

November 2011 ■ RFF DP 11-47

# Deposit-Refund Systems in Practice and Theory

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## Abstract

A deposit-refund system combines a tax on product consumption with a rebate when the product or its packaging is returned for recycling. Deposit-refunds are used for beverage containers, lead-acid batteries, motor oil, tires, various hazardous materials, electronics, and more. In addition, researchers have shown that the approach can be used to address many other environmental problems beyond waste disposal. By imposing an up-front fee on consumption and subsidizing “green” inputs and mitigation activities, a deposit-refund may be able to efficiently control pollution in much the same way as a Pigovian tax. Theoretical models have shown that alternative waste disposal policies, such as virgin materials taxes, advance disposal fees, recycled content standards, and recycling subsidies are inferior to a deposit-refund. These results have been corroborated in calibrated models of U.S. waste and recycling. And in theoretical models that consider joint environmental problems and product design considerations, the deposit-refund continues to have much to recommend it as a component of an overall socially optimal set of policies. More empirical research into deposit-refund systems is needed, particularly the upstream systems used for many products. In these systems, the processors or collectors of recyclables—rather than consumers—receive the refund. Upstream systems may have lower transaction costs and better environmental outcomes than traditional downstream systems.

**Key Words:** deposit-refund, waste disposal, recycling, source reduction, illegal dumping, Pigovian tax, advance disposal fee, upstream pollution, design for environment

**JEL Classification Numbers:** H23, Q53, Q58

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## Deposit-Refund Systems in Practice and Theory

Margaret Walls\*

### Introduction

A deposit-refund system combines a tax on product consumption with a rebate when the product or its packaging is returned for recycling or appropriate disposal. The best-known example of a deposit-refund system in the United States is the system of fees and reimbursements for beverage containers, currently in place in ten states. These so-called “bottle bills” were originally adopted to combat litter problems, but the approach has now been applied to much more than soft drink cans and bottles. Deposit-refunds have been established for other kinds of containers, lead-acid batteries, motor oil, tires, various hazardous materials, electronics, and more. And the deposit-refund approach can be used to address many other environmental problems well beyond waste disposal, such as air and water pollution. By imposing an up-front fee on production or consumption and using those fee revenues to rebate “green” inputs and mitigation activities, a deposit-refund policy may be able to efficiently control pollution in much the same way as a Pigovian tax (Bohm 1981; Fullerton and Wolverton 2000).

A deposit-refund has three potential advantages over a Pigovian tax, however. First, it avoids the “midnight dumping” problem often associated with a Pigovian tax, a problem that is especially serious in the case of solid and hazardous waste disposal (Sigman 1995). When legal disposal is directly taxed, households and firms seek out alternative disposal options, which include burning and illegal dumping, if those options are easy or penalties are small. The deposit-refund approach circumvents this problem by providing rebates for materials returned for recycling. Second, a Pigovian tax has monitoring and enforcement problems in many settings. Litter is one example; taxing litter directly is ineffective given the difficulty monitoring it so a deposit-refund applied to bottles, packaging, plastic bags, and other products that often end up as litter may be appropriate. Nonpoint source pollution is another example. In this case, it is possible that a tax (deposit) on more easily monitored fertilizer sales combined with a subsidy (refund) for appropriate farmer mitigation activities may provide some of the incentives of a Pigovian tax without that policy’s need to monitor individual pollutants. Third, tax evasion and avoidance is less of a problem with a deposit-refund system than with a Pigovian tax. It is

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difficult to evade taxes on product sales. Households and firms thus invest in generally beneficial activities to increase their refund payments rather than harmful activities to avoid tax payments. An *upstream* deposit-refund system, in which the refund is paid to processors of recyclable materials or to collectors of materials upon delivery to processors, rather than *downstream* to consumers who return materials to collection centers, may be especially beneficial in this regard. This upstream model is discussed further below.

## The Deposit-Refund in Practice

### ***Bottle Bills***

Oregon passed the first bottle bill, or container deposit law, in the United States, in 1971. The law imposed a deposit on all beer and soft drink containers that would be refunded upon return of the containers for recycling. As of mid-2011, ten states and eight Canadian provinces had some kind of bottle bill.<sup>1</sup> Almost all states set the deposit – and refund – at 5 cents per container; Michigan’s deposit-refund is 10 cents and California’s is 5 cents for containers less than 24 ounces and 10 cents for larger containers. In all states except California, the amount has stayed the same over the years with no increase for inflation.

The traditional type of bottle bill—in place in all of the bottle-bill states except California and Hawaii—works through distributors and retailers, with retailers playing the role of middlemen. Specifically, retailers pay distributors a deposit for each can or bottle purchased; the retailers then turn around and collect those deposits from consumers who purchase beverages. When a consumer returns a container for recycling, the retailer refunds the deposit to the consumer and recoups that money from the distributor, often with a small handling fee included. Because not all containers are returned, some unrefunded deposits remain in the system; this money stays with retailers and distributors in all states except Michigan and Massachusetts, where the money must be returned to the state.

The deposit-refund programs in California and Hawaii work somewhat differently. Retailers still collect deposits from final consumers and turn those collected deposits over to distributors. Distributors, in turn, pay the deposits to the state government. But the transfer of refunds and used containers between retailers and distributors is avoided in this system.

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<sup>1</sup> Eleven programs were in place until January 31, 2011, when Delaware’s law was repealed. For more on bottle bills in the United States, see <http://www.bottlebill.org>.

Consumers return containers to a variety of redemption locations and receive refunds that come directly from the state-managed program. In this system, all unclaimed deposits stay with the state.<sup>2</sup>

### **Batteries**

Forty-four states in the United States have some kind of deposit-refund program for lead-acid batteries. Many of the states have used model legislation developed by the Battery Council International (BCI), which recommends that retailers charge a \$10 fee (deposit) on all batteries sold, with the fee waived or returned if the customer brings back a used battery for recycling within 30–45 days of purchase. The lead in batteries is valuable, and even without the deposit-refund system, recycling was already high for this product—86 percent according to BCI.<sup>3</sup> But illegal disposal of lead can cause serious environmental problems, thus providing the rationale for government intervention. With widespread adoption of the deposit-refund approach, the recycling rate for lead-acid batteries has climbed to 97 percent. Moreover, the plastic in batteries is also now recycled at fairly high rates—between 60 and 80 percent, according to BCI.

### **Tires**

Illegal disposal of scrap tires can also pose a serious environmental problem, as can disposal of whole tires in landfills. Scrap tire piles have been known to catch fire and burn for lengthy periods—sometimes for years. The piles have also proven to be serious breeding grounds for mosquitoes and can leach toxic chemicals into groundwater. Furthermore, disposal of whole tires in landfills creates problems as the tires tend to rise to the surface.

To raise funds to address the stockpile problem and to prevent future problems by increasing recycling and proper disposal, almost all states in the United States now assess fees on tire purchases. The fees typically range from \$0.50 to \$2 for passenger vehicle tires and from \$3 to \$5 for heavy truck tires. These deposits are not generally refunded to consumers as in bottle-bill and lead-acid battery programs. But a variation on the deposit-refund concept still applies in many states; the revenues collected through deposits are used to subsidize scrap tire processors

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<sup>2</sup> See <http://www.calrecycle.ca.gov> for more on the California system. Ashenmiller (2009) and Beatty, Berck, and Shimshack (2007) provide some empirical analyses of the California system.

<sup>3</sup> The BCI information on battery recycling and state laws can be found at <http://www.battery council.org/LeadAcidBatteries/BatteryRecycling/tabid/71/Default.aspx>.

or sales of products made from scrap tires.<sup>4</sup> Instead of rebating deposits to consumers who return tires for recycling, the rebate goes to the actual recyclers. This upstream deposit-refund approach, mentioned briefly above, has some virtues over the traditional downstream, retail-based system. First, it avoids the transaction and administrative costs associated with collection and sorting of postconsumer recyclables. Second, paying refunds to processors rather than consumers means fewer transactions, which also reduces administrative costs. Third, incentivizing processing rather than collection may help avoid situations in which materials are collected for recycling but are not really recycled<sup>5</sup> because processors are paid the subsidy (refund) only when they purchase materials to process and sell for use as an input to the manufacture of a new product.

### **Motor Oil**

Canada has a national used motor oil recycling program that fits a slightly different upstream model. The program, which started in the Western Canadian provinces of Alberta, Manitoba, and Saskatchewan but now is widespread across most provinces, relies on a fee—called an *environmental handling charge*—paid by all wholesale suppliers of motor oil, oil filters, and containers. The collected fee revenues are used to pay a *return incentive* to collectors and processors who deliver used oil to government-approved processing facilities.<sup>6</sup> Interestingly, even though the refunds are paid to authorized collectors and transporters, the generators of used oil, including do-it-yourself oil changers, farmers, and others, have also benefited: collectors in Alberta have reportedly paid generators up to 37 percent of the return incentive for turning in their used oil and 35 percent of the return incentive for oil filters (Palmer and Walls 2002).

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<sup>4</sup> See the Rubber Manufacturers Association's state legislation chart, available at [https://www.rma.org/publications/scrap\\_tires/index.cfm?PublicationID=11507](https://www.rma.org/publications/scrap_tires/index.cfm?PublicationID=11507), for more information on program specifics.

<sup>5</sup> A recent paper by Ino (2011) argues that illegal dumping of materials that are collected for recycling but are not actually recycled calls for a downstream deposit-refund system in which the refund is smaller than in the case where illegal dumping is not an option. The author also argues that a product “take-back” program with tradable credits for recycling is the second-best option in such cases. But an upstream system in which either processors are subsidized or collectors are paid the refund when they deliver materials to reprocessors retains the optimality of the deposit-refund system without these adjustments.

<sup>6</sup> The program is run in each province by an oil industry association, not the government. See <http://usedoilrecycling.com>.

Recycling rates are quite high in the Canadian program. Each of the provinces reports recycling rates separately: rates for used oil range from 77 to 91 percent;<sup>7</sup> containers and filters, which were not recycled at all before the program was implemented, have recycling rates that range from 50 to 88 percent, and 77 to 91 percent, respectively.

California has a similar used oil program. The California Oil Recycling Enhancement Act requires manufacturers to pay 27 cents per gallon for all motor oil sold in the state. This fee is refunded to certified collectors, including curbside collectors, and industrial generators. Certified collection centers and curbside collectors receive a return incentive of 40 cents per gallon; industrial generators receive 16 cents per gallon.<sup>8</sup> Like the Canadian program, this upstream deposit-refund system also generates relatively high recycling rates. In 2007, the volume of motor oil recycled was 58.9 percent of the volume sold in that year; accounting for the approximately 35 percent of oil burned during use, this implies a recycling rate of about 90 percent.

### **Consumer Electronics**

Recycling of electronic products, such as computers, televisions, cell phones, and other electronic items, which make up a growing fraction of the waste stream, is difficult and costly. The approach adopted by many European countries to address the problem is product “take-back,” or what has come to be known as *extended producer responsibility* (EPR). These programs mandate that manufacturers take back products from consumers at the end of the product’s life and ensure that a specific fraction of the material in the products is recycled.<sup>9</sup>

In the United States, the federal government and most states have balked at adopting the take-back approach and have failed to come up with alternative programs to deal with electronic waste. California is an exception, however; in 2003, the state passed the Electronic Waste Recycling Act of 2003: Covered Electronic Waste Payment System (S.B. 20/S.B. 50), which authorized the assessment of a *waste recycling fee* on the retail sale of electronic devices.

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<sup>7</sup> About 35 percent of oil is burned off during use. Recycling rates in the Canadian program account for this—that is, this rate reflects the amount recycled in a given year divided by estimated used oil volumes, not oil sales.

<sup>8</sup> Re-refiners also receive an incentive of \$0.02/gallon beginning in 2013 for re-refined base lubricant produced from used oil that is generated and collected in California.

<sup>9</sup> A description of EPR and a summary of policies in different member countries of the Organisation for Economic Co-operation and Development can be found at

[http://www.oecd.org/document/19/0,3746,en\\_2649\\_34281\\_35158227\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/document/19/0,3746,en_2649_34281_35158227_1_1_1_1,00.html).



Subsequent regulations assessed the fees on televisions, computer monitors, and laptops; in 2011, the fees range from \$6 to \$10, depending on screen size. Revenues collected from the fees are used to provide recycling incentive payments to authorized collectors and reprocessors. This program is thus another example of an upstream deposit-refund system. The refunds in the program—in other words, the recycling incentive payments—cover a range of materials, well beyond the televisions and computers on which the fees are placed. The legislation set the refund payments at 28 cents per pound of total weight, though future regulations are permitted to establish an alternative refund structure.

## **The Deposit-Refund in Theory**

### ***Models of Consumption, Production, Waste, and Recycling***

Several theoretical studies have investigated the efficiency of deposit-refund systems as a means of reducing waste disposal and have compared the policy to alternatives, such as a waste disposal fee, a virgin materials tax, a take-back mandate, a product tax (often referred to as an *advance disposal fee*) recycling subsidies, and recycled content standards.

The early generation of these studies constructed models in which a consumer product is produced using virgin and secondary materials, and solid waste residuals are leftover as a by-product of consumption. These mass balance models show that when solid waste disposal in private markets is unpriced, the private market equilibrium generates too much waste and too little recycling relative to the social optimum; also, producers use too much of the virgin materials input in production relative to the secondary material (Dinan 1993 Palmer and Walls 1997). If a second externality, from illegal disposal, exists, then the Pigovian solution is problematic. Several studies demonstrate that a deposit-refund policy can achieve the social optimum in this setting, efficiently controlling both legal and illegal waste disposal (Fullerton and Kinnaman 1995). These studies also show that other policies are not necessary, including taxes or subsidies on inputs to production.

Several studies also show that alternatives to the deposit-refund are inferior. Neither a virgin materials tax nor a recycling subsidy can achieve the social optimum. A recycled content standard also cannot achieve the social optimum unless it is combined with taxes on both labor and consumption (Palmer and Walls 1997). And the optimal tax rates in this case are complicated and depend on the form of the production function.

The theoretical findings have been validated empirically. In a simple model of waste and recycling—parameterized using 1990 U.S. data on waste disposal volumes, quantities of recovered materials, secondary and final material prices, and estimated price elasticities of supply and demand for 18 individual materials—Palmer, Sigman, and Walls (1997) find that the deposit-refund can achieve specified waste-reduction targets at roughly half the marginal social costs of a recycling subsidy or an advance disposal fee. Although the advance disposal fee leads to source reduction—reductions in the volumes of materials and products generated—it fails to incentivize recycling. Conversely, the recycling subsidy increases recycling but, by lowering production costs (the subsidy makes secondary materials cheaper), it actually increases the volume of products generated. The deposit-refund provides incentives for both source reduction and recycling.

Few econometric studies have analyzed deposit-refund programs; most of the focus has been on the impacts of “pay-as-you-throw” unit-based pricing of household waste disposal and free curbside collection of recyclables (Jenkins et al. 2003; Kinnaman and Fullerton 2000; Hong, Adams, and Love 1993). However, recent work by Viscusi, Huber, and Bell (2011) that relied on a large national survey of households and assesses the role of curbside programs, state bottle bills, and social norms finds that bottle bills have a large impact on household recycling of plastic water bottles. The survey finds that households are inclined to be “all-or-nothing” recyclers—in other words, they either recycle virtually all of the plastic water bottles they consume or almost none. In this setting, and controlling for a detailed set of individual characteristics and regional factors, the results show that deposit-refund laws tend to transform nonrecyclers into diligent recyclers. In states with deposit-refund laws that cover plastic water bottles, 87 percent of survey respondents reported recycling 80 percent or more of the bottles they consume. In states with no deposit-refund system, the figure is 53 percent. This study and other work by these authors also finds that this economic factor dominates the impact that social norms have on recycling (Viscusi et al. forthcoming).

### ***Interactions between Solid Waste and Pollution Externalities***

Interest in life-cycle, or “cradle-to-grave,” assessments of the environmental impacts of products grew in the mid to late 1990s. In the view of some experts and environmental advocates, these life-cycle costs could be used to set advance disposal fees that would internalize all of the environmental costs associated with products. In a model that includes upstream pollution associated with production, upstream solid waste residuals, and downstream (postconsumer) solid waste, Walls and Palmer (2001) show that the advance disposal fee cannot

fully internalize all externalities, consistent with a longstanding general result in economics, attributable to Tinbergen (1967), that at least as many policy instruments are needed as policy problems. The deposit-refund remains an attractive instrument in this setting, if combined with Pigovian taxes on emissions and upstream residuals. If these latter two instruments are infeasible, a deposit-refund is still called for, but the optimal deposit is larger than the refund and additional policy instruments (taxes and subsidies on other inputs) are required. Similarly, if the upstream pollutant is addressed with an input-based or performance-based standard, Walls and Palmer show that the deposit-refund holds but must be combined with other instruments to reach the full social optimum.

In the same way that the theoretical findings about a deposit-refund were validated with a simple calibrated model of waste disposal and recycling, these findings about the interaction between downstream waste and upstream emissions policies have also been explored numerically. Acuff and Kaffine (2011) modified the model of waste and recycling described by Palmer, Sigman, and Walls (1997) to include greenhouse gas emissions. They find that the deposit-refund policy remains the least-cost option for reducing waste disposal except at very low levels (below 5 percent) of targeted waste reductions. At these low levels, the advance disposal fee turns out to be the least-cost option because of the greater reductions in greenhouse gas emissions it achieves. One difference in this setting with upstream and downstream environmental externalities is the form the deposit-refund takes. To be set optimally, Acuff and Kaffine (2011) find that the deposit and refund need to vary by material because the level of greenhouse gas emissions varies by material.

### ***“Design for Environment” and Extended Producer Responsibility***

In 1991, Germany passed its well-known Ordinance on the Avoidance and Recovery of Packaging Waste, which required producers to take back the packaging associated with their products after consumption and ensure that a specified percentage of it is recycled each year.<sup>10</sup> The motivation for the product take-back approach, which eventually spread to many other countries in Europe, Japan, and elsewhere, was to provide incentives for producers to make changes that would reduce waste management costs. It was envisioned that those changes would include product downsizing, improvements in the recyclability and reusability of products,

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<sup>10</sup> The system is often referred to as the “Green Dot” system for the green dots placed on packages eligible for take-back.

material substitution, and engagement in a range of so-called “design for environment” (DfE) activities. The thinking was that, if producers were forced to take back and manage products at end-of-life, they would invest in DfE measures to reduce those management costs.

Investigation by economists into this DfE phenomenon has revealed that it does not, by itself, justify a producer take-back mandate (Fullerton and Wu 1998; Calcott and Walls 2000, 2005). When producers have a choice over, for example, the “recyclability” of the products they make, the deposit-refund approach remains an efficient policy instrument. And importantly, the existence of functioning recycling markets, bolstered by the recycling subsidy, or refund, provides incentives for design—in other words, highly recyclable products are more valuable in the marketplace. Recent work by Ino (2011) shows that a product take-back approach combined with tradable recycling credits can do as well as a deposit-refund and may be preferred in some situations. On the other hand, transaction costs associated with setting up and administering a tradable credit system are likely to be high.

The notion of producer take-back has gradually been replaced in policy circles by the more general concepts of EPR and *product stewardship*. EPR has taken on a variety of meanings, but the Organisation for Economic Co-operation and Development has defined it as a policy approach in which a producer’s responsibility for its product extends to the postconsumer stage of the product’s life cycle. This responsibility may be a physical one, as in a take-back mandate, or a financial one, in which the costs of end-of-life waste management are borne by the producer.<sup>11</sup>

A deposit-refund system is compatible with the EPR concept, and in fact, as EPR has taken hold in many countries, versions of the deposit-refund have been adopted (though the term is not used). In many programs, an up-front fee is assessed on product sales and the proceeds are then used to fund collection and recycling programs. This is, in fact, how the German system works. Most producers do not physically collect materials themselves, but rather belong to a producer responsibility organization that assumes responsibility for collection and recycling and covers the cost of the service through member company fees. Those fees are assessed per pound of material and vary by material type. Unfortunately, however, the system does not pay a refund per pound of material recycled. In fact, most EPR programs miss the opportunity to provide

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<sup>11</sup> For more information, see

[http://www.oecd.org/document/19/0,3746,en\\_2649\\_34281\\_35158227\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/document/19/0,3746,en_2649_34281_35158227_1_1_1_1,00.html).

proper recycling incentives by using lump-sum payments for the establishment of recycling facilities or for the operation of collection systems. Although these kinds of systems provide incentives for source reduction, they do not similarly spur recycling. As many studies have shown, both activities are needed to efficiently and cost-effectively reduce waste disposal volumes.

## Concluding Remarks

Deposit-refund systems combine a tax per unit of product sales with a subsidy per unit returned for recycling. Many studies have shown that a deposit-refund can provide the same incentives as a Pigovian tax on waste disposal—that is, incentives for efficient levels of source reduction and recycling—without that policy’s attendant illegal disposal problems. In fact, the deposit-refund approach can be used in many settings beyond waste disposal. In situations where emissions are difficult to monitor and attribute to a specific entity, taxing product sales and subsidizing mitigation activities or “clean” inputs may have much appeal.

In the waste arena, many examples of deposit-refund types of policies can be found, and the most innovative use an upstream approach: rather than provide a refund to consumers who return products to recycling collection centers, these programs subsidize either collectors who deliver materials to reprocessors or the reprocessors themselves when they turn collected material into useable secondary materials for production. These upstream systems are likely to have lower transaction costs and may be less inclined to lead to sham recycling—situations in which materials are collected for recycling but are not actually recycled. Unfortunately, in some cases, the policy does not provide per-unit subsidies, but rather lump-sum payments for the establishment of recycling centers or to cover operation costs.

Empirical research into deposit-refund systems and EPR programs has been limited. Policymakers would particularly benefit from future work investigating the outcomes of these upstream deposit-refund systems. Compared with the traditional downstream approach, how does this upstream model fare? How are waste volumes and the amount of recycling affected, all else being equal? Econometric research is difficult given the lack of variability in prices and the difficulty of measuring outcomes, but variability across U.S. states may help. Case studies could also provide valuable information. Given the efficiency properties of the deposit-refund approach in theory, more research into actual programs in practice would advance the environmental economics field and provide guidance to policymakers.

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