Skipping the Bag: The Intended and Unintended Consequences of Disposable Bag Regulation

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Abstract

Bans on goods associated with negative externalities decrease consumption of the banned product, but may be ineffective at reducing the externality itself if close substitutes are left unregulated. We find that plastic bag bans lead retailers to circumvent the regulation by providing free thicker plastic bags which are not covered by the ban. A regulation change that replaced the ban with a tax on all disposable bags generated large decreases in disposable bag use. Our results suggest that plastic bag bans – stricter, but more narrowly-defined regulations – are less effective than market-based incentives on a more comprehensive set of products.

JEL Codes: H23, H71, Q53

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I. Introduction

Many recent government and corporate policies aimed at reducing a variety of negative externalities include regulations that ban the provision of externality-generating products. However, these policies often ban only a narrow subset of products associated with the underlying externality. For example, the Department of Justice banned "bump stocks" which assist in rapid fire shooting after a Las Vegas mass shooting (White, 2019) rather than placing stricter regulations on all assault weapons. Similarly, Starbucks recently banned distribution of plastic straws at its stores to reduce environmental waste (Rochman, 2018) and New York City attempted to pass a restaurant ban on sugar-sweetened beverages over 16 ounces to curb obesity (Grynbaum, 2014).

But do these policies achieve their intended goal? One concern with narrowly-defined bans is that they may leave close substitutes unregulated, creating unintended consequences of the policies. In the case of assault weapon bans, gun manufacturers devised several adaptations to comply with the ban while still providing consumers with a nearly identical product.[1] Along with the plastic straw ban, Starbucks introduced a new strawless "cold-cup lid" which required *more* plastic than the original lid and straw combined (Britschgi, 2018).[2]

One potential reason for the relatively narrow scope of these types of regulations is that, in many cases, it is politically infeasible to ban a broader class of products, such as a ban on all soda (Brescoll, Kersh and Brownell, 2008). However, there are several cases of governments successfully passing incentive-based policies, such as a tax or a fee, on a wider range of products. For example, many state and local governments levy taxes on soda (of all sizes and sold in all establishments). These policies are less strict in one sense – all products are still available for consumption – but may nonetheless be more effective since they leave fewer substitutes unregulated.

We examine the relative effectiveness of these two policy designs – a narrowly-defined ban versus a tax on a broader base of products – in the context of recent regulations on the use of disposable shopping bags. Disposable bag regulations were first introduced in the United States only a decade ago, but have experienced rapid growth in this short period: as of 2017, one out of six people lived in a jurisdiction covered by a state or local government ordinance regulating plastic bags (Wagner, 2017). As is the case with soda, regulations of disposable bags commonly take two forms: a ban on plastic bags (a subset of all disposable bags) or a tax on all disposable bags. To date, no regulations have considered an outright ban on all disposable shopping bags. In this paper, we examine the effect of two such regulations in the city of Chicago. In 2015, Chicago passed a law banning all single-use plastic bags less than 2.25 mils thick – the most common design of disposable bag regulations in the US – leaving all other types of disposable bags unregulated.[3] This law was repealed starting in 2017 and replaced with a 7-cent tax on all disposable bags (both plastic and paper bags of all

[1] For example, gun manufacturers created a device called a "binary trigger" which serves the same purpose as a bump stock, but circumvents the federal ban (White, 2019).

[2] The New York City ban was ruled unconstitutional before it was ever in effect, however, lab experiments suggests that if retailers had responded to the policy by bundling smaller sodas together at the same price as a larger, banned soda (i.e., one 24 ounce soda versus two 12 ounce sodas), this could lead to higher consumption of soda (Wilson, Stolarz-Fantino and Fantino, 2013).

[3] Similar stand-alone bans will be the statewide regulation of New York (March 2020), Delaware (January 2021), and Connecticut (July 2021) as well.

thicknesses) one month later.

To estimate the effect of these policies on disposable bag use, we collected a unique individual-level data set on bag use for 24,002 shoppers by observing customers at grocery stores in the city of Chicago ("treatment" stores) and in the surrounding suburbs that were not regulated by either policy ("control" stores) from November 2016 to March 2018. This sample period spans three policy regimes: (i) the Chicago plastic bag ban, (ii) a period of no regulation, and (iii) the Chicago tax on all disposable bags, allowing us to estimate the relative effectiveness of the two regulation designs as well as the impact of the repeal of the ban and the implementation of the tax using a difference-in-differences design.

We find that disposable bag use in Chicago remained high during the plastic bag ban: 82 percent of customers in Chicago used an unregulated disposable bag – either a paper bag or a plastic bag thicker than 2.25 mils – which remained free during the ban. Additionally, the repeal of the ban had no effect on the likelihood of using a disposable bag. In contrast, we find that the implementation of the tax in the subsequent months led to a large decrease in disposable bag use.[4] When comparing the relative effectiveness of the two policies, we find that the proportion of customers using a disposable bag decreased by 33 percentage points during the tax relative to during the ban leading to a decrease of just over one disposable bag per trip. This effect appears largely persistent: the reduction in the share of customers using a disposable bag remained large and statistically significant throughout the first year of tax's implementation, though we do observe a rebound effect equivalent to roughly one quarter of the initial effect of the tax by the end of the sample period.

The results on overall disposable bag use suggest that the tax was significantly more effective than the ban at changing customer behavior. Moreover, these results mask an important unintended consequence of the plastic bag ban. When we consider the effects of the two policies on the type of disposable bag used, we find that the ban successfully eliminated thin plastic bag use (as designed). However, it led retailers to provide free *thick* single-use plastic bags with a thickness roughly just over the 2.25 mils defined in the ban, five times the amount of plastic in a standard plastic grocery bag. During the ban, over 40 percent of customers shopping in Chicago used a free thick plastic bag with the remaining disposable bag users taking a paper bag. These thick plastic bags were then

[4]While the estimate of the repeal of the ban is likely a lower bound estimate for the effect of the ban's implementation due to potential habit formation, the estimate of the effect of the tax is likely an underestimate for the same reason.

phased out once the ban was repealed.

Taking the composition of bags used into account, we find that during the tax policy, customers used significantly less plastic *and* paper than during the ban – a decrease equivalent to the amount of plastic in roughly four thin plastic bags and one paper bag per trip. As a result, analyses that take into account the composition of bags used (rather than just the number of disposable bags used), including those considering the life-cycle environmental impact of the different types of bags used, substantially increase our estimate of the relative effectiveness of the tax compared to the ban. While we do not have data on bag reuse, our estimates decrease only slightly if we assume that thick plastic bags and paper bags are reused, for example, as bin liners – in fact, customers must reuse these bags at least six times as often as thin plastic bags to no longer statistically conclude that the tax is more effective than the ban, far more often than suggested in the literature (Prendergast, Wai Ng and Lee Leung, 2001).

This paper contributes to a recent literature on the effect of disposable bag regulations on consumer behavior. Previous research on disposable bag regulations shows that taxes on disposable bags as well as plastic bag bans coupled with a fee for paper bags ("hybrid bans") lead to large decreases in disposable bag use that are similar in magnitude to our estimates of the effect of the Chicago tax.[5] However, stand-alone bans on plastic bags are the most common type of disposable bag regulation in the US, yet to our knowledge, we are the first paper to rigorously evaluate the effect of a policy of this design. Importantly, we are able to compare the two policy designs within the same city rather than relying on cross-state comparisons which may be biased due to differences in the populations. Our findings suggest that the success of the policies estimated in prior research relies on the fact that those policies regulated *all* forms of disposable bags. We find that bans – stricter, but more narrowly-defined regulations that leave close substitutes unregulated – are not effective at reducing the use of disposable bags and, in fact, may increase overall environmental costs by changing the composition of types of bags used.

Our paper also contributes to a broader literature on the unintended consequences of bans on goods associated with negative externalities. This literature largely focuses on behavioral responses taken on the part of the consumer that undermine the effectiveness of the policy. For example,

[5]For example, Homonoff (2018) finds that a five-cent tax in the Washington Metropolitan Area on all disposable bags led to a 42 percentage point decrease in disposable bag use. Taylor and Villas-Boas (2016) find a similar effect (a 35 percentage point decrease) of a California policy that combines a plastic bag ban with a five-cent paper bag fee.

school bans on soda lead to increases in soda purchased for the home (Lichtman-Sadot, 2016), state bans on payday loans decrease payday loan use, but increase the use of pawn shops (Bhutta, Goldin and Homonoff, 2016), and a Mexican policy that banned drivers from using their car one day per week led to the unintended consequence of increasing the number of cars in circulation (Davis, 2008). In the context of disposable bag regulations, partial regulation may generate environmental leakage.[6] For example, Taylor (2019) finds that plastic bag bans coupled with paper bag fees lead to increases in sales of plastic trash bags, partially offsetting the environmental benefits of the policy. Most closely related to our paper, Adda and Cornaglia (2010) compare the relative effectiveness of taxes and bans on tobacco use at reducing second-hand smoking and find that excise taxes on cigarettes decrease exposure to second-hand smoke, while restaurant and workplace smoking bans increase second-hand smoking by increasing smoking in the home. Our findings complement these various results on regulation-avoidant behavior on the part of the consumer, by demonstrating similar behavior on the side of the producer: the introduction of free thick plastic bags.

This paper is organized as follows. Section II provides an overview of disposable bag ordinances in the US as well as specific details on the policies in the city of Chicago. Section III describes the data used in our analyses. Section IV presents estimates of the effect of the two policies on disposable bag use. Section V concludes.

II. Institutional Background

A. History of Disposable Bag Ordinances in the United States

Each year, Americans consume an estimated one hundred billion plastic bags (Clapp and Swanston, 2009). While plastic bags are often recyclable, only 12 percent are ultimately recovered (US EPA 2016). Unrecycled bags frequently end up in landfills, clog storm drains, or find their way into local waterways or trees costing local governments between 3 and 8 billion dollars per year to clean up (Taylor and Villas-Boas, 2016). Over the past decade, many state and local governments throughout the United States have passed laws regulating the use of single-use disposable bags in an attempt to curb these environmental costs. As of September 2017, one out of every six individuals in the

[6] Environmental leakage occurs when partial regulation of environmentally harmful products directly results in increased consumption of the products in unregulated parts of the economy (Fowlie, 2009).

US lived in a jurisdiction with a disposable bag ordinance (Wagner, 2017).

Disposable bag legislation has largely been driven by local governments – as of August 2019, over 450 local ordinances restricting the use of plastic bags were in place in 28 states throughout the country.[7] These policies commonly take one of three forms: (i) a stand-alone plastic bag ban, (ii) a disposable bag fee, or (iii) a hybrid ban plus fee.[8]

The first plastic bag regulation in the United States was implemented in San Francisco which banned all single-use plastic bags starting in 2007.[9] The ban applied to thin, single-use plastic bags less than 2.25 mils thick, but left the use of all other bags, such as paper bags, unregulated.[10] It was several years before another city passed a disposable bag ordinance; however, this original policy design is still the policy choice of many local and state governments. Almost all existing state and local ordinances include a ban on single-use plastic bags, with many policies using the same 2.25 mils cutoff to define "single-use". Stand-alone plastic bag bans can be found in 26 states and comprise over half of all local ordinances.[11] Additionally, stand-alone bans will soon be the effective statewide bag regulation in New York, Delaware, and Connecticut.

An alternative policy places a fee on each disposable bag a customer uses rather than prohibiting the use of plastic bags. Washington, D.C. became the first US city to implement a policy of this type with the passage of the Anacostia River Cleanup and Protection Act in 2010. This law required that grocery stores must charge a five-cent tax on all plastic and paper bags. Policies with this incentive-based design are much less common – fewer than 30 local ordinances charge for plastic bags instead of banning them altogether.

A third policy design, often referred to as a hybrid ban or a "second generation ban" (Romer and

[7] Seven states have passed statewide legislation as well including California, Connecticut, Delaware, Maine, New York, Oregon, and Vermont. Additionally, Hawaii has a defacto statewide law since all counties in the state have implemented a disposable bag regulation.

[8] Additionally, as of August 2019, seventeen states had passed a preemptive "ban on bans" which prohibited laws banning the use of plastic bags.

[9] One exception was a "soft ban" on plastic bags initiated in Maine in 1989 in which retailers were to required to offer only paper bags unless a customer specifically requested a plastic bag (Wagner, 2017). The policy was repealed three years later.

[10] For context, standard single-use plastic bags are 0.5 mils thick while 2.25 mils is roughly the thickness of a commercial garbage bag. The Plastic Bag Recycling Law banned the use of fees on plastic carryout bags with a thickness less than 2.25 mils, creating a common definition of a single-use plastic bag (Romer and Tamminen, 2014). This policy was later amended to include a fee for paper bags starting in 2012.

[11] To compute this estimate, we identified the number of ordinances by type in each state that has a disposable bag legislation. This estimate includes all ordinances that are passed before or after statewide policy but does not consider the size of the population affected by each local ordinance, only the number of ordinances of each regulation design that have been successfully passed.

Tamminen, 2014), couples a plastic bag ban with a paper bag fee, typically in the range of five to fifteen cents per bag. Originally designed in response to a California supreme court ruling requiring all plastic bag regulations to be coupled with regulations on paper bags, this policy has also become a popular design outside of California. Plastic bag bans with paper bag fees currently exist in fifteen states and are the statewide policy choice of California, Maine, Oregon, and Vermont.

B. Chicago Disposable Bag Ordinances

In August 2015, the city of Chicago introduced its first policy regulating the use of disposable shopping bags: a stand-alone ban on single-use plastic bags. Like many other plastic bag bans throughout the country, the ban applied to thin, single-use plastic bags defined as plastic bags less than 2.25 mils thick. The policy first applied only to large stores (defined as over 10,000 square feet), but was expanded to include all chains and franchises in August 2016.[12] Stores that provided plastic bags prior to the ban were required to provide reusable bags, recyclable paper bags, or commercially compostable plastic bags once the ban was implemented.

Importantly, the ban did not apply to other types of disposable bags including plastic bags thicker than 2.25 mils or paper bags. As a result, stores that previously offered free paper bags continued to do so. Additionally, several of the larger retailers that had previously offered thin plastic bags instead began offering customers free *thick* plastic bags with a thickness roughly just over the threshold designated by the ban.[13]

Recognizing this unintended response by the retailers, in November 2016, the Chicago City Council repealed the ban effective January 1, 2017. In its place, the council implemented a new regulation, the Chicago Checkout Bag Tax,[14] which levied a 7-cent tax on all disposable bags.[15] Reusable bags with a price of 50 cents or more were exempt from the tax. This tax was scheduled to go into effect the same date of the ban repeal, but was postponed until February 1, 2017, leaving

[12]The ban applied to all retail establishments selling perishable or non-perishable goods, including but not limited to clothing, food and personal items, but not to restaurants or any store that is not a chain store or franchise with "chain" defined as three or more stores with common ownership.

[13]Similar behavior among retailers in Honolulu County, Hawaii was reported after a plastic bagban in 2015 (Solomon, 2016).

[14]Chicago, Illinois, Municipal Code ch. 3-50.

[15]Five cents from each taxed unit was paid to the city while the remaining two cents remained with the retailer. Customers purchasing groceries with benefits from the Supplemental Nutritional Assistance Program or a similar governmental food assistance program are not subject to the tax (Chicago, Illinois, Amendment of Municipal Code ch. 11-4 by adding Article XXIII).

one month (January 2017) without any disposable bag regulation.

C. Prior Research on Effectiveness of Disposable Bag Ordinances

There is an ongoing policy debate about whether and how to implement disposable bag regulations in the US. However, there is limited rigorous research investigating how policies to reduce disposable bag use affect consumer behavior. Most empirical studies report simple differences, i.e., outcomes before and after a policy change, failing to account for confounding factors such as changes in social norms about the acceptability of using disposable bags that may have motivated policy interventions in the first place. As a result, reported reductions in disposable bag use may be upward biased (Rivers, Shenstone-Harris and Young, 2017).

There are two notable exceptions in the US context. Taylor and Villas-Boas (2016) estimate the effect of a hybrid plastic bag ban plus five-cent minimum paper bag fee and Homonoff (2018) estimates the effect of a five-cent tax on all disposable bags (both paper and plastic).[16] Both studies collect data on individual-level bag use observed at stores in regulated and unregulated cities before and after the policy was implemented.[17] Though these studies evaluate policies with different designs that were implemented in different locations, both find that the policy in question led to a very large decrease in disposable bag use – the hybrid ban led to a 35 percentage point decrease in the proportion of customers using a disposable bag, while the tax on all disposable bags led to a 42 percentage point decrease. Though the effects of the two policies on the likelihood of using any disposable bags were quite similar, the policy choice did impact the type of bag that a customer used. Under the tax policy, most customers who continued to use a disposable bag used a thin plastic bag when available. In contrast (and by construction), customers who continued to use disposable bags during the hybrid ban primarily used paper bags.[18] If plastic bags are more environmentally harmful than paper bags, this evidence suggests that hybrid bans are more effective at reducing these costs; however, paper bags have their own environmental impact making

[16] The policy evaluated in Taylor and Villas-Boas (2016) was implemented in Richmond, California in 2014, while the policy evaluated in Homonoff (2018) was implemented in Montgomery County, Maryland in 2012.

[17] Poortinga et al. (2016) and Rivers, Shenstone-Harris and Young (2017) use a similar research design to study the effect of a 5p/[5 cent] tax on disposable bags in England and Toronto, respectively, but rely on survey data on typical bag use rather than observational data from grocery stores.

[18] One exception was at a discount chain that offered a popular alternative, a 15-cent thick-plastic reusable bags (Taylor and Villas-Boas, 2016).

the relative effectiveness of the two policies unclear.[19]

In spite of the prevalence of stand-alone bans, to our knowledge, our study provides the first evaluation of this policy design. An important distinction between stand-alone bans versus hybrid bans or stand-alone taxes is that under the latter two policies, all disposable bags – thin plastic, thicker plastic, and paper bags – fall under the regulation. In contrast, stand-alone bans on plastic bags leave potential close substitutes, i.e., other types of disposable bags, unregulated. Therefore, it may be inappropriate to extrapolate the effects of disposable bag regulations of these different designs to stand-alone bans. Additionally, Chicago is one of the few cities that has experimented with two types of bag regulations: a stand-alone ban and a stand-alone tax. This allows us to compare the two types of policies in the same city (in fact, the exact same stores) rather than relying on a cross-state comparison.

III. Data

To evaluate the effectiveness of the two disposable bag regulations implemented in Chicago, we collect individual-level data on bag use among customers at grocery stores in the City of Chicago who were subject to the disposable bag regulations, as well as customers shopping in a set of grocery stores located in the same county as Chicago but just outside the city limits who were not subject to any disposable bag regulations during the period of analysis. Our primary data set is comprised of data collected during three time periods: November-December 2016 (the final months of the plastic bag ban), January 2017 (the month in which stores were not subject to any disposable bag regulation), and February-March 2017 (the first months of the tax). We supplement our main data set with follow-up collection periods roughly once per quarter for the first year of the tax's implementation to estimate the persistence of any estimated effect over time.[20]

The sample includes data on bag use from twelve grocery stores: eight stores were located in Chicago and four stores were located in the surrounding suburbs within Cook County, Illinois which did not implement any disposable bag regulations.[21] The stores in the sample were limited to large

[19] For example, production of paper bags requires more energy and creates more air and water pollution than plastic bag production; additionally, paper bags require more energy to recycle and transport (Taylor and Villas-Boas, 2016).

[20] Specifically, we collect data in three additional waves: May 2017 (quarter 2), October-November 2017 (quarter 3), and January-March 2018 (quarter 4).

[21] Suburban sample stores were located in the cities of Evergreen Park, Melrose Park, North Riverside, and Oaklawn. See Figure 1 for a map of store locations.

chain grocery stores for ease of comparison across locations. Of the eight sample stores in Chicago, half were located in lower-income neighborhoods and half were located in higher-income neighborhoods so as to be more representative of the city as a whole. Comparison stores in the suburbs were chosen for similarity with the Chicago stores on ZIP code-level demographic characteristics.[22]

To collect the data, researchers stood by the exit of a sample store and recorded individual-level data on the number and type of bags each customer used (thin plastic, thick plastic, paper, or reusable), as well as visually-assessable demographic characteristics, such as sex and race, of all customers exiting the store. Researchers visited a given store for either 40 minutes, or for the observation of 100 consumers, whichever came first. The visits took place during either a daytime (ten in the morning to four thirty in the afternoon) or evening (four thirty in the afternoon to eight at night) shift during weekdays only. Each of the 12 sample stores received an average of 12 visits during the main sample period (November 2016 to March 2017) and an additional 12 visits during the follow-up period (May 2017 to March 2018). Our final sample includes data on roughly 1,000 customers per store in each sample period for a total of 24,002 individual customers.

Table 1 presents store-level statistics on the race and sex of customers in our sample as well as the median income in the ZIP code in which the store is located. As previously mentioned, half of the stores in the sample were selected from ZIP codes with median incomes below that of Cook County ($61,405 in 2017) and half were located in ZIP codes above the county's median income. In Chicago, the racial composition of the customers in our sample closely tracked neighborhood income with higher-income stores serving predominantly white customers, while customers in lower-income stores were almost exclusively non-white. Customers shopping in a given suburban store were not as racially homogeneous as those in Chicago, nor did racial composition correlate as closely with neighborhood income. Most sample stores had a higher proportion of female customers ranging from one half to two thirds of all customers.

IV. Results

As mentioned in the previous section, our data spans three different policy regimes in Chicago: a stand-alone ban on thin plastic bags, a tax on all disposable bags, and a period in between

[22] For additional comparability, Chicago stores were chosen to avoid close proximity to subway lines, since suburban customers are more likely to drive their cars to the grocery store than use public transportation.

with no regulation. To highlight the conditions under which each policy would lead to a decrease in disposable bag use, we provide a simple model of demand in the Appendix. While the tax alters the utility function of all disposable bag users, the effectiveness of the policy relies on their elasticity of demand. In contrast, the plastic bag ban impacts only plastic bag users and the effect on overall disposable bag use depends solely on whether these consumers prefer reusable bags to the available free disposable bags (paper or thick plastic). This section empirically estimates the relative effectiveness of the two policy designs.

Table 2 presents summary statistics on bag use separately for sample stores in Chicago and the surrounding suburbs in each of the three policy regimes. Stores located in Cook County but outside of Chicago were not subject to any disposable bag regulation. Column 1 shows that during our first sample period (the last months of the Chicago ban) 90 percent of customers in unregulated stores in the suburbs used at least one disposable bag during the observed shopping trips with the average customer using three disposable bags per trip.[23] Eight percent of customers used a reusable bag and five percent used no bags at all. Notably, columns 2 and 3 show that these statistics change very little across policy regimes: the proportion of customers using a reusable bag remains between 90 and 92 percent throughout the sample period.

Columns 4 through 6 present the same statistics for sample stores in Chicago. Here we find a slightly lower, but still large fraction of customers using disposable bags during the ban – 82 percent of Chicago customers used at least one disposable bag with the average customer using two disposable bags per trip. Correspondingly, we observe a slightly higher proportion of customers using a reusable bag (13 percent) or no bag at all (9 percent). Unlike in the suburban stores, we do observe changes in bag use in Chicago over time. While the rate of disposable bag use remains constant during the month after the ban is repealed, we observe a large decrease in disposable bag use once the tax was implemented.

[23]We define disposable bags as any bag that is distributed for free by the store. These can be thin plastic bags, thick plastic bags, or paper bags. We define reusable bags as heavier-weight bags sold by the store or tote bags brought from home.

A. Effects on Disposable Bag Use

To estimate the effect of each policy on various measures of bag use, we employ a difference-in-differences specification. We begin by estimating the following regression:

$$Y_{isht} = \alpha + \beta_1 Chicago x Ban_{st} + \gamma_1 Ban_t + \beta_2 Chicago x Tax_{st} + \gamma_2 Tax_t + \lambda Z_s + \eta X_i + \rho D_h + \epsilon_{isht} \quad (1)$$

Y_{ist} is a measure of bag use for individual i shopping in store s during time period t. $Chicago$ is an indicator for shopping in a store in Chicago, Ban is an indicator for shopping during the ban (November-December 2016), and Tax is an indicator for shopping during the first quarter of the tax (February-March 2017). The model also controls for store fixed effects (Z_s), customer demographic characteristics (X_i), and an indicator for shopping during daytime versus evening hours (D_h).[24] The coefficient on $Chicago x Ban$ (β_1) is the difference-in-differences estimate measuring the effect of the ban compared to the period immediately after the ban was repealed during which there was no disposable bag regulation in Chicago (January 2017). Similarly, the coefficient on $Chicago x Tax$ (β_2) estimates the effect of the implementation of the tax relative the the no regulation period.

Panel A of Table 3 presents the results of this analysis for the four bag use variables in Table 2. We first consider the estimates of the effect of the ban repeal (β_1). Column 1 shows that repealing the ban had no effect on the likelihood of using a disposable bag – the point estimate is less than one percentage point and is not statistically significant. Column 2 shows a similarly small and not statistically significant decrease in the number of disposable bags as a result of the ban repeal. Somewhat unsurprisingly given these null effects on disposable bag use, columns 3 and 4 show no evidence of a statistically significant change in the likelihood of using a reusable bag or using no bags at all.

Turning to the estimates of the effect of the implementation of the tax (β_2), we observe a very different pattern. Column 1 shows that during the first quarter of the tax's implementation, the likelihood of a customer using a disposable bag decreases by 33 percentage points relative to the no regulation period. This corresponds to a decrease in just over one bag per shopping trip (column 2).

[24] We present standard errors clustered at the store level (as they are more conservative), though our results are robust to using wild-bootstrap p-values to obtain t-statistics from pseudo standard errors (Cameron, Gelbach and Miller, 2008) to account for the fact that we only have 12 clusters in the data.

The tax led to an increase of 17 percentage points in the likelihood of using a reusable bag (column 3) and an increase of 16 percentage points in the likelihood of using no bags at all (column 4).

When comparing estimates of β_1 and β_2, it is important to note that we estimate the impact of the initial implementation of the tax but the repeal of the ban, and that the change in behavior resulting from the introduction versus the repeal of the ban need not be symmetric. For example, if the behavioral change induced by the ban changed customer habits, effects of the ban might persist after its repeal. Rivers, Shenstone-Harris and Young (2017) find evidence against this behavior after the repeal of the Toronto bag tax: reusable bag use increased following the implementation of a five-cent tax in Toronto, but this effect did not persist after the tax was repealed. However, given that in Chicago the tax was announced at the same time as the repeal of the ban, this announcement may have mitigated a rebound in disposable bag use during the period between the two policies. By the same argument, if the ban did indeed lead to a decrease in disposable bag use that persisted after the repeal, the estimate of the effect of the tax is likely to be underestimated: customers who developed a habit of avoiding disposable bags in response to the ban may also have been customers who would have responded to the tax.

Nonetheless, the high rate of disposable bag use observed in Chicago during the ban (82 percent) provides us with a useful upper bound of the effect of the ban: if all customers used a disposable bag in the absence of the ban and every customer that stopped using disposable bags as a result of the ban continued to do so after the ban was repealed, the introduction of the ban led to at most a decrease of 18 percentage points in the proportion of customers using a disposable bag. This suggests that even with extreme assumptions about the asymmetry of the introduction and repeal of the ban, the tax was almost twice as effective as the ban at reducing the proportion of customers using a disposable bag.

To avoid concerns about behavior in the no regulation period, Panel B of Table 3 compares the relative effectiveness of the ban and the tax by estimating the following model:

$$Y_{isht} = \alpha + \beta Chicagox Tax_{st} + \gamma Tax_t + \lambda Z_s + \eta X_i + \rho D_h + \epsilon_{isht} \tag{2}$$

In this regression, we exclude data from January 2017 so that the reference group consists of customers observed during the last months of the ban rather than the period with no regulation,

allowing us to compare bag use during the ban directly to bag use during the tax. All variables are defined as those in equation (1). As a result, β measures the effectiveness of the tax relative to the ban.

Column 1 shows that the proportion of customers using a disposable bag was 33 percentage points lower during the tax than during the ban. On average, customers used roughly one less disposable bag during the tax relative to during the ban (column 2). The decrease in disposable bag use was driven roughly equally by a switch to reusable bags and the choice to forgo bags altogether (columns 3 and 4). Taken together, these results suggest that the tax was substantially more effective at reducing disposable bag use than the ban.

B. Composition of Disposable Bags

The previous section shows large differences in the relative effectiveness of the ban and the tax on the proportion of customers using a disposable bag and the number of bags used. However, these outcomes group all types of disposable bags (paper versus plastic, thin versus thick) together, potentially masking important differences in the composition of disposable bags used under different policies.

Figure 2 presents the proportion of customers in our sample that used a disposable bag during each of the three policy regimes – ban, no regulation, and tax – separately for sample stores in Chicago and the surrounding suburbs. The height of each bar represents the proportion of customers using at least one disposable bag, while the shading describes the type of disposable bag used: thin plastic, thick plastic, paper, or a combination of two or more.

The first bar, for example, shows that during the last months of the Chicago ban, 90 percent of customers in unregulated stores in the suburbs used at least one disposable bag during the observed shopping trips. The vast majority of customers (81 percent) used only thin plastic bags, 4 percent used only paper bags, and 5 percent used both paper and plastic bags. No customers in suburban stores used a thick plastic bag, suggesting that these stores did not offer that option. The next two bars show that bag use – both the fraction of customers using any disposable bags and the composition of types of bags – is largely unchanged across the three policy regimes for stores in the suburbs.

The following three bars repeat the analysis for stores in Chicago. As shown in Table 2, stores in Chicago experience a slightly lower, but still large fraction of customers using disposable bags in Chicago during the ban – 82 percent of customers used at least one disposable bag. However, the composition of disposable bags used during the ban differed greatly across locations. In Chicago, no customers used a thin plastic bag, suggesting that the ban was implemented as intended. However, unlike in the suburbs, a substantial fraction of Chicago customers used a thick plastic bag (41 percent) and a much higher proportion used paper bags (also 41 percent). Once the ban was lifted, the proportion of customers using thick plastic or paper bags decreased and thin plastic bags were reintroduced, though the proportion of customers using any disposable bag remained unchanged until the implementation of the tax.[25]

Table 4 compares bag use by type during the ban to bag use during the tax as in equation (2).[26] Each column estimates the relative effects of the two policies on the likelihood of using a specific type of disposable bag: thick plastic bags, thin plastic bags, paper bags, or a mix of types. Under the tax policy, customers were 33 percentage points less likely to use only thick plastic bags and 27 percentage points less likely to use only paper bags relative to the bag use under the ban. This was partially offset by a 23 percentage point increase in the proportion of customers using only thin plastic bags and a 3 percentage point increase in the proportion of customers using multiple types of disposable bags. These results suggest that the policy choice affects not only the prevalence of disposable bag use, but the composition of bags used and that ignoring the unintended consequence of the introduction of thicker plastic bags during the ban would underestimate the costs associated with the policy. We address this question directly in the following section.

C. Environmental Footprint

As mentioned in Section II, plastic bags and paper bags each come with their own set of environmental costs – for example, plastic bags generate more litter and are more difficult to recycle,

[25] While the use of thick plastic bags decreased after the repeal of ban, 28 percent of customers shopping in Chicago used a thick plastic bag in the month after the repeal. This number decreased to only 7 percent during the tax. In fact, no customers in our data used a thick plastic bag after March of 2017. This is consistent with a scenario in which stores continued to offer thicker bags after the repeal so as to deplete their stores, but that this type of bag was no longer available once the original supply ran out.

[26] Importantly, this specification excludes the period in which stores were beginning to phase out the use of thick plastic bags (the no regulation period), but had not yet completed the process.

while paper bags require more energy to produce and that production creates more air and water pollutants. Therefore, to assess the effectiveness of the policies in question on overall environmental costs, we must understand the relative costs of the different types of bags used.

In this section, we estimate the relative amount of plastic and paper used under the different policies. Additionally, we use estimates of the relative impact of the three types of disposable bags on global warming as measured by the UK's Environment Agency (Edwards and Fry, 2011). This report assesses the life cycle environmental impacts of the production, use, and disposal of different types of shopping bags. The report finds that the environmental costs of paper bags are four times that of thin plastic bags and that the costs of thick plastic bags are five times that of thin plastic bags. This report does not provide estimates of absolute costs of each type of bag, only relative costs of one type of bag versus another. Nonetheless, this allows us to estimate the relative environmental costs of the bags used under the different policy regimes.

Table 5 estimates the effect of the tax relative to the ban on environmental costs. We first consider the relative effect of the tax on the amount of plastic and paper used. We use estimates from Edwards and Fry (2011) to create a measure of total plastic used per shopping trip where the units are in numbers of thin plastic bags (column 1). Specifically, we assume that thick plastic bags generate five times as much plastic as thin plastic bags – this assumption is equivalent to assuming that thick plastic bags have a thickness just over the 2.25 mil threshold and that thin plastic bags have a thickness of 0.5 mils, a common estimate of the thickness of standard thin plastic bags. Column 2 estimates the relative effectiveness of the policies on the amount of paper used per shopping trip where units are in number of paper bags. The results show that during the tax, customers used significantly less paper *and* plastic: the average customer used 0.7 fewer paper bags and an equivalent of almost four fewer thin plastic bags per trip during the tax relative to during the ban.

Column 3 combines these estimates to create an overall measure of the environmental footprint generated by the composition of disposable bags used using the estimates from Edwards and Fry (2011). Specifically, the outcome variable is measured in units of cost generated from one thin plastic bag. For example, a customer who uses five thin plastic bags generates five units of cost; similarly, a customer who uses one thin plastic bag and one paper bag also creates five units of cost since the environmental cost of one paper bag is four times that on one thin plastic bag. We find

that, relative the ban, the tax led to a reduction in environmental costs equivalent to the use of 6.5 thin plastic bags per shopping trip.

D. Robustness to Bag Reuse

One concern with the estimates in Table 5 is that customers may be more or less likely to reuse a disposable bag based on the type of bag. For example, Prendergast, Wai Ng and Lee Leung (2001) find that paper bags are reused almost twice as many times as plastic bags. If customers are more likely to reuse paper or thick plastic bags than thin plastic bags, the analysis in Table 5 will overstate the relative effectiveness of the tax in terms of environmental cost reduction. This also highlights a limitation of our data collection – while our researchers attempted to determine if a disposable bag was a new disposable bag, they could not always perfectly determine that the disposable bag had not been brought from home to be reused.[27]

Table 6 repeats the analyses in Table 5 allowing for reuse of paper and thick plastic bags. Specifically, we assume that thin plastic bags are used only once, while paper and thick plastic bags are used two times each (i.e., reused once). Even after this adjustment, we still observe significant differences in the amount of plastic and paper used under the two policies: customers use an equivalent of three fewer thin plastic bags and 0.5 fewer paper bags during the tax relative to the ban. Taken together, estimates in column 3 suggest that the tax led to a reduction in environmental costs equivalent to the use of 5 single-use thin plastic bags per shopping trip relative to the ban. Repeating the analysis in column 3 for additional reuses (see Appendix Table 1) shows that paper and thick plastic bags must be used a minimum of six times as often as thin plastic bags in order to no longer detect a significantly larger effect of the tax relative to the ban on overall environmental footprint – more than three times as often as suggested in Prendergast, Wai Ng and Lee Leung (2001). This suggests that our conclusions about the relative effectiveness of the two policies is robust to accounting for differences in reuse of different types of bags.

[27] Similarly, in our calculations in Table 5, we are only considering the environmental costs of disposable bags and not reusable bags. However, Edwards and Fry (2011) estimate that standard reusable bags must be reused more than 10 times in order to generate lower environmental costs than a single-use plastic bag. By ignoring the costs of reusable bags, our calculations implicitly assume that reusable bags are reused a sufficient number of times such that their costs (relative to those of disposable bags) are negligible.

E. Effect of Tax over Time

This section uses additional data collected quarterly over the following year to assess whether the initial effect of the tax persisted over time. Figure 3a plots the proportion of customers using a disposable bag during the six data collection periods: the ban, the no regulation period, and the first four quarters of the tax separately for shoppers in Chicago and the surrounding unregulated suburbs. The figure shows that disposable bag use in the suburbs was relatively flat throughout the entire data collection period with a range of 87 to 92 percent of customers using at least one disposable bag per trip. In contrast, there was a large decrease in disposable bag use in Chicago in the first quarter of the tax. The difference in disposable bag use between Chicago and the suburbs, however, appears to decrease slightly starting in the third quarter. Figure 3b presents the same analysis for the average number of bags used per trip and exhibits a similar trajectory: disposable bag use was substantially lower in Chicago after the tax was implemented, but the number of disposable bags used appears to rebound somewhat over time.

Table 7 presents estimates from a regression that provides separate difference-in-difference estimates for the effect of the tax relative to the ban for each of the first four quarters of the tax's implementation. Specifically, the regression modifies the analysis in Panel B of Table 3 by including data from the follow-up period, adding separate main and interaction effects for each of the additional quarters.

Column 1 corresponds to Figure 3a, presenting results of the effects of the tax on the likelihood of using any disposable bags in a given trip. As in Table 3, we find that the tax led to a 33 percentage point decrease in the proportion of customers using a disposable bag relative to the ban. This effect decreased slightly to a 31 percentage point change in the second quarter, though the difference between the two quarters is not statistically significant. However, by the end of the first year of the tax, we estimate that the tax led to a decrease in the proportion of customers using a disposable bag of 25 percentage points relative to the ban, an effect that is statistically significantly smaller than the effect measured in the first quarter of the tax's implementation.

This rebound effect is consistent with a model in which the salience of the tax decreases over time, potentially through a reduction in media coverage. Alternatively, prior literature suggests that the large observed behavioral response to disposable bag taxes may be due in part to loss

aversion (Homonoff, 2018) – if a customer's reference price for a disposable bag is initially zero, a tax would feel like a loss. Our findings suggest that while customers may originally perceive a tax on disposable bags as a loss, their reference price may change over time as they acclimate to the tax, consistent with a model of expectations-based reference dependence (Kőszegi and Rabin, 2006). In other words, if customers come to expect that bags cost seven cents, the tax no longer feels like a loss and, as a result, the behavior change driven by their desire to avoid a loss fades.

Column 2 shows a similar pattern for the number of disposable bags used per trip: the tax led to a decrease of just under one disposable bag used per trip in the first quarter of the tax relative to the ban, but the effect is smaller and not statistically significant by the end of the first year. However, this estimate is somewhat misleading since customers who use thick plastic bags need to use fewer bags to carry the same amount of groceries. Columns 3 and 4 consider the effects of the tax on the amount of plastic used (measured in units of thin plastic bags as in Table 5) and the number of paper bags used, respectively. Here we find that the amount of plastic or paper used at the end of the first year of the tax was statistically significantly lower that the amount used during the ban. Additionally, we find no statistically significant differences in the amount of plastic or paper used during the first quarter of the tax compared to one year after the tax's implementation.

V. Conclusion

This paper evaluates the relative effectiveness of two policies in Chicago aimed at reducing the use of disposable shopping bags: a ban on thin plastic bags and a tax on all disposable bags. We do so by comparing changes in disposable bag use in response to the repeal of a plastic bag ban and the subsequent introduction of a disposable bag tax in the city of Chicago. We find that the ban repeal had no effect on the proportion of customers using a disposable bag, while the implementation of the tax led to a large decrease. Additionally, the ban led to the introduction of free thick plastic bags, a product that was eliminated after the ban was repealed. This suggests that all disposable bag regulations do not appear to be equally effective: the tax was significantly more successful than the ban at reducing the proportion of customers using a disposable bag as well as the amount of paper and plastic used.

It is worth noting several key limitations to estimating the overall environmental benefits (or

costs) of the policies. First, we do not have data on purchases of plastic trash bags which may offset the decreases in overall plastic used (Taylor, 2019). Second, we do not have data on reuse of different types of bags. For example, if customers reuse thick plastic bags many more times than thin plastic bags (by our estimates, roughly 20 times as many), then a switch from thin to thick bags could actually reduce environmental costs (Edwards and Fry, 2011). Similarly, we do not calculate environmental costs associated with reusable bags; therefore, if the tax increases purchases of reusable bags (rather than use of existing reusable bags), our estimates would overstate the environmental benefits of the tax.[28] Lastly, we do not address other potential unintended consequences associated with the disposable bag regulations, such as increases in checkout wait times (Taylor, 2020).

Nonetheless, given the rapid expansion of regulations restricting the use of disposable bags, our results have important implications for policymakers considering regulations of different designs. One potential implication of our findings is that increasing the thickness of plastic bags regulated by plastic bag bans may discourage retailers from providing alternative free plastic bags. However, this policy change may simply lead to a larger shift toward disposable paper bags which have their own environmental costs. Our findings also have implications for policymakers choosing between market-based policies and stand-alone bans. For example, Connecticut is transitioning from a 10-cent disposable bag fee to a plastic bag ban in 2021. Similarly, New York City passed a five-cent fee on all disposable bags in 2016 which was overturned and replaced with a statewide policy banning the use of thin plastic bags. The New York State policy gives individual counties the option of implementing a five-cent fee on paper bags – our results suggest that the success of the New York policy rests heavily on the choice that the individual counties make.

[28] Edwards and Fry (2011) estimates that non-woven polypropylene reusable bags must be reused at least 11 times more than a thin plastic bag in order to have a smaller environmental footprint.

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Appendix: Modeling Responses to Disposable Bag Regulations

This appendix models customer behavior under the various disposable bag regulation designs by building on a simple model describing the choice to use a disposable bag versus a reusable bag from Homonoff (2018). Customers must choose between either a disposable bag or a reusable bag and receive utility b_i (which can be positive or negative) if they use a disposable bag[29] – in other words, b_i is the utility benefit of using a disposable bag relative to using a reusable bag. Customer i's wealth is denoted by w_i, d_i is an indicator for whether the customer chose a disposable bag, and utility is additively separable between w and b such that customer i's utility is defined as $U_{N,i}(w_i, d_i) = u(w_i) + d_i b_i$.

A customer will choose to bring a reusable bag when $U_i(w_i, 1) \geq U_i(w_i, 0)$. Given the utility function we describe, this means that customers will bring a reusable bag if $b_i < 0$,, e.g., if bringing a reusable bag generates moral utility for the customer. This model easily extends to the case where customers have two choices of disposable bags: plastic and paper. Each customer has a preference for one type of disposable bag over the other – they prefer paper or plastic – and so b_i becomes the utility from using the customer's preferred disposable bag relative to a reusable bag.

We begin by considering the effect of a regulation that levies a tax of x on each disposable bag (both paper and plastic). The customer's utility function then becomes $U_{T,i}(w_i, d_i) = u(w_i - d_i x) + d_i b_i$. Here the condition to bring a reusable bag simplifies to $u(w_i) - u(w_i - x) > b_i$. Assuming that utility is strictly increasing in wealth, customers who chose to use a reusable bag before the regulation will be unaffected by the tax policy, while disposable bag users may switch to reusable bags depending on their elasticity of demand. Since the tax applies to both types of disposable bags, the policy will not impact the type of disposable bag a customer chooses for those who continue to use a disposable bag.

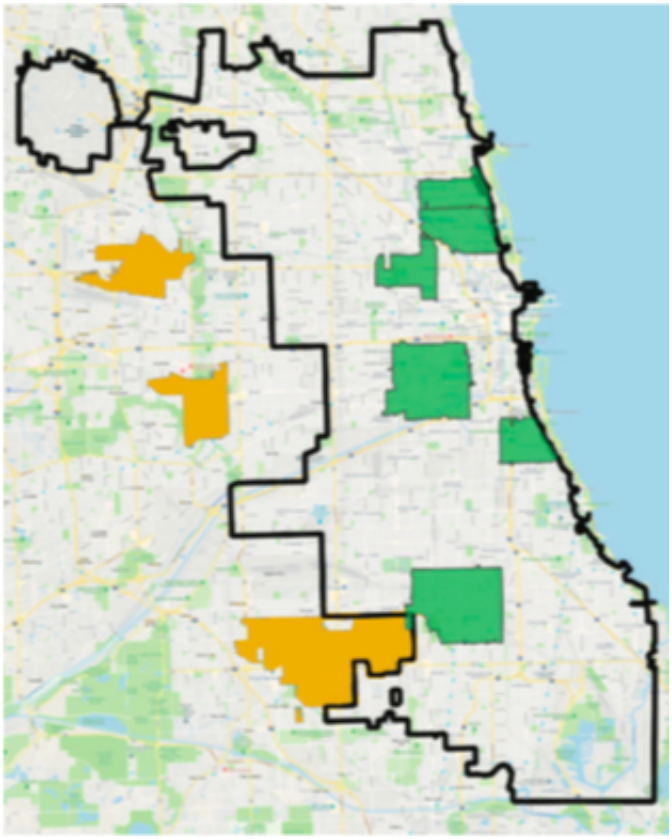
Next we consider the effect of a ban on plastic bags that leaves other types of disposable bags unregulated. Here we must define two separate utility benefits: $b_{i,Plastic}$ is the relative benefit of plastic versus reusable bags and $b_{i,Paper}$ is the relative benefit of paper versus reusable bags. As with the tax, customers who used a reusable bag before the regulation ($b_{i,Plastic} < 0$ and $b_{i,Paper} < 0$) will continue to do so; similarly, for customers whose preferred choice is paper ($b_{i,Paper} > 0$ and $b_{i,Paper} >$

[29] For example, b_i may be positive if customers enjoy the convenience of disposable bags or incur costs associated with remembering a reusable bag, but may be negative if they derive moral disutility from using a disposable bag.

$b_{i,Plastic}$), the policy will have no effect on behavior since their chosen bag is unregulated. However, customers who chose plastic bags before the regulation ($b_{i,Plastic} > 0$ and $b_{i,Paper} < b_{i,Plastic}$) will no longer have access to their preferred choice. These customers can either switch to using paper bags or reusable bags, a choice which depends on their relative preferences over the two remaining options: if $b_{i,Paper} < 0$, the customer will switch to using a reusable bag, but if $b_{i,Paper} > 0$ the customer will take a paper bag.

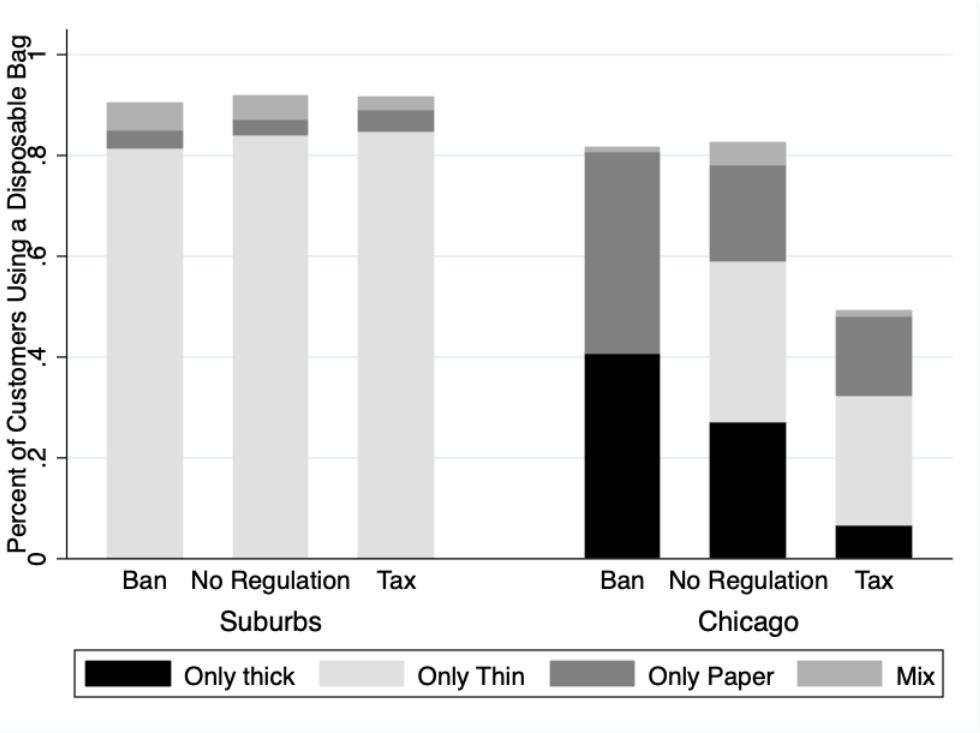
Taken together, these results highlight that the two regulations impact different populations and that their effectiveness at curbing disposable bag use depends on different parameters. Specifically, the tax policy alters the utility function of all disposable bag users (both paper and plastic), while the plastic bag ban impacts the choice set of only plastic bag users. Additionally, the tax policy will only be effective at decreasing disposable bag use if the demand for disposable bags is relatively elastic, while the effectivness of the ban relies on whether the affected population prefers paper to reusable bags.

Figure 1: Map of ZIP Codes Included in Sample



Green areas represent the ZIP codes of Chicago stores included in our study sample. Orange areas represent the ZIP codes of suburban stores included in our study sample. The black boundary is the border of the city of Chicago.

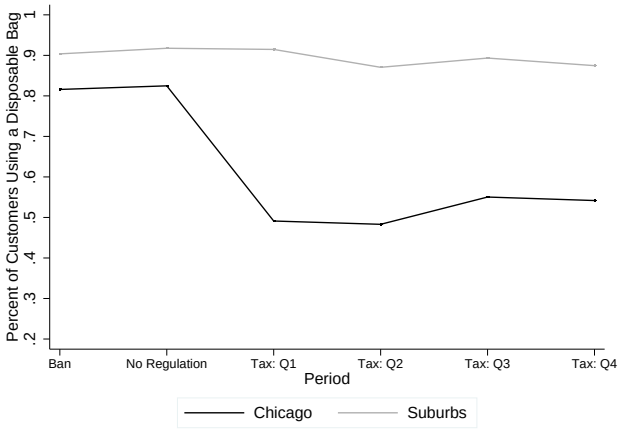
Figure 2: Disposable Bag Use by Bag Type



The height of each bar represents the proportion of customers using a disposable bag separately for Chicago and the surrounding suburbs during the three main study periods: the Chicago plastic bag ban (November-December 2016), the one month of no regulation following the ban's repeal (January 2017), and the first months of the Chicago disposable bag tax (February-March 2017). Shading represents the proportion of customers who used only thick plastic bags, only thin plastic bags, only paper bags, or a mix of disposable bag types.

Figure 3: Disposable Bag Use Over Time

(a) Proportion of Customers Using a Disposable Bag



(b) Average Number of Disposable Bags Used per Trip

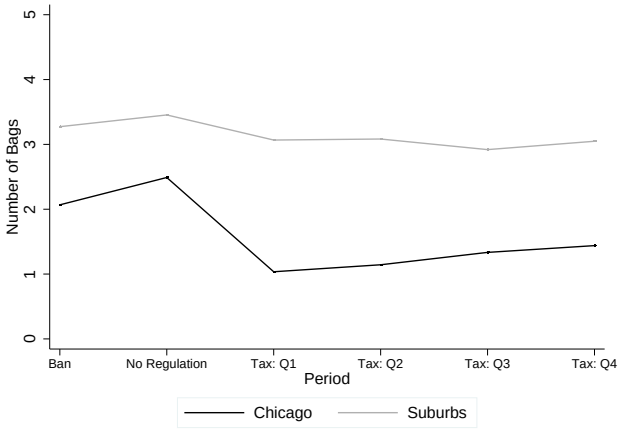


Figure reports the proportion of customers using a disposable bag (Panel A) and the average number of disposable bags used per trip (Panel B) separately for Chicago and the surrounding suburbs during the six study periods: the Chicago plastic bag ban (November-December 2016), the one month of no regulation following the ban's repeal (January 2017), and the first four quarters of the Chicago disposable bag tax (February 2017 - March 2018).

Table 1: Sample Store Characteristics

Store	Observations	Chicago	% White	% Male	Median Income
1	2,005		43.4	42.7	45,548
2	1,801		46.9	39.7	70,270
3	2,190		30.1	36.0	65,744
4	2,401		68.7	40.1	57,410
5	1,646	x	1.3	40.9	32,557
6	2,039	x	74.8	44.3	78,796
7	2,101	x	80.1	45.9	88,256
8	1,910	x	7.6	36.9	25,343
9	2,095	x	62.4	50.5	71,019
10	2,185	x	72.5	49.1	71,019
11	1,971	x	1.0	39.5	32,557
12	1,658	x	7.7	40.2	35,112

Table reports the number of observations per store, store location, the fraction of sample members who were white and male, respectively, and the median household income in the store's ZIP code. Each observation refers to one shopping trip. Sample sizes reported include observations from the full study period (November 2016-March 2018).

Table 2: Bag Use by Location and Policy

	Suburbs			Chicago		
	Ban	No Regulation	Tax	Ban	No Regulation	Tax
	(1)	(2)	(3)	(4)	(5)	(6)
Any Disposable Bag	0.90	0.92	0.91	0.82	0.82	0.49
	(0.30)	(0.28)	(0.28)	(0.39)	(0.38)	(0.50)
Any Reusable Bag	0.08	0.04	0.06	0.13	0.14	0.33
	(0.27)	(0.19)	(0.24)	(0.33)	(0.34)	(0.47)
No Bags	0.05	0.05	0.04	0.09	0.07	0.21
	(0.21)	(0.22)	(0.20)	(0.28)	(0.26)	(0.41)
# Disposable Bags	3.27	3.45	3.07	2.07	2.49	1.04
	(3.02)	(3.00)	(2.70)	(2.10)	(2.66)	(1.60)
Observations	1,454	1,370	1,406	2,694	2,568	2,724

Table reports the fraction of customers using any disposable bags, any reusable bags, and no bags at all along with the average number of disposable bags used per trip separately for customers shopping in Chicago and the surrounding suburbs under different policy regimes. The "Ban" period refers to the final months of the Chicago plastic bag ban (November-December 2016), "Tax" refers to the first two months of the Chicago disposable bag tax (February-March 2017), and "No Regulation" refers to the one-month period after the repeal of the ban and before the implementation of the tax (January 2017). Standard deviations in parentheses.

Table 3: Effect of Disposable Bag Regulation on Bag Use

	Any Disposable Bag	# Disposable Bags	Any Reusable Bag	No Bag
	(1)	(2)	(3)	(4)
A. Effect of Ban and Tax vs. No Regulation				
ChicagoxBan	-0.004	-0.232	-0.037	0.024
	(0.033)	(0.165)	(0.028)	(0.018)
Ban	-0.005	-0.166	0.027	-0.006
	(0.030)	(0.113)	(0.028)	(0.013)
ChicagoxTax	-0.332***	-1.087***	0.168***	0.160***
	(0.030)	(0.270)	(0.022)	(0.028)
Tax	-0.000	-0.348***	0.022***	-0.014
	(0.013)	(0.109)	(0.006)	(0.009)
Observations	12,216	12,216	12,216	12,216
B. Relative Effect of Tax vs. Ban				
ChicagoxTax	-0.330***	-0.860***	0.204***	0.138***
	(0.037)	(0.221)	(0.033)	(0.020)
Tax	0.006	-0.172	-0.004	-0.010
	(0.021)	(0.168)	(0.022)	(0.007)
Observations	8,278	8,278	8,278	8,278
Dep Var Mean	0.918	3.454	0.039	0.053

Standard errors clustered at the store level in parentheses. Outcome variables are indicators for whether a customer used any disposable bags (column 1), any reusable bags (column 2), and no bags at all (column 3) as well as the number of disposable bags used per trip (column 4). "Chicago" is an indicator for shopping in Chicago (versus the surrounding suburbs), "Ban" is an indicator for shopping during the Chicago plastic bag ban (versus during the period with no disposable bag regulation), and "Tax" is an indicator for shopping during the Chicago disposable bag tax (versus during the period with no disposable bag regulation). Panel A includes customers shopping in either the ban, the no regulation, or the tax period (reference group = no regulation); Panel B includes only customers shopping in either the tax or the ban period (reference group = ban). All regressions control for customer sex and race as well as store, time of day, and data collector fixed effects. Dependent variable mean evaluated for customers in the suburbs during the no regulation period. *p<.05; **p<.01; ***p<.001.

Table 4: Effect of Disposable Bag Tax vs. Plastic Bag Ban on Disposable Bag Use

	Only Thick	Only Thin	Only Paper	Mix Disposable
	(1)	(2)	(3)	(4)
ChicagoxTax (vs. Ban)	-0.325**	0.234***	-0.267**	0.029**
	(0.115)	(0.046)	(0.099)	(0.012)
Tax	0.003	0.024	0.006	-0.027**
	(0.018)	(0.030)	(0.012)	(0.011)
Observations	8,278	8,278	8,278	8,278
Dep Var Mean	0.001	0.813	0.036	0.054

Standard errors clustered at the store level in parentheses. Outcome variables are indicators for using only thick plastic bags (column 1), only thin plastic bags (column 2), only paper bags (column 3), or using a mix of disposable bag types (column 4). "Chicago" is an indicator for shopping in Chicago (versus the surrounding suburbs) and "Tax" is an indicator for shopping during the Chicago disposable bag tax (versus during the the Chicago plastic bag ban). Analyses exclude the one month period of no disposable bag regulation between the plastic bag ban and the disposable bag tax. All regressions control for customer sex and race as well as store, time of day, and data collector fixed effects. Dependent variable mean evaluated for customers in the suburbs during the Chicago bag ban. *p<.05; **p<.01; ***p<.001.

Table 5: Effect of Disposable Bag Tax vs. Plastic Bag Ban on Environmental Costs

	Amount Plastic	Amount Paper	Environmental Footprint
	(1)	(2)	(3)
ChicagoxTax (vs. Ban)	-3.771**	-0.684*	-6.473***
	(1.523)	(0.339)	(0.886)
Tax	-0.118	-0.011	-0.260
	(0.126)	(0.050)	(0.237)
Observations	8,278	8,278	8,278
Dep Var Mean	3.093	0.186	4.018

Standard errors clustered at the store level in parentheses. Outcome variables are indicators for total plastic used per shopping trip where the units are in numbers of thin plastic bags (column 1), total paper used per shopping trip where the units are in numbers of paper bags (column 2) and the environmental cost generated from the use of both plastic and paper bags measured in units of cost generated from one thin plastic bag (column 3). Calculations assume that environmental costs of paper bags and thick plastic bags are four and five times that of thin plastic bags, respectively, and that all disposable bags are reused the same number of times. "Chicago" is an indicator for shopping in Chicago (versus the surrounding suburbs) and "Tax" is an indicator for shopping during the Chicago disposable bag tax (versus during the the Chicago plastic bag ban). Analyses exclude the one month period of no disposable bag regulation between the plastic bag ban and the disposable bag tax. All regressions control for customer sex and race as well as store, time of day, and data collector fixed effects. Dependent variable mean evaluated for customers in the suburbs during the Chicago bag ban. *p<.05; **p<.01; ***p<.001.

Table 6: Effect of Disposable Bag Tax vs. Plastic Bag Ban on Environmental Costs - Robustness to Bag Reuse

	Amount Plastic	Amount Paper	Environmental Footprint
	(1)	(2)	(3)
ChicagoxTax (vs. Ban)	-2.872**	-0.513*	-4.873***
	(1.209)	(0.254)	(0.694)
Tax	-0.129	-0.009	-0.263
	(0.105)	(0.037)	(0.204)
Observations	8,278	8,278	8,278
Dep Var Mean	4.018	0.139	3.831

Standard errors clustered at the store level in parentheses. Outcome variables are indicators for total plastic used per shopping trip where the units are in numbers of thin plastic bags (column 1), total paper used per shopping trip where the units are in numbers of paper bags (column 2) and the environmental cost generated from the use of both plastic and paper bags measured in units of cost generated from one thin plastic bag (column 3). Calculations assume that environmental costs of paper bags and thick plastic bags are four and five times that of thin plastic bags, respectively, and that thin plastic bags are used only once, while paper and thick plastic bags are used two times each (i.e. reused once). "Chicago" is an indicator for shopping in Chicago (versus the surrounding suburbs) and "Tax" is an indicator for shopping during the Chicago disposable bag tax (versus during the the Chicago plastic bag ban). Analyses exclude the one month period of no disposable bag regulation between the plastic bag ban and the disposable bag tax. All regressions control for customer sex and race as well as store, time of day, and data collector fixed effects. Dependent variable mean evaluated for customers in the suburbs during the Chicago bag ban. *p<.05; **p<.01; ***p<.001.

Table 7: Effect of Disposable Bag Tax vs. Plastic Bag Ban by Quarter of Implementation

	Any Disposable Bag	# Disposable Bags	Amount of Plastic	Amount of Paper
	(1)	(2)	(3)	(4)
Chicago x Tax Q1	-0.330***	-0.879***	-3.886**	-0.680*
	(0.036)	(0.236)	(1.512)	(0.329)
Chicago x Tax Q2	-0.314***	-0.559**	-4.117**	-0.617**
	(0.034)	(0.186)	(1.779)	(0.277)
Chicago x Tax Q3	-0.252***	-0.227	-4.041**	-0.469
	(0.033)	(0.347)	(1.676)	(0.276)
Chicago x Tax Q4	-0.248***	-0.319	-3.970**	-0.495*
	(0.028)	(0.244)	(1.634)	(0.248)
Tax: Q1	0.007	-0.159	-0.142	-0.004
	(0.020)	(0.187)	(0.138)	(0.052)
Tax: Q2	-0.021	-0.471***	-0.370	-0.117
	(0.028)	(0.118)	(0.485)	(0.160)
Tax: Q3	-0.023	-0.502	-0.171	0.033
	(0.024)	(0.399)	(0.722)	(0.124)
Tax: Q4	-0.026	-0.195	0.137	0.092
	(0.026)	(0.302)	(0.763)	(0.119)
Observations	20,064	20,064	20,064	20,064
Dep Var Mean	0.904	3.273	3.093	0.186

Standard errors clustered at the store level in parentheses. Outcome variables are indicators for whether a customer used any disposable bag (column 1), the number of disposable bags used per trip (column 2), total plastic used per shopping trip where the units are in numbers of thin plastic bags (column 3) and total paper used per shopping trip where the units are in numbers of paper bags (column 4). "Chicago" is an indicator for shopping in Chicago (versus the surrounding suburbs). "Tax: Q1" through "Tax: Q4" are indicators for shopping during each of the first four quarters of the Chicago disposable bag tax, respectively, with an omitted category of the period during the Chicago plastic bag ban. Analyses exclude the one month period of no disposable bag regulation between the plastic bag ban and the disposable bag tax. All regressions control for customer sex and race as well as store, time of day, and data collector fixed effects. Dependent variable mean evaluated for customers in the suburbs during the Chicago bag ban. *p<.05; **p<.01; ***p<.001.

Appendix Table 1: Effect on Environmental Footprint by Reuse

	1 Reuse	2 Reuses	3 Reuses	4 Reuses	5 Reuses
	(1)	(2)	(3)	(4)	(5)
ChicagoxTax (vs. Ban)	-4.873***	-3.273***	-1.672***	-0.627**	-0.383
	(0.694)	(0.518)	(0.380)	(0.237)	(0.229)
Tax	-0.263	-0.266	-0.268	-0.278	-0.278
	(0.204)	(0.183)	(0.179)	(0.208)	(0.211)
Observations	8,278	8,278	8,278	8,278	8,278
Dep Var Mean	3.831	3.644	3.457	3.418	3.393

Standard errors clustered at the store level in parentheses. The outcome variable in all columns is the environmental cost generated from the use of one single-use plastic bag. Calculations assume that the environmental costs of paper bags and thick plastic bags are four and five times that of thin plastic bags, respectively. Each column makes a different assumption about the number of reuses of paper and thick plastic bags relative to thin plastic bags: columns 1 through 5 assume that thin plastic bags are used only once but paper and thick plastic bags are reused one to five times, respectively. "Chicago" is an indicator for shopping in Chicago (versus the surrounding suburbs) and "Tax" is an indicator for shopping during the Chicago disposable bag tax (versus during the the Chicago plastic bag ban). Analyses exclude the one month period of no disposable bag regulation between the plastic bag ban and the disposable bag tax. All regressions control for customer sex and race as well as store, time of day, and data collector fixed effects. Dependent variable mean evaluated for customers in the suburbs during the Chicago bag ban. *p<.05; **p<.01; ***p<.001.