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Increasing Recycling through Container Deposit

A Fixed Effects analysis of the Swedish increase in Container Deposit September 2010

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Abstract:

This thesis analyzes the impact on recycling from the increase in the deposit on metal cans that took place in Sweden, September 2010. This is done by using a fixed effects model, fixed on municipality, month and year. Additionally, the thesis investigates the response of different socioeconomic groups to this change by investigating the interaction between deposit and variables for the socioeconomic factors of interest. Interactions for income, education, immigration, environmental awareness, and population density are investigated. The results show that, on average, the recycling in each of the Swedish municipalities have increased by 24.739 units per month, this represents an elasticity of recycling with respect to container deposit of 0.04. The results further indicate that there is strong negative interaction between deposit and income, suggesting that as income increases, the individual will be less responsive to a change in deposit. Contrary to theory, the results indicate positive interaction between deposit and education, indicating that, as education increases the individual becomes more responsive to a change in deposit.

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1. Introduction

Recycling can be seen as part of the solution for increasing landfills and climate change. And as recycling become more important to governments, they look for policies to encourage it. Government efforts to increase recycling usually focus on one of three methods, or more commonly a combination of them. The first, and most used, is to decrease the cost in time and effort of recycling, by, for example, increasing the availability of recycling stations. The second is to make people aware of the hidden costs of not recycling by giving information, to increase knowledge. And the third is to use monetary incentives, such as unit pricing on garbage or container deposit. Today several countries, and various states of, for example, Australia and the United States, are considering implementing container deposit schemes as a way to encourage recycling.

Although there is considerable interest in container deposit as a policy tool, there is little available research to base policy decisions on. In many cases, when researching recycling, container deposit has been left out since it is assumed to follow somewhat different mechanisms than other types of recycling, or perhaps because it is seen as not relevant. However, I consider container deposit to be comparable with other recycling policies, and that therefore the same theoretical base can be used for evaluation. This assumption is strengthened by Campbell et al., 2016, that compare container deposit to other policy measures, finding it to be an efficient, if somewhat limited, policy tool. They do, however, find that container deposit does not affect other recycling to a significant degree.

After the monetary value of the deposit have been set, it has, in most cases, tended to stay the same. There are a few likely causes for this. The first is that the producers are in control of the deposit system, with government oversight, in most places creating a monopoly situation. There is also a general belief that once a container deposit system is in place, the most cost efficient way to further increase recycling is through information (Returpack AB 2012). While this may be the truth, I believe that the level of the deposit should not be forgotten, as increasing the monetary incentives to recycle should lead to increased recycling. As with most things, a combination of different policy measures should produce the best effect.

Although there are several studies showing that container deposit has a positive effect on recycling, Campbell et al (2016) and Viscusi et al (2012), to mention a couple, to my knowledge there are no successful studies on the effects of changing the monetary value of the deposit on recycling behaviour. This means that the increase in the deposit of metal cans, implemented September 2010 in Sweden, presents a rare opportunity to investigate what, if any, effects increasing the deposit within an existing deposit system will have.

Making use of this opportunity, I will study how recycling have changed when the Swedish container deposit on metal cans increased. I will do this by using a fixed effects model, fixed on municipality, month, and year to estimate the effects of a changing deposit on total recycling within the deposit system of *Returpack*. I will also investigate the interaction between the changing deposit and several socioeconomic factors that have been shown to be important indicators for recycling. I will investigate interactions for income, education, immigration, environmental awareness, and population density. By doing this, I will see if these socioeconomic factors have an impact on how communities react to the change in deposit.

2. Background

Container deposit have been used by companies since the late nineteenth century as a way to reclaim reusable containers. Most modern container deposit systems focus instead on recycling, and are controlled by the state, directly or indirectly. Sweden have had a modern container deposit system in place in since 1984, and with the implementation of the current regulation in June 2005 (Förordning 2008:26), the system got the form that it has today. This regulation simply states that the producers of ready to drink products in plastic bottles or metal cans are responsible for adequate recycling of these containers, and that they must be part of an approved container deposit system, or they will be forced to pay fines. And while the regulation states that there must be a monetary compensation, it does not say anything about the level of that compensation.

2.1 Returpack

Today the private company *Returpack* have the only approved container deposit system in Sweden. *Returpack* is jointly owned by its trading and brewery sector companies, the Swedish brewery association (Sveriges bryggerier), the association of Swedish food traders (Livsmedelshandlarna) and the association of Swedish retailers (Svensk Dagligvaruhandel). Since *Returpack* offer deposit on returned containers, the producer responsibility is fulfilled to the full extent of the law. Today *Returpack* have a monopoly position, and this is likely to continue as they have full market coverage and are owned by the potential customers for any competitor. This makes the barriers to entry to the market high. Although there is government oversight through the Swedish board of agriculture (Jordbruksverket), it is still possible that there are some distortions to the market from the owners of *Returpack* not wanting to increase the price of their products. From this, together with a known focus on information as the primary mean of affecting recycling, it can be assumed that the deposit is less than what would be the social optimum level if all factors were taken into account.

2.2 Container deposit in the world

Besides Sweden there are several countries that have more or less comparable container deposit systems in place, notably the Nordic countries and Germany. There are also countries like Australia and the USA where the different states each have their own solution, some fully implementing container deposit, and some not at all (Jorgensen, 2013). Most literature agree that there are many important factors other than money that play a role in any decision to recycle, it is also true that countries with container deposit seem to experience higher recycling rates than others. And in the United States, states with a working container deposit system have higher rates of recycling than states without (Campbell et al., 2016). In both cases it is difficult to know how much of this difference comes from the container deposit system, and how much is simply from differences between states and countries. It can be argued that communities where the population is more environmentally conscious, it is more likely that the government can find support for implementing container deposit.

Although there is a cost in administering a recycling system, that will in most cases by law fall on the producers, this cost should be recuperated, as the producers get to keep any deposits that are not claimed as profit. This means that, as long as the return rate is not near complete, the producer can expect to profit from container deposit. Contrary to this, the producers have, in debates on whether or not to implement container deposit systems, often come down against the implementation of container deposit. This was, for example, the case in Australia where Coca Cola publically spoke against container deposit, claiming that it would bring great and unnecessary extra costs to the individual consumer (The Coca Cola Company 2013).

3. Literature

The first question to ask when working with container deposit is if container deposit actually increase recycling. This have been shown by, for example, Campbell et al (2016), finding that imposing deposit on water bottles in the USA gives significant positive results. They show that states with container deposit programs have roughly double the bottle recycling rates compared to other states. Viscusi et al (2012) also finds that while other measures give larger aggregated effects, there are significant positive effects of the presence of container deposit possibilities in the community. And that it can, on an individual level, make non-recycling individuals start to recycle.

One desirable effect for a recycling policy is transferability, that an increase in the targeted type of recycling will also lead to an increase in other types of recycling. Campbell et al (2016) find that, while container deposit gives good results for the targeted container types, it does not significantly increase other recycling. This somewhat limits the possible utility of container deposit compared to other policy choices. This suggests that it is best used together with other policy measures to target specific problem areas. How Bottle deposit affects the poorest in the society have been addressed by Ashenmiller (2011), finding that they can benefit by collecting discarded containers if the deposit is of a sufficient level.

Although in some ways Container deposit can be seen as a special case, Viscusi et al., (2012) find that bottle deposit follows the expected economic logic. And as shown by Fullerton & Wolverton (2000) with deposit on water bottles, deposit theory can be generalized for different types of containers. There is no reason to expect cans to differ from bottles in any significant way that will affect this study.

Work on developing the economic theory of container deposit have been intermittently ongoing since the 1970s. Schnitzel (1976) makes an attempt to explain the mechanisms of how the implementation of container deposit will affect the consumer by developing a consumer utility maximization problem. Fullerton & Wolverton (2000) develops the reasoning by equating container deposit to Pigouvian tax, in that non-compliance by not recycling imposes a tax in

the form of the lost deposit. The clean behaviour of recycling will then not be taxed at all. While focusing on the effects of changing deposit within an existing deposit system, I will make use of the theory of the individual response to deposit that have been developed by Viscusi et al., (2013), following the work of Bohm (1981). This theory builds on utility theory with the utility maximizing individual.

We know that psychological factors, such as warm glow, social norms, and environmental values, play a big part in the decision to recycle. This have been empirically shown by for example Abbott et al (2013) and Barr & Gilg (2007). The later builds on a framework developed by Barr et al (2001), that investigate the link between values, intention and psychological variables on environmental behaviour. The theory of warm glow in particular is developed by Andreoni (1990), discussing the risk of crowding out voluntary good behaviour by implementing monetary incentives.

The literature on container deposit generally focus on the question whether or not implementing deposit is effective. Although there is not a great wealth of research on the subject, the empirical results are fairly conclusive in that container deposit work as intended. However, to my knowledge there have been no work on the effects of changing an existing deposit. My work will focus on the effects of the change in deposit that was implemented on the fifteenth of September 2010 in Sweden. To do this, I will draw from the individual utility theory of recycling developed for deposit by Viscusi et al., (2013) and Bohm (1981). From this, and the theory of altruism developed by, among others, Andreoni (1990) I will also investigate the response of different socioeconomic groups to the change in deposit.

4. Theory

As the deposit system is intended to increase the individual incentives to recycle, we should examine individual choice to recycle. In the case of container deposit, the theory of the individual choice to recycle has been developed by Viscusi et al., (2013) and Bohm (1981) among others. Starting from utility theory, where the individual is assumed to maximize utility, we assume that the utility of recycling comes in two parts. The first part is the monetary benefit, in this case the deposit, of recycling, and the second part is the sense of satisfaction, or warm glow, that the individual experience from benefiting the society and fulfilling social norms. The cost of recycling is the time and money spent, for example on transporting the containers to an appropriate recycling station.

4.1 The individual choice to recycle

To simplify the theoretical model, the individual is assumed to not get any utility from other disposal methods than recycling. It is also assumed that there is a cost associated with all types of disposal, through recycling or through other modes of disposal such as throwing the container in the garbage. In the model, the cost of recycling will be called C_D, The cost of non-recycling modes of disposal will be called C_T. The monetary benefit of the deposit will be P and the non-monetary, warm-glow, benefit of recycling will be A. There is also a utility cost from not recycling, for example guilt, that will be called G. From this, a model of the individual recycling decision can be represented as follows:

$$P + A \geq C_D - C_T - G \quad (4.1)$$

Here the individual will choose to recycle if the benefit, deposit and non-monetary, is greater than the extra cost of recycling in relation to other modes of disposal. If the deposit is to have an impact, the cost of recycling must be greater than the non-monetary benefit of recycling, that is:

$$A \leq C_D - C_T - G \quad (4.2)$$

Otherwise a rational individual will choose to recycle all containers with or without deposit (Huber & Viscusi, 2011).

The model can be further developed by splitting up the cost of recycling C_D into two parts. The first part is a fixed cost C_{D0}, this cost is not dependent on the number of containers recycled and can, for example, be the cost of transporting containers to a recycling station. The second part is a variable cost C_{D1} that increases linearly with each container. This can, for example, be the time needed to prepare each container for recycling. This means that the cost of recycling n containers can be written as:

$$C_D = C_{D0} + C_{D1} * n \qquad (4.3)$$

The cost of other modes of disposal can be split up into a fixed and a variable part in the same way:

$$C_T = C_{T0} + C_{T1} * n \qquad (4.4)$$

Replacing the cost expressions in equation (4.1) with the expanded cost expressions, while assuming linearity against number of containers recycled for P, A and G, we can see that, for a utility maximizing individual recycling n containers, it will also be utility maximizing to recycle $n + 1$ containers (Viscusi et al. 2013):

$$P + A \geq \frac{C_{D0}}{n} + (C_{D1} - C_{T1} - G) \qquad (4.5)$$

Given linearity, and with the assumption that the marginal cost of recycling an extra container is low, we can expect that this will give corner solutions, that is, we expect that the individual will ether recycle all containers, or no containers. This is consistent with empirical findings of for example Viscusi et al (2012). Since few individuals should be outside of these two groups, raising the deposit should primarily affect those that do not already recycle within the deposit system. This also means that the individuals, for whom the increase in deposit provide sufficient additional incentive to start recycling, should thereafter recycle most or all affected containers. It should also be noted that different containers can have different marginal costs, resulting in recycling individuals not recycling particular containers. An example of containers with increased marginal cost of recycling is those containers that are consumed outside the home, for example at sporting events or concerts. This means that as the share of recycled containers increase, the effects of additional increases in deposit should have decreasing effect, as the containers not already recycled might have particularly high marginal cost of recycling.

Considering the findings of Campbell et al (2016) that there is low transferability in recycling changes from container deposit policy, this may be caused by deposit recycling and other recycling being recycled at different places. This would mean that the fixed costs of other recycling will not have changed when an individual starts to recycle containers with deposit. In the case of Sweden this may be the case, as deposit reclamation can often be done in connection to food shops, unlike other recycling.

4.2 The psychology of recycling

Since we know that there is recycling even when there are no policies in place to encourage it, the idea that there are non-monetary reasons to recycle is strongly support. Andreoni (1990) develops the theory of why people engage in altruism, focusing on impure altruism. This develops the idea that the benefit of a gift to the individual are in two parts, one as part of the public good and one as a private good with the giver purchasing satisfaction, or warm glow, by giving. The same argument can be used for a number of psychological motivations such as social norms, where the giver, besides the public good benefit, lose utility or wellbeing by breaking social norms, and gain utility from following social norms (Abbott et al., 2013).

A simple model for the expected change in recycling resulting from a change in deposit from 0.5 sek to 1 sek is presented in figure (4.1), where this change is represented by Δ Q. The part of recycling that is not motivated by deposit is here represented by the intercept. The size of the intercept will be different for different groups depending on how they value the other possible motivations to recycle such as warm glow and guilt, but also depending on the valuation of their own time and contribution. The elasticity of recycling with respect to deposit will then be the slope, or $\Delta Q * (deposit/recycling)$.

Figure 4.1: A simplified case of recycling under two different levels of deposit. Recycling that will take place without deposit is shown by the intercept. The increase in recycling as a result of the increase in deposit is represented by Δ Q.
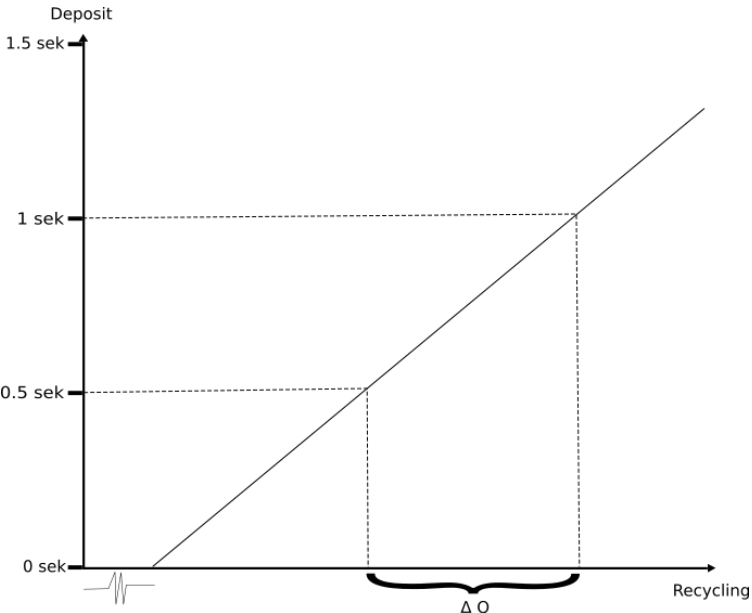
Each individual will react differently to a change in deposit, but the general case shown in figure (4.1) can be adapted for different subgroups in society. The exact mechanics of this is individual specific, but looking at socioeconomic groups we can expect some general within-group similarities. We can, for example, expect that high income individuals will react differently to low income individuals.

The differences between different groups can be expected to come in two parts. The first part is the economic incentives to recycle, which for higher income goes two ways. First by increasing the opportunity cost of time it incentivises lower recycling, and second if there is positive income elasticity with regards to the environment, increasing income increases the warm glow benefits of recycling (Viscusi et al., 2012). We can also expect that higher income will mean that container deposit will be a smaller part of any budget constraint consideration, since we know that foodstuff becomes a less prominent part of the budget as income increases. The second part that can be expected to cause differences between groups are the non-monetary reasons to recycle affecting the recycling decision. For example, both the warm-glow benefits of recycling, and the guilt of not recycling should increase with greater education. Since we expect that education will increase both awareness of the environmental risks of not recycling, and the valuation of the potential benefit of the individual contribution. In figure (4.1), this would mean that as both education and income increase, the expected intercept will increase, as more recycling should be taking place even in the absence of deposit. And as the intercept increase, we can expect the change in recycling from changing the deposit to go down, as, when more of the recycling is already taking place, a greater part of the remaining possible recycling will have increased marginal cost of recycling.

4.3 Socioeconomic groups

The socioeconomic factors I will focus on are: income, education, immigration, population density, and the environmental awareness of the community. As discussed above I expect that, as both income and education increase, the response to an increase in deposit will decrease, that is, I expect the elasticity to decrease. Following Barr et al., (2001) I expect that increasing knowledge will also increase positive actions, in this case recycling. Since education is not the only source of knowledge it reasonable to look directly at environmental knowledge or awareness. This should then lead to greater initial recycling, as the environmentally aware individual can be expected to value a healthy environment highly. Knowing this, I expect that increased environmental awareness will also result in lower response to a change in deposit and thereby a lower elasticity of recycling with respect to deposit.

Both population density and share of immigrants in the population have been shown to be important indicators for recycling by Hage & Söderholm (2008), with a higher share of immigrants indicating more recycling, while higher population density usually indicates lower recycling. It is not clear how ether of these will behave in the context of container deposit. For population density, there are significant differences in recycling behaviour between countryside and city. Countryside populations tend to recycle more, however much of the difference is through in-home recycling, such as composting, which should not affect containers in the deposit system. I expect that the effect of increasing the deposit will be greater as population density increases, since I expect the fixed costs of recycling within the deposit system to be smaller in the city, as recycling stations should be more prevalent. Even though it has been shown that immigrant groups tend to recycle more than other groups, it is not clear why. It may be that they see the social norm to recycle as stronger than others, in which case they should have a lower elasticity than the general case. Or it may be that recycling is seen as way to supplement income, in which case they should have a higher elasticity than the general case. Since we know that immigrant groups tend to have lower income than the average, I expect that as the share of immigrants in the community increases, the response, and thereby the elasticity, will increase.

4.4 Hypotheses

To sum up, from the theory I expect that increasing the deposit on containers will increase the recycling of those containers. I also expect that this effect will be different depending on socioeconomic groups. In table (4.1) I present the expected effects for the different groups examined, in relation to the general case of Sweden. The expected changes in response presented are in relation to an increase in the corresponding variable.

Table 4.1: The expected response in relation to the general case of Sweden as the different socioeconomic variables increase.

Socioeconomic indicator	*Expected response to an increase in the indicator*
Income	Decreasing response and lower elasticity
Education	Decreasing response and lower elasticity
Environmental awareness	Decreasing response and lower elasticity
Share of immigrants	Increasing response and higher elasticity
Population density	Increasing response and higher elasticity

5. Data

5.1 Constructing the dataset

The dataset used is based on data received from *Returpack*. It covers all recycling within their system and it is sorted according to the type of container and the deposit level. The Recycling in each of these categories is observed every month between January 2008 and December 2015, for each of the municipalities of Sweden. This means that it is monthly panel data. Since it covers the Swedish municipalities between January 2008 and December 2015 the dataset has 27840 observations. And the dataset is strongly balanced.

To the data from *Returpack*, data on income, education, immigration, population, population density, and consumer price index (CPI) have been added from Statistics Sweden (SCB). This data is on a yearly basis, and income, education, and immigration data lacks values for 2015, so for these indicators the values of 2014 have been taken as values for 2015. Education level is calculated as the share of the municipal population with greater than high school education, and immigration is calculated as the share of the population that is ether born outside of Sweden or have two parents born outside of Sweden. The population density, population per kilometre squared, is used to proxy urbanization.

To proxy the environmental awareness of the population, I use a yearly survey done by the newspaper Miljöaktuellt, that score the municipalities on a number of different parameters. As the requirements and possible full points available have changed for each year of the study, I have used the relative placement of the municipality as its environmental score, number one being the best and number 290 being the worst score.

In the original data from *Returpack*, data on containers sold have also been included, and as I wish to investigate the effects of changing the container deposit on recycling, the best measure to look at would be the recycling rate, that is, to what extent the containers sold will be recycled. The problem with this measure is that often sale and recycling does not take place in the same monthly time period, making this measure somewhat suspect with the current data. Therefore, I will instead use the total recycling as the dependent variable. I chose this measure instead of the recycling of cans, as it will negate the problem of substitution between the different categories of containers in response to the change in deposit. Cans also constitute the majority of all recycling within the system, making it likely that any effect on the recycling of cans will

carry over to recycling in general within the system.

Since the implementation of the change in deposit was gradual, it is not possible to put a single date on the change in policy, there is recycling of both 1 sek and 0.5 sek cans within the system all the way through to December 2015. What is possible, is to see the difference between the recycling of 1 sek and 0.5 sek cans in each municipality, and to see which type is the dominant for each time period. A variable for deposit can then be added at 0.5 when recycling of 0.5 sek cans is dominant, and 1 when recycling of 1 sek cans is dominant. This deposit variable can then be adjusted for inflation using the consumer price index (CPI) giving the variable of interest, named CPIdeposit.

Table 5.1: The names of the variables used with a closer description and type.

Variable	*Description*	*Type*
period	Monthly, jan 2008 to dec 2015	time variable
municipality	The Swedish municipalities	Identifying variable *(nominal)*
recycling	Total recycling within the deposit system	Dependent variable *(continuous)*
sales	Total sales of recyclables with deposit	Dependent variable *(continuous)*
income	Median yearly income, adjusted for inflation	Independent variable *(continuous)*
CPIdeposit	Dominant type of deposit, adjusted for inflation	Independent variable *(continuous)*
shareEDU	Share of municipal population with more than high school education	Independent variable *(fraction)*
shareIMI	Share of municipal population born outside of Sweden, or with two parents born outside of Sweden	Independent variable *(fraction)*
popKM2	Population per kilometre squared	Independent variable *(continuous)*
envirorank	Environmental ranking	Independent variable *(ordinal)*

Table (5.1) show the variables used, along with a description of what they show and what type of variable they are. Period and municipality are used to sort the data into unique observations, making this a panel dataset. Recycling is the monthly recycling of containers within the deposit system for each municipality. Income and popKM2 (population density) are continuous variables. ShareEDU (share of educated) and shareIMI (share of immigrants) are fractions. CPIdeposit is a continuous variable for the real deposit offered for metal cans to recycling individuals. Envirorank is an ordinal variable for the municipal ranking between 1 and 290 on environmental work.

The final dataset that is used is a strongly balanced panel dataset with 27840 observations, sorted on municipality and monthly time between January 2008 and December 2015. Even though it would have been interesting to investigate, data on individual recycling is not available, as the recycling data of *Returpack* is sorted on municipality. However, I believe that the current dataset presents some advantages, primarily in that the entire population of recycling individuals affected by the change in deposit are covered.

5.2 Descriptive data analysis

Table 5.2: Descriptive statistics of the dataset in use, showing the mean, standard deviation, minimum, and maximum for the variables in use.

Variable	Obs	Mean	Std. Dev.	Min	Max
recycling	27,840	425363.1	774126.4	2209	1.23e+07
CPIdeposit	27,840	.751923	.2758965	.43085	1.0071
income	27,840	236137	24055.85	185465.5	343500
shareEDU	27,840	.1764539	.0557253	.1031279	.4704298
shareIMI	27,840	.1268908	.0698442	.0378638	.5225568
envirorank	27,840	145.0345	81.68114	1	290
popKM2	27,840	140.2637	491.3481	.2	5307.6

In table (5.1) we see descriptive statistics over the dataset used, the table shows that for several of the variables, notably recycling, there is great variation between the observations. Much of this variation is caused by the difference between the different municipalities.

Figure 5.1: The average total recycling, the average recycling of cans, and the average recycling of PET bottles over time.
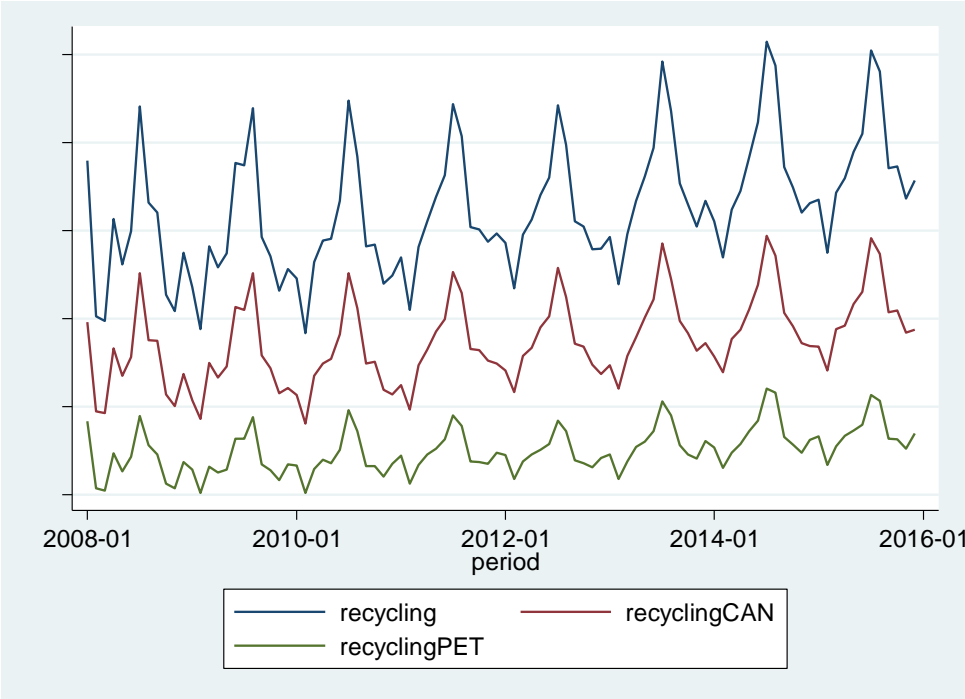

Figure (5.1) show the average recycling over time of metal cans, of PET bottles, and the average of the total combined recycling. We can see that the recycling of cans makes up the greater part of the total recycling for the entire period. We can also see that there is clear evidence of seasonality in the data. There seem to be a break at around 2010/2011, which we would expect with increasing deposit, however, we can also see that there seem to have been an increase in the recycling of other types of containers which could either indicate a time trend, or it could indicate that contrary to the findings of Campbell et al (2016) the recycling of all containers have increased with the increasing deposit.

Figure 5.2: Mean residuals after having controlled for month, using recycling data.
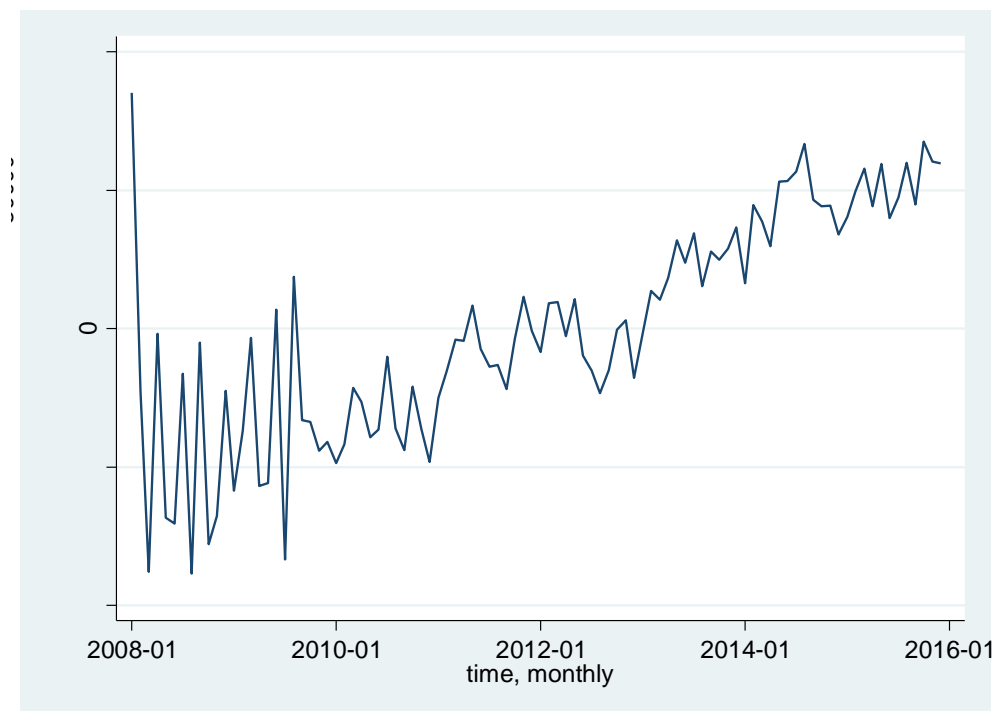
Since there is clear seasonality in the recycling data, I use month fixed effects, that is control for what month of the year the data is from. Looking at the residuals from this, presented in figure (5.2), we can see that there is a time trend with recycling increasing over time in what appear to be a linear fashion.

Figure 5.3: Mean residuals after having controlled for month and year, using recycling data.
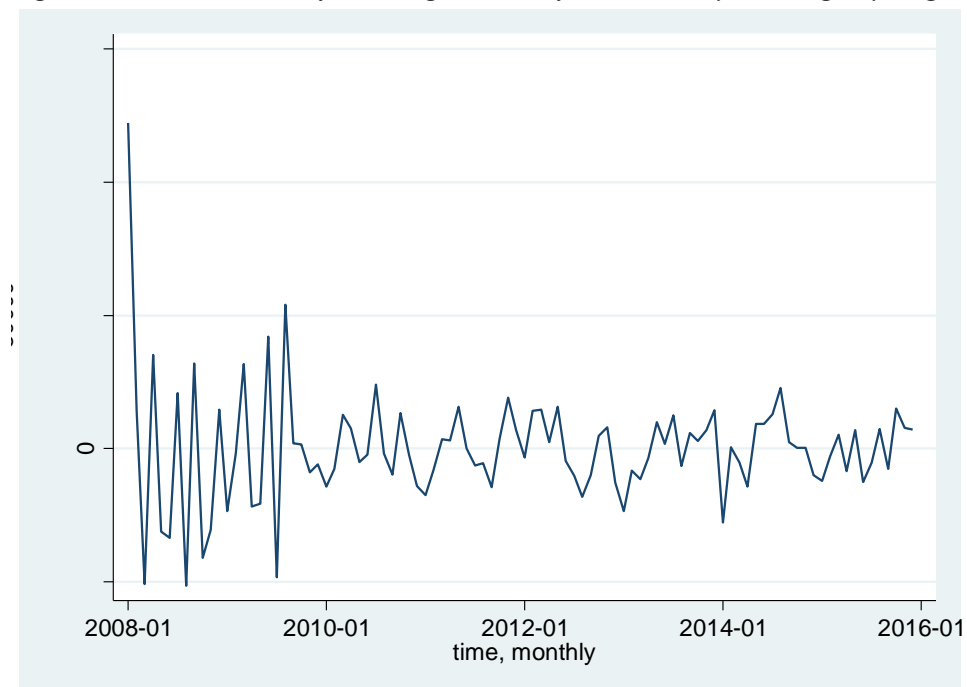
To handle the time trend seen in figure (5.2), I also use fixed effects for year, that is, I additionally control for which year the data corresponds to. Looking at the residuals after having controlled for both month and year, presented in figure (5.3), we see that both the time trend and the seasonality appear to be gone.

Figure 5.4: The mean recycling, and sales of recyclable containers over time.
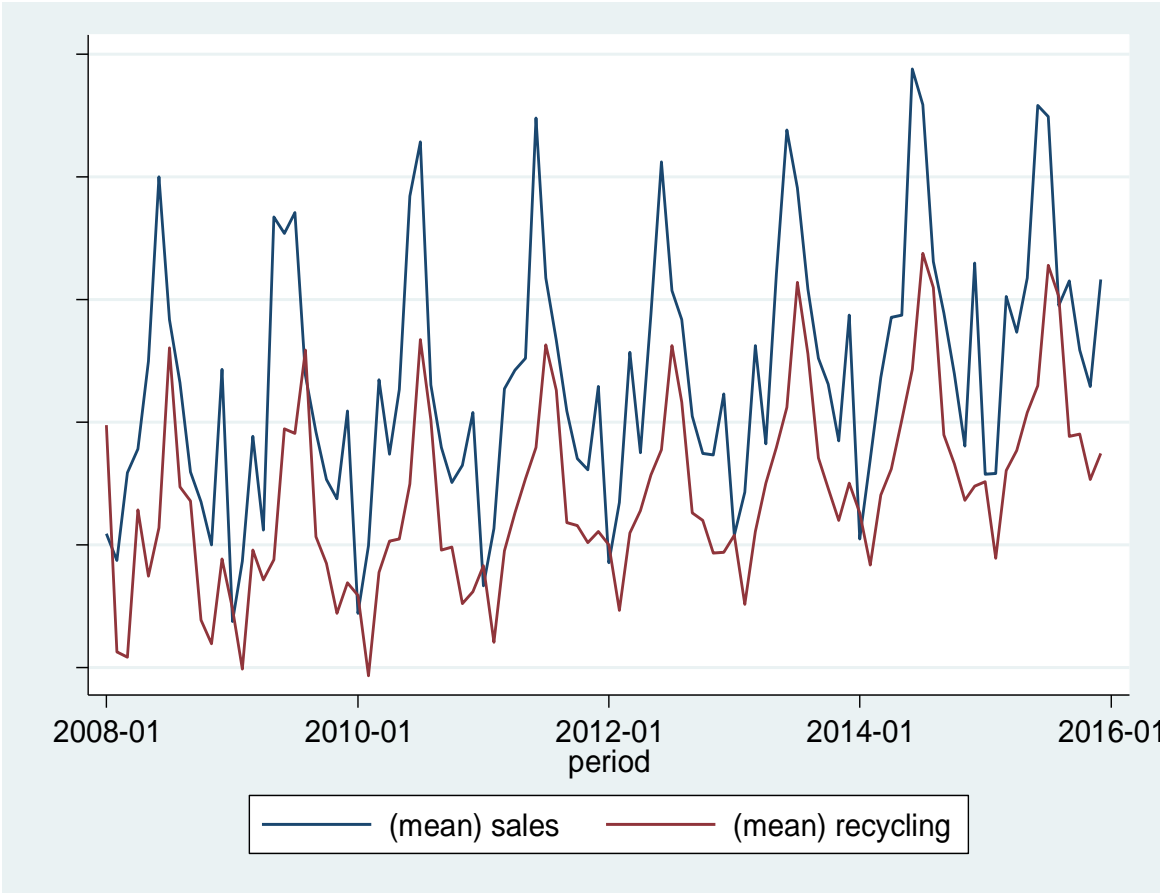

Figure (5.4) show the average recycling and sales of recyclable containers over time. During the time period investigated there are no clear indications of beaks in the relative pattern between the sales and the recycling of container. Sales seem to follow an increasing time trend with strong seasonality with corresponding, but lagged pattern, for recycling.

Figure 5.5: The real deposit offered, in 2014-year value of Swedish krona.
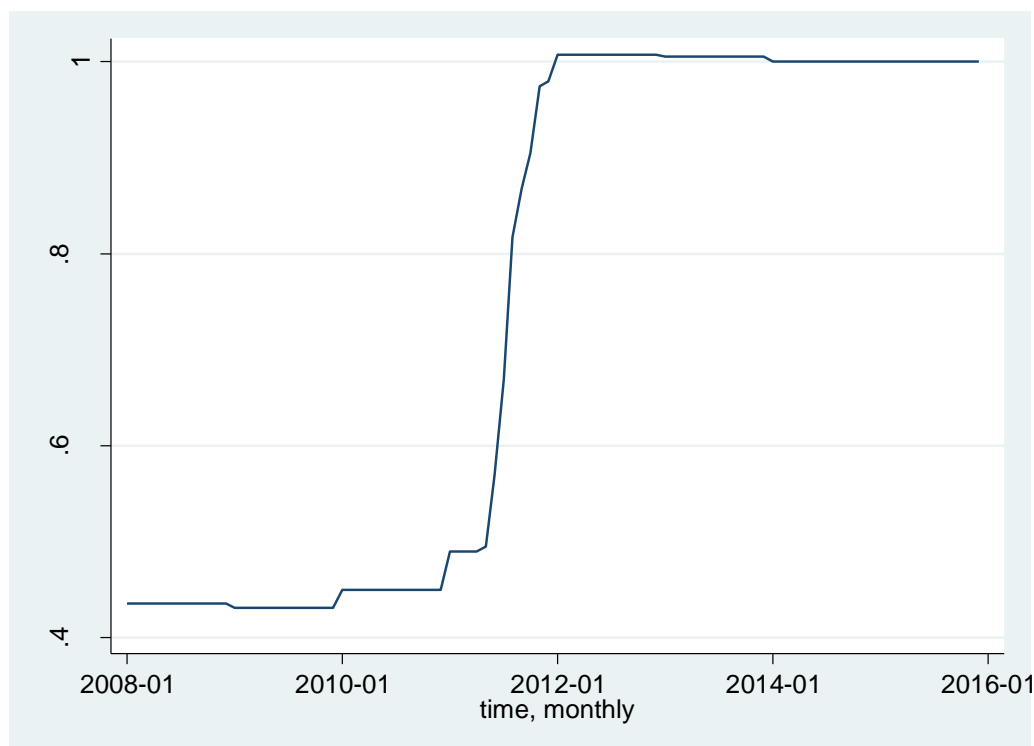
Figure (5.5) show the mean real deposit given to individuals recycling in Sweden between January 2008 and December 2015. The deposit has been adjusted for inflation using consumer price index to 2014 year values. Between January 2010 and January 2012, we can see the gradual implementation of the increased deposit, as recycling in the different municipalities switch dominance from the 0,5 sek deposit to the 1 sek deposit. We can also see that inflation did not affect the mean value of the deposit to a significant degree during this period.

6. Methodology

We know that there are systematic differences between the municipalities investigated, as seen in table (5.2). We can also clearly see that there is seasonality in the data, and looking at the residuals after having controlled for seasonality in figure (5.2) there seem to be a time trend. This means that the regular, or in this case pooled, OLS estimation will be both biased and inconsistent since there will be covariance between the error term and the independent variables.

6.1 The general fixed effects model

To solve these problems, I use a fixed effects model to control for systematic variation. An individual fixed effects model works by taking the averages over time for that individual and subtracting them from each observation, this is called within transformation. The same type of within transformation can be used to control systematic variation over time by averaging for time period of interest.

To handle the systematic difference between municipalities I use municipal fixed effects. I also introduce time fixed effects to control for the systematic variation over time. The time fixed effect is introduced in two parts, monthly controlling for seasonality, and yearly controlling for the time trend. Incorporating these elements with a regular OLS model gives us the model that is used to estimate the effects of changing deposit on recycling:

$$\text{recycling}_{it} = \beta_0 + \beta_1 \text{CPIdeposit}_{it} + \beta_2 X_{it} + \text{month}_t + \text{year}_t + \text{municipality}_i + u_{it} \quad (6.1)$$

Here recycling is the full recycling within the deposit system handled by *Returpack*, CPIdeposit is the deposit adjusted for inflation, X is a vector of socioeconomic factors affecting the recycling in a municipality, composed of income, share of educated, share of immigrants, environmental ranking, and population per kilometer squared. Month is the month of the year, and year is the year between 2008 and 2015.

If recycling is replaced by sales in equation (6.1), it is possible to investigate if the change in deposit have had any effects on the sales of recyclable containers.

$$\text{sales}_{it} = \beta_0 + \beta_1 \text{CPIdeposit}_{it} + \beta_2 X_{it} + \text{month}_t + \text{year}_t + \text{municipality}_i + u_{it} \quad (6.2)$$

6.2 Interaction

Next, we will look at the interactions between the deposit and the socioeconomic factors included in the model, through the vector X. This is done by adding a multiplicative term for each interaction, this term is the variables multiplied by the deposit. The coefficient for this term will then show us if there are any interaction. If the coefficient is significant, there is interaction in how the deposit and that variable, for example income, affect recycling. A positive value would imply that for higher values of the variable, we can expect a greater response to a change in deposit. Adding these interaction terms to equation (6.1) we get:

$$\begin{aligned}
\text{recycling}_{it} = \beta_0 + \beta_1 \text{CPIdeposit}_{it} + \beta_2 X_{it} + \beta_3 \text{interactionincome}_{it} + \\
\beta_4 \text{interactioneducation}_{it} + \beta_5 \text{interactionimigration}_{it} + \beta_6 \text{interactenvironment}_{it} + \\
\beta_6 \text{interactpopulationkm2}_{it} + \text{månad}_t + \text{år}_? + \text{kommun}_i + u_{it} \quad (6.3)
\end{aligned}$$

I chose to regress all interaction terms together, as to run them separately would fail to control for the rest of the, assumed present, interactions. This model uses time and municipal fixed effects in the same way seen in equation (6.1).

The assumptions that we need to make for the fixed effects model to be valid are, for the municipal fixed effects that the municipal specific effects are correlated to the independent variables. This is true for all variables included in the vector X, as we know that there are systematic differences between the Swedish municipalities for all of the socioeconomic factors investigated. For the time fixed effects part of the model, month and year, we assume that the time specific effects are correlated with the independent variables. Since we know that there is both time trend and seasonality, this is a valid assumption to make.

When using fixed effects, it is possible to pair it with many different econometrical models, as it is simply used as a way to control for systematic differences in the data. Having used fixed effects to control for systematic differences, the data seem to exhibit a stochastic trend, as seen in figure (5.3). Because of this I assume linearity and homoscedasticity, and I use linear regression to estimate the effects of changing the deposit on recycling. This means that we also need to consider the assumptions needed for the OLS regression to be valid. After the linearity assumption, it is important to consider the assumption that the data is normally distributed, this assumption should be sufficiently satisfied, as according to the central limit theorem, large samples will converge on approximate normality. I Also assume that there is no significant measurement error as I have access to the full recycling data from *Returpack*, and I consider Statistics Sweden (SCB) to be a reliable source of data. The data for environmental ranking is more problematic, but as it is there to capture the signaled environmental commitment by the municipality, scores on stated municipal environmental work should be sufficient. Having taken all of this into account, I also assume independence of errors and no perfect multicollinearity, as the fixed effects controls for systematic variation.

7. Results

7.1 The general population

In table (7.1), seen below, we can see the result of three different regressions on how the total recycling is affected by the changes in the deposit on metal cans. The first model presented in the table is the pooled OLS model (OLS), it gives a high and highly significant coefficient. However, since we know that there is systematic variation in the data this model is both biased and inconsistent. The second model shown, (Fixed effects 1), use fixed effects on month and municipality. If there is no time trend, this will be the correct model. If this is the case, there should not be any great difference in coefficient if we add fixed effects for year. This is not the case and I chose to use fixed effects model 2 (Fixed effects 2), that controls for month, taking care of seasonality, municipality, taking care of the time invariant differences between the municipalities, and year, controlling for time trend. The choice of this model is strengthened when looking at the residuals having used month and year fixed effect figure 5.3. This model gives a highly significant coefficient of 24.739, that is, the increase in the deposit from 0.5 sek to 1 sek resulted in an increased recycling within the deposit system of 24.739 units on average per municipality and month. This means that for Sweden the elasticity of recycling with respect to deposit $\varepsilon = 0.0437321$.

Table 7.1: The estimated coefficients of how the change in deposit have affected total recycling, using pooled OLS (OLS), fixed effects with respect to month and municipality (fixed effects 1), and fixed effects with respect to month, year, and municipality (fixed effects 2).

VARIABLES	OLS	Fixed effects 1	Fixed effects 2
CPIdeposit	281,746***	37,034***	24,739***
	(13,139)	(13,691)	(8,506)
Month fixed effects	No	Yes	Yes
Year fixed effects	No	No	Yes
Municipality fixed Effects	No	Yes	Yes
Observations	27,840	27,840	27,840
R-squared	0.440		
Number of kommun		290	290

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

7.2 Interactions

Looking at the interaction coefficients estimated, and shown in table (7.2) below, we can see that there are highly significant negative interactions between income and deposit, indicating that as income increases the response to changing deposit decreases. We can also see positive interaction coefficients, significant at the 10% level, for the share of educated people, indicating that as these shares go up, the response to an increased deposit increases. Nether immigration, environmental score, or population density show any significant interactions, the standard error being almost as large as the coefficients for all of them.

Table 7.2): The estimated coefficients for the interaction terms, estimated using fixed effects regression. All interaction terms were tested together.

VARIABLES	Interactions
CPIdeposit	529,201***
	(177,784)
interactionincome	-2.931***
	(0.999)
interactioneducation	835,722*
	(502,309)
interactionimigration	353,424
	(332,305)
interactenvironment	-300.3
	(254.0)
interactpopulationkm2	136.5
	(123.7)
Constant	-312,367
	(604,941)
Observations	27,840
Number of municipality	290

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In table (7.3) we see the result of regressing the deposit adjusted for inflation on the sales of recyclables within the deposit system using the same model as for recycling, but replacing the dependent variable with sales. Although the coefficient is negative, it is not significant, indicating that the change in deposit have not significantly affected sales. This means that we can interpret any positive recycling outcomes as positive for the society.

Table 7.3: Deposit adjusted for inflation (CPIdeposit) regressed on the sales of recyclables, using municipal, month, and year fixed effect

VARIABLES	(1) Sales
CPIdeposit	-595,859
	(953,436)
Constant	7.177e+06***
	(477,409)
Observations	96
R-squared	0.929

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

8. Conclusion

The regression results shown in table (7.1) clearly show that increasing the deposit did have a positive effect on recycling in Sweden. Although this effect is low, resulting in a calculated elasticity of 0.04, it represents a real increase in the amount of cans recycled. In table (5.3), we can also see that the increase in deposit did not have a significant effect on sales, the standard error being higher than the coefficient itself. The detected increase in recycling is fully beneficial for the society, as we get the benefit of increased recycling without a corresponding loss in utility and company profits from loss of sales.

The estimated interaction coefficient for income is highly significant at the one percent level and negative following what we expect from theory. This means that the population of higher income municipalities are less responsive to changes in deposit, indicating that the elasticity of recycling with respect to deposit is lower for high income individuals.

Contrary to what can be expected from theory, the estimated interaction coefficients for the share of educated people are positive and significant. This indicates that municipalities with a higher share of educated people will be more responsive to changes in deposit. This goes against the theory, since we expect that higher education will lead to greater initial recycling. We would therefore expect an individual with higher education to have less room left over for further increases in recycling, since more of the containers that are left to recycle will have increased marginal cost of recycling. That we see the contrary effect may be caused by individuals with higher education valuing the signalling effect of an increase in recycling higher than others. They would then consider ether the warm glow benefits of recycling to have increased, or they would consider the non-monetary costs of not recycling to have increased, perhaps by considering the social norm to recycle to have been strengthened.

None of the remaining estimated interaction coefficients, for share of immigrants, environmental score, and population density, are significantly different from zero. For all of these coefficients, the standard errors are nearly the same as the coefficients themselves. This may be caused by the highly significant, and comparably large, income interaction effect overshadowing the other estimated interaction effects. However, it means that we cannot draw any conclusions for how these factors affect the recycling response to an increased deposit.

These results show that increasing the monetary incentives to recycle, through increasing the container deposit, is a valid method of increasing recycling. The results also indicate that it could be valuable to look at the level of deposit when implementing a deposit system, beyond the question of whether or not to implement at all. The interaction results show that the response is greater among low income groups, and they show that municipalities with a greater share of educated people in the population responded more. This indicate that container deposit can be a valid way of reaching the groups that recycle less in society. That there are also no statistically significant effects on sales indicate that the 2010 increase of the deposit on metal cans in Sweden was socially beneficial.

A feature of the fixed effects model is that, while the obtained results are valid for the tested population, they are not directly transferable to the general population. In the case of Sweden this is not a problem, as the full population are part of the sample through the municipality level data. It does however, create a problem when implications of the results outside of Sweden. In general, the results suggest that for an existing deposit system the level of the deposit should be continuously monitored, and that changing the deposit can be a valid tool to fulfil desired recycling goals. The strong interaction between the response to the change in deposit and income suggests that the level of the deposit affect the recycling decision of low-income groups to a great extent. As low-income groups tend to recycle less than others. this makes container deposit a good tool to reach non-recycling individuals and get them to start recycling. That there are no significant effects on sales from the change in deposit suggests that changing the deposit will not generate significant social losses, at least for the relatively small levels of deposit in place in most countries.

The more similar to Sweden a recycling market is, the more these results will be able to tell us about possible outcomes in that market. The Nordic countries share a lot of traits when it comes to how recycling is organized, and are similar in many other ways as well. This means that the results obtained here should be able to tell us a great deal about how the other Nordic countries would react to a similar increase in deposit. For the countries where the deposit system is similar to the Swedish one, in that a deposit is reclaimable for each container recycled, the results indicate that the level of that deposit should be investigated as an increase may result in increased recycling. For the recycling markets where the deposit is primarily organized as a lottery, such as Taiwan, the results will not be directly transferable as the benefit of each

recycled container is signalled differently. It does however indicate that an increased expected pay out for the lottery can increase recycling, as the expected monetary benefit of each recycled container should increase.

For further understanding how container deposit affects the individual choice to recycle, it would be valuable to use individual data to see how the change in incentives will affect individuals of different characteristics. Since the results obtained in this paper comes from a single change in the container deposit of Sweden, results obtained from different places and for different times would increase the understanding of how deposit levels affect the effectiveness of container deposit as a policy tool.

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