Weinberg (1987) notes that fuel use by distributors in Michigan is estimated to have increased 25% per case of beer and 32% per case of soda.

Most state programs boast that the bottle bill has led to the creation of jobs. In New York, the implementation of a deposit-refund system reportedly resulted in a net increase of 4,100 to 5,100 new jobs (Friedland and Perry, 1995). Job creation is mainly in the retail, transportation, and recycling industries (Moore and Scott, 1983). On the other hand, the GAO (1990) reports that a shift from non-refillable to refillable containers means job losses in glass and can manufacturing. Opponents of the bottle bill voice concern that a loss in skilled jobs is exchanged for an increase in largely unskilled jobs.

Questions about the cost of a deposit-refund system such as the bottle bill also have countered these seemingly impressive statistics. Production and distribution costs to the beverage industry have reportedly increased as a result of compliance with the bottle bill (GAO, 1990). The increase in cost is especially evident for firms responsible for collecting the bottles, distributing the refund, and storing the bottles after they are returned. The sheer number of small transactions that take place each day also cost the firm a great deal. In a report issued by the GAO (1990), the increase in cost is estimated to lie between 2.4 and 3.2 cents per container. Ackerman et al (1995) report that Massachusetts' firms face a cost increase of 2.3 cents per container.[19] When viewed by the ton, such costs are substantial. For steel cans, 2.3 cents per can translates into a cost of $320 per ton of waste reduced. For aluminum cans it is even higher: $1300 per ton. Landfilling, in most cases, is a much cheaper disposal alternative. In weighing costs against benefits, several studies find that bottle bills -- as they are currently run -- may not in fact be economically efficient.[20]

According to the Project 88 report (Stavins, 1991), the design of a deposit-refund system is the primary determinant of its success or failure. For instance, a single-tiered system, where the refund is the same for all containers regardless of differences in recycling value, has lower transaction costs than a multi-tiered system, where different containers have refund values that depend on the material from which they are made. However, the single-tiered system is a poorer estimate of the true social cost (Jenkins and Lamech, 1992). Drop-off requirements can also affect the inconvenience costs to the consumer. In Oregon, for instance, a consumer can drop off beverage containers to any store that carries that brand, regardless of where the beverage was originally purchased. Retailers do not have to sort the containers because distributors have an agreement among themselves on collection and credit for containers.

---

[19] These costs do not include administrative costs to government or political rent-seeking costs to firms.

[20] Porter (1978) concludes that in Michigan, for a five cents per container average time cost, the average benefit received from proper disposal must be greater than $12.48 per person annually (in 1974 dollars) in order for the deposit-refund system to be considered economically worthwhile. Using Porter's framework, Naughton et al (1990) estimate the average inconvenience costs in California of returning aluminum, non-refillable glass and plastic containers. Per container, estimates ranged from 29 to 57 cents.

Evidence also indicates that administrative costs decrease significantly for a more consolidated system. In California, for example, the deposit-refund system is run by the state instead of by the retail firms. In a "standards and prices" approach[21] a minimum return rate of 80% is mandated, and the deposit-refund system is adjusted to reach that goal (Naughton et al, 1990). Redemption centers are jointly arranged by retailers within convenience zones of a half-mile radius (e.g. at a centrally-located grocery store), so that retailers do not have to be directly involved in redeeming cans and bottles (Mrozek, 1995). The state also pays a handling fee to recycling centers to collect and process cans. Unclaimed deposits are used to pay for administration. Costs are much lower in California than in other states, approximately 0.2 cents per can. For steel cans, this translates into a decreased cost from $320 to $28 per ton of garbage reduced. For aluminum, the costs decrease from $1300 to $120 per ton (Palmer et al, 1996).[22]

B. Deposit-Refund Systems for Other Items in the U.S.

Deposit-refund systems in the United States have also been used to promote oil recycling through the return of used motor oil, and lead recycling through the return of lead-acid car batteries.[23] Two states that have battery deposit-refund systems are Rhode

---

[21] See Baumol and Oates (1971) for more on the "standards and prices" approach.

[22] Technology can also play an important role in making the deposit-refund system more efficient. One such technology is the reverse vending machine. It can be installed in a grocery store where consumers then load their beverage containers into the machine. The items are placed on a conveyor belt where each is scanned to distinguish valid containers from invalid ones, as well as type (if the refund differs by type) of container. The machine then either prints out a voucher or pays the proper refund to the consumer. Thus, the store need not dedicate extra personnel to the task of refunding money or sorting containers (Pang, 1996).

[23] Nationally, "do-it-yourselfers" apparently account for 50% of the illegal dumping of oil, while they only account for 5% of the recycling of oil (Stavins, 1991). Thus, a deposit-refund system that creates incentives to discourage littering and illegal dumping is a promising policy tool. Also, reportedly 80% of lead consumption in the United

Island and Maine. Other states have unlegislated deposit-refund systems run by industry.[24] Most of the benefits as well as the criticisms listed above for bottles also apply here. The fact that both oil and lead are health hazards and costly to clean-up means that a deposit-refund system may be more useful than other policy instruments. Sigman (1995b) examines the determinants of the illegal dumping of lubricating oil and finds evidence that a deposit-refund system is a useful method for decreasing illegal disposal; the availability of opportunities for the reuse of oil are found empirically to affect illegal dumping. Several problems specific to the return of car batteries and oil are noted throughout the literature. One such problem is the possibility that a refund that is set too high will induce individuals either to steal car batteries or to bring in a cheaper oil-like substance to get the offered refund. Thus, it is important to set both the deposit and the refund at an appropriate level.[25] Another problem discussed is the fact that refunds are often available only in large urban areas (Jenkins and Lamech, 1992). Rural populations (which may be significant, depending on the country) may not recycle oil or return car batteries if they have to drive into the city to return the product.

Evidence of other deposit-refund systems in the U.S. is scattered. Idaho has a deposit-refund system in place for old tires (Dinan, 1993). In that state, a $1 up-front user fee is assessed on each new motor vehicle tire purchased. From these fees, retreaders are paid a $1 subsidy for each retreaded tire, and other end-users of old tires

---

States is attributable to lead-acid batteries (Sigman, 1995a). Therefore, concentrating on lead-acid batteries when formulating policy seems justified.

[24] Such lead-acid battery deposit-refund systems reportedly exist in Arizona, Arkansas, Connecticut, Idaho, Michigan, Minnesota, New York, and Washington (Sigman, 1995a).

[25] Analogous rebates are offered in programs that buy up old cars. Alberini et al (1994) note several potential problems with this type of program. Individuals might be induced to let their cars deteriorate more than otherwise, or they may bring old cars into the jurisdiction in order to get the rebate.

are paid $20 per ton (Idaho Department of Health and Welfare, 1996).[26] Also, Maine reportedly has a deposit-refund system in place for commercial pesticide containers (Stavins, 1991).

C. Experiences with Deposit-Refund Systems Outside of the U.S.

Deposit-refund systems have also been used outside of the United States. Within the OECD, the number of deposit-refund systems in each country has grown 35% to 100% between 1987 and 1993; this growth is mainly caused by a concern for packaging waste (Barde and Opschoor, 1994). **Table 2** provides the number of deposit-refund systems in existence in mainly OECD countries, and it shows the types of items covered under these systems. Sweden and the United States are reported to have four different types of deposit-refund systems in place. Norway, Austria, Germany, Canada, and Australia all have three deposit-refund systems in operation; the remaining countries have only one or two systems. The most commonly covered items under a deposit-refund system are metal cans, plastic and glass containers, and car hulks. Some of the more unusual items covered by a deposit-refund system include fluorescent light bulbs in Austria, and logging in Indonesia.

Japan has its own "bottle bill" with a return rate of 92% (Rhee, 1994). Korea also has two main deposit-refund systems in place: one on glass bottles, and one on solid and toxic waste. The program for solid waste covers items such as televisions, washing machines, tires, and batteries. Evidence suggests that Korea's deposit-refund systems have not been successful. Proper disposal of toxic wastes has been extremely low; only 8% of firms paying the initial deposit receive a refund. In total for Korea, approximately US$ 16.9 million has been collected in deposits while only US$ 38,000 has been returned as refunds. Taiwan also has a deposit-refund system for 12 different

---

26 Waste tires are principally used as a fuel supplement. The Idaho tax-subsidy combination for tires was scheduled to end by July 1, 1996.

TABLE 2: Deposit-Refund Systems by Country

COUNTRY	NUMBER OF D-R SYSTEMS	ITEMS AFFECTED
Australia	3	Metal cans, plastic containers, glass bottles
Austria	3	Plastic containers, glass bottles, fluorescent bulbs
Belgium	1	Glass bottles
Canada	3	Metal cans, plastic containers, glass bottles
Denmark	2	Plastic containers, glass bottles
Estonia	1	Glass bottles
Finland	2	Plastic containers, glass bottles
France	1	Glass bottles
Germany	3	Plastic containers, glass bottles, packaging
Greece	1	Car hulks
Iceland	2	Plastic containers, glass bottles
Indonesia	1	Logging
Japan	1	Beverage containers
Korea	2	Glass bottles, several solid and toxic waste items
Netherlands	2	Plastic containers, glass bottles
Norway	3	Car hulks, plastic containers, glass bottles
Portugal	1	Metal cans, plastic containers, glass bottles
Sweden	4	Car hulks, metal cans, plastic and glass bottles
Switzerland	1	Glass bottles
Taiwan	1	12 product items
Turkey	1	Glass bottles
United States	4	Metal cans, plastic and glass bottles, car batteries

Source: Barde and Opschoor (1994), and OECD (1994b).

products. In 1992, the return rate -- at least for PET bottles -- rose substantially, to just under 80%. Before, however, it was 41%.

One reason listed for Japan's success -- and for the relative failure of bottle bills in Taiwan and Korea -- is the long history of deposit-refund systems run by private industry in Japan prior to the government program (O'Connor, 1994). Also, in Korea, the government deliberately set the deposit and refund too low because of a concern about inflation (Rhee, 1994).

A more creative use of the two-part instrument has been attempted in Indonesia. This country has experimented with a deposit-refund system in order to try to slow deforestation. Loggers pay an up-front fee before harvesting trees and then receive a refund when the logged trees are replaced with saplings. However, initial findings show this scheme to be ineffective. Even with the subsidy, the net benefits of replanting is reported to be less than the net benefits from not doing so (O'Connor, 1994). Thus, little replanting actually takes place.

Many instances of deposit-refund systems appear in Europe, mostly on beverage containers.[27] Return rates are between 40 and 100%, depending on the country and the type of container. A few of these programs are discussed below in more detail.

Sweden has deposit-refund systems for items such as aluminum cans, other beverage containers, and car hulks. The Swedish government has attempted to enforce a mandatory return rate of 75%. Evidence regarding car hulks, however, is not encouraging. Due to a small refund of SEK 300, and 12 years without adjusting for inflation (at which point the refund was the equivalent of SEK 120), returns of car hulks have been low (OECD, 1994a). The promised refund cannot compete with alternatives to returning the car hulks, such as storing or selling the parts and then dumping the remaining hulk (OECD, 1989).

---

[27] Andersen (1994) states that a system of fees coupled with subsidies is appealing relative to an emissions tax for the countries he focuses on -- Denmark, France, Germany, and the Netherlands -- for reasons of political acceptability.

Norway also has a deposit-refund for car hulks. Contrary to its Swedish counterpart, Norway's deposit-refund system works quite well, mainly due to a higher refund. The return rate is estimated to be between 90 and 99%. The deposit is paid when a new car is purchased, and the refund is given when a car is taken to a scrapping facility. One criticism of the Norwegian deposit-refund system is a lack of scrapping facilities in convenient locations (OECD, 1989).

The Netherlands has private deposit-refund systems in place for PET and glass bottles. The 1992 government budget also provided for the obligatory return of batteries, refrigerators, aluminum cans, and oil in the event that the current industry system fails (OECD, 1994a). Failure is defined by the government as less than a 30% return rate (OECD, 1989).[28] Also, the Dutch literature has discussed the feasibility of a deposit-refund system for controlling polluting substances such as cadmium and nitrates. Any domestic or imported product containing the polluting substance would be subject to a deposit upon sale. Refunds would be provided once the item was properly disposed of or exported.

Germany has had a deposit-refund system in place for lubricating oil since 1969. Fresh oil is taxed and a subsidy is provided to incinerators and reprocessors of used oil (Bohm, 1981). Greece has a deposit-refund system for car hulks older than 15 years. A refund is given upon the purchase of a new car if it meets emissions requirements and the old car is returned (OECD, 1989). Estonia reportedly has a deposit-refund system on glass bottles. However, the system functions poorly due to a lack of return locations (OECD, 1994b).

A few other examples of proposed presumptive tax-subsidy combinations are found in the literature. One of the most interesting examples is that of an international deposit-refund system for carbon removal from the atmosphere (Fisher et al, 1995).

---

[28] Again, the "standards and prices" approach in Baumol and Oates (1971) is being used; a standard of 30% is set, and then a pricing mechanism, in the form of the deposit-refund system, is adjusted to attain the standard.

Citizens of each country would pay the proposed tax when they purchase a product manufactured using a polluting process. The subsidy, in the form of a credit to the country's emissions quota, is given when a country demonstrates certified carbon removal. Another suggestion is to use the coupling of a tax and a subsidy to induce the recovery of CFCs from refrigerators and air conditioners (Fisher et al, 1995). Bohm (1981) also proposes a deposit-refund system for sulfur dioxide. A deposit would be required on fuel, based on its sulfur content, and a refund would be paid to firms when sulfur was recovered from the air.

So far, almost all of the policies reviewed here still relate to explicit deposit-refund systems with a particular link from the deposit to the refund. A major point of this paper, however, is that the two-part instrument can be defined more broadly and employed more widely. Indeed, virtually *all* governments already employ implicit two-part tax-subsidy combinations. For example, a sales tax or value-added tax is collected on the purchase of all items, while the collection of household waste is subsidized through the provision of free municipal garbage services. "Proper" household disposal is subsidized by this curbside collection, since the city pays for the trucks, work force, and tipping fees. The alternative is a Pigovian waste-end tax that would collect the marginal social cost per bag of garbage put on the curb for collection. This Pigovian tax might work well in suburbs and small towns where illegal dumping is not prevalent, but it would not work well in rural or urban areas where the fee can easily be avoided by dumping garbage on deserted roads, vacant lots, or in commercial dumpsters (Fullerton and Kinnaman, 1995). This improper disposal is avoided by the free collection of garbage, and municipal solid waste budgets are often financed by a local sales tax. The resulting combination is a two-part instrument, whether intended or not.

V. CONCLUSION

This paper builds two relatively simple general equilibrium models to demonstrate the equivalence between the Pigovian tax and the combination of a presumptive tax and performance subsidy. These models also help demonstrate the flexibility of this two-part instrument. To analyze the usefulness of the tax-subsidy combination, we review conceptual problems with its implementation and practical problems with the actual use of the tax-subsidy combination throughout the world. While the tax-subsidy combination is increasingly being used, in the form of a deposit-refund system, we argue that more flexible interpretations are important to explore. The two parts of such a policy do not have to apply to the same side of the market. Enactment might be easier, for example, if firms pay the tax while consumers receive the subsidy. The tax and subsidy do not have to equal one another, and they can apply to different goods altogether. Compared to a Pigovian tax, a two-part instrument may be easier to enforce, may be easier to enact, and can still force the market to recognize the social cost of disposal.

References

Ackerman, Frank, Dmitri Cavander, John Stutz, and Brian Zuckerman. Preliminary Analysis: The Costs and Benefits of Bottle Bills. Draft Report to U.S.EPA/Office of Solid Waste and Emergency Response. Boston: Tellus Institute, January 1995.

Alberini, Anna, David Edelstein, Winston Harrington, and Virginia D. McConnell. "Reducing Emissions from Old Cars: The Economics of the Delaware Vehicle Retirement Program." Discussion Paper, no. 94-27. Washington DC: Resources for the Future, 1994.

Andersen, Mikael Skou. Governance by Green Taxes: Making Pollution Prevention Pay. Manchester: Manchester University Press, 1994.

Barde, Jean-Phillippe, and Johanes Baptist Opschoor. "From Stick to Carrot in the Environment." The OECD Observer 186 (Feb/March 1994): 23-27.

Baumol, William J., and Wallace E. Oates. "The Use of Standards and Prices for Protection of the Environment." Swedish Journal of Economics 73 (March 1971): 42-54.

Baumol, William J., and Wallace E. Oates. The Theory of Environmental Policy. SecondEdition. New York: Cambridge University Press, 1988.

Bohm, Peter. Deposit-Refund Systems. Washington DC: Resources for the Future, 1981.

Bovenberg, A. Lans, and Ruud A. de Mooij. "Environmental Levies and Distortionary Taxation." American Economic Review 84 (September 1994): 1085-89.

Container Recycling Institute. Beverage Container Deposit Systems in the United States. Washington, DC: Container Recycling Institute, January 1992.

Cropper, Maureen, and Wallace E. Oates. "Environmental Economics: A Survey." Journal of Environmental Literature 30 (June 1992): 675-740.

Dinan, Terry M. "Economic Efficiency Effects of Alternative Policies for Reducing Waste Disposal." Journal of Environmental Economics and Management 25 (December 1993): 242-56.

Eskeland, Gunnar. "A Presumptive Pigovian Tax: Complementing Regulation to Mimic an Emissions Fee." The World Bank Economic Review 8.3 (September 1994): 373-94.

Eskeland, Gunnar, and Shantayanan Devarajan. Taxing Bads by Taxing Goods: Pollution Control with Presumptive Charges. Washington, DC: World Bank, 1996.

Fisher, Brian, Scott Barrett, Peter Bohm, J.K. Mubazi, Anwar Shah, and Robert Stavins. "An Economic Assessment of Policy Instruments to Combat Climate Change." Report of Working Group III of the Intergovernmental Panel on Climate Change. Switzerland, 1995.

Friedland, Shelly, and Amy Perry. Many Happy Returns: A Retrospective of the Massachusetts Bottle Bill. Massachusetts: MASSPIRG, March 1995.

Fullerton, Don. "Why Have Separate Environmental Taxes?" in James M. Poterba, ed., Tax Policy and the Economy. 10, Cambridge: MIT Press for the National Bureau of Economic Research, 1996.

Fullerton, Don. "Environmental Levies and Distortionary Taxation: Comment." American Economic Review 87 (March 1997).

Fullerton, Don, and Thomas Kinnaman. "Garbage, Recycling, and Illicit Burning or Dumping." Journal of Environmental Economics and Management 29 (July 1995): 78-91.

Gupta, Ashok K. Letter. Albany: New York State Department of Environmental Conservation, May 1996.

Harrington, Winston, Margaret A. Walls, and Virginia McConnell. "Shifting Gears: New Directions for Cars and Clean Air." Discussion Paper, no. 94-26-REV. Washington, DC: Resources for the Future, 1994.

Idaho Department of Health and Welfare, Division of Environmental Quality. Idaho Waste Tire Disposal Annual Report to the Legislature. Boise, 1996.

Iowa Department of Natural Resources. Beverage Container Law Overview. Received June 1996.

Jenkins, Glenn P., and Ranjit Lamech. "Market-Based Incentive Instruments for Pollution Control." International Bulletin of Fiscal Documentation 46.11 (November 1992): 523-38.

Krogulski, Marilyn. "Litter Did We Know." Iowa Conservationist 53.4 (July/August 1994): 20-22.

Lee, Dwight R., Philip E. Graves, and Robert Sexton. "Controlling the Abandonment of Automobiles: Mandatory Deposits vs. Fines." Journal of Urban Economics 31 (1992): 14-24.

Massachusetts Executive Office of Environmental Affairs. Provisions for Recycling of Beverage Containers. Massachusetts, September 1989.

Miedema, Allen K. "Fundamental Economic Comparisons of Solid Waste Policy Options." Resources and Energy 5 (March 1983): 21-43.

Moore, W. Kent, and David L. Scott. "Beverage Container Deposit Laws: A Survey of the Issues and Results." The Journal of Consumer Affairs 17.1 (Summer 1983): 57-80.

Mrozek, Janusz. "Beverage Container Recycling: Incentives versus Attitudes as Explanations of Behavior." Working Paper. Georgia Institute of Technology. November 1995.

Naughton, Michael, Frederick Sebold, and Thomas Mayer. "The Impacts of the California Beverage Container Recycling and Litter Reduction Act on Consumers." The Journal of Consumer Affairs 24.1 (Summer 1990): 190-220.

New York Department of Environmental Conservation. Report on Unclaimed Beverage Container Deposits. New York: Division of Solid Waste, 1994.

Organisation for Economic Cooperation and Development. Economic Instruments for Environmental Protection. Paris: OECD, 1989.

Organisation for Economic Cooperation and Development. Environment and Taxation: The Cases of the Netherlands, Sweden and the United States. Paris: OECD, 1994a.

Organisation for Economic Cooperation and Development. Managing the Environment: The Role of Economic Instruments. Paris: OECD, 1994b.

O'Connor, David. "The Use of Economic Instruments in Environmental Management: The East Asian Experience." in Applying Economic Instruments to Environmental Policies in OECD and Dynamic Non-Member Countries. Paris: OECD, 1994.

Oregon Department of Environmental Quality. Oregon's Bottle Bill: The 1982 Report. Oregon: Oregon Dept. of Environmental Quality, 1982.

Palmer, Karen, Hilary Sigman, and Margaret Walls. "The Cost of Reducing Municipal Solid Waste." Working Paper. Washington, DC: Resources for the Future. 1996.

Pang, Tanya. "Empty Bottles Fill Coffers of Norwegian Firm." The Reuter European Community Report. April 28, 1996.

Pigou, Arthur C. The Economics of Welfare. Fourth edition, London, UK: MacMillan and Co., 1932.

Porter, Richard C. "A Social Benefit-Cost Analysis of Mandatory Deposits on Beverage Containers." Journal of Environmental Economics and Management (December 1978): 351-75.

Porter, Richard C. "Michigan's Experience with Mandatory Deposits on Beverage Containers." Land Economics 59.2 (May 1983): 177-94.

Rhee, Ho-Saeng. "The Use of Economic Instruments in Environmental Protection in Korea." in Applying Economic Instruments to Environmental Policies in OECD and Dynamic Non-Member Countries. Paris: OECD, 1994.

Russell, Clifford. "Monitoring and Enforcement" in Paul Portney, ed. Public Policies for Environmental Protection. Washington DC: Resources for the Future, 1990.

Russell, Clifford. "Economic Incentives in the Management of Hazardous Wastes." Columbia Journal of Environmental Law 13.2 (Spring 1988): 257-74.

Sigman, Hilary. "A Comparison of Public Policies for Lead Recycling." RAND Journal of Economics 26.3 (Autumn 1995a): 452-78.

Sigman, Hilary. "Midnight Dumping: An Empirical Analysis of Illegal Waste Oil Disposal." Working Paper. University of California, Los Angeles. April 1995b.

Stavins, Robert N. Project 88-Round II: Incentives for Action: Designing Market-Based Environmental Strategies. Sponsored by Timothy Wirth, and John Heinz. Washington, DC: U.S. Senate, May 1991.

Swierzbinski, Joseph E. "Guilty Until Proven Innocent - Regulation with Costly and Limited Enforcement." Journal of Environmental Economics and Management 27.2 (September 1994): 127-146.

United States General Accounting Office. Trade-Offs Involved in Beverage Container Deposit Legislation. Washington, DC: U.S.GAO, November 1990.

Wahl, Mary. Letter to State Representative Lisa Naito. Oregon Department of Environmental Quality. Portland, 1995.

Weinberg, Perry S. "Mandatory Deposit Legislation in Virginia: Recycling the Bottle Bill." Virginia Journal of Natural Resources Law 7.1 (Fall 1987):175-215.