Skipping The Bag

Assessing the impact of Chicago's tax on disposable bags

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About

Tatiana Homonoff, PhD is an Assistant Professor of Economics and Public Policy at NYU's Robert F. Wagner School of Public Service. Her research focuses on identifying areas in which behavioral economics can improve public policy, primarily in the areas of tax policy, public assistance, and consumer finance. Prior to joining NYU, she was an Assistant Professor in the Department of Policy Analysis and Management at Cornell University. She recently served as a Faculty Fellow at the White House's Social and Behavioral Sciences Team (SBST). Homonoff received a Bachelor's from Brown University and a PhD in Economics from Princeton University.

ideas42 is a non-profit innovation firm that applies insights from behavioral science to create lasting positive social impact. ideas42 is the largest general practice applied behavioral science firm in the United States. In 2014, ideas42 helped launch and run the White House Social and Behavioral Sciences Team, and it currently runs behavioral design teams for the cities of Chicago and New York and a number of other public administrations. ideas42 has a full-time team of 95 trained in behavioral design and rigorous evaluation methods. Its staff is augmented by guidance from a Board of Scientific Advisors, including three Nobel laureates and leaders in applied behavioral science, and by close collaboration with 65 Academic Affiliates from leading research universities.

The University of Chicago Energy & Environment Lab partners with civic and community leaders to identify, rigorously evaluate, and help scale programs and policies that reduce pollution, conserve limited natural resources, and improve environmental outcomes, while ensuring access to reliable and affordable energy. A shared effort of the University of Chicago Urban Labs and the interdisciplinary Energy Policy Institute at the University of Chicago (EPIC), the Energy & Environment Lab uses natural experiments, randomized controlled trials, behavioral economics, and machine learning to help policymakers identify and generate evidence around innovative approaches to their most pressing environmental and energy-related challenges.

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Executive Summary

One hundred billion plastic bags are used annually in the United States.[1] While plastic bags are often recyclable, just over 10 percent are actually recycled.[2] Unrecycled bags often end up in landfills, clog storm drains, or find their way into local waterways or trees. Meanwhile, disposable paper bags have their own environmental impact: the paper industry—including paper bags and other paper products—contributed 21 percent of all toxic air releases in the US in 2016.[3] Noting the environmental impact that disposable plastic and paper bags have on the environment, cities across the United States have been implementing policies to curb disposable bag use since 2007. In 2015, the City of Chicago joined their ranks when it implemented a ban on single-use plastic bags.[4]

In addition to raising revenue, taxes can be used as a policy tool to change people's behavior by increasing the price of the taxed good, thereby discouraging its consumption. For example, many municipalities levy taxes on goods such as cigarettes, alcohol, or soda, in part to curb consumption of these products. In November 2016, the City repealed its thin plastic bag ban, effective January 1, 2017, and replaced it with a 7-cent tax on all disposable paper and plastic bags, effective February 1, 2017.[5,6] This study measures the impact of the disposable bag tax on consumer behavior by observing bag use from both before and after the tax went into effect, from November 2016 through March 2018.

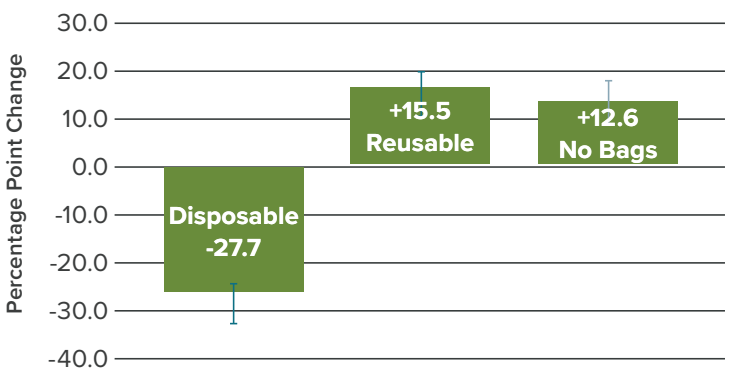
How much an individual changes his or her consumption in response to a tax depends in part on how large the tax is—the larger the tax, the larger the corresponding behavior change. Given the small size of the Chicago bag tax, one might assume that the tax would lead to only modest decreases in disposable bag use. However, research from behavioral economics suggests that even small incentives—when designed with human behavior in mind—can have a large impact on behavior. Three possible mechanisms for this large impact are as follows:

1. **Reference dependence:** People are loss averse, meaning that they react more strongly to losses than to gains of the same amount. When disposable bags are untaxed, an individual's "reference point" is that bags are free. After the tax, they experience a loss when they use a bag, which may motivate them to change their behavior.

2. **Salience:** A tax on a previously free bag is very noticeable, and the more noticeable a tax, the more it will drive behavior. Signage at checkout and verbal reminders from cashiers may further increase salience of the tax.

3. **Habit formation:** Habits are automatic responses that are developed through repeated exposure to external cues. For example, consumers may be accustomed to using disposable bags every time they shop. While the previous two mechanisms may drive an initial switch to reusable bag use, habit formation is key to creating sustained behavior change.

The research team studied bag use behavior at large chain grocery stores in and around Chicago, observing nearly 25,000 consumers. We evaluate the impact of the bag tax on consumer behavior by comparing shoppers at stores inside Chicago (subject to the tax) to stores outside Chicago (not subject to the tax), before and after the tax went into effect.



We find that the bag tax significantly reduced disposable bag use and increased reusable bag use. Chicago's bag tax led to a significant decrease in the likelihood of consumers using disposable bags, a change that occurred within the first month of the tax and persisted through the first year of implementation. The likelihood of consumers using any reusable bags or no bag at all also increased significantly. The number of disposable bags used per person decreased overall, though that effect has somewhat diminished over time.

Before the tax went into effect, 82% of consumers shopping in the sample stores in Chicago used at least one disposable bag per trip. **Over the next year, the bag tax led to a decrease of 27.7 percentage points in the likelihood of using any disposable bags** (95% Confidence Interval: -31.7, -23.7).

At the same time that fewer consumers were using disposable bags, there were also more consumers using reusable bags due to the tax. **Before the tax, only 13% of consumers in Chicago used a reusable bag during their trip. Over the next year, reusable bag use more than doubled, increasing by 15.5 percentage points** (95% CI: 11.0, 20.1)**.**

In addition to shifting to reusable bags, more consumers in Chicago opted to forgo bags altogether. Before the tax, just 8% of consumers in Chicago did not use any bags when grocery shopping. **Over the next year, the likelihood of not using bags increased by 13 percentage points** (95% CI: 8.1, 17.1).

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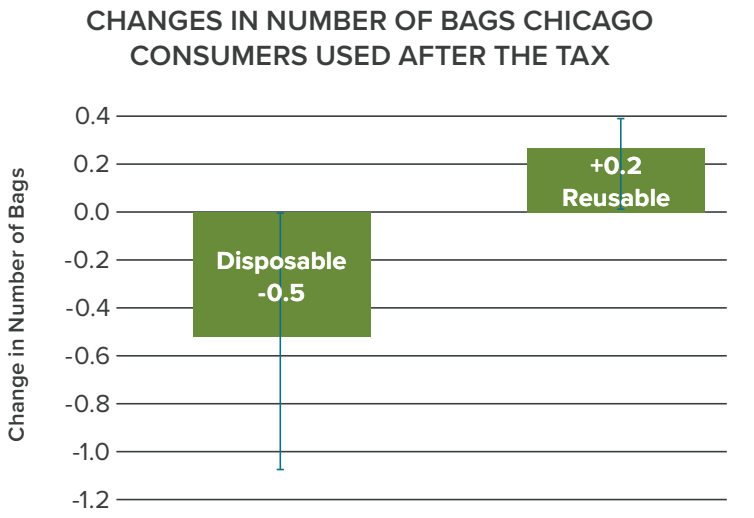


Additionally, the number of disposable bags used per shopping trip decreased after the tax. Consumers reduced the number of disposable bags used by 0.51 bags per trip (95% CI: -1.04, 0.01) over the year, from a baseline of 2.3 disposable bags per trip. Reusable bag use increased by 0.25 bags per shopping trip (95% CI: 0.14, 0.36), more than double the baseline of 0.2 reusable bags per trip.

These results suggest that the Chicago bag tax led to an overwhelming effect on bag use. The likelihood of consumers using disposable bags significantly decreased, with roughly half of consumers switching to using a reusable bag while the other half used no bags at all. Importantly, these effects persisted a year after the tax's implementation. Altogether, these results provide further evidence that even a small bag tax can have a large impact on consumer behavior.

In 2015, the City of Chicago banned single-use plastic bags, joining several cities in the United States implementing policies to curb disposable bag use.[7] Just over a year later, in November 2016, the City repealed the plastic bag ban and replaced it with a 7-cent tax on disposable paper and plastic bags that went into effect in February 2017.[8,9] The City of Chicago commissioned a joint study with the behavioral design lab ideas42 and researchers from New York University and the University of Chicago Energy & Environment Lab to assess the impact of the tax on consumer bag use behavior from November 2016 through March 2018.

Background

One hundred billion plastic bags are used annually in the United States.

In North America, more than 100 municipalities have implemented legislation to curb disposable bag use.

Evidence shows that bag tax legislation and ordinances can reduce bag use.

One hundred billion plastic bags are used annually in the United States.[10] Plastic bags can be recycled, but many end up in landfills, clog storm drains, or find their way into local waterways or trees. While plastic bags are often recyclable, just over 10 percent are actually recycled according to the US Environmental Protection Agency.[11] Most plastic bags that are not recycled end up in landfills, where it can take up to 1,000 years for them to decompose. Paper bags also have significant environmental impacts: the paper industry—including paper bags and other paper products—contributed 21 percent of all toxic air releases in the US in 2016.[12]

Many governments have tried to curb disposable bag use over the last 20 years. One of the earliest examples of legislation aimed at reducing disposable bag use in Western nations is the Irish "Plastax"—a €0.15 tax on plastic bags implemented in 2002 and later raised to €0.22 in 2007.[13] After the implementation of the bag tax in Ireland, countries in the United Kingdom began to implement their own bag taxes, set at £0.05, starting with Wales in 2011[14] and followed by Northern Ireland, Scotland, and England soon afterwards.[15]

In North America, more than 100 municipalities have implemented legislation to curb disposable bag use. There are two main types of policies: **outright bans, and taxes or fees.** In 2007, San Francisco became the first major city in the US to enact disposable bag legislation, banning non-biodegradable plastic bags and later adding a 10-cent fee for paper bags in 2012.[16] Los Angeles enacted a similar ban and fee in 2011,[17] followed by Seattle in 2012 with a thin plastic bag ban and a 5-cent fee.[18] Cities such as Montreal[19] and Boston[20] opted for standalone bans on single-use plastic bags while others, such as Washington, DC,[21] opted for a standalone tax on both disposable paper and plastic bags. In 2014, California became the first state to enact a ban on single-use plastic bags. The legislation in California also mandates provision of reusable bags or recycled paper bags with a minimum 10-cent fee.[22]

Evidence shows that bag tax legislation and ordinances can reduce bag use. Evaluations of these policies by implementing agencies have found them to be successful in reducing disposable bag use.[23,24] Reports from the taxes in Ireland, Wales, and England evaluating trends in bag use before and after the tax have shown reductions in bag use of more than 80%.[25,26,27] In Ireland, the reductions

were largely persistent five years after implementation.[28,29] In the US, researchers have evaluated legislation in Montgomery County, MD and Richmond, CA using data on bag use before and after the respective policy changes in the counties that passed legislation, as well comparable neighboring counties that did not. Montgomery County, which imposed a 5-cent tax on disposable paper and plastic bags, saw a reduction in disposable bag use of over 40 percentage points and an increase in reusable bag use of over 30 percentage points.[30] The plastic bag ban in Richmond decreased total disposable bag use, but increased the number of consumers using paper bags. The 5-cent paper bag fee that accompanied the plastic bag ban in Richmond led to a decrease in the number of consumers using any disposable bags.[31]

However, bag fees and bans still face backlash from a variety of stakeholders. At least ten states have acted to prevent local bag legislation, arguing that such action is necessary to protect small businesses from the burden of complying with many local ordinances that set different rules and requirements.[32] In Texas, a ban on single-use bags in Laredo was struck down in June 2018 by the Texas Supreme Court on the grounds that that local legislation around disposable bags is preempted by a state law barring prohibition or restriction on containers and packages.[33,34]

Other challenges to bag legislation have come from lawsuits filed on behalf of the plastics industry and concerns about the potential regressive nature of bag taxes. In 2012, Toronto repealed its 5-cent plastic bag fee in favor of a bag ban. However, facing lawsuits, the ban was then overturned before it went into effect, leaving the city with no fee or ban.[35] Dallas faced similar issues in 2015 when, due to legal challenges, the city repealed a 5-cent bag fee that had only been in effect less than one year.[36] In 2017, New York City was poised to become the largest US city to impose a 5-cent bag fee,[37] but the legislation was preempted by the New York state government due to concerns about disproportionate costs borne by low-income consumers. In signing the preemption bill, New York Governor Andrew Cuomo referred to the issue of plastic bags as a "statewide challenge."[38] In April 2018, Governor Cuomo proposed a statewide single-use plastic bag ban, similar to Chicago's bag ban.[39]

In 2015, Chicago banned chain stores from providing single-use plastic bags at checkout. The ban, like many of the single-use plastic bag bans in other municipalities, excluded plastic bags that met certain requirements, including but not limited to being at least 2.25 mm thick.[40] As a result of the ban, larger chain retailers in Chicago abandoned thin plastic bags. In their place, they either offered thicker, reusable plastic bags, some for purchase and some for free, or switched to paper bags.[41] This change did not appear to directly impact individual consumer behavior, as people could continue using the thicker reusable bags as single-use bags. **In November 2016, the Chicago City Council repealed its ban on plastic bags and replaced it with a 7-cent tax on all paper and plastic checkout bags effective February 1, 2017**.[42] To mitigate any potentially regressive effects of the tax, the ordinance exempted purchases made through food assistance benefits from the tax.[43]

While there is an ongoing policy debate about whether and how to implement different bag use policies, there is limited rigorous research investigating how bag taxes influence consumer behavior. This study contributes to the research around bag taxes by studying the behavior change impacts of recent bag use legislation in Chicago.

Behavioral Mechanisms

Taxes have often been used as policy levers to discourage consumption of certain products associated with negative externalities—such as those that contribute to pollution—by making them more expensive. However, in order to create meaningful behavior change, the tax must be sufficiently large. Typical supply-and-demand economics, therefore, might predict that a 7-cent tax could be too small a disincentive to dissuade consumers from using a disposable bag. However, research in behavioral science provides several mechanisms that suggest that even small taxes can be surprisingly effective, particularly when levied on goods or services that have traditionally been consumed free of cost. We consider three of these mechanisms below, including reference dependence, salience, and habit formation.

This study does not attempt to disaggregate the individual effectiveness of each mechanism. However, the combination of these mechanisms provides an explanation for how the design of Chicago's bag tax could lead to large behavior changes despite its small size.

Mechanism 1: Reference Dependence

Rather than considering only the final price of a good, individuals often exhibit reference-dependent preferences, meaning that they evaluate outcomes based on gains or losses from a reference point.[44] Individuals tend to experience losses more strongly than equivalent gains, i.e., they are "loss averse."[45] Additionally, research has shown that a price of zero may be an especially impactful reference point. [46] In other words, consumers tend to respond more strongly to price differences from zero than to differences of the same magnitude between non-zero prices (e.g., $0 to $1 vs. $1 to $2).

For example, a common marketing practice known as "high-low" pricing[47] exploits individuals with reference-dependent preferences by displaying an artificially high price tag (inducing a high reference price), then subsequently marking down the item.[48] When a consumer sees that a sweater has been marked down from $50 to $30, it will seem like a better deal than if the same sweater had always cost $30, even though the final price is the same in both cases.

Since disposable bags were previously provided free of charge, it is likely that consumers' reference price for disposable bags was zero. Therefore, paying a tax on these bags causes consumers to experience a loss. While 7-cents for a disposable bag is a relatively small cost, especially compared to the price of a bag full of groceries, the prospect of having to pay for a formerly free item may cause loss-averse individuals to consider alternative behaviors.

In contrast, policies that offer small rewards to incentivize reusable bag use—for example, certain stores in Chicago that offer consumers a 5- or 10-cent bonus per reusable bag used—cause consumers

to experience a gain relative to the reference price of zero. If these shoppers are loss-averse, then a small tax on disposable bags will yield a larger behavior change than an equivalent reward for not using a disposable bag.[49,50]

Mechanism 2: Salience

The more salient a tax is, the more effective it is at being a driver of behavior change.[51] The salience of a tax, that is, how noticeable and important it seems, is dependent on how the tax is perceived and construed.[52] For example, a change in a tax that is included in the posted price of a good (a more salient tax) leads to larger changes in consumption of the good than a change in a tax that is added at the register (a less salient tax), as the decision making point to purchase a good often occurs before reaching the register.[53]

There are several reasons why Chicago's bag tax is more salient than other commodity taxes. First, the tax garnered significant media attention,[54] and notice of the tax implementation is often displayed at the register. Many cashiers also continue to verbally remind shoppers of the tax at the time of purchase. Second, the tax is listed as its own line item on grocery receipts, rather than being bundled with other taxes like sales taxes. Lastly, since disposable bags were previously free, the implementation of any cost may have been a particularly salient price change relative to other goods that had a non-zero price.[55] For example, a tobacco tax is an added cost to an item that already has a price, whereas single-use disposable bags provided at checkout have no price other than the tax.

Mechanism 3: Habit Formation

A habit is an automatic response to an external trigger (or cue), developed through repetition of that behavior in consistent contexts.[56,57,58] When people grocery shop regularly, they form habits around disposable bag use because they are repeatedly encountering a consistent external trigger—for example, hearing "Paper or plastic?"—that cues the response of using a disposable paper or plastic bag. Once the habit is formed, disposable bag use may become an automatic decision that no longer requires active thinking, rather than the result of actively weighing the costs and benefits of each bag for each purchase.[59]

Since habits are triggered by external cues, disrupting the trigger may be an effective way to change the habit.[60,61] When a fee for disposable bags is introduced, it interrupts the automaticity of using a disposable bag because the cue triggering the habitual behavior has changed. Over time, consumers may carry reusable bags or refuse to use disposable bags out of habit. These behaviors may become more automatic over time, just as using disposable bags was automatic prior to the tax.

Importantly, habit formation may be a key mechanism to creating sustained, rather than temporary, behavior change. For example, reference-dependent consumers might stop using disposable bags after the tax is implemented because they want to avoid experiencing a loss. However, as they acclimate to the tax, their reference price may shift and the tax may no longer feel like a loss. Similarly, the salience of the new tax may fade over time as media attention decreases or as cashiers call less attention to the fee at checkout. However, if consumers form habits around reusable bag use, the tax could nonetheless lead to a persistent decrease in disposable bag use.

Methodology and Data

The key purpose of this study is to understand the impact that the Chicago bag tax has had on consumer behavior. Specifically, what is the impact of the disposable bag tax on the number of consumers using any disposable or reusable bags? What is the impact on the number of bags that consumers use of each type? Lastly, are the effects of the tax persistent over time, or do they grow stronger or weaker? The following section describes the research design and data used in this study to evaluate these questions.

Research Design

In order to evaluate the impact of the bag tax, we would ideally like to know what bag use would have looked like in the absence of the policy and compare that behavior to bag use under the new regulation. While in the real world, we cannot observe the behavior of the same people both with and without the regulation, we can do our best to estimate a counterfactual to use as a comparison: what would have happened to people had the regulation not been implemented. There are many ways to define a comparison group. For example, some studies may compare bag use before and after policy implementation and attribute any observed changes in bag use to the policy.[62] However, if there are unobserved factors that differ between the pre- and post-period, such as seasonal differences in bag use, these estimates will not capture the true effect of the policy. Alternatively, other studies estimate the policy's effect by considering differences in bag use in locations that are covered by the regulation versus locations that are not.[63] Similarly, these estimates may not yield the true effect of the policy if consumers in different cities use disposable bags at different rates due to reasons other than the regulation, such as differences in environmental norms or access to public transportation.

A more credible estimate of the effect of the policy can be obtained by combining these approaches, i.e., using both comparisons across time (before and after the policy) *and* location (regulated and unregulated stores). Using only one of the approaches in isolation requires us to make the (likely invalid) assumption that, were it not for the policy, bag use would have been the same in both time periods or in both locations. In contrast, using the two comparisons together allows us to make a more plausible assumption: that *trends* in bag use over time in the two areas change at the same rate. If so, the change in bag use over time in the unregulated stores can provide a reasonable measure of how bag use in the regulated stores would have changed over time in the absence of the policy. Subtracting that difference from observed changes over time in the regulated area provides a measure of bag use change that can be directly attributed to the implementation of the policy. This methodology is, therefore, referred to as a "difference-in-differences" design. See **Appendix Figure A1** for a graphical representation of this methodology.

Data

The Chicago bag tax is a city-wide policy, affecting retail businesses within the city limits beginning February 1, 2017, but leaving stores located just outside the city unregulated. The research team collected data at several large grocery chain stores in Chicago and its neighboring suburbs, tracking consumer bag use before and after the tax was implemented. Specifically, data were collected from November 2016, when the tax was announced, through March 2018, just over a year after the tax went into effect. Data were collected in six different periods, two prior to the tax and four after the tax was implemented:

1. (Pre-Period) November 28, 2016 through December 8, 2016
2. (Pre-Period) January 9, 2017 through January 24, 2017
3. February 20, 2016 through March 2, 2017
4. May 8, 2017 through May 30, 2017
5. October 17, 2017 through November 20, 2017
6. January 9, 2018 through March 6, 2018

The sample consisted of eight "treatment" stores located in Chicago that were subject to the tax starting on February 1st and four "control" stores located in the Chicago suburbs that are not subject to the tax. Since our data include observations of bag use behavior before and after the tax, in stores that were subject to the tax in addition to those that were not, this allows us to implement the difference-in-differences analysis described above. Sample stores were selected to include a mix of stores in both high- and low-income neighborhoods with control stores selected to match the Chicago stores on ZIP code-level demographics for race and income. For further details on store selection and data collection, see the **Appendix.**

Regression Model

The tables included in the following section use a difference-in-differences model to estimate the effect of the tax on various measures of bag use. Measures of bag use include two groups of outcomes: indicators for using any disposable or reusable bags (or no bags at all), as well as the number of bags used per consumer for each type of bag. Specifically, we estimate the following model:

$$Outcome_{ist} = \beta_0 + \beta_1 ChicagoxPost_{st} + \beta_2 Chicago_s + \beta_3 Post_t + \varepsilon_{ist}$$

for individual *i*, store *s*, and time period *t*. *Chicago* is an indicator variable for shopping in Chicago and *Post* is an indicator for shopping after the implementation of the tax (the post period). *ChicagoxPost* is an interaction of *Chicago* and *Post*, i.e., an indicator variable for shopping in Chicago during the post period. The coefficient of interest, β_1 measures the effect of the tax on bag use in Chicago relative to bag use in the suburbs. Additional controls include fixed effects for each sample store, individual-level measures of race and gender, an indicator for shopping during daytime versus evening hours, and research assistant fixed effects. Standard errors are clustered at the store level.

Results

Customers were much less likely to use a disposable bag, and switched to reusable bags or no bags at all.

Customers used fewer disposable bags and more reusable bags.

People were much less likely to use disposable bags overall during the first year, but the magnitude of impact diminished over time.

The effects of the tax were largely the same for consumers shopping in low- and high-income neighborhoods.

From November 2016 through March 2018, research assistants observed bag use at grocery stores in Chicago and its suburbs, collecting data on the number and type of bags used per consumer, the observed demographic characteristics of shoppers, and the time of data collection by store. In total, the research assistants observed 24,499 shoppers.

Result 1: The tax led to a large decrease in the likelihood of using a disposable bag, with consumers switching to using reusable bags or no bags at all.

Before the tax went into effect, roughly 82.0% of consumers in Chicago used at least one disposable bag, 13.2% used at least one reusable bag, and 7.8% did not use any bags (see **Table 1**). **Table 2** presents our main results on the effect of the bag tax on bag use using data collected through March 2018, just over one year after the tax was implemented. We find that the tax led to a 27.7 percentage point reduction ($p<0.001$, 95% CI: -31.7, -23.7) in the likelihood of a consumer using any disposable bags. In addition, the likelihood of consumers using any reusable bag or forgoing a bag increased by 15.5 percentage points ($p<0.001$, 95% CI: 11.0, 20.1) and 12.6 percentage points ($p<0.001$, 95% CI: 8.1, 17.1), respectively. Taken together, the tax led to a large decrease in the proportion of consumers using a disposable bag, with roughly half of consumers switching to reusable bags while the rest opted for no bags at all.

Result 2: The tax led to a decrease in the number of disposable bags used and an increase in the number of reusable bags used per consumer.

We find that the tax also impacted the number of reusable and disposable bags used per consumer. Before the tax went into effect, consumers in Chicago used an average of 0.2 reusable bags and 2.3 disposable bags per trip (see **Table 1**). As seen in **Table 2**, after the tax went into effect, the number of reusable bags used increased by 0.25 bags per consumer ($p<0.001$, 95% CI: 0.14, 0.36). The tax also led to a decrease in the number of disposable bags used by 0.51 bags per consumer ($p<0.1$, 95% CI: -1.036, 0.010).

Result 3: The tax led to a decrease in the likelihood of using disposable bags throughout the first year of implementation, but the magnitude of that impact diminished over time.

To understand whether the impact of the tax changed over time, we estimate the tax's effect at four different follow-up periods: Feb-Mar 2017, May 2017, Oct-Nov 2017, and Jan-Mar 2018). **Table 3** displays the corresponding estimates of the impact of the bag tax at each of the four post periods, and **Figures 1-5** display the measures of bag use over all time periods. Comparing the Jan-Mar 2018 time period ("the late period") to the Feb-Mar 2017 time period ("the early period"), the effects of the tax on the likelihood of disposable bag use attenuated, decreasing from a 33.0 percentage point reduction in the early period ($p<0.001$, 95% CI: -40.0, -26.5) to a 23.9 percentage point reduction in the late period ($p<0.001$, 95% CI: -28.8, -19.0), a statistically significant difference ($p<0.05$). The effects also attenuated for the likelihood of not using a bag, from a 14.8 percentage point increase in the early period ($p<0.001$, 95% CI: 9.6, 19.9) to a 9.8 percentage point increase in the late period ($p<0.01$, 95% CI: 3.9, 15.6), also a statistically significant difference ($p<0.05$). The likelihood of using a reusable bag did not change significantly between the early period and the late period.

Turning to the average number of bags used, we find that the effect of the tax on disposable bags used in the early period was a 0.97 bag reduction ($p<0.01$, 95% CI: -1.49, -0.45) from a baseline of 2.3 bags. Additionally, consumers increased reusable bag use by 0.33 bags ($p<0.001$, 95% CI: 0.18, 0.47). By the late period, the reduction was 0.19 disposable bags per consumer and no longer statistically significant. The number of reusable bags had increased to 0.25 bags in the late period ($p<.001$, 95% CI: 0.12, 0.37), representing a slight attenuation from the effects in the prior year.

Figure 1:

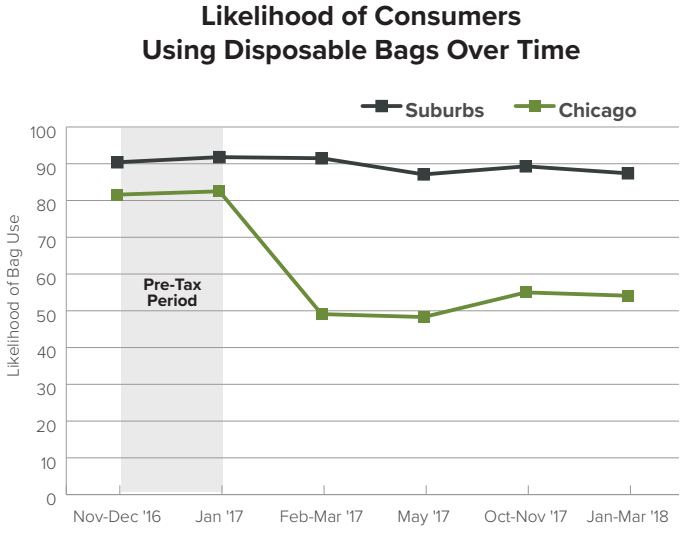


Figure 2:

Likelihood of Consumers Using Reusable Bags Over Time

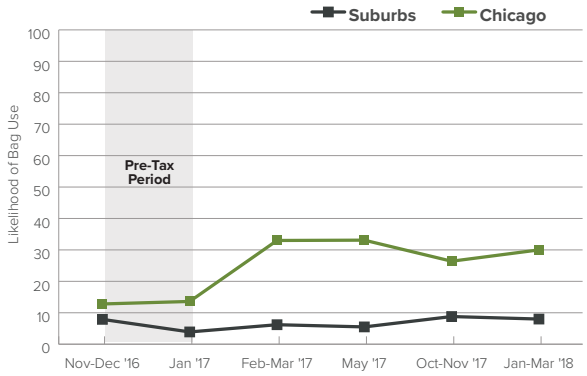


Figure 3:

Likelihood of Consumers Using No Bags Over Time

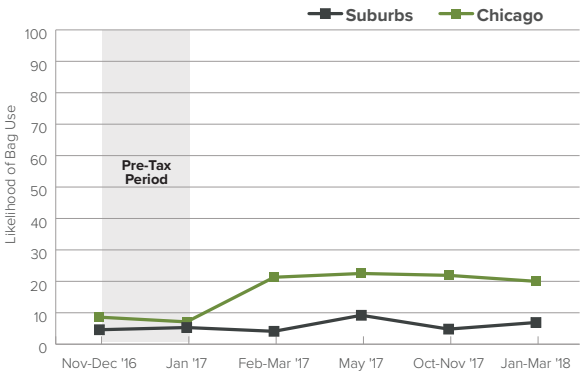


Figure 4:

Disposable Bag Use Per Consumer Over Time

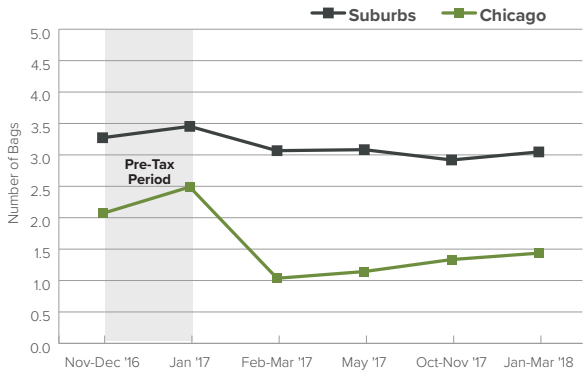
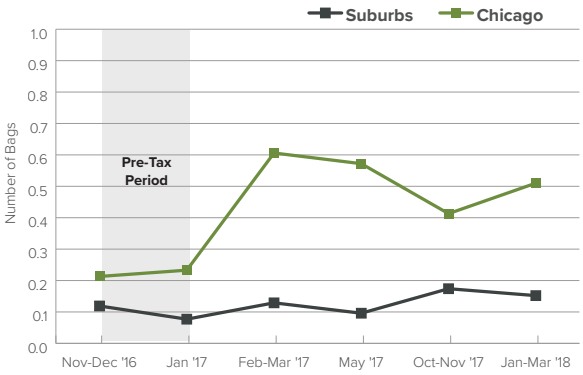


Figure 5:

Reusable Bag Use Per Consumer Over Time



Result 4: The effects of the tax were largely the same for consumers shopping in low- and high-income neighborhoods.

Our sample stores included chains in both high- and low-income neighborhoods.[i] In **Table 4,** we investigate whether the bag tax had different effects for consumers shopping in neighborhoods with different average income levels, split by the median income level in our sample. We find no significant differences in the effect of the tax on the likelihood of using a disposable bag across the two types of neighborhoods: the likelihood of consumers shopping in neighborhoods above the median income in our sample using any disposable bags decreased by 26.6 percentage points after the tax ($p<0.001$, 95% CI: -29.7, -23.5), which is not statistically different from the change observed in lower-income neighborhoods (a difference of -2.3 percentage points, $p>0.05$, 95% CI: -9.5, 4.8). However, compared to consumers in higher-income neighborhoods, consumers in lower-income neighborhoods were more likely to switch to using no bags at all (a difference of 8.2 percentage points, $p<0.05$, 95% CI: 2.0, 14.4) rather than using a reusable bag (a difference of -4.3 percentage points, $p>0.05$, 95% CI: -12.2, 3.5).

[i] Neighborhoods are categorized as high income if they are above the median ZIP code level household income of $65,744, and low income if they are below the median.

Conclusion

A small bag tax can have a large and persistent impact on consumer behavior.

Overall, this study finds that the bag tax has had a large effect on bag use in Chicago more than a year after its implementation. During the study period, the proportion of consumers using a disposable bag dropped by 27.7 percentage points from a baseline of 82.0%. The proportion of consumers using a reusable bag more than doubled: reusable bag use increased by 15.5 percentage points from a baseline of 13.2% of consumers. Additionally, the proportion of consumers using no bags at all increased by 12.6 percentage points from a baseline of 7.8% of consumers. While the effects of the tax diminished over time, they remain large and significant over a year after the tax was implemented. In addition to large reductions in the likelihood of consumers using any disposable bags, this study also found significant reductions in the number of disposable bags used per consumer ($p<0.1$). Together, these observed effects provide strong evidence that a small bag tax can have a large and persistent impact on consumer behavior.

While this report provides strong evidence that the bag tax had a large impact at our sample stores in Chicago, there are some important limitations to the study. The study includes data from a small number of stores that are not necessarily representative of all stores in Chicago as a whole. While the sample includes stores in both high- and low-income neighborhoods, there may be other unobserved characteristics of these stores that make the sample unique. Additionally, the sample includes only large grocery stores, while the tax applies to all grocery and retail stores. These limitations make it difficult to extrapolate the results found here to overall disposable and reusable bag use in Chicago.

Nonetheless, this evaluation contributes to the growing literature of evidence-based research on the effectiveness of disposable bag regulations. In commissioning this study, the City of Chicago has been proactive in determining the extent and magnitude of the effects of its policies on its consumers. Moreover, the study provides information that can assist other municipalities in making decisions about the use of different policy tools aimed at decreasing disposable bag use.

Table 1: Observed Bag Use for Chicago and Suburban Stores in Pre-Period

	CHICAGO	SUBURBS
Proportion using any disposable bags	82.0%	91.0%
Proportion using any reusable bags	13.2%	6.0%
Proportion using no bags	7.8%	5.0%
Number of disposable bags used per consumer	2.3	3.4
Number of reusable bags used per consumer	0.2	0.1

Table 2: Effect of Bag Tax on Various Measures of Bag Use from November 2016 to March 2018

	Likelihood of Use			Number of Bags Used per Consumer	
VARIABLES	**(1) DISPOSABLE**	**(2) REUSABLE**	**(3) NO BAG**	**(4) DISPOSABLE**	**(5) REUSABLE**
ChicagoxPost	-0.277*** (0.018)	0.155*** (0.021)	0.126*** (0.020)	-0.513* (0.238)	0.250*** (0.051)
Post	-0.037** (0.013)	0.025** (0.010)	0.011 (0.008)	-0.595*** (0.163)	0.081*** (0.025)
Control Mean	0.896	0.070	0.056	3.133	0.130
Observations	24,499	24,499	24,499	24,499	24,499

Standard errors clustered at the store level in parentheses.

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

Columns (1), (2), and (3) indicate the change in the likelihood of bag use by type of bag.

Columns (4) and (5) indicate the change in the number of bags used per consumer by type of bag.

All columns include demographic and time of day controls, as well as store and RA fixed effects.

Table 3: Effect of Bag Tax on Various Measures of Bag Use in Four Follow-Up Periods

	Likelihood of Use			Number of Bags Used per Consumer	
	(1) DISPOSABLE	(2) REUSABLE	(3) NO BAG	(4) DISPOSABLE	(5) REUSABLE
Feb-Mar 2017	-0.330***	0.186***	0.148***	-0.969***	0.330***
	(0.030)	(0.024)	(0.024)	(0.236)	(0.066)
Observations	12,216	12,216	12,216	12,216	12,216
May 2017	-0.303***	0.200***	0.119***	-0.438	0.336***
	(0.023)	(0.019)	(0.031)	(0.218)	(0.054)
	10,139	10,139	10,139	10,139	10,139
Oct-Nov 2017	**-0.251*** **	**0.119*** **	0.126***	**-0.153**	**0.148** **
	(0.025)	(0.030)	(0.015)	(0.335)	(0.061)
	12,252	12,252	12,252	12,252	12,252
Jan-Mar 2018	**-0.239*** **	0.155***	**0.098** **	**-0.187**	0.245***
	(0.022)	(0.025)	(0.027)	(0.200)	(0.056)
	14,150	14,150	14,150	14,150	14,150
Full Data	-0.277***	0.155***	0.126***	-0.513*	0.250***
	(0.018)	(0.021)	(0.020)	(0.238)	(0.051)
	24,499	24,499	24,499	24,499	24,499

Standard errors clustered at the store level in parentheses.

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

Columns (1), (2), and (3) indicate the change in the likelihood of bag use by type of bag.

Columns (4) and (5) indicate the change in the number of bags used per consumer by type of bag.

Bolded cells denote a statistically significant difference (p<0.05) from Feb-Mar 2017. All columns include demographic and time of day controls, as well as store and RA fixed effects.

Table 4: Effect of Bag Tax on Any Disposable Bag Use by Neighborhood Income

	Likelihood of Use			Number of Bags Used per Consumer	
VARIABLES	(1) DISPOSABLE	(2) REUSABLE	(3) NO BAG	(4) DISPOSABLE	(5) REUSABLE
ChicagoxPostxLow-Income	-0.023	-0.043	0.082**	-0.510	-0.111
	(0.033)	(0.036)	(0.028)	(0.365)	(0.089)
ChicagoxPost	-0.266***	0.177***	0.086***	-0.276	0.305***
	(0.014)	(0.024)	(0.011)	(0.249)	(0.067)
Post	-0.034**	0.014	0.017**	-0.560**	0.057***
	(0.011)	(0.008)	(0.007)	(0.213)	(0.017)
PostxLow-Income	-0.006	0.022**	-0.013**	-0.054	0.049*
	(0.012)	(0.009)	(0.005)	(0.311)	(0.026)
Control Mean	0.896	0.070	0.056	3.133	0.130
Observations	24,499	24,499	24,499	24,499	24,499

Standard errors clustered at the store level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Columns (1), (2), and (3) indicate the change in the likelihood of bag use by type of bag.
Columns (4) and (5) indicate the change in the number of bags used per consumer by type of bag.
All columns include demographic and time of day controls, as well as store and RA fixed effects.

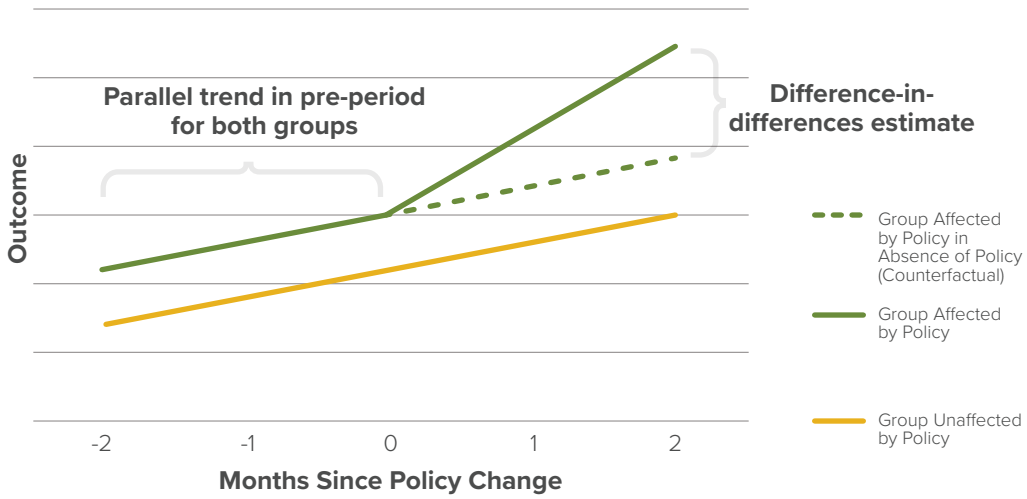
Neighborhoods are categorized as high income if they are above the median ZIP code level household income of $65,744, and low income if they are below the median.

Appendix

Study Design

The following figure presents a graphical representation of the difference-in-differences methodology used in this study. This methodology compares behaviors of a "treatment" group that is affected by a policy (green) to a "control" group that is unaffected by the policy (blue), before and after the implementation of that policy. The key identifying assumption is that trends in behavior across the two groups would have been the same were it not for the implementation of the policy. In the graph, this means that behavior in the treatment group would have followed the dashed line in the absence of the policy. Therefore, any differences between the dashed line (the assumption) and the solid line (the observed behavior) can be attributed to the policy.

Figure A1: Difference-in-Differences Methodology



Sample Selection

Our sample consists of a set of "treatment" stores located in the city of Chicago that were subject to the tax starting in February 2017 and a set of "control" stores in the neighboring suburbs that are not subject to the tax. In order for our control stores to provide a reasonable counterfactual for consumer behavior in the absence of the tax, we took several steps to ensure comparability of the two sets of stores. First, we decided to include only large chain stores, focusing on chains with locations in both Chicago and its suburbs since stores of the same chain are more likely to have similar policies

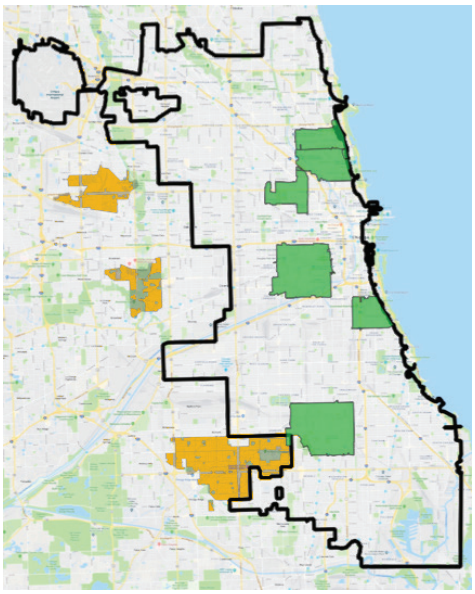
and types of shoppers. Second, we selected control stores located in neighborhoods with similar demographics to our Chicago stores, since bag use may differ by socio-demographics. Specifically, we matched our treatment and control stores based on ZIP code-level measures of race and income. In addition to matching demographics for Chicago and suburban stores, we made an effort to select stores with geographic and demographic variation within Chicago so as to be representative of the city as a whole (see **Table A1**). Third, Chicago stores were chosen to avoid close proximity to subway lines, since suburban consumers are more likely to drive their cars to the grocery store than use public transportation. Lastly, while Chicago's disposable bag tax applies to all retailers, we focus only on bag use in grocery stores since these purchases are more likely to be a repeated, stable behavior, whereas clothing or department store purchases may be more variable.

After dropping one of our original sample stores due to the store's closure between May 2017 and October 2017, our final sample consisted of twelve stores across three different chains.[ii] Four of the stores were control stores in Chicago suburbs and eight were treatment stores within Chicago city bounds. See **Figure A2** for a map of store locations.

Table A1: ZIP Code-Level Demographics in Sample

	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Percent White	0.9	88.9	61.0	34.2
Percent Black	3.5	99.0	26.6	37.7
Percent Hispanic	0.9	69.5	21.1	23.6
Median Income	$25,343	$88,256	$57,005	$21,373

Figure A2: Map of ZIP Codes Included in Sample



The black outline represents Chicago city limits.

Green areas represent Chicago ZIP codes included in the study.

Yellow areas represent suburban ZIP codes included in the study.

[ii] An additional seven stores from an original sample of 20 stores were removed before data collection, as research activities were not possible in these locations.

Data Collection

Data used in this study were collected in-person by research assistants at each sample store location. Research assistants visited the grocery stores and recorded the number and type of bags used as consumers were checking out and leaving the store. Specifically, they recorded the number of reusable and disposable bags used by each consumer, as well as whether a consumer used no bags at all. Additionally, they recorded each consumer's observable demographic characteristics, including race and gender.

Data collection was limited to 100 observations or 40 minutes per visit, with an average of 54 visits per period, and occurred during the daytime (10am to 4:30pm) or evening (4:30pm to 8pm) hours. Data were collected Monday through Thursday from 10am to 8pm and Fridays from 10am to 3pm. We chose not to visit stores on Friday evenings or weekends, as shopping behavior may differ between weekdays and weekends, with more variability on weekends.

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