Analysis of a Florida Beverage Container Deposit Refund System

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Introduction

On an average day Floridians consume some 36 million sodas and other container beverages. Though they soon recycle about 6 million of the containers, most of the other 30 million wind up as landfill, and some wind up as litter. As Florida's urban areas grow, convenient landfill sites become harder to find, and litter is a particular concern in a state that attracts retirees and tourists because of its natural beauty and a climate that encourages enjoying the outdoors.

One way to slow landfill growth and reduce litter would be to mandate recycling, requiring people to bring their empty containers to collection sites. Such a mandate, however, would be heavy handed and difficult to enforce. Better would be to reward people for recycling, using a mechanism that mimics market incentives—collect a deposit at the time of sale and return it when the empty container is brought to a collection site. Such a policy, known as a beverage container deposit refund system (BCDRS), has been adopted by ten states with a third of the nation's population.

Many people may favor a BCDRS because it strikes them as fair. Those who fill our landfills with durable containers or litter instead of recycling should pay the cost they impose on others. Though we are sympathetic to concerns about fairness, we restrict our analysis to the efficiency of a BCDRS, leading us to consider the role of markets in waste disposal and recycling.

While markets normally do a good job of allocating resources, people may overproduce litter and waste if all associated costs are not borne by those creating the litter or waste. Similarly, people may recycle too little if some of the benefits of recycling accrue to someone besides those bearing the costs of recycling. A BCDRS creates a financial incentive to discourage litter and waste and encourage recycling, thus relying on market mechanisms to overcome potential inefficiencies in waste disposal and recycling outcomes.

In addition, unredeemed deposit revenue (UDR) typically accrues or escheats to the state. UDR, net of any handling fees paid to offset the cost of processing returned containers and other program costs, can be used to finance other programs or to offset taxes. Because taxes distort decisions and create administrative and enforcement costs, it costs society more than a dollar to raise a dollar of tax revenue Net UDR can reduce this excess burden of taxation.

Summary of Main Findings

- With an optimized BCDRS, the incremental benefit of a returned beverage container, net of processing costs, is just under 2.5¢. A deposit of 2.5¢ per container would result in net benefits to Floridians of about $141 million per year (the exact amount depends on future resource prices) and net UDR of about $70 million per year. Rounding the deposit up to 3¢ reduces net benefits to about $139 million and increases net UDR to about $83 million.
- A 5¢ per container deposit would result in lower net benefits because individuals would make returns that cost up to 5¢ but have benefits of only about 2.5¢. Net UDR would be about the same as with a 3¢ deposit.
- Net UDR falls as the deposit increases beyond about 4¢ per container as higher deposits result in higher redemption rates and therefore higher payouts of refunds and handling fees. Net UDR may become negative for higher deposits.
- The impact on beverage consumption, and therefore beverage related employment, is likely to be zero for all practical purposes because: i) the deposit and handling costs are low relative to beverage prices, ii) beverage consumption responds far less than

proportionally to price increases, and iii) consumers cannot easily avoid the price increase by substituting one beverage for another if the deposit is charged on almost all easily substitutable container beverages.

- Over a horizon of ten years or more, the impact on total employment will be essentially zero. But with a current unemployment rate of 12%, Floridians are concerned about creating jobs between now and then. While confident quantitative statements about the near term effects of a BCDRS on jobs are not possible, it is entirely plausible that a BCDRS could add modestly to near term job creation.
- Net UDR could be used to fund public sector jobs that would otherwise be cut. For example, it could be used to put some of the large number of recent college graduates who planned to become teachers but have been unable to find jobs to work teaching Florida's children. That would generate about 1,400 net jobs if annual net UDR is $70 million.
- If $70 million in annual net UDR is used to offset other state taxes, the resulting reduction in the excess burden of taxation would be about $14 million per year. That could result in about 280 jobs at an annual full cost of $50,000 per job. Using UDR to fund tax offsets that improve the efficiency of the tax system could boost intermediate term job creation.

Background

As of January 2011 ten states have “bottle bills” creating BCDRSs. These programs are successful in increasing recycling. Michigan, the only state with a 10¢ per container base deposit, has the highest return rate, about 97%. Return rates in the other states, all of which have a 5¢ per container base deposit, average about 76%, with moderate year to year and state to state variability.[1] By contrast, the beverage container recycling rate in Florida is about 16%.[2]

A BCDRS conserves resources, reduces litter and waste disposal costs, and improves environmental quality. Yet, markets usually do an excellent job of guiding resource use while interference with market forces often has unintended consequences. Markets work because people weigh their own benefits against their own costs, so no transaction occurs unless it makes each person better off. A BCDRS makes sense only if there are compelling reasons to think that without one the market is getting the benefit-cost assessment wrong when it comes to the recycling and disposal of beverage containers. The reasons the market might get these benefit-cost calculations wrong revolve around the related issues of property rights, external benefits, transactions costs, and coordination failures. In particular, market transactions are likely to ignore reductions in landfill and litter costs and in greenhouse gas (GHG) emissions.[3]

Recycling reduces landfill costs simply by reducing the amount of waste. However, if only one individual recycles, waste management companies will see no noticeable change in costs, prices will not change, and the individual who undertook the additional recycling will see no reduction in their waste bill. Thus, there is no individual incentive to recycle in order to reduce waste disposal costs. But, if everyone recycled, waste costs and therefore prices and individual bills would fall. Similarly, recycling reduces litter clean up costs, but the benefits are spread over all

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[1] California Dept. of Resources and Recovery (2010b); Stutz and Gilbert (2000); The Iowa Policy Project (2005); State of Hawaii (2009); Massachusetts Dept. of Environmental Protection (2010); Oregon Dept. of Environmental Protection (2010); New York State Dept. of Environmental Protection (2006); DSM Environmental Services (2007).

[2] Florida Dept. of Environmental Protection (2008).

[3] The basic analysis goes back to A.C. Pigou (1920) and now appears in nearly all Principles of Economics textbooks.

taxpayers, not captured by the individual making a specific decision to recycle a specific container. Therefore, both reductions in litter clean up costs and reductions in waste disposal costs are largely left out of the market benefit-cost calculation.

Using recycled instead of virgin material creates an additional external benefit by reducing GHG emissions. Reducing GHG emissions has become the dominant environmental issue of the day. Although the *Great Recession* and continuing employment slump have put it on the back burner, dealing with the potential consequences of GHG emissions or paying for their reduction will likely be one of the dominant economic issues of the not too distant future. Though global climate change is certainly not completely understood, given the current state of knowledge a business-as-usual emissions path leads to serious risk. Even those who consider the odds of the most severe potential consequences to be slim are likely to think their large magnitude outweighs their small probability, and therefore to favor reasonable steps to address GHG emissions. A BCDRS may be one such step.

However, the potential benefits of reduced GHG emissions due to recycling containers in Florida spill over to the residents of the nation and world as a whole. Floridians receive these benefits approximately in proportion to their share of total population. The tendency of the effects of GHG emissions to create global, not local, spillovers means that ultimately, efforts to address the issue will have to be at the national level, and probably coordinated internationally.

That complicates the treatment of GHG reductions in a state level analysis. If Floridians wish to "do their part", GHG reductions should be counted fully as benefits. But state policy makers might prefer not to count GHG reductions, since only a tiny share of the benefits accrue to Floridians. Therefore, we present estimates of the likely magnitude of these benefits for those who wish to count them, but leave them out of the benefit-cost calculation.

The last potential benefit of a BCDRS flows from the UDR it generates. The costs of taxes exceed revenues generated because they distort decisions and create costs associated with administration and enforcement. Economists refer to the loss of value arising from these distortions as a deadweight loss (DWL). For example, any project a business would find worthwhile if there were no taxes but which is unprofitable with current tax rates contributes to the DWL of taxation. If UDR is used to reduce taxes, while the UDR itself represents a transfer from beverage consumers to taxpayers (who are largely the same people), the reduction in the DWL is a net gain to the residents of Florida.

One potential cost of a BCDRS is the creation of a DWL from distorting choices related to beverage consumption. However, changes in beverage consumption will almost certainly be *very* small—essentially zero—for three related reasons. First, even if prices rise by slightly more than the amount of the deposit, that still represents a small *percentage* increase in price. Second, all available empirical evidence suggests consumption responses to beverage price changes are, proportionally, much smaller than the price change—only about one third as large.[4] So, a 10% increase in prices for soft drinks, for example, holding all other prices constant, might reduce the quantity of soft drinks demanded by at most 3.5%. But, third, all beverage prices will increase by a similar amount. Increases in the prices of beer, bottled water, tea, and energy drinks will boost the demand for soft drinks, for the most part canceling the decrease in quantity demanded due to the increase in the price of soft drinks. Basically, the price of almost all readily substitutable container beverages will go up, so

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[4] See Fogarty (2010), Kinnucan et al (2001), Wang et al (1996), Yen et al (2004), and Zheng et al (2008).

individuals cannot avoid the price increase on one type by switching to another type, and they will not respond to the overall price increase by drinking significantly less in total.[5] Thus, we are convinced any potential DWL from changing beverage consumption associated with a BCDRS with a small deposit (5¢ or less) is *very* small.

Rationale[6]

Consider a very simple hypothetical private market for recycled beverage containers in which individuals return their empty containers to collection locations which are run by firms (hereafter referred to as recyclers) which process the empty containers and sell the scrap material to manufacturers.[7] When manufacturers decide whether to buy from a recycler, they weigh raw material and energy savings relative to virgin materials (which includes the cost of complying with current environmental regulations) against the price they have to pay for scrap material. When recyclers decide whether to take in and process empty containers, they consider the price they will receive from manufacturers, their own handling and processing costs, and how much they have to pay individuals to return recyclable containers.

This hypothetical market will produce recycling to the extent the scrap value (s) exceeds the sum of recycler costs (h), which include a fair rate of return, and individual return costs (c), or as long as $s > h + c$. However, if external benefits (x) such as reductions in landfill use and litter clean up were captured by a party to the market transactions, that is, if the property rights to these benefits were clearly defined and easily enforceable, the recycling market would produce additional recycling as long as the sum of scrap value and external benefits exceeds the sum of handling and return costs, or as long as $s + x > h + c$. To the extent external benefits are significant, handling and return costs are not prohibitive, and scrap values are not so high that everything is recycled regardless of external benefits, the market produces too little recycling.

We can think of a BCDRS as a quasi-market mechanism that mimics a private market in which ownership rights to the external benefits are clearly defined and readily enforceable. Ignoring, for now, the role of UDR in reducing the DWL of taxation, the deposit in an idealized BCDRS equals benefits less handling costs $(d = s + x - h)$. This creates an incentive to return any containers for which the return cost is low enough that benefits exceed costs, maximizes the net gains created by the program, and ensures benefits will exceed costs. If scrap values are too low to cover handling costs, it may be necessary to set a handling fee equal to the difference $(h - s)$ to be paid to recyclers to induce them to accept and process empty containers, depending on program details.

Deposits collected from those who do not return their containers usually become UDR to the state.[8] As discussed above, UDR itself is not a net benefit or a net cost, rather it is simply a transfer from beverage consumers to taxpayers. It can, however, reduce the DWL from taxation, creating an additional benefit. Therefore the

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[5] The estimates in Kinnucan et al (2001) imply the sum of own and cross price elasticities for beverage groups is near 0.

[6] Relevant literature includes Calcott & Walls, M. (2000), Dinan (1993), Fullerton & Wolverton (2000, 2005), Massell and Parish (1968), Palmer, Sigman, & Walls (1997), Palmer & Walls (1997) and Porter (1978, 1983).

[7] Depending on the exact structure of the program, recyclers could be independent integrated firms or these functions might be performed by beverage retailers and distributors. Who performs these functions does not affect the argument.

[8] Depending on program details, UDR may escheat to the state or accrue more directly, but most states with a BCDRS claim the revenue one way or the other.

(optimal) deposit is also adjusted to take account of this additional benefit.[9]

So the idea behind a BCDRS, as opposed to mandatory recycling, is to set the deposit (*d*) paid by consumers and any handling fees paid to recyclers to make sure all benefits and costs are internalized. Of course, the deposit and handling fee do not represent net costs or benefits. Rather, they are transfers set to mimic how efficient market prices affect decisions.

Benefit-Cost & UDR Estimates

Table 1 presents basic information for aluminum, glass, and plastic containers, along with the weighted average for all types.[10] The number of containers is the Container Recycling Institute's 2006 Florida estimate—about 13 billion in total. Since total income was about the same in 2010 as it was in 2006 (due to the recession), there is no reason to expect the number of containers to have changed by much. Containers per ton (row 2) are based on recent California data.[11] California's program involves extensive monitoring and therefore generates a great deal of useful data.

The handling cost estimates in Table 1 (row 3) are also based on California data.[12] It is important to recognize significant economies of scale are involved in handling returned containers. Reverse vending machines (RVMs) used at high capacity can result in low handling costs. In California, where the system is designed to make sure volume at redemption centers is high, the average recycling cost is about 1.5¢ per container. However, if volume is too low to justify RVMs, manual redemption can be used, though it costs more—about 3¢ per container in Vermont.[13] The deposit in California is 5¢. At lower (higher) deposits, the recycling rate would likely be lower (higher) and therefore average handling costs would likely be higher (lower).

The population-weighted Florida average Class I landfill tipping fee in 2008 was $46 per ton.[14] There are two reasons to suspect this might be a slight underestimate, or lower bound, of the cost of disposing of beverage containers in landfills. First, recycling may reduce transport and collection costs. Second, beverage containers are likely more durable, on average, than other household waste. Therefore, their share in the final amount of landfill space taken up by household waste likely exceeds their share of incoming tons of household waste.

We extrapolate the value of litter reduction from data on roadside litter clean up costs for the Florida state highway system (from the Florida Department of Transportation) using the ratio of total to state highway system centerline miles and the share of beverage containers in litter collected. This gives an estimated savings of $12.78 per additional ton of beverage containers recycled. This estimate does have limitations. First, non state system roads may have less litter intensity because they have less traffic intensity. Second, and probably more important, this ignores litter clean up in other areas that may be more costly. Third, this estimate assumes all gains are in the form of cost savings, holding the average level of litter constant over a clean up cycle, instead of allowing for a complete re-optimization. Thus, we think of this as a lower bound on the value of litter clean up.

Adding the landfill and litter savings per ton gives $58.65, and dividing by containers per ton gives estimated litter and landfill savings per

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[9] The math is not as neat as $d = s + x - h$ (see footnote 25).

[10] In all tables, bi-metal is included in the weighted average but not listed separately as it is only 1/5000th of all containers. Plastic is the weighted average of PET and HDPE containers.

[11] California Department of Resources Recycling and Recovery, 2010c.

[12] California Department of Resources Recycling and Recovery, 2010c.

[13] DSM Environmental Services, Inc., 2007.

[14] The private landfills we were able to contact charge slightly less.

Table 1: Volume, Handling Cost, and Benefits by Container Type

Container Type	Aluminum	Glass	Plastic	Weighted Average
Containers (Billions)	6.42	2.77	3.92	N/A
Containers per Ton (Thousands)	58.6	3.80	29.36	38.27
Handling Cost (¢/Container)	1.07	2.27	1.61	1.49
Litter & Landfill Savings (¢/Container)	0.10	1.54	0.21	0.44
Scrap Value (¢/Container)	2.48	0.11	1.23	1.61

Sources: Container Recycling Institute (2008), California Dept. of Resources Recycling and Recovery (2010d, 2010e, 2011), Florida Dept. of Environmental Protection (2008), Florida Dept. of Transportation (2009), Florida Center for Solid and Hazardous Waste Management (2002), U.S. Environmental Protection Agency (2010)

container (row 3). In the calculations below, allow for the possibility that this is an underestimate.

Scrap values (row 4) are average 2010 scrap prices paid under California's beverage container recycling program.[15] The scrap value for glass is likely underestimated as it includes glass coming through curbside recycling, the proportion of mixed glass is likely much lower for deposit containers than curbside containers, and the scrap price for mixed glass is negative. Based on data from *Strategic Materials, Inc.*, the weighted average glass scrap price excluding mixed glass in the Southeast region in 2010 was 0.63¢ per container. While we use 0.11¢ per container in our calculations, the true value will be higher to the extent the share of mixed glass is lower, possibly by as much as ½¢ per container.

Resource prices (e.g. crude oil, aluminum, and carbon allowances), and therefore scrap values, vary considerably over time. Figure 1 shows inflation adjusted prices for scrap and virgin aluminum, scrap plastic, crude oil, and scrap glass from 1999 through 2010, expressed as an index equal to 100 in 2010.[16] Resource prices fell sharply during the recent recession, and are now recovering. If those prices had continued to grow from their July 2008 level at the trend observed the previous 5 years, their 2010 level would have been approximately 50% higher. Much of the rapid increase prior to 2008 stemmed from rapid growth in developing nations such as China and India. Though interrupted by the recession, that long run trend continues, especially since those countries were not hit as hard by the global recession as were the U.S. and Europe. While no one has a crystal ball, the probability resource prices will remain at current levels for long is low. Resource prices may soon return to their pre-recession levels and trends or zoom even higher.

To estimate the value of GHG reductions, we first convert the market price of European Carbon Allowances to short tons and U.S. dollars.[17] The result is multiplied by the U.S. Environmental Protection Agency's estimates of tons of CO2e reduction per ton of recycled material and divided by containers per ton. On average, this yields an additional benefit of ¼¢ per container recycled. The result is not included in Table 1 because almost all of this additional benefit spills over to the non Floridians. But, those who feel Florida should "do its part" to reducing GHG emissions while waiting for a comprehensive national policy may want to add this to the net benefits of a BCDRS.

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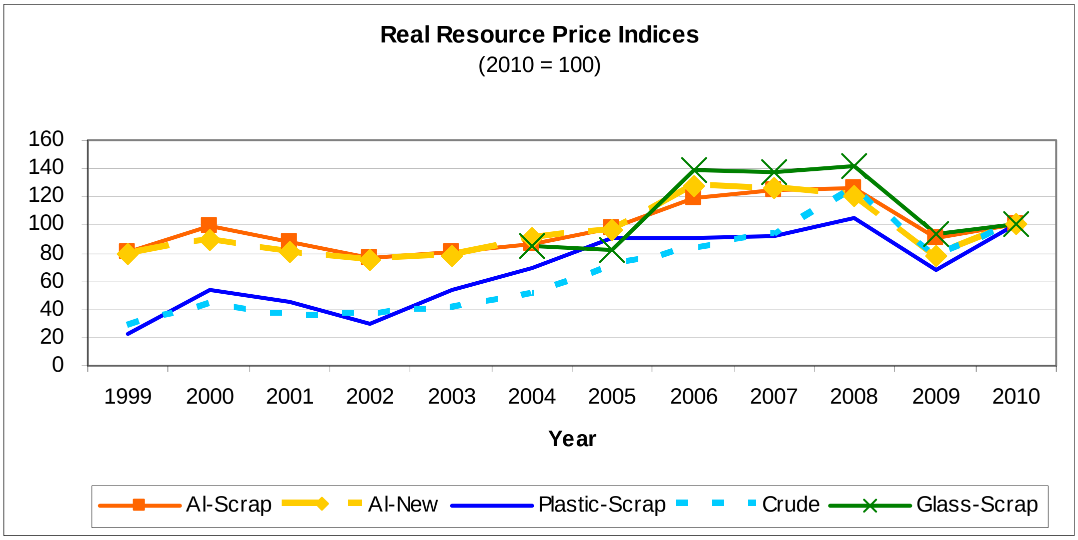
[15] California Department of Resources Recycling and Recovery (2011) contains data for October, November, and December. Historical data provided via e-mail.

[16] Glass scrap prices are shown only for 2004 to 2010 due to suspected inconsistencies in the earlier data.

[17] Carbon Allowance prices are from Intercontinental Exchange (2011). The exchange rate used was $1.2943/1€ from January 7, 2011.

Figure 1: Real Resource Price Indices (2010 = 100)



Sources: California Department of Resources Recycling and Recovery, IndexMundi (2011), U.S. Bureau of Labor Statistics (http://www.bea.gov/national/index.htm#gdp), U.S. Energy Information Administration (http://www.eia.gov/dnav/pet/pet_pri_wco_k_w.htm)

Table 2 presents estimates of the net benefit per recycled container before individual return costs are subtracted and the reduction in the DWL associated with UDR is added $(s+x-h)$ for aluminum, glass, and plastic, as well as the weighted average. Table 2 also presents estimates of the private net benefit to a recycler, which are simply scrap prices less handling costs $(s-h)$. Estimates are presented for three scenarios—low, medium, and high—because resource prices, and therefore scrap values, are likely to rise in the near future, and because the value of landfill and litter savings in Table 1 was likely a lower bound.

The low scenario corresponds to the 2010 values shown in Table 1. Thus, it may be thought of as a lower bound estimate of the net benefits of a BCDRS. The medium scenario is based on both scrap and external benefit values 50% above the level in Table 1. We think this scenario is more likely to match resource prices in the near future and that it makes a reasonable allowance for the fact that the landfill and litter savings listed in Table 1 may somewhat understate actual values. The high scenario is based on scrap and external values double the level of Table 1. This scenario would represent a world in which resource values soar above their pre recession trend and in which the external benefits in Table 1 are vastly underestimated. While we think this scenario is not very likely to occur in the near future, it can be thought of as an upper bound for the likely benefits of a BCDRS in Florida, just as the low scenario can be thought of as a lower bound for the likely benefits.

In the low scenario, a BCDRS makes sense for aluminum if the individual return cost is small enough, but not for any other material. While it would make the most sense to have an aluminum only program at current prices, the weighted average value of benefits less handling costs is slightly positive, at 0.56¢ per container. Therefore, a comprehensive program (for all materials) could still have benefits in excess of costs. However, this depends crucially on attaining the efficiency and economies of scale needed to keep recycler handling costs as low as assumed (about 1.5¢ per container) and also on average individual return costs being quite low.

In the medium and high scenarios, the sum of scrap and external values exceeds

Table 2: Total and Private Benefits - Handling Costs (¢/Container)

Scenario	Calculation	Aluminum	Glass	Plastic	Weighted Average
Low	Benefit - Handling Cost (*s+x-h*)	1.51	-0.61	-0.24	0.56
	Scrap Value - Handling Cost (*s-h*)	1.41	-2.16	-0.46	0.12
Medium	Benefit - Handling Cost (*s+x-h*)	2.80	0.21	0.51	1.58
	Scrap Value - Handling Cost (*s-h*)	2.65	-2.10	0.18	0.92
High	Benefit - Handling Cost (*s+x-h*)	4.09	1.04	1.27	2.60
	Scrap Value - Handling Cost (*s-h*)	3.89	-2.04	0.83	1.73

handling costs for all materials. For aluminum and plastic, the increase in net benefits per container between the low, medium, and high scenarios is due primarily to increased scrap values. Given the relatively low scrap value of glass, relatively large proportional increases in scrap values would not make the net benefit positive. Therefore, the increase in the net benefits for glass between the low, medium, and high scenarios is largely due to increases in the landfill and litter savings estimates. The fact that glass scrap values will be higher than reported in Table 1 if the proportion of mixed glass turns out to be low enough should also be kept in mind.

Looking at the estimates of scrap values less handling costs, or private net benefits, and recalling that at low recycling rates handling costs would be higher, we can see why recycling rates are low absent a BCDRS. In the low scenario, a recycler would be willing to pay at most 1.41¢ per aluminum container. However, if individuals receive only 1.41¢ per container, the volume of returned containers would be very low, so handling costs would be correspondingly higher than our estimate, making recycling even aluminum containers uneconomical from a private perspective. Similarly in the medium and high scenarios, if a recycler were to offer 0.18¢ or 0.83¢ per empty plastic container, respectively, recycling rates would be low, making handling costs higher and recycling plastic completely uneconomical from a private perspective. Even for aluminum in the medium and high scenarios, adding the amount of external benefits to the deposit boosts recycling and reduces handling costs, making recycling more economical.

Moreover, the difference between scrap value and handling cost in Table 2 does not take into account the initial transactions costs associated with setting up a system to handle the logistics of collection and transportation of materials. A bottle bill *potentially* reduces these costs since it specifies the default parameters of responsibilities for collection and transportation–typically the default responsibility for collection lies with retailers and the default responsibility for transportation lies with distributors. This is potentially *very* important because no one individual can likely capture enough of the gains from recycling to make bearing these initial transactions costs worthwhile. Therefore, even though the scrap value of aluminum exceeds the estimated handling cost by 2.65¢ in the medium scenario, it is unlikely the market outcome absent a BCDRS would involve a high recycling rate.

Regarding handling fees, in all three scenarios scrap values are higher than handling costs on average. In the low scenario, low recycling volume would likely change this. However, in the medium and high scenarios, while somewhat lower recycling volume would likely produce somewhat higher handling costs, it is unlikely average handling costs would significantly exceed scrap values. Therefore, it would not be necessary to pay handling fees if the same party incurs all recycling costs and receives all scrap revenue, so that high aluminum revenues offset high glass costs and revenues from high volume redemption centers offset costs at low volume centers.

However, in the event the program cannot be structured in this way, without carefully designed handling fees recyclers would not want to run redemption centers in areas with low container volume or high shares of glass. If retailers were required to accept returns in these areas and distributors required to collect them, they would have to increase prices to cover these costs. Therefore, it may be important to pay handling fees out of UDR to help overcome the objections of retailers and distributors.[18]

We deduct 1¢ per container returned from UDR to cover handling fees and other program costs. States vary considerably in the resources devoted to program administration. In some, only a portion of the time of a few employees with other primary assignments is devoted to program administration. In others, for example California, program administration is more extensive. Without going into great detail about the exact design of the program, we don't know precisely how much revenue is needed to ensure the program truly is self funded and to help achieve buy-in from manufacturers, distributors, retailers, and recyclers. However, that coordination problem is very complex, and therefore beyond the scope of this study. Since, on average, scrap values exceed processing costs, and since the administrative costs of a well designed program should be small, we believe an allowance of 1¢ per returned container ($70 million to $100 million in total depending on return rates) is sufficient to cover handling fees and other program costs. The reader should bear in mind our use of this approximation does *not* indicate a 1¢ flat handling fee is optimal.

To estimate (total) net benefits and unredeemed deposit revenues in each scenario, it is necessary to estimate redemption rates (*r*) and individual return costs (*c*) for different deposit values. These estimates are closely related. The literature on BCDRS generally claims that, all else equal, higher deposits and greater convenience of returns are associated with higher redemption rates. This makes sense because the incentive to return empty containers is higher when the deposit—and therefore the refund—is higher and when the cost of returns is lower.

A BCDRS obviously results in an increase in the deposit and refund value from 0. The fact that the deposit in Michigan is double that of other states—10¢ instead of 5¢—and return rates in Michigan are about 20 percentage points higher than return rates in other states provides some evidence that the deposit level has an important effect on return rates. Additionally, in California (the only state where we have data on redemption rates for different deposit values) redemption rates show a modest positive correlation with the inflation adjusted deposit over time.

A BCDRS also increases the convenience of recycling by greatly increasing the number of locations where containers may be returned. Redemption rates in California in 1988 and 1989 were 55% and 56% when the deposit was 1¢ and 2¢, respectively. However, recycling rates absent a BCDRS in Florida are only at 16%. This suggests the additional convenience of returning containers under a BCDRS has important effects on return rates. Similarly, a BCDRS may increase the *salience* of recycling.

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[18] If the role of recycler is filled by retailers and distributors, it is not uncommon to require the distributor to pay handling fees to the retailer. It is also possible to impose an additional fee on beverage sales to fund these costs. Such measures amount to an additional excise tax on beverages to fund the program. It could also be thought of as charging a deposit higher than the refund value. We simply subtract handling fees from UDR rather than modeling such a tax.

If we assume those with return costs more than the deposit ($c>d$) do not return empty containers and those with return costs less than or equal to the deposit ($c \leq d$) do return them, the deposit represents the return cost of the marginal returned container. Operationally, the threshold deposit at which a particular container would be returned defines the return cost of that container.

In Florida, the recycling rate with no BCDRS is 16%. In states with a 5¢ deposit, the average recycling rate is about 76%. Therefore, it appears the combination of increasing the deposit from 0¢ to 5¢ *and* the increase in convenience and salience resulting from a BCDRS increases recycling by about 60 percentage points. We assume half of this is due to increased convenience and salience and half is due to the increased deposit. Specifically, we assume that with an average BCDRS recycling would be 46% even if the deposit were 0 and that redemptions rise by about 6 percentage points per 1¢ increase in the deposit $((0.76-0.46)\div 5=0.06)$. Our calculations therefore *assume* the redemption rate under a BCDRS in Florida will equal 0.46 plus 0.06 times the deposit in cents, $r(d)=0.46+0.06d$.[19]

Assuming this linear approximation for redemptions *implies* return costs per container are approximately 0 for 46% of containers sold and are uniformly distributed between 0 and the deposit for other returned containers. That means that for containers redeemed beyond the first 46%, the estimated average return cost per container is half the deposit.[20]

Finally, we need an estimate of the DWL associated with taxation. Most estimates tend to suggest raising $1 of tax revenue costs about $1.20. Some studies suggest the number is slightly lower, while others suggest it is much higher.[21] Therefore, we use $0.2 as the estimate of the DWL of raising $1 of tax revenue. That implies each $1 of UDR used to reduce or to avoid the increase of other taxes generates a net benefit of $0.20.

Table 3 presents annual estimates of UDR, UDR net of a 1¢ per container allowance for handling fees and other program costs, and net gains, under the three different benefit scenarios for different deposit levels.[22] Under current resource prices and lower bound estimates of external benefits—the low scenario—the net benefit would be an estimated $85 million at a 1.5¢ deposit (the optimum rounded to the nearest half penny in this scenario). However, the estimated return rate at a deposit of 1.5¢ is only 55%, while the handling cost estimate is based on recent California data with a considerably higher return volume. The lower recycling volume means higher handling costs, and therefore lower net benefits than indicated in Table 3. Therefore, in practice, a comprehensive BCDRS might not pass a benefit-cost test in the low scenario.

In the medium scenario, which we believe best represents conditions in the near future, net benefits are $141 million and net UDR is $70 million at a deposit of 2.5¢ (the optimum rounded to the nearest half penny). Rounding up to a deposit of 3¢ per container, estimated net benefits fall to $139 million and net UDR increases to $83

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[19] Moderate parameter variations result in only small changes in our results and do not affect our basic conclusions.

[20] Total annual return cost is then $C(d)=0.03Qd^2$ where Q is the total number of beverage containers purchased annually. Return cost per container sold is $c(d)=0.03d^2$

[21] Ballard (1988), Browning (1987), Feldstein (1999), Fullerton (1991), Jorgenson, et al (2001), and Stuart (1984) are eamples.

[22] Calculation of the optimal deposit accounting for the DWL of taxation is more complex. If g is the net gain per unit sold and λ is the net DWL per dollar of tax revenue, the optimal deposit maximizes:

$g(d)=(r(d)-r(0))(s+x-h)+\lambda(d-r(d)(d+f))-c(d)$.

Assuming a linear approximation of the redemption rate as a function of the deposit, letting α denote the slope, assuming the deposit is double for large containers, and letting m be the share of small containers plus 2 times the share of large containers, the optimal deposit is:

$d=(s+x-h+(\lambda m/\alpha)(1-r(0))-\lambda f)/(1+2\lambda m)$.

Table 3: Benefit-Cost and Unredeemed Deposit Revenue Estimates

(Benefit, Cost, and Revenue are $Millions/Year)

Base Deposit[a] (¢)	1.5	2.0	2.5	3.0	4.0	5.0
Redemption Rate (r)	55.0%	58.0%	61.0%	64.0%	70.0%	76.0%
Recycler Handling Costs	17.54	23.38	29.23	35.07	46.77	58.46
Individual Return Costs	8.86	15.75	24.60	35.43	62.98	98.41
Unredeemed Deposit Revenue	104.07	129.51	150.32	166.51	185.01	185.01
Less 1¢/return	31.90	53.40	70.28	82.53	**93.16**	85.29
Benefit (Low)	110.93	123.27	134.69	145.18	163.39	177.90
Net Gain	**84.54**	84.14	80.86	74.68	53.65	21.04
Benefits (Medium)	163.20	179.57	195.01	209.52	235.77	258.33
Net Gain	136.81	140.44	**141.18**	139.02	126.03	101.46
Benefits (High)	215.48	235.86	255.32	273.86	308.15	338.75
Net Gain	189.09	196.74	201.49	**203.36**	198.41	181.88

[a] The deposit is assumed to be double the base level for containers 25 ounces or larger. The share of large containers is estimated from California Department of Resources Recycling and Recovery, 2010c.

million. A BCDRS with a deposit of 5¢ would result in much lower net benefits in both the low and medium scenarios, net benefits could be negative if we have underestimated handling or return costs, and net UDR would be only $85 million, essentially the same as with a 3¢ deposit.

Net UDR achieves its maximum level of $93 million at a deposit of 4¢ and then falls as the deposit increases from there. That is because the redemption rate is sufficiently higher that the increase in payouts swamps the increase in initial revenues. If the handling fee is not 0, UDR eventually becomes negative as the deposit increases above 5¢.

Implications of the Estimates

From a benefit-cost perspective, a BCDRS with a deposit of 2.5¢ or 3¢ (possibly double for large containers) appears very reasonable. For scrap values and landfill and litter savings values anywhere between the low and high scenarios considered in our report, net benefits would not be much lower with a 2.5¢ deposit than with the optimal deposit. After allowing 1¢ per container to fund program costs, including handling fees, net UDR is $70 million.

While our approximation of redemption rates may not be exact, redemption rates are likely to be lower than those in other states if the base deposit is 2.5¢ instead of 5¢—50% to 70% seems a likely range depending on salience and convenience. Experience with BCDRS in other states indicates behavior responds relatively quickly, meaning redemption rates plateau quickly rather than rising gradually for many years. However, it seems reasonable to think redemption rates might be a bit lower in the first year or so, resulting temporarily in smaller net benefits and larger UDR, since habits may change quickly but probably not instantaneously.

One could argue that a 2.5¢ or 3¢ deposit is too low to get anyone's attention because people do not take things worth only a few pennies seriously. If no one bothers to think about how refunds might add up over time, even individuals who incur return costs per container less than the deposit might not realize it is worthwhile to return their used containers. If making the deposit equal to a nickel instead of two or three pennies makes people take it more seriously and therefore actively decide if it is worth their time to return containers, one might be more inclined to favor a 5¢ deposit even if the optimal deposit, were everyone perfectly informed and perfectly rational all the time, is only 2.5¢. The fact that all states with a BCDRS but Michigan currently set the deposit at 5¢ might lend some credibility to this argument.

The problem with adopting a 5¢ deposit when the net benefit from recycling another container is much smaller is that many individuals who decide to return containers will incur return costs less than 5¢ but higher than the difference between benefits and handling costs $(s + x - h < c)$, and their recycling will generate net losses. Of course, if the average return cost (c) remained low enough, the program would still create total benefits in excess of total costs with a deposit of 5¢. Unfortunately, return costs are idiosyncratic and subjective, and we have no precise data on them—our calculations are based only on a theoretically reasonable approximation.

We do know return costs are low for some containers, since recycling rates are above 0 without a BCDRS. Michigan's experience is convincing evidence that return costs are higher than 5¢ per container for a significant fraction of containers, which suggests return costs between 2.5¢ and 5¢ for many containers as well. We do not, however, know the average value in the range between 0¢ and 5¢.

To put this question in perspective, the data in Table 1 indicate about 13 billion potentially recyclable beverage containers are sold annually in Florida, meaning an average individual would generate about 58 containers per month. Adjusting for the value of the reduced DWL of taxes, the average benefit of returned containers less handling costs, given a deposit of 5¢ and a redemption rate of 76%, is about 1.95¢ per container in the medium scenario. So imagine asking the average individual if they would sort, store, and return their 58 containers in exchange for \$1.13 (0.0195×58=1.13) each month. If they yes, a BCDRS with a base deposit of 5¢ and handling fees and other costs paid from unredeemed deposits makes economic sense in the medium scenario. If they say no, it does not.

There are other ways to get people's attention than raising the deposit to 5¢ when a deposit of 2.5¢ is better based on the benefit-cost calculation. For example, the "Don't Mess with Texas" campaign has apparently been quite successful at reducing litter in Texas.[23] A similar, well designed, campaign should be able to make sure people are aware of the opportunities to return their containers, and of the benefits of doing so, at a reasonable cost and without distorting the appropriate incentive that would be created by a deposit of 2.5¢.

We argued above that any DWL resulting from increased beverage prices was likely to be very small. For completeness, we calculate a rough upper bound for this DWL. Suppose the following. 1) The deposit is 5¢, though we recommend less. 2) The average own price elasticity of demand is -0.5, though most estimates are smaller in magnitude. 3) The sum of cross price elasticities is half the magnitude of the own price elasticity, though evidence suggests the cross price effect is larger relative to the own price elasticity. 4) The average container beverage price is 50¢. While sodas sold by the carton cost a bit less, other beverages cost considerably more, making this an underestimate. 5) The effective price increase equals the deposit, since consumers receiving refunds also incur return costs.

Given these assumptions, price increases by 10%, so quantity falls by 2.5%, or 328 million units. The lost consumer surplus is between 0 and

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[23] See, for example, NuStats (2010) and Texas Department of Transportation (2010).

5¢ per beverage not purchased. Assuming the average lost consumer surplus is 2.5¢ per unit reduction in consumption, the total loss is \$0.025×328, or \$8.2 million. While that is very small relative to the net benefits in Table 3, assumptions 1-4 each led to overestimating this DWL. With values more reflective of the best point elasticity estimates and a 3¢ price increase, consumption falls less than 1% and the DWL is well under \$2 million.

Taken as a whole, the analysis suggests a BCDRS can improve on market recycling outcomes in Florida. The external benefits are large enough that given resource values we are likely to see in the near future, some degree of additional recycling is economically desirable if the frictions that prevent it from occurring on its own can be overcome. However, the analysis also strongly suggests a modest base deposit of 2.5¢ or 3¢ per container would make a much better starting point than a base deposit of 5¢. The more modest deposit greatly increases the chance the BCDRS will produce net gains and yields about the same net UDR.

Program Design and Compliance

Even when a BCDRS makes sense in the abstract, things may not work out well in practice unless the program is carefully designed. A complete consideration of practical legislative and administrative issues in implementing a BCDRS is beyond the scope of this report. But, we would be remiss if we did not note some of the likely issues.

First, the program should be structured to minimize administrative and compliance costs. That means including *ex-ante* strategies to promote compliance where possible rather than relying too heavily on *ex-post* interventions such as investigations and penalties, which can be more expensive. In practice this involves structuring the program to provide automatic incentives for compliance and to provide incentives for involved parties to police the activities of one another.

Second, to be self funding, a BCDRS must minimize fraudulent redemptions, including both returns of containers from out of state and attempts to receive multiple refunds for the same container. Typically efforts to deal with these issues include: 1) reporting requirements for and audits of redemption centers, retailers, and distributors; 2) limits on the number of containers an individual can redeem in one day; and 3) penalties for violators. Compared to some states, the threat of out-of-state redemptions would be limited by Florida's peninsular shape. Few people commute daily into or out of Florida.

Third is the basic issue of making it convenient for individuals to return their containers. This means ensuring there are enough well located redemption sites and that those locations fulfill their obligations appropriately. Mechanisms are needed to: 1) incentivize convenient redemption centers, 2) inform consumers about the workings of the system, 3) take and investigate consumer complaints, and 4) penalize noncompliance.

Fourth, the system for setting and allocating handling fees requires careful thought. Recyclers with low volume (or a high share of glass) are likely to experience handling costs in excess of scrap values. The most efficient solution in the highest cost locations is simply not to provide redemption centers, since costs exceed benefits. However, that is probably not politically feasible since customers in those areas will pay deposits. Yet, if the handling fee is the same for all locations, prices will have to increase to make up the difference in high cost locations, placing those in such areas at a relative disadvantage anyway.

On efficiency grounds, it is important to avoid encouraging excess entry of redemption centers in any given location, since that would reduce scale economies and therefore increase handling costs. In areas where density is highest, a flat handling fee available to any redemption center or recycler would encourage exactly this sort of excessive entry and duplication of costs. Thus, the system to determine how many recyclers in any given area can receive handling fees, and how much they can receive, must be carefully thought out.

A partial solution might be for total handling payments to increase with the total volume processed but for the handling fee per unit to fall with the total volume processed. If the rate structure is set carefully and retailers are allowed to refuse to accept returns as long as a redemption center is nearby, this could help create appropriate incentives for the most efficient configuration of redemption centers. However, such a scheme might become complex and more costly to administer.

Fifth, a BCDRS will impact net revenues to curbside recyclers. Some containers which currently generate scrap revenue in excess of costs will be diverted, but some containers that reduce net revenue will be also be diverted. Assuming curbside recyclers can claim refunds for containers not diverted (as is the case elsewhere), they will receive higher net revenue for containers that are not diverted. Thus the net impact on revenue is theoretically ambiguous—but it is unlikely to fall greatly and may increase.

We do not profess to know the best way to design the details of a BCDRS. While anyone considering a BCDRS for Florida should be aware of the issues considered above, they do not constitute an exhaustive list. However, a small task force that investigates the experiences of the ten states with BCDRSs should be able to devise a workable plan.

Employment

Opponents of a BCDRS are likely to claim it will cost jobs, particularly in the beverage industry. Proponents are likely to claim it will boost jobs, especially in the recycling sector. The simple truth is that in the long run, the labor market adjusts according to demographics so that everyone who wants work at prevailing wages gets a job. Since a BCDRS does not change the age structure of the population, preferences about working versus other options (like leisure, retirement, or being a stay-at-home parent), or improve the efficiency with which the economy is able to match workers quickly to the jobs they are best suited for, it will have no net impact on the number of jobs in the long run.

A BCDRS will likely have a small effect on the composition of jobs. In particular, there will be more employment in certain types of recycling and perhaps more employment in recycling generally. There will likely be less employment in waste management and disposal, since there will be less waste to manage and dispose of. Those extra recycling workers mean there will be fewer workers in some other sector, but, there is no good way to know what that sector might be.

The important thing about the effect of a BCDRS on employment in the long run has nothing to do with the number of jobs and everything to do with the efficiency of the job structure. If market forces are missing external benefits and costs, a well designed BCDRS will make the job structure more efficient and raise real output per worker.

With a million Floridians currently seeking work but not finding it, the major focus is on creating jobs not in the long run but in the next five years. Florida's labor market is far worse than the nation's, mainly because the recession was worse here than nationally. Adding to that, the woes in the housing market make it very difficult to sell a house here to find a job elsewhere.

Anything that creates jobs in Florida at this junction helps both the labor housing markets.

Though we are not able to provide precise quantitative estimates of the effect of a bottle bill on near term job creation, we do have a few observations. First, for reasons elaborated above, a bottle bill will not reduce consumption or employment in the beverage industry. Second, because recycling will generate more available raw material in Florida, there might be some shift of related jobs to Florida. Third, state revenue from unclaimed deposits could be used to reduce other taxes or to protect jobs that would otherwise be cut due to tight state and local budgets, for example the jobs of beginning teachers, either of which increases near term job creation.

Suppose net UDR is $70 million and that current efforts to trim the state budget result in a reduction of K-12 operating budgets, fewer new teaching positions, and layoffs of some of the most recently hired teachers. The average starting teacher salary in Florida in 2010 was approximately $35,000.[24] Allowing for benefits and payroll and employer taxes, and rounding up, suppose it costs $50,000 per year to hire a new teacher. Then UDR could fund 1,400 teaching jobs. The fact that the UDR was taken out of the economy would reduce spending and jobs, but the effects of the spending of the 1,400 teachers would exactly balance that, resulting in a net increase of 1,400 jobs.[25]

Alternatively, suppose the $70 million of net UDR is used to increase the state's share of the Florida Education Finance Program, reducing local property taxes by an equal amount. Let us not over-estimate the significance of that. Taxes on a median-value Florida house ($133,000) would fall by only about $7. But every bit helps. The resulting reduction in the DWL from the property tax would be about 20% of the tax reduction, or about $14 million in total. That is equivalent to an increase of $14 million in net spending, which would create the equivalent of 280 jobs paying $50,000 per year (tax and benefit inclusive). Of course, these jobs would not materialize as quickly as just hiring 1,400 more beginning teachers, but they would likely materialize gradually over the next few years.

In addition, if the revenue were used to improve the efficiency of Florida's tax system, thus helping to reducing the aggregate value of the DWL of taxation, intermediate term net job creation might be somewhat higher. For example, net UDR could be used to help fund shifting the corporate income tax to apportionment 100% on sales, as is the practice is most states, instead of half on capital and labor. Again, though the effect on job creation might be small relative to the size of the economy, it would be in the right direction.

Summing Up

A summary of the best logically consistent argument in favor of implementing a BCDRS in Florida might go something like the following. The costs of litter, waste, and GHG emissions associated with beverage containers are not fully captured in market prices. At resource prices likely to be reached in the immediate future, recycling beverage containers makes economic sense. A BCDRS is a market based policy designed to encourage recycling without resorting to mandatory recycling rules. A BCDRS also generates state revenue, potentially reducing the excess burden of taxation. A BCDRS with a base deposit of 2.5¢ or 3¢ per container can serve as a modest step toward reducing the costs of transitioning to a world with higher resource prices, including more stringent limits on GHG emissions. While the future is highly uncertain, it is better to take reasonable steps to prepare for

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[24] Florida Department of Education, 2010.

[25] As shown in principles of macroeconomics textbooks, the balanced budget multiplier is 1 in the short run when the economy is at significantly less than full employment.

such a transition and have it not occur than to be unprepared for it if it does occur.

A BCDRS will have no impact on the number of jobs in the long run, though it may result in a more efficient employment structure in the form of higher real productivity. In the short run, given tight state budgets and current unemployment, if UDR is used to offset taxes or to prevent cutting jobs of state or local workers, for example K-12 teachers, a BCDRS would provide a moderate boost to job creation.

On the other hand, a summary of the best logically consistent argument against a Florida BCDRS might go something like the following. If resource prices reach very high levels, market forces will produce most economically beneficial recycling anyway. In the intermediate case, a BCDRS could improve matters in theory. But, government involvement is likely to have unintended and unforeseen consequences, so we should only add to the scope of government intervention when the net benefits are large and nearly certain. If a 5¢ deposit is adopted instead of a more modest deposit of 2.5¢, return and handling costs may outweigh gains. Moreover, current resource prices are not high enough to clearly justify even a perfect BCDRS, and if they are at some time in the future, we can revisit the question at that time.

On the whole, the potential net gains from a BCDRS are modest on a per capita basis and sensitive to assumptions about resource prices and handling and return costs—if handling costs turned out to be like Vermont's any net gains would disappear. So, those who oppose government involvement in the marketplace unless the net gains are large and nearly certain may not be convinced that a BCDRS is a good idea. But, a well implemented and efficiently run BCDRS with a deposit of 2.5¢ or 3¢ per container and handling costs similar to those of California would create net gains over the next 20 years with a present value of around $70-$120 per Floridian (depending resource prices and the discount rate used). Further, net UDR could be used to boost near term job creation. So, there are sound reasons for those who believe Florida should implement policies to reduce waste and litter and encourage recycling to favor a BCDRS.

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