What Impacts Bottle Deposit Rates?

Antony Jippov

November 2022

Abstract

I study the impact of bottle deposit amounts, state recycling characteristics, economic factors, and demographic traits on container deposit redemption rates to analyze whether the 60% redemption rate goal of the "Break Free from Plastic Pollution Act" is realistic across all states. In line with prior research, I find that education, gender, certain racial groups, unemployment, and GDP growth do not contribute to bottle redemption rates, proportionately youthful populations have higher redemption rates, and that more affluent populations tend to redeem bottles less frequently. I determine that value of the deposit and the access to curbside recycling play positive roles in increasing redemption rates, and the percent of bottles covered under the legislation decreases redemption rates. I conclude that the proposed five-cent deposit is likely insufficient to achieve the policy goal, however an increase to a ten-cent deposit may be sufficient.

1 Introduction

Since the early 1970s, several U.S. states have implemented some version of a "Bottle Bill," a law enacted to encourage consumers to return their empty aluminum, glass, and plastic bottles for a small deposit. Of the ten states that currently have laws like this in place, the majority provide a five cent incentive per container returned; Michigan and Oregon offer ten cents for every container, California offers ten cents for bottles in excess of 24 ounces, and Maine and Vermont offer 15 cents on liquor bottles.[1] By and large, these laws have remained constant over their 40 to 50 year life spans, and, as such, the value of their incentives has decreased substantially in real terms. Oregon, the first state to enact such legislation in 1971, recognized this dilemma and raised their deposit amount from five to ten cents in 2017. This led to an immediate 14% increase in redemptions in 2017, and a further 11% in 2018, resulting in an 86% redemption rate in 2019, up from just 64% in 2016. Despite Bottle Bills being a relatively small part of the U.S.'s overall sustainability strategy, they can nonetheless provide us valuable insight into the effects of economic incentives on consumer behavior.

While these programs have been largely decentralized, there has been growing momentum to create a national policy surrounding bottle deposit incentives. Most notably and recently, the 117th Congress drafted a bill originally entitled the "Break Free from Plastic Pollution Act," an amendment to the "Solid Waste Disposal Act" of 1965, which seeks to implement the five cent incentive across all 50 states, which is to be

[1]Source: Container Recycling Institute

ratcheted up to ten cents after five years of operation. Furthermore, the program would seek to establish minimum thresholds for returns: 60% for those states which are new to the program, and 75% returns for those states which already have a Bottle Bill in place. Given the historical data, this benchmark does not seem unreasonable. Most states achieve this 60% rate year over year, and several states have even had redemption rates consistently near or above 80%.[2] If the current redemption rates are so high, then why does the Break Free from Plastic Pollution Act only aim for 60% returns? Are the economic circumstances of the states which do not have Bottle Bills substantially different from those which already do? Are their divergent demographic characteristics significantly impactful? Is there perhaps some other underlying cultural or behavioral explanation?

In this paper, I attempt to provide answers to these questions. Specifically, I look at the existing data from those states which already have Bottle Bills active and examine what economic and demographic factors play a role in deposit rates, as well as how much increasing an incentive boosts return rates. I take a closer look at Oregon's redemption rates, for two reasons. First, as already mentioned, Oregon changed their incentive structure in 2017, raising their deposit per bottle from five to ten cents. Second, I was able to obtain a detailed breakdown of Oregon's bottle deposit return rates by type of product, glass, aluminum or plastic. I will analyze Oregon's data in order to draw conclusions about potential policy ramifications of the proposed bills.

For the analysis conducted on the total set of states, I approach these questions using a linear model to reveal the associations of each of the economic and social variables. I find that a five-cent incentive increase leads to a 22% higher return rate. I also find that macroeconomic factors, such as unemployment rate and GDP growth, do not affect bottle redemption rate, but that personal consumption expenditure (a proxy for affluence) is negatively correlated with redemption rates. Furthermore, I find that educational attainment and gender are insignificant in determining redemption rates, but that a proportionately large youth population positively contributes to redemption rates.

I also construct linear models for the impacts of different types of container materials (glass, aluminum, plastic) specifically in Oregon. Specifically, I regress the aforementioned macroeconomic variables (unemployment rate, GDP growth rate), as well as personal consumption expenditure, bottle deposit amount, and total sales of each container type on redemption rates of each container type. Since the demographic makeup of Oregon is relatively stable over the period of 2009 to 2021 that I evaluate, I forego investigating the previously discussed demographic variables. While the regression results I ran are not statistically significant, likely due to the size of the data, I discuss the potential implications of Oregon's increased deposit amount on the redemption rates of glass, aluminum, and plastic.

[2] Source: Container Recycling Institute

Finally, I take the results from my first regression and estimate the redemption rates in the remaining 40 states which do not currently have Bottle Bills implemented. At the five cent incentive proposed by the Break Free from Plastic Pollution Act, I find that only ten states would reach the 60% redemption goal. However, after raising the incentive to ten cents, I find that 31 states would reach this 60% mark. Of the nine remaining states that still do not achieve a 60% redemption rate, I find that six of them would only require twelve cents to his this mark. New Hampshire requires the highest incentive, at 21 cents.

My contribution to the literature is twofold. First, I revisit existing papers discussing demographic implications on recycling rates. I confirm several previous results (e.g. differences in recycling rates by gender and wealth), and I propose theories about less-studied characteristics (e.g. differences by race). Second, I study the effects of macroeconomic trends on a state level on redemption rates, which is not a particularly well-studied question in the literature. Additionally, this paper could be used to provide insights to the attainability of the goals set forth by new legislation. As mentioned earlier, most states already consistently strike above (sometimes well above) the 60% goal put forth by the Break Free from Plastic Pollution Act. However, there are some states which struggle to reach this milestone, and which have seen declining return rates year over year. Through these findings, I hope to shed light on which factors contribute most to making these policies successful.

The remainder of this paper is structured as follows: I discuss the existing literature on economic incentives in Section 2, particularly with respect to policies that affect recycling and any that discuss existing Bottle Bills. I then provide a detailed description of the data sets I use and their sources in Section 3, and provide an explanation of my methodology in Section 4. I finally present my results in Section 5 and then provide conclusions and closing remarks.

2 Literature Review

In this section, I provide my hypotheses as to which economic and demographics affect bottle deposit redemption rates. I then explore the literature surrounding deposit-refund systems and their alternatives, as well as the demographic and economic factors that influence their efficacy. Finally, I discuss how I plan to test my hypotheses and contrast them to previous results from the literature.

When it comes to age, I believe that states with a relatively high proportion of young individuals will redeem more deposits, and ones with relatively high proportions of older individuals will redeem less. I suspect this largely due to my perception of political affiliations among young and old individuals. I view younger voters are more liberal-minded, and thus more likely to support "green" policies, and I believe older voters to be more conservative, and therefore less interested in these types of policies.

I anticipate that unemployment rate plays a positive role in determining redemption rates. I suspect this because the marginal cost of time spent collecting bottles for redemption is significantly less when unemployed than when the individual has a job. Additionally, there is anecdotal evidence that suggests that homeless individuals contribute significantly to deposit rates. In a press release from May of this year, the New York Public Interest Research Group (NYPIRG) indicated that up to 10,000 low-income and homeless individuals rely on "canning" (the process of collecting containers from public trash bins and redeeming them for deposit) to supplement their income.

Consequently, I anticipate that more affluent states will have lower overall container deposit redemption rates. As the note from the NYPIRG suggests, I expect that wealthier individuals would rather use other methods of recycling to dispose of their waste, as the marginal cost of their time is relatively high, and the economic incentive is insufficient to motivate them.

Finally, I anticipate that an increase in the percent of bottles covered by a state's Bottle Bill would decrease the overall redemption rate, while also increasing the absolute number of units redeemed. Without an information campaign educating consumers on containers that can be returned, it is unlikely that previously unredeemable containers will be returned at the same rate as those that have been redeemable for years.

One of the primary interests of analysis is the ways in which the demographic makeup of a state influences the overall bottle redemption rate. In a 1995 paper entitled "Who Recycles and When? A Review of Personal and Situational Factors," Schultz, Oskamp, and Mainieri discuss the factors that potentially influence attitudes about recycling, synthesizing the results of several prior papers. Some of the topics they consider are beyond the scope of this paper, such as "Personality Variables" and "Knowledge" (i.e. whether the consumer knows about the program in the first place). They do, however, consider demographic variables in their discussion. Analyzing the results from prior studies, they claim that the people with the highest level of environmental concern "tend to be young, female, better educated, urban dwellers, and ideologically liberal" (Schultz, 1995). They go on to say that, while exhibiting environmental concern is often a good indicator of one's penchant to recycle, it is not always strictly correlated with recycling behavior. Looking at the results of six studies regarding age conducted by Hopper & Nielson (1991), Oskamp et al. (1991), Gamba & Oskamp (1994), Webster (1975), Vining & Ebreo (1990), and Lansana (1992), Schultz concludes that the results of these prior studies are too disparate to draw any meaningful conclusions from, noting that insufficient controlling for education might have played a role in the inconsistent results. Drawing from these same papers, Schultz also concludes that there is insufficient evidence to suggest a correlation between gender and recycling behavior. He argues that recycling decision are made at the household level, and thus there is substantial measurement error in the gender of the recycler.

Citing Jacobs, Oskamp, and Vining and Ebreo, Schultz claims that there is a positive relationship between affluence and recycling, i.e. people who make more money are more likely to recycle. Finally, Schultz discusses the potential correlation between different racial groups and recycling, and concludes that there are too few studies to draw any reasonable conclusions about the topic. Given these papers, I decided to include the following state-level variables in my analysis: the percent of the population below 18 years old ("%Under18") and above 65 years old ("%Over65"), the proportions of White, Black, Asian, and Latino residents ("White," "Black," "Asian," and "Latino," respectively), the percent of residents above 25 years old who hold high school ("%HS") and bachelor's degrees or higher ("%Bachelor"), and a binary variable indicating whether the state had more male or female residents ("BinFemale"), where a 1 indicates more female than male.[3]

A paper written by Margaret Walls, entitled "Deposit-Refund Systems in Practice and Theory," discusses how deposit-refund laws might affect behavior, and why they are now prevalent in the recycling of used materials in other industries (batteries, tires, etc.). In order for a Bottle Bill to function, there need to be three main parties (apart from the customer): distributors, retailers, and the state government. Generally, when retailers purchase wholesale goods from distributors (e.g. PepsiCo), part of the cost of their purchase is the cost of the bottle deposit. This deposit cost is then passed on to the consumer when she buys the product from a retailers, she may or may not choose to recoup it. If not, this money stays with the retailer (except in Michigan and Massachusetts, where the money is returned to the state). Of course, if the consumer returns their container, then they receive the deposit back.

Walls continues to argue that the structure of deposit-refund systems are more effective than policies they are often compared to, such as Pigouvian taxes. The existence of a rebate for the materials returned avoids the issue of illegal dumping associated with a Pigouvian tax. Further, the deposit-refund system more effectively monitors the negative externalities it tries to prevent. For example, taxing individuals based on street litter is rather difficult, since it's impossible to deduce who is responsible for disposing of it improperly.

Walls makes the assertion that "few econometric studies have analyzed deposit-refund programs," and that the primary focus has been on "Pay as you Throw" (PAYT) models. These models charge households or communities per unit of refuse collected, which incentivizes the production of less waste rather than the recycling of the waste that those individuals do produce. This changes consumer behavior, specifically by reducing the consumption of goods with more packaging.[4]

I now outline several of the hypotheses I will test in light of the literature discussed above. While previous papers have focused on the differences in recycling rates between races, they have largely been isolated to individual communities or geographic locations. My analysis overcomes this limitation by looking at data across several states, effectively controlling for cultural and behavioral differences. This is also true

[3]Note that "Latino" is not mutually exclusive with the other three categories.
[4]Source: Bubb, Ferguson, Trostel, Turner (2008)

of differences in recycling rates between men and women. Finally, prior research regarding age and recycling has focused on recycling rates within several age ranges. By looking at the proportions of residents at the extremes (i.e. below 18 years old and above 65 year old), who I believe are more likely to fall into the extremes of recycling behaviors, we might hope to see conclusive results in comparison to previous studies.

3 Data

My first data set is comprised of data from three main sources. For bottle redemption rate data, I rely on publicly available records which are managed by the Container Recycling Institute. This data includes the yearly aggregate return rates for the ten states that currently have Bottle Bill legislation, from 2013 to 2021. It also includes information regarding the amount of deposit (five or ten cents), what percentage of all beverage units are covered by deposit, as well as information regarding the proportion of the population with curbside recycling access. The aggregate returns data is shown in Table 1. Note that Maine, Vermont, and Iowa are missing several years of data, so they are omitted from my analysis.

As previously mentioned, an increase in economic incentive (i.e. bottle deposit) should noticeably increase redemption rates, and I expect my analysis to demonstrate this. I also suspect, perhaps counter-intuitively, that an increase in curbside recycling access will increase actually increase redemption rates. I suspect this because I think that recycling behavior is at least partially culturally/behaviorally motivated. Therefore, I think those places which have curbside recycling might be inherently more inclined to redeem deposits. Empirically, this is supported by a 2002 report published by the Container Recycling Institute, entitled "Understanding Beverage Container Recycling: A Value Chain Assessment." In it, they find that the ten states which currently accept deposits have an overall beverage container recycling rate of 71.6%, which more than two and a half times the rate for non-deposit states, at just 27.9%. This difference might self-fulfilling, as those states which already have deposits might be behaviorally more inclined to recycle in the first place.

I merged the bottle redemption data with data from two other publicly available sources. From the Federal Reserve Economic Database (FRED), I gathered state-level data on gross domestic product growth rate and unemployment rates. There is a lack of prior research analyzing the effects of the economy on deposit rates, so I wanted to explore the relationships that exist there, or demonstrate that no such ones exist. I also got data on personal consumption expenditure from FRED, which I normalized per capita.[5] Due to the extensive literature looking at the relationship between affluence and recycling rates, I want to confirm that with my own analysis, and so I use personal consumption expenditure per capita as a stand-in for wealth.

[5] The tickers for Alaska, respectively, for these data are: AKNQGSP, AKUR, AKPCE. The first two letters indicate the state abbreviation.

The second public source I utilize is the U.S. Census Bureau, from which I gather population and demographic information on the state-level. This includes the percent of the population under 18 years of age and above 65 years of age, proportions of White, Black, Latino, and Asian residents, data on educational attainment (percent of adults 25 years or older with high school and bachelors degrees), and whether the state had more male or female residents, the last of which was synthesized into a binary variable.[6] Given the prior research described in Section 2, I suspect that gender and educational attainment will not play significant factors in influencing return rates, whereas a more youthful population will positively affect return rates. I include the variables describing racial demographics in my analysis in order to expand upon the research conducted by Oskamp et. al. (1991) and Vining & Ebreo (1990), who did not come to any conclusions on the topic.

I also conduct analysis on a second, smaller data set, which focuses specifically on data from Oregon. I do this for three reasons. The first is that the data from Oregon stretches back slightly further than the rest, so I can look at trends from 2009 to 2021. The second is due to Oregon's aforementioned policy change in 2017. Having a data set with two different deposit amounts provides invaluable insight as to what to expect when I construct my own predicted return rates given my regression results. The third is that Oregon is the only state where I was able to get a detailed breakdown of return rates based on the type of container redeemed, plastic, glass, or aluminum. For each of these types of containers, I have total counts and percentages of containers redeemed, as well as the total amount of containers sold per year. This data is shown in Tables 2 and 3. I acquired this data through a conversation with the Oregon Department of Environmental Quality (ODEQ).[7] This data was augmented with the economic and demographic information above.

4 Methodology

I start by outlining the three main goals of my analysis. First, I want to deduce what factors increase deposit redemption return rates. I suspect that an increase in economic incentive (i.e. the jump from five cents to ten cents) plays a large role in this, but, given the consensus of the literature, I also believe that certain socioeconomic factors, such as personal consumption expenditure per capita (a proxy for affluence), likely also are indicative of a population's willingness to redeem deposits. To understand these relationships, I conduct a linear regression analysis on the first data set discussed above, which includes the information from the seven states for which I have bottle data. The regression is as follows:

[6] In the description of my regression and in the results that follow, these variables will be referred to as "%Under 18," "%Over 65m" "%White," "%Black," "%Latino," "%Asian," %HS," "%Bachelor's," and "More Women," respectively.

[7] Special thanks to Peter Spendelow, ODEQ Solid Waste Analyst, for access to this data.

$$\%Returned = \alpha + \beta_1 \times DepositAmount + \beta_2 \times \%Covered + \beta_3 \times \%CurbsideAcess$$

$$+\beta_4 \times UnemploymentRate + \beta_5 \times GDPGrowthRate$$

$$+\beta_6 \times ConsumptionPerCapita + \beta_7 \times \%Under18$$

$$+\beta_8 \times \%Over65 + \beta_9 \times White$$

$$+\beta_{10} \times Black + \beta_{11} \times Latino$$

$$+\beta_{12} \times Asian + \beta_{13} \times \%HS$$

$$+\beta_{14} \times \%Bachelors + \beta_{15} \times MoreWomen + \epsilon$$

Second, I use the second data set to conduct a case study on Oregon, which will consist of three regressions. These regressions will exclude the demographic variables for Oregon, as the Census Bureau data does not update these sufficiently regularly. My three regressions will look at the return rates of glass, aluminum, and plastic containers separately, and will make use of the same economic variables as regressors (unemployment rate, GDP growth, personal consumption expenditure per capita), as well as the information regarding deposit amount. Since the percent of containers covered and curbside access variables do not change within the state over time, they will be omitted as well.

The reason I chose to conduct these regressions is to see whether different deposit rates and economic environments incentivize different redemption behavior. For example, if the deposit amount increases from five to ten cents, I might see an increase in plastic and glass redemption rates, but aluminum rates might stay stagnant. This would have large policy implications, since different states might have different bottle preferences. New Jersey might have proportionately high rates of plastic bottle usage, while Washington might prefer aluminum more heavily. Ideally, I would have conducted this analysis on all ten states (with the inclusion of the demographic variables as well), but this level of granularity is not readily available publicly, and the decentralized nature of the legislation in question manifests itself in a lack of uniformity of data storage.

Finally, once I have presented these results, I project the potential success of a National Bottle Bill to those states which do not currently have ones in place. Specifically, I predict whether their economic and demographic circumstances might allow them to achieve the 60% minimum goal put forth by the Break Free from Plastic Pollution Act. I start by looking at all states with the proposed deposit value of five cents. For those states that do not reach the 60% barrier, I estimate what is the minimum deposit amount necessary to reach that goal. Finally, I look at what the redemption rates would be assuming a ten cent deposit, proposed by the Break Free from Plastic Pollution Act after five years of implementation. To create these estimates, I use the corresponding economic and demographic data for 2019, the most recent year for which I have complete economic data (e.g. Gross Domestic Product Growth, Unemployment Rate, etc.) which is not drastically affected by the COVID-19 pandemic.

5 Results

5.1 Empirical Results

The regression results from analyzing all states are shown in Table 4. As I predicted, the deposit amount has a strong positive association with redemption rates. This can be seen (by the reader) graphically as well: in Figure 1, the two states which have ten cent incentives, Michigan and Oregon, also have the highest return rates. Additionally, we can see that Oregon's line spikes in 2017, which is the year in which they increased their deposit from five to ten cents. Curbside recycling access strongly positively affects bottle return rates. This lends credence to my earlier hypothesis that, despite the fact that curbside recycling is often viewed as an alternative to bottle redemption (Walls, 2011), there is some behavioral component which motivates individuals to redeem bottles at a higher rate in spite of the presence of the curbside option. Conversely, the percentage of containers covered by the program negatively influences redemption rates: the more bottles that fall under the purview of the Bottle Bill, the fewer, proportionately, get redeemed.

Some of my macroeconomic variables do not seem to influence bottle redemption decision-making. According to my results, neither state unemployment rate nor state GDP growth rate were statistically significant. This seems to imply that the economic outlook or trend of the state does not bear much weight on individuals' willingness to redeem their deposits. However, the personal consumption expenditure of the state's inhabitants does negatively correlate with their return rates.[8] This suggests that the more people have to pay for goods and services, the less likely it is they are to redeem bottle deposits. One could argue that more affluent individuals might forego returning their containers given that they view the marginal effort of returning them larger than the monetary compensation they would receive. However, this seems to run counter to the existing literature on the topic, as Jacobs et al. (1984), Vining & Ebreo (1990), Oskamp et al. (1991), and Gamba & Oskamp (1994) all showed significant positive relationships between income and recycling rates. My divergent result might be caused by two factors. The first is that these previous studies looked at isolated populations which had higher than average incomes, whereas my analysis is conducted

[8] Note that the relatively small coefficient in Table 4 is due to the magnitude of the consumption per capita variable. While most other variables were expressed as a decimal, I kept this variable as its original dollar amount. Thus, the coefficient yielded by the regression is the change per dollar.

at a state-level. Additionally, my measurement for wealth is personal consumption expenditure per capita, which, while useful, is likely an oversimplification. If I were to conduct my analysis again, I would try to construct a more comprehensive data set with respect to income and wealth statistics.

The regression results looking at demographic variables are somewhat mixed. Age is significantly positively correlated with increased redemption rates, both the percent of the population that is above 65 years old and below 18 years old. A proportionally large youth population might explain a state's willingness to invest more effort into bottle redemption, and recycling more broadly, as younger individuals tend to be more environmentally-conscious (Oskamp, 1995). Taken together, these results suggest that the marginal value of time plays an important role in determining redemption rates. People over 65 years old are largely retired, and therefore have more time to spend redeeming deposits than someone who still has a full-time job. Similarly, people under the age of 18 both might not have a full-time job, and earn lower pay when they do, so they have greater incentive to redeem bottle deposits.

When it comes to race, the percent of White and Latino residents are statistically insignificant, while the percent of Black and Asian residents are significant. Neither the percent of adults with high school degrees nor percent of adults with bachelor's degrees or higher was statistically significant, which again suggests that the marginal value of time plays a role in determining redemption rates. Finally, whether the state had a higher female population than male population was not shown to affect the redemption rate of the state. All of these results are once again consistent with the previous literature.

I will now discuss the results of the regressions on glass, aluminum, and plastic container redemption rates in Oregon from 2009 to 2021, the results of which are shown in Tables 5, 6, and 7. My first regression shows the change in glass container redemption rates against the deposit amount, unemployment rate, GDP growth, personal consumption expenditure per capita, and total sales of glass containers. My results are not significant at a .05 threshold. This is likely due to my rather small data set: I only have access to thirteen data points, one for each year from 2009 to 2021. Nevertheless, it is interesting to note that the general trends look rather similar to the results from the full data set above. The deposit amount still plays a large factor in increasing redemption rates, although not quite as much as before. Unemployment rate and GDP growth rate, while insignificant, are still slightly negatively and positive correlated, respectively. Consumption per capita is also nearly identical. Finally, the results seem to suggest that the total number of glass bottles sold negatively impacts their return rate. One possible explanation is that increased scale leads to greater difficulty in record-keeping.

The regression concerning aluminum containers yields similar results. Once again, none of the results are significant, but the magnitude of the deposit amount seems to once again play a large factor in increasing redemption rates. Unemployment rate and GDP growth rate both had their signs changed: aluminum redemption rates are weakly positively associated with unemployment rate, and negatively with GDP growth. The magnitude of the coefficient on consumption per capita remains the same, but is also now negative instead of positive. The sale of aluminum seems to have virtually the same effects as does the sale of glass. The regression on plastic return rates is also insignificant. The largest difference with respect to the other two container types is the magnitude of the deposit amount coefficient: 66% greater than the glass result, and 47% greater than the aluminum result.

While the results of the above three regressions are not statistically significant, it is still relevant to discuss the potential ramifications of deposit amounts on redemption rates. Looking at Figure 2, we can see steadily declining or flat rates of change of container redemption rates from 2009 until 2016. In 2017, when the legislation was updated, we can see a spike in redemption rates for all three container types. This trend reverses in 2020, likely due to the COVID-19 pandemic, but redemption rates increase again in 2021, though not back to their pre-pandemic rates. Anecdotally, this suggests that the return rate for each container type is positively affected by the increased incentive.

Figures 3, 4, and 5 show the redemption rates and total sales of glass, aluminum, and plastic containers over time, respectively. Interestingly, the total sales of glass containers was increasing until 2018, but started to decline rapidly in 2019 and after. This roughly corresponds to the 2017 change in deposit amount from five to ten cents. The opposite can be said for aluminum and plastic containers: starting in 2017, the rate of growth seems to significantly increase for both of these types of containers. This is at least a suggestion that there is some relationship between the value of a deposit and the types of containers consumers elect to purchase. Furthermore, this lends credence to the idea that the incentive causes people to return containers. Those people who plan on returning containers are seemingly more willing to do so when the containers are light and unbreakable, i.e. not made of glass.

5.2 Policy Implications

I will now discuss the potential policy implications of the results discussed above. Specifically, using my regression results from the seven-state data set, I predict redemption rates for the 40 states that do not currently have Bottle Bills, and analyze whether the 60% minimum target set forth by the Break Free from Plastic Act is a realistic goal. My predicted results by state are shown in Table 8, and the distributions are shown in Table 9.

To construct these estimates, I had to make some assumptions. First, data regarding curbside recycling access on a state level is not readily available. According to a report published by The Recycling Partnership, entitled "The State of Curbside Recycling in 2020," the percent of Americans with curbside access is 59%.

This is the figure I use for my calculations. Additionally, since those 40 states do not have Bottle Bills in place, ascertaining what percent of containers would be covered under the legislation is rather difficult. Given the data that I have about the amount of containers covered by existing legislation, as well as the language put forth by the Break Free from Plastic Pollution Act, which includes most beverage categories as potentially redeemable, I use an estimate of 75% of containers covered. Finally, for economic and demographic variables, I use data from 2019 to avoid the temporary impacts that COVID-19 had on GDP growth and unemployment rates.

Table 11 shows the minimum necessary deposit value for states to achieve a 60% return rate for states that do not achieve it at a five cent deposit. Table 10 shows the distribution of values in Table 11. When predicting the redemption rates for a ten cent deposit, 31 of the 40 states hit the 60% benchmark, with more half of them reaching an even more ambitious 70%. This falls in line with what I postulated earlier, that an increased incentive would noticeably increase redemption rates. IThe table shows that even when ten cents is not enough to guarantee a 60% redemption rate, the necessary amount is often not significantly larger than ten (with the exceptions of Colorado, Rhode Island, and New Hampshire). This suggests that a five cent starting deposit value might be too low to incentivize the rates of returns that Break Free from Plastic Pollution Act aims for, and that a ten cent deposit might be required to achieve its desired impacts. Alternatively, the bill could be amended to include a provision which calculates an "targeted" deposit rate by state (much like I did) in order to achieve its 60% more consistently.

The redemption rate predictions for a five cent deposit suggest that it is an insufficiently large incentive to achieve the goals set forth by the Break Free from Plastic Pollution Act. Only 10 out of the 40 states achieved predicted rates of over 60%, many of them failed to even reach 30%. My mean predicted value of 46.8% is therefore significantly lower than the average redemption rates in states that currently have Bottle Bills, which in 2019 was 67%. While these results might seem discouraging, perhaps there is a behavioral component which has not been accounted for in my analysis. All of the existing Bottle Bills has been active legislation for at least the past 40 years (Oregon's is 51 years old this year), and they have not substantially changed in that time period. This could imply one of two scenarios. One is that those states which have Bottle Bills have them because they are the only states whose residents care for them, and are therefore inherently more likely to recoup their deposits. Alternatively, the states which already have Bottle Bills in place might have artificially inflated redemption rates because the trend of returning containers for deposit has been ingrained in the state's culture over the past decades.

It might be the case that my regression requires more refining, and that I am not considering other variables which might carry weight in other states. For example, while I tried to proxy for environmental consciousness with the age variables, it could be the case that a more explicit variable describing the politics of the state, or even county, if possible, is warranted, as suggested by Oskamp et. al (1991). Another variable I might consider is population density. It is possible that infrastructure in large cities is more conducive to easy bottle deposit redemption. For example, large pharmacy/convenience store chains like Walgreens, Rite Aid, etc., have in store deposit containers where individuals can come in with their containers and return them. In less urban areas, this redemption method might not be as prevalent, if it indeed exists at all, due to the potential lack of large chain convenience stores. This ties into my assumption about curbside recycling access: more rural communities simply might not have the infrastructure to meet the assumed 59% figure.

6 Conclusion

In this paper, I study the impacts of deposit amounts on the bottle redemption rates, in conjunction with macroeconomic and demographic variables. I find significantly positive impacts on redemption rates by deposit amount, curbside recycling access, age demographics, and Black and Asian population proportions. I also find significant negative relationships between return rates and the percent of containers covered under the Bottle Bill legislation and the personal consumption expenditure per capita. Unemployment rate, GDP growth, the population proportion of White and Latino residents, educational attainment and whether a state had more female residents all did not statistically affect redemption rates.

I view the results above through the lens of the Break Free from Plastic Pollution Act, and determine whether the bill, as currently constructed, can hope to reach its 60% redemption rate goals across all 50 states. I determine that at a 5 cent deposit rate, this goal is largely untenable. Raising the deposit to ten cents significantly improves redemption rates so that 31 out of the 40 states currently without Bottle Bills would be expected to reach this 60% threshold.

I specifically look at data from Oregon to try to draw conclusions about deposit amounts and redemption rates for different types of containers, i.e. glass, aluminum, and plastic. While the results are not statistically significant, in large part because of the small size of the data set, anecdotally, a change in deposit amount might affect the return rates of different container types by varying degree. This is a topic I believe merits further research, both economically and for policy purposes. Economically, it might be the case that products packaged in glass might be viewed as more luxurious than those packaged in aluminum cans or plastic bottles, and therefore appeal more to higher-earning consumers. From a policy perspective, if glass, aluminum, and plastic container redemption rates really do change at different rates given their deposit value, then it is imperative that policy-makers take into account the purchasing preferences of the state so as to not accidentally incentivize a worse outcome than before, e.g. a lower overall redemption rate.

References

[1] Beder, Sharon. “Economic Incentives for Environmental Protection.” *Ecodate*, 15 no. 3 (July 2001): 6-7.

[2] Bubb, Nicholas, Paul Ferguson, Amy Trostel, and Andrew Turner. “Improving Recovery of Recyclable and Reusable Materials in Wisconsin: The Feasibility of a Bottle Bill and Other Policy Options.” *Workshop in Public Affairs, Domestic Issues*, 869 (May 2008).

[3] Carson, Ryan. “Statewide Groups and Legislators Hold 40th Birthday Party for the ‘Bottle Bill”’ *Press Release*, (May 2022).

[4] Gamba, Raymond J., and Stuart Oskamp. “Factors influencing community residents’ participation in commingled curbside recycling programs.” *Environment and Behavior* 26, no. 5 (1994): 587-612.

[5] Hopper, Joseph R., and J. M. Nielson. “Recycling as 29. Hair, JF, WC Black, BR Babin, RE Anderson and Altruistic Behavior: Normative and Behavioral RL Tatham, 2006. Multivariate Data Analysis (6th Strategies to Expend Participation in a Community edition).” *New Jersey: Prentice Hall. Recycling Program. Environment and Behavior*, 30 (1991): 195-220.

[6] Lansana, Florence M. “Distinguishing potential recyclers from nonrecyclers: A basis for developing recycling strategies.” *The Journal of Environmental Education* 23, no. 2 (1992): 16-23.

[7] Mouw, Scott. “State of Curbside Recycling Report, 2020.” *The Recycling Partnership, Internal Paper*, (2020).

[8] Oskamp, Stuart, Maura J. Harrington, Todd C. Edwards, Deborah L. Sherwood, Shawn M. Okuda, and Deborah C. Swanson. “Factors influencing household recycling behavior.” *Environment and Behavior* 23, no. 4 (1991): 494-519.

[9] Schultz, P. Wesley, Stuart Oskamp, and Tina Mainieri. “Who Recycles and When? A Review of Personal and Situational Factors.” *Journal of Environmental Psychology* 15 (1995): 105-121.

[10] Skumatz, Lisa, and David Freeman. “Pay as you Throw (PAYT) in the U.S.: 2006 Update and Analyses.” *Skumatz Economic Research Associates*, (2006).

[11] U.S. Congress. Senate. *Break Free From Plastic Pollution Act*, 117th Cong., 1st sess., introduced in Senate 2021. https://www.congress.gov/bill/117th-congress/senate-bill/984

[12] Vining, Joanne, and Angela Ebreo. “What makes a recycler? A comparison of recyclers and nonrecyclers.” *Environment and Behavior* 22, no. 1 (1990): 55-73.

[13] Walls, Margaret. “Deposit-Refund Systems in Practice and Theory.” *Resources for the Future, Discussion Paper*, (November 2011).

[14] Webster Jr, Frederick E. “Determining the characteristics of the socially conscious consumer.” *Journal of Consumer Research* 2, no. 3 (1975): 188-196.

[15] Whittaker, Heather. ”How a Federal Bottle Bill Can Increase Recycling Rates in the United States.” PhD diss., Honors College of Middle Tennessee State, 2021.

[16] Yung, Yau. “ Domestic Waste Recycling, Collective Action and Economic Incentive: The Case in Hong Kong.” *Waste Management*, 30 (July 2010): 2440-2447.

7 Appendix

Table 1: Aggregate Return Rates by State: 2013-2021

State	2013	2014	2015	2016	2017	2018	2019	2020	2021
Michigan	.95	.94	.93	.92	.91	.89	.89	.73	.75
Maine	.90	–	–	–	.84	–	–	.76	–
Oregon	.71	.68	.64	.64	.73	.81	.86	.77	.81
Vermont	.76	–	–	–	–	–	–	.78	.78
California	.74	.71	.72	.72	.68	.66	.67	.62	.61
Hawaii	.74	.71	.67	.65	.62	.63	.63	.62	.62
New York	.62	.64	.65	.66	.65	.64	.64	.64	.70
Iowa	.78	–	–	.65	–	–	–	–	–
Massachusetts	.66	.66	.59	.56	.57	.52	.50	.43	.38
Connecticut	.57	.53	.51	.49	.52	.50	.50	.44	.46

Figure 1: Aggregate Return Rates by State: 2013-2021

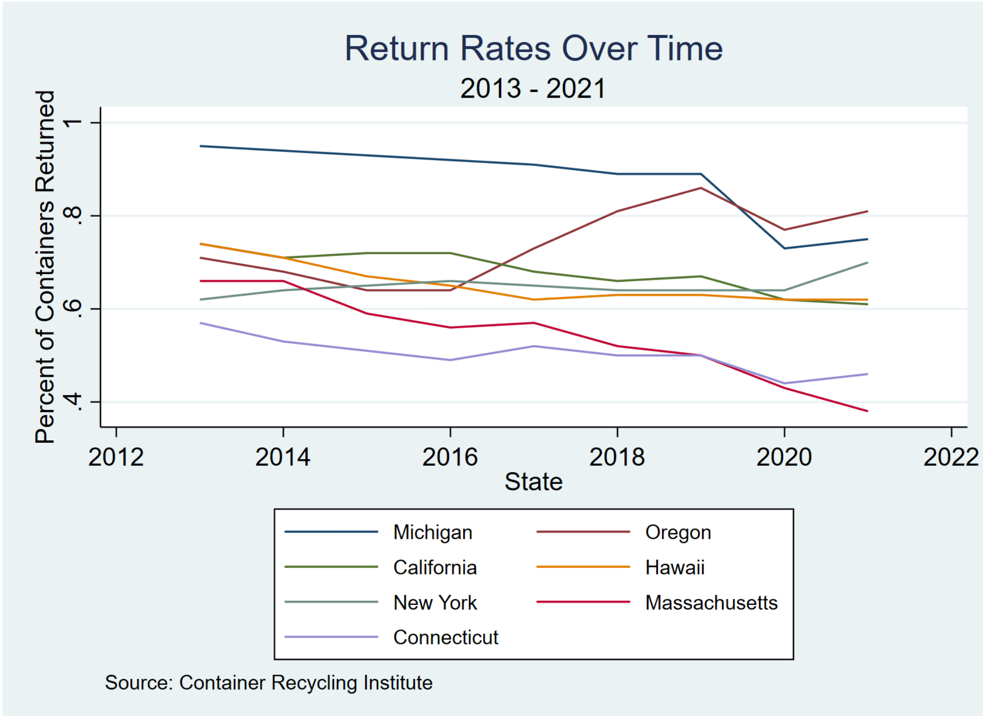

Table 2: Return Rates by Container Type: Oregon, 2009-2021

Year	% Glass	% Alum.	% Plastic	% Total
2009	.7986	.8392	.5035	.7504
2010	.774	.7920	.5320	.7206
2011	.774	.8200	.5700	.7446
2012	.7845	.7706	.5438	.7095
2013	.7485	.7632	.5790	.7097
2014	.7191	.7421	.5536	.6826
2015	.6760	.7089	.5190	.6445
2016	.6517	.6992	.5459	.6431
2017	.6717	.7805	.6848	.7325
2018	.7558	.8693	.7492	.8102
2019	.7683	.8964	.8348	.8578
2020	.6697	.8082	.7494	.7721
2021	.7359	.8328	.7842	.8060

Table 3: Return Amounts and Sales by Container Type, Millions of Units: Oregon, 2012-2021

Year	Glass Returned	Alum. Returned	Plastic Returned	Total Returned	Glass Sales	Alum. Sales	Plastic Sales	Total Sales
2012	201.04	695.91	244.02	1140.98	256.27	903.02	448.75	1608.04
2013	202.85	674.80	256.48	1134.13	271.02	884.19	442.94	1598.16
2014	202.82	663.23	272.27	1138.32	282.04	893.71	491.82	1667.56
2015	201.48	637.99	278.68	1118.15	298.05	899.97	536.99	1735.01
2016	191.91	642.29	303.38	1137.58	294.45	918.64	555.76	1768.85
2017	209.08	756.73	396.70	1362.50	311.27	969.49	579.32	1860.08
2018	241.84	918.16	553.72	1713.72	319.97	1056.22	739.07	2115.27
2019	233.29	1014.36	601.61	1849.25	303.65	1131.59	720.64	2155.87
2020	197.57	1062.67	569.46	1829.70	295.01	1314.83	759.86	2369.70
2021	195.61	1164.16	678.85	2038.62	265.80	1397.90	865.62	2529.31

Figure 2: Percent of Redeemed Containers by Type: Oregon, 2009-2021

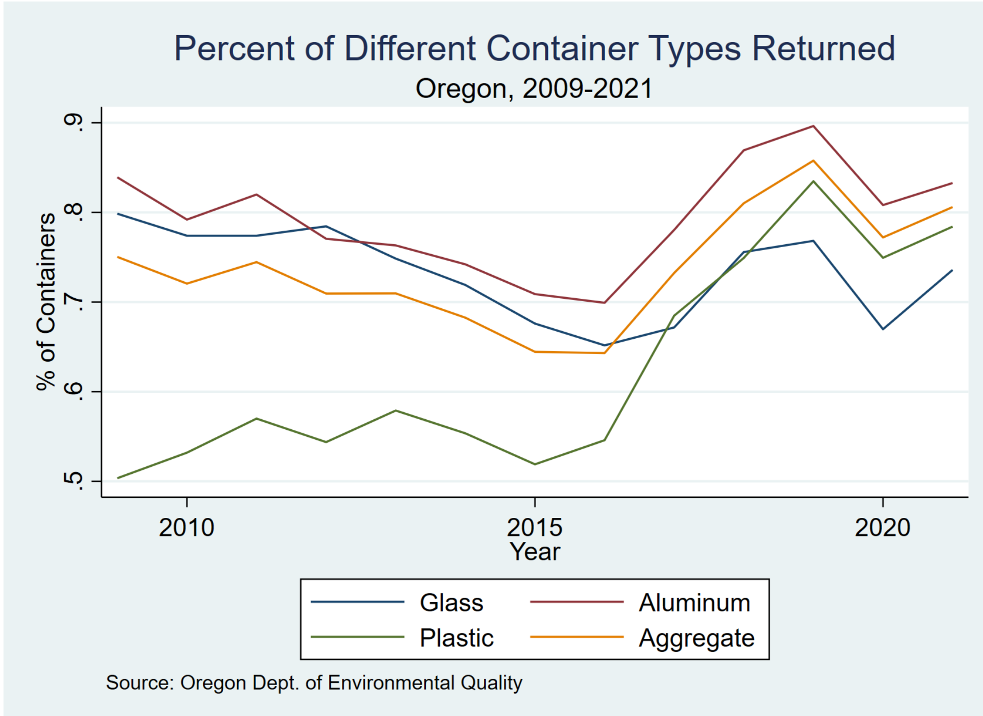

Table 4: Regression Results All States, 2013 - 2021

N of Obs. = 63, Adjusted R^2 = .8792

Variable	Coefficient	Std. Err.	t	P> | t |	95% Confidence	Interval
Deposit Amount	4.455934	0.6205133	7.18	0.000	3.207623	5.704246
%Covered	-1.079409	0.2842168	-3.8	0.000	-1.65118	-0.5076389
%Curbside Access	1.550427	0.4267217	3.63	0.001	0.6919738	2.40888
UR	-0.61739	0.88086	-0.7	0.487	-0.0238946	0.0115467
GDP Growth	0.2280609	0.24814	0.92	0.363	-0.2711324	0.7272542
Personal Cons. Per Capita	-0.0000114	3.50E-06	-3.25	0.002	-0.0000184	-4.35E-06
%Under 18	13.08321	3.919899	3.34	0.002	5.197387	20.96903
%Over 65	6.79353	2.493405	2.72	0.009	1.777447	11.80961
%White	0.0550656	0.1882552	0.29	0.771	-0.323655	0.4337863
%Black	0.7626894	0.2130681	3.58	0.001	0.3340516	1.191327
%Latino	0.0149853	0.2684025	0.06	0.956	-0.5249708	0.5549415
%Asian	0.5850923	0.2696163	2.17	0.035	0.0426943	1.12749
%HS	0.1723315	1.0831	0.16	0.874	-2.006585	2.351248
%Bachelor's	-0.7042005	0.4228975	-1.67	0.103	-1.55496	0.1465594
More Women	-.0955081	.0480166	-1.99	0.053	-.192105	.0010887
Const.	-3.504688	1.702551	-2.06	0.045	-6.929778	-.0795971

Table 5: Regression Results for Glass Redemption Rates: Oregon 2009-2021

N of Obs. = 13, Adjusted $R^2 = -0.3576$

Variable	Coefficient	Std. Err.	t	P> | t |	95% Confidence	Interval
Deposit Amount	2.2635	1.829569	1.24	0.284	-2.816187	7.343197
Unemployment Rate	-0.0122269	0.0288288	-0.42	0.693	-0.0922686	0.0678148
GDP Growth Rate	0.217268	1.337789	0.16	0.879	-3.931565	3.110114
Personal Cons. Per Capita	-0.0000177	0.0000108	-1.09	0.336	-0.0000416	0.0000181
Total Glass Sales	-0.0023788	0.002021	-1.18	0.304	-0.00799	0.0032324
Const.	1.755835	.8991809	1.95	0.123	-0.740691	4.252362

Table 6: Regression Results for Aluminum Redemption Rates: Oregon 2009-2021

N of Obs. = 13, Adjusted $R^2 = 0.3581$

Variable	Coefficient	Std. Err.	t	P> | t |	95% Confidence	Interval
Deposit Amount	1.737545	1.820923	0.95	0.394	-3.318148	6.793238
Unemployment Rate	0.1029879	0.1355521	0.76	0.490	-0.2733651	0.4793409
GDP Growth Rate	-2.021662	2.996172	-0.67	0.537	-10.34037	6.297064
Personal Cons. Per Capita	0.0001143	0.0001569	0.73	0.507	-0.0003214	0.0005499
Total Aluminum Sales	-0.0023163	0.0031358	-0.74	0.501	-0.0110226	0.0063899
Const.	-1.897843	3.452113	-0.55	0.616	-11.48245	7.686759

Table 7: Regression Results for Plastic Redemption Rates: Oregon 2009-2021

N of Obs. = 13, Adjusted $R^2 = 0.8223$

Variable	Coefficient	Std. Err.	t	P> | t |	95% Confidence	Interval
Deposit Amount	2.575309	1.568989	1.64	0.176	-1.780903	6.931521
Unemployment Rate	-0.0037646	0.0147719	-0.25	0.811	-0.044778	0.0372487
GDP Growth Rate	-0.8538848	1.082979	-0.79	0.475	–3.860716	2.152946
Personal Cons. Per Capita	0.0000114	0.000022	0.52	0.632	-0.0000496	0.0000723
Total Aluminum Sales	-2.50E-07	0.000619	0.00	1.000	-0.0017184	0.0017189
Const.	0.0807698	0.4821096	0.17	0.875	-1.257781	1.419321

Figure 3: Percent of Redeemed Glass Containers vs. Total Glass Sales: Oregon, 2009-2021

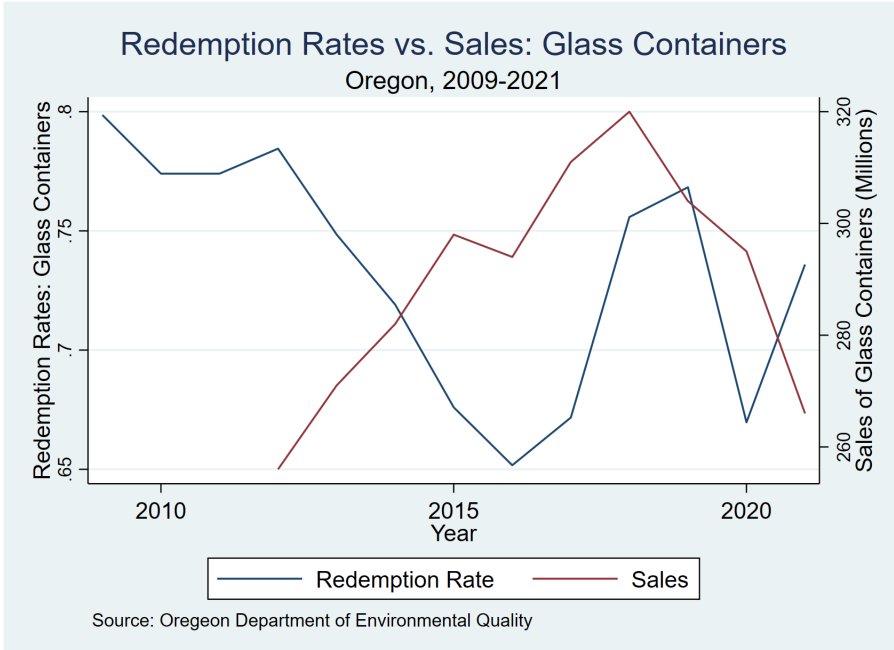

Figure 4: Percent of Redeemed Aluminum Containers vs. Total Aluminum Sales: Oregon, 2009-2021

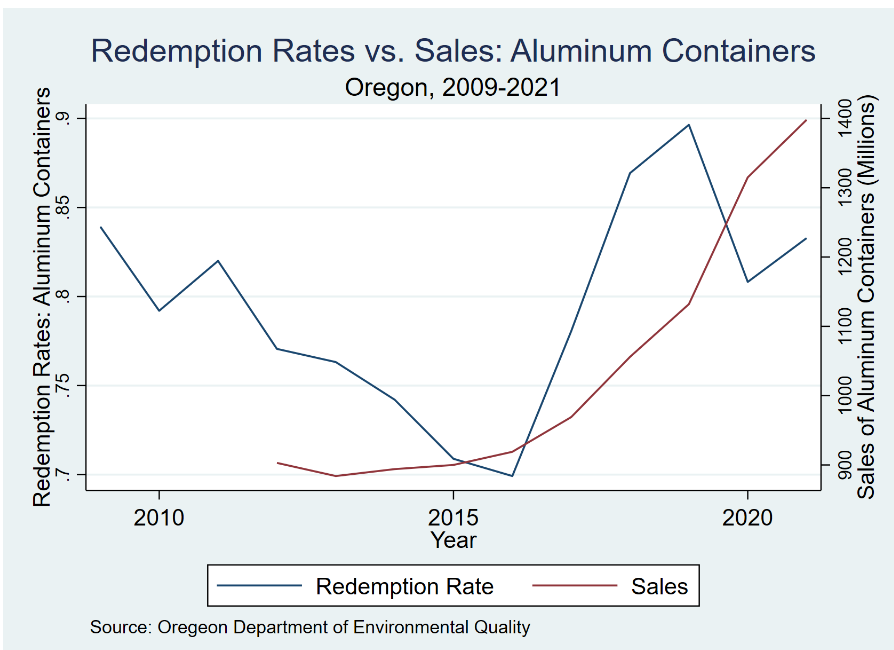

Figure 5: Percent of Redeemed Plastic Containers vs. Total Plastic Sales: Oregon, 2009-2021

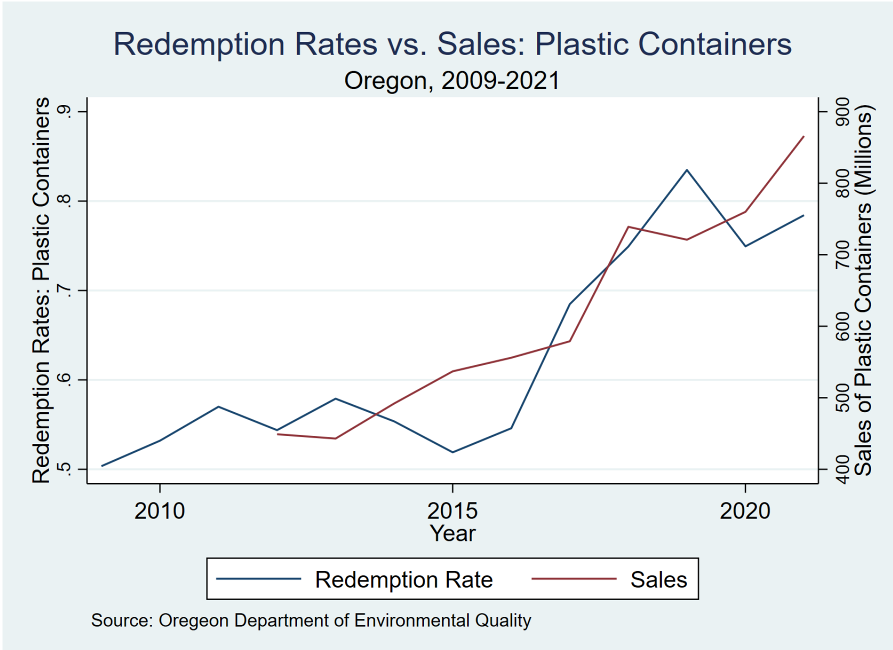

Table 8: **5¢ and 10¢ Predicted Redemption Rates by State**

State	5¢ Prediction	5¢ Prediction > .6?	10 ¢ Prediction	10¢ Prediction > .6?
Alabama	0.654259376	1	0.877056076	1
Alaska	0.396549723	0	0.619346423	1
Arizona	0.490888704	0	0.713685404	1
Arkansas	0.723403677	1	0.946200377	1
Colorado	0.096006883	0	0.318803583	0
Delaware	0.465170141	0	0.687966841	1
Florida	0.36987958	0	0.59267628	0
Georgia	0.592971738	0	0.815768438	1
Idaho	0.815574657	1	1.038371357	1
Illinois	0.334425382	0	0.557222082	0
Indiana	0.558536191	0	0.781332891	1
Kansas	0.689034404	1	0.911831104	1
Kentucky	0.522115101	0	0.744911801	1
Louisiana	0.748760134	1	0.971556834	1
Montana	0.450233093	0	0.673029793	1
Nebraska	0.725167955	1	0.947964655	1
Nevada	0.549602137	0	0.772398837	1
New Hampshire	-0.153100896	0	0.069695804	0
New Jersey	0.23860985	0	0.46140655	0
New Mexico	0.549873236	0	0.772669936	1
North Carolina	0.460717923	0	0.683514623	1
North Dakota	0.566727536	0	0.789524236	1
Ohio	0.490792822	0	0.713589522	1
Oklahoma	0.668417728	1	0.891214428	1
Maryland	0.385744717	0	0.608541417	1
Minnesota	0.494754479	0	0.717551179	1
Mississippi	0.893721338	1	1.116518038	1
Missouri	0.49166989	0	0.71446659	1
Pennsylvania	0.284084519	0	0.506881219	0
Rhode Island	0.002643847	0	0.225440547	0
South Carolina	0.584099616	0	0.806896316	1
South Dakota	0.784696356	1	1.007493056	1
Tennessee	0.489125766	0	0.711922466	1
Texas	0.584107987	0	0.806904687	1
Utah	0.917542977	1	1.140339677	1
Virginia	0.307357236	0	0.530153936	0
Washington	0.270348572	0	0.493145272	0
West Virginia	0.418047677	0	0.640844377	1
Wisconsin	0.458568354	0	0.681365054	1
Wyoming	0.579966159	0	0.802762859	1
Totals		10		31

Table 9: Summary Statistics for 5¢ and 10¢ Estimates

Variable	N	Mean	S.D.	P25	P50	P75
5¢	40	.4987774	.2222776	.3911472	.4932122	.6236156
10¢	40	.7215741	.2211719	.6139439	.7160089	.8464122

Table 10: Summary Statistics for Minimum Deposit Amount to Reach 60% Redemption (States that do not succeed at 5¢)

Variable	N	Mean	S.D.	P25	P50	P75
Deposit Amount	30	.0924115	.0401676	.0613103	.0807581	.1096003

Table 11: Minimum Necessary Deposit Amount in Cents to Reach 60% Redemption (States that do not succeed at 5¢)

State	Deposit Amount to Reach 60% Redemption
Alaska	9.56583
Arizona	7.44868
Colorado	16.31061
Delaware	8.02585
Florida	10.16437
Georgia	5.15773
Illinois	10.96003
Indiana	5.93054
Kentucky	6.7479
Montana	8.36107
Nevada	6.13103
New Hampshire	21.90108
New Jersey	13.11032
New Mexico	6.12495
North Carolina	8.12577
North Dakota	5.74671
Ohio	7.45083
Maryland	9.80832
Minnesota	7.36192
Missouri	7.43115
Pennsylvania	12.08977
Rhode Island	18.40586
South Carolina	5.35684
Tennessee	7.48824
Texas	5.35666
Virginia	11.56749
Washington	12.39804
West Virginia	9.08337
Wisconsin	8.17401
Wyoming	5.4496