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Spillover Effects of Grocery Bag Legislation: Evidence of Bag Bans and Bag Fees

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Abstract

We investigate the unintended consequences of carryout grocery bag (CGB) regulations by looking at the impact on sales of alternative plastic bag products. We extend the literature by studying two types of CGB regulations, bag bans and bag fees. Using retail scanner data and employing a general synthetic control method, we find that both types of CGB regulations are associated with significantly higher plastic trash bag sales. We estimate that CGB regulations lead to an average increase in purchased plastics of 127 pounds per store per month, ranging from 30 to 135 (37–224) pounds for 4-gallon (8-gallon) trash bags. These results confirm previous findings on bag bans and provide new evidence on bag fees. In general, the effects do not differ across CGB regulations, but some heterogeneity exists. Our results highlight unintentional spillover effects of narrowly targeted policies on other unregulated waste.

Keywords Carryout grocery bag regulations · Scanner data · General synthetic control model · Unintentional policy effect

1 Introduction

Plastic use and associated contamination are increasingly a concern for the public and policy makers. For example, there is now widespread attention to marine plastic pollution that can lead to about 90% of Asia and the Pacific's coral reefs dead by 2050 (Asian Development Bank 2019). Without immediate action, many fear that plastic waste will lead to the deterioration of oceans and declining fish stocks, which would threaten food security, the global economy and the livelihoods of millions. As a result, efforts to reduce plastic waste generation and address ocean debris have grabbed the international spotlight (Thompson et al. 2004).

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Regulations on the use of carryout grocery bags (CGB) have been emerging around the world (Clapp and Swanston 2009). For example, Ireland has introduced a 15 Euro cent tax on plastic CGBs since 2002 (Convery et al. 2007). Taiwan regulated free plastic CGBs in 2002 and extended to ban single-use plastic straws in 2019 (Taiwan Environmental Protection Administration 2019). South Africa has enacted legislation on plastic CGBs in 2003 (Dikgang et al. 2012). Wales in the United Kingdom also has introduced a charge for single-use CGBs in 2011. In the U.S., regulations on CGBs can be classified into two ways: bans for plastic CGBs, and fees for plastic and/or paper CGBs. California became the first state to enact legislation imposing a statewide ban on single-use plastic CGBs at large retail stores in August 2014.[1]

Several previous studies investigate the effect of imposing a bag tax/levy for plastic bags on plastic bag use and environmental attitudes. Convery et al. (2007) conduct interviews with households and leaders of the retail sector in Ireland. They show that the introduction of a plastic bag levy (€ 0.15 per bag) significantly reduced the usage of plastic bags, and the associated administration costs are about 3% of annual revenues from the plastic bag levy (€ 12–14 million). Poortinga et al. (2013) study environmental attitude change and behavioral spillover effects in Wales by conducting telephone interviews before and after the implementation of a single-use carrier bag charge. Their quasi-experimental results suggest that increases in the use of a reusable bag in Wales (the treated area) are much higher than in England (the control group). The Welsh population shows more supportive attitudes after the implementation of the policy. Thomas et al. (2016) also study the spillover effect of behavioral attitude caused by the single-use CGB charge in Wales. They use face-to-face survey data with longer periods across Wales (treated), England (controlled), and Scotland (controlled). The results show that the single-use CGB charge effectively promotes the use of reusable bags in Wales, but positive behavioral spillover effects are not detected in England and Scotland. Martinho et al. (2017) conduct face-to-face surveys before and after the implementation of a plastic bag tax in Portugal. Their results show a 74% reduction in lightweight disposable plastic bag consumption and a 61% increase in the usage of reusable bags. They also find that distance to the coast, which links to a perception of marine litter, has a weak influence on the acceptability of policy and environmental identity.

In addition to imposing bag fees, there are other ways to regulate single-use plastic CGBs. Homonoff (2018) examines the relative effects of a tax on disposable CGB use and a reward for reusable bag use. She finds that a $0.05 tax on disposable CGBs decreases CGB use by over 40 percent, while a reward generates virtually no effect on behavior. Taylor and Villas-Boas (2016) study the effect of plastic CGB bans and bag fees for paper bags on disposable CGBs (including plastic and paper bags) and reusable bag demand. Their result shows that both policies lead to a significant increase in reusable bag usage, but bag bans cause remarkably increases in paper bag demand.

Additionally, the welfare gains of CGB policies are likely overstated if policy makers ignore a long-term policy effect, potential increases in unregulated plastic bag consumption, and non-monetary costs (e.g., time costs). Dikgang et al. (2012) use retailer data to examine the effectiveness of a plastic bag levy in South Africa. They find that the levy only succeeded in curbing usage of plastic bags in the short-run. In the long-term, their result suggests that the effectiveness of the plastic bag levy is diminishing due to an inelasticity

[1] According to the National Conference of State Legislatures. http://www.ncsl.org/research/environment-and-natural-resources/plastic-bag-legislation.aspx. Accessed October 25, 2019.

of using plastic bags. Taylor (2019) shows that the banning of plastic CGBs leads to a 50 million pounds decrease in plastic CGBs, but a 12-million-pound increase in trash bag purchases. Taylor (2020) also finds that grocery bag policies increase supermarket checkout duration and transaction duration by 3% and 10%, respectively, driven by purchases of paper bags. The associated result further suggests that a 1-min increase in average transaction duration leads to a 1.2% decrease in the likelihood a customer returns to a store in subsequent weeks.

As there are different CGB policies, their effect on actual plastic reductions and retail business may vary. Hence, the objective of this study is to investigate the impact of different CGB regulations on sales of alternative plastic bag products and generating plastic weights. The regulations considered in this study include bans on grocery carryout plastic bags and various fees for CGBs. We estimate the effect of these policies on purchases of different types of trash bag products, which have been found to be alternative plastic bag products to CGBs (Taylor 2019).

To the extent that CGBs and purchased trash bags are substitutes, economic theory would suggest that the effect of a fee policy could be quite different from that of a ban; while a fee on CGBs increases the price (e.g., from 0 to 5¢ per bag), a ban effectively raises that price to infinity. When we estimate the effect of the two policies on trash bag purchases, however, we find no statistically significant difference for most bag types but a mixed result in some cases. We also estimate the increase in the weight of the plastic in the trash bags purchased due to the regulations and compare that increase to the plastic in the CGBs that are not used. Methodologically, we contribute to this literature by using a synthetic control approach, which offers more robust counterfactual series that can be used to estimate the causal effect of the policies (Abadie 2021; Arkhangelsky et al. 2019; Athey and Imbens 2017). This study confirms the results from a previous California study (Taylor 2019), which uses the same scanner data but different methods. Our analysis extends further to bag fee policies in Washington D.C. and Maryland, which are distinct from Californian CGB policies.

2 The Scope of the Study and Data

2.1 Selections of Study Areas

This study selects counties that implemented bag fee policies before 2014 due to data availability. Instead of focusing on city-wide policies, this paper uses county-level data, which can provide more observations than a smaller scope of study areas. Moreover, Nielsen retailer scanner data is available at 3-digit zip code level, Thus, it would be difficult to identify the policy effect at a granular jurisdiction level. Based on these selection criteria, the interest of areas includes Washington D.C., Montgomery County (MD), San Luis Obispo County (CA), and Santa Clara County (CA). Figure 1 presents a geographical illustration of the study areas. Washington D.C. and Montgomery County imposed $0.05 for paper bags and plastic bags on January 1, 2010, and January 1, 2012, respectively. San Luis Obispo County implemented bag bans on plastic bags and imposed $0.1 for paper bags on October 1, 2012. Santa Clara County also implemented a bag ban on plastic bags but charged $0.15 for paper bags on January 1, 2012. Table 1 summarizes the types of CGB policies and the effective date of each study area.

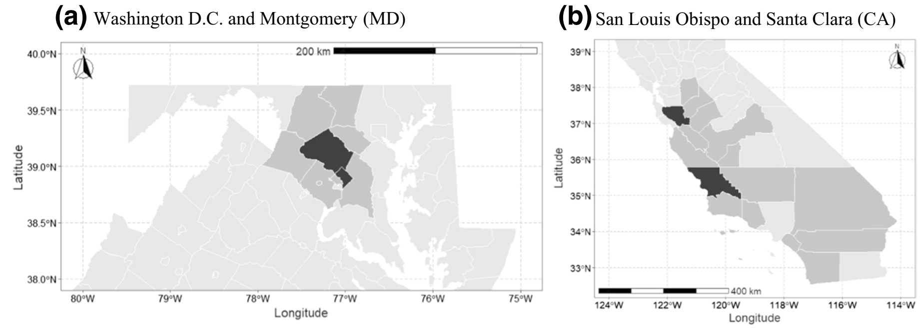

Fig. 1 Geographical illustration of study areas. *Note* Black areas represent the treated counties; dark gray areas represent the control counties. In Panel a, treated counties are Montgomery (black area in the west) and Washington D.C. (black area in the east); adjacent control counties are Arlington, Carroll, Fairfax, Frederick, Howard, Loudoun, and Prince George's. In Panel b, the treated county is San Louis Obispo (black area in the south) and Santa Clara (black area in the north); adjacent control counties are Fresno, Kern, Kings, Merced, Monterey, Orange, San Benito, Santa Barbara, San Joaquin, Stanislaus, Riverside, and Ventura. Two sets of the control counties from the above two panels are used as the donor pool for constructing synthetic controls

Note that San Luis Obispo City within San Luis Obispo County implemented city-wide CGB legislation on April 20, 2012, a few months before the county-wide CGB regulation took place in San Luis Obispo County. Similarly, Palo Alto, which is a small city within Santa Clara County, implemented a policy in 2009, whereas other cities in Santa Clara County did not implement policies until 2012. Los Angeles County has also implemented its county-wide CGB legislation since January 1, 2014. Nevertheless, several cities within Los Angeles implemented city-wide CGB regulations in multiple distinct timings before the implementation of the county-wide grocery bag legislation, such as Malibu (May 1, 2009), Calabasas (July 1, 2011), Long Beach (August 1, 2011), Santa Monica (September 1, 2011), and Pasadena (July 1, 2012). Thus, this paper does not study the county-wide CGB policy in Los Angeles County.

We use a selection of counties that have not implemented CGB regulations in California, Maryland, and part of Virginia to create a synthetic controlled county for the interest of jurisdictions (i.e., San Luis Obispo County, Santa Clara County, Washington D.C., and Montgomery County). Those candidate control counties include Arlington, Carroll, Fairfax, Frederick, Howard, Loudoun, Prince George's, Fresno, Kern, Kings, Merced, Monterey, Santa Barbara, Orange, Riverside, San Bernardino, San Diego, San Benito, San Joaquin, Stanislaus, and Ventura.

2.2 Description of Data

This study uses Nielsen retail scanner data set, including around 35,000 participating grocery, drug, mass merchandisers, and other stores from 2006 to 2014. The data set provides store information (e.g., retailer codes, store type, and 3-digit zip code) and product information (e.g., price, quantity sold, and product type) at sampling stores. Our goal is to study the unintentional effect of CGB regulations on the sales of trash bag products. We study four different sizes of trash bags in this study: 4 gallon, 8 gallon, 13 gallon, and above 13 gallon.

Table 1 Summary statistics and respective policy information for each county of interest

	Washington D.C	Montgomery county (MD)	San Luis Obispo county (CA)	Santa Clara county (CA)	All sample counties
Policy type	5¢ for paper and plastic CGBs	5¢ for paper and plastic CGBs	10¢ for paper bags + Ban on plastic CGBs	15¢ for paper bags + Ban on plastic CGBs	
Effective date	January 1, 2010	January 1, 2012	October 1, 2012	January 1, 2012	
Adjusted gross income (1000 USD per capita)	38.322	46.569	27.278	52.664	29,060
	(5.325)	(4.985)	(2.425)	(8.403)	(11,938)
Population density (100 ppl/mile^2)	8.969	1.953	0.076	1.406	1388
	(0.340)	(0.054)	(0.001)	(0.032)	(2348.5)
Counts of bags, 4 gal (counts/store)	8680	13,696	5860	22,392	7393
	(6692)	(5659)	(3802)	(7794)	(5018)
Price, 4 gal (USD/bag)	0.062	0.067	0.070	0.059	0.061
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Counts of bags, 8 gal (counts/store)	13,811	8563	3564	11,798	4912
	(10,525)	(2975)	(1235)	(3685)	(4064)
Price, 8 gal (USD/bag)	0.108	0.089	0.084	0.090	0.082
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Counts of bags, 13 gal (counts/store)	14,467	14,113	5616	7953	8761
	(2078)	(2394)	(910)	(1226)	(4101)
Price, 13 gal (USD/bag)	0.169	0.169	0.176	0.167	0.165
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Counts of bags, > 13 gal (counts/store)	4005	3391	1280	1348	2134
	(683)	(618.35)	(300.86)	(337.83)	(1345)
Price, > 13 gal (USD/bag)	0.269	0.274	0.286	0.287	0.267
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations (months × counties)	67	81	61	65	2275

The summary statistics shown in the upper part of the table are mean and standard deviation (in parentheses). First four columns present statistics for four treated counties, and the last column presents statistics for all treated and 21 control counties. For the reference, U.S. average adjusted gross income per capita in 2010 is $56,255 (Internal Revenue Service 2021), and the average population density is 87.4 population/mile^2 in 2010 (U.S. Census Bureau 2021)

In addition to scanner data, the effective dates of regulatory policies of plastic bags in different regions of the U.S. were collected from the National Conference of State Legislatures[2] and (Bag the Ban 2019). This study also uses county-level adjusted gross income data from the Internal Revenue Service and population density data from U.S. Census Bureau. To use the retailer scanner data and the above county feature data together, store-level scanner data is aggregated to the county-level. All data are aggregated to the county level and presented in terms of totals per store, resulting in a data set with monthly observations from January 2006 to December 2014. Since the number of stores in the scanner data varies in each study area over time, we use bag sales measured as "count per store" as our dependent variable in order to alleviate changes in total sales induced by changing the number of sample stores over the study period. Summary statistics of the variables are presented in Table 1.

3 Methods

This study applies a generalized synthetic control method (Arkhangelsky et al. 2019; Xu 2017) to estimate changes in the sales of different types of trash bags with the retail scanner and census data. The generalized synthetic control model extends the conventional synthetic control model (Abadie et al. 2010; Abadie and Gardeazabal 2003) by adding interactive fixed effects (Bai 2009) and can be expressed:

$$Y_{it} = \delta_{it} D_{it} + X_{it}^{\prime} \beta + \theta_i + \lambda_t + u_{it}, \tag{1}$$

where Y_{it} is log of the bags (of various sizes) sold per store in county i in month t; D_{it} equals 1 if county i has been exposed to the treatment prior to time t and equals 0 otherwise; δ_{it} is the average treatment effect on county i in month t; X_{it} is a set of controls for county i in month t (unit price, income, and population density); θ_i and λ_t represent fixed effects for each county and month of the year, controling for unobserved geographical and seasonal factors; and u_{it} is an idiosyncratic error term. The unit of the price variable is $/bag. Income is adjusted gross income in each county measured in U.S. dollars. Population density is in people/sq. mile.

To estimate and compare the effects of distinct CGB regulations on trash bag sales, the impact on sales of four trash bag types is estimated separately in four treated counties (i.e., San Luis Obispo County, Santa Clara County, Washington D.C., and Montgomery County). Hence, sixteen (4 types of trash bags ×4 treated counties) generalized synthetic control estimations are conducted. The estimation is conducted in Statistical Software R using the *gsynth* package (Xu 2017). Note that scanner data is pseudo-panel data in which not every store participates in Neilsen's survey every period. With store-level data, the synthetic control model needs to address the sparsity induced by unbalanced panel data, and it is more computationally difficult to find the optimal weight to form the convex combination of untreated units, leading to a consequence of the curse of dimensionality (Abadie 2021). Thus, this study uses the average store-level data at the county level, yielding a full panel dataset so we can apply the synthetic control model for analyzing the county-level policy effects. Counties that have not implemented CGB regulations in California,

[2] National Conference of State Legislatures, http://www.ncsl.org/research/environment-and-natural-resources/plastic-bag-legislation.aspx. Accessed October 25, 2019.

Maryland, and Virginia mentioned in Sect. 2.1 are used for creating a synthetic controlled county for each of the treated counties. Note that since the City of San Luis Obispo within San Luis Obispo County implemented city-wide CGB legislation on April 20, 2012 before the county-wide CGB regulation on October 1, 2012, the treated time for the analysis of San Luis Obispo County is set to April, 2012 to avoid a potential concern of an Ashenfelter dip (Ashenfelter 1978).

4 Empirical Results

4.1 Overview Synthetic Control Estimations

Figures 2 and 3 present differences in the estimated policy effect on sales between the treated counties and synthetic control countries for each type of trash bag. The solid black lines represent a difference in trash bag sales per store/month between a treated county and synthetic control. The area shaded in grey indicates a 95% confidence interval constructed by bootstrapped standard errors. The vertical black dashed lines indicate policy effective months in Washington D.C. (January 2010), Montgomery (January 2012), San Louis Obispo (April 2012), and Santa Clara (January 2012). The time variable of the x-axis is rescaled to the months during which the CGB legislation took place.[3] Specifically, 0 indicates the month the policy was implemented, 1 indicates one month after implementation, and − 1 indicates one month before implementation.

Figure 2a–h show that there are noticeable increases in sales of 4 and 8 gallon trash bags between each treated county and synthetic control county immediately after the implementation of the CGB legislation in the study areas. It is plausible that consumers may treat disposable CGBs as substitutes for small purchased bags, but this seems unlikely for large bags. Hence, to test the robustness of our results, in Fig. 3a–h we carry out the same analysis for 13 and above 13 gallon trash bags, and here we find no similar effect. These results suggest that the CGB legislation had a causal effect on the purchase of smaller plastic bags, compared to areas in which there was no bag legislation, sales of 4 and 8 gallon trash bags increased in the treated areas immediately after the implementation of the policies and that effect has persisted and even grown in some counties.

Overall, differences in sales only increase in 4 and 8 gallon trash bags during the post-treatment period, and the differences in sales of all types of trash bags are near zero in the pre-treatment period across different study areas, implying that in the absence of the CGB regulations, the constructed synthetic controls are as similar as the treated counties. However, note that the estimation for 8 gallon trash bags in Washington D.C. appears to have some deviations from zero during the pre-treatment period, indicating that a group of control counties cannot well construct a synthetic Washington D.C. for the 8 gallon trash model, resulting in a larger variation of the estimated effect in the post-treatment period.

[3] Following Abadie (2021) we use all observations that are available for the post-treatment period. This results in different pre- and post-treatment lengths across the different programs. In "Appendix B" we present all results (figures and tables) for equivalent analysis in which we restrict the sample so that the post-treatment periods are equivalent across programs, this results in a substantially smaller data set for some jurisdictions. While qualitatively the effects are similar to our base analysis, the statistical significance is diminished.

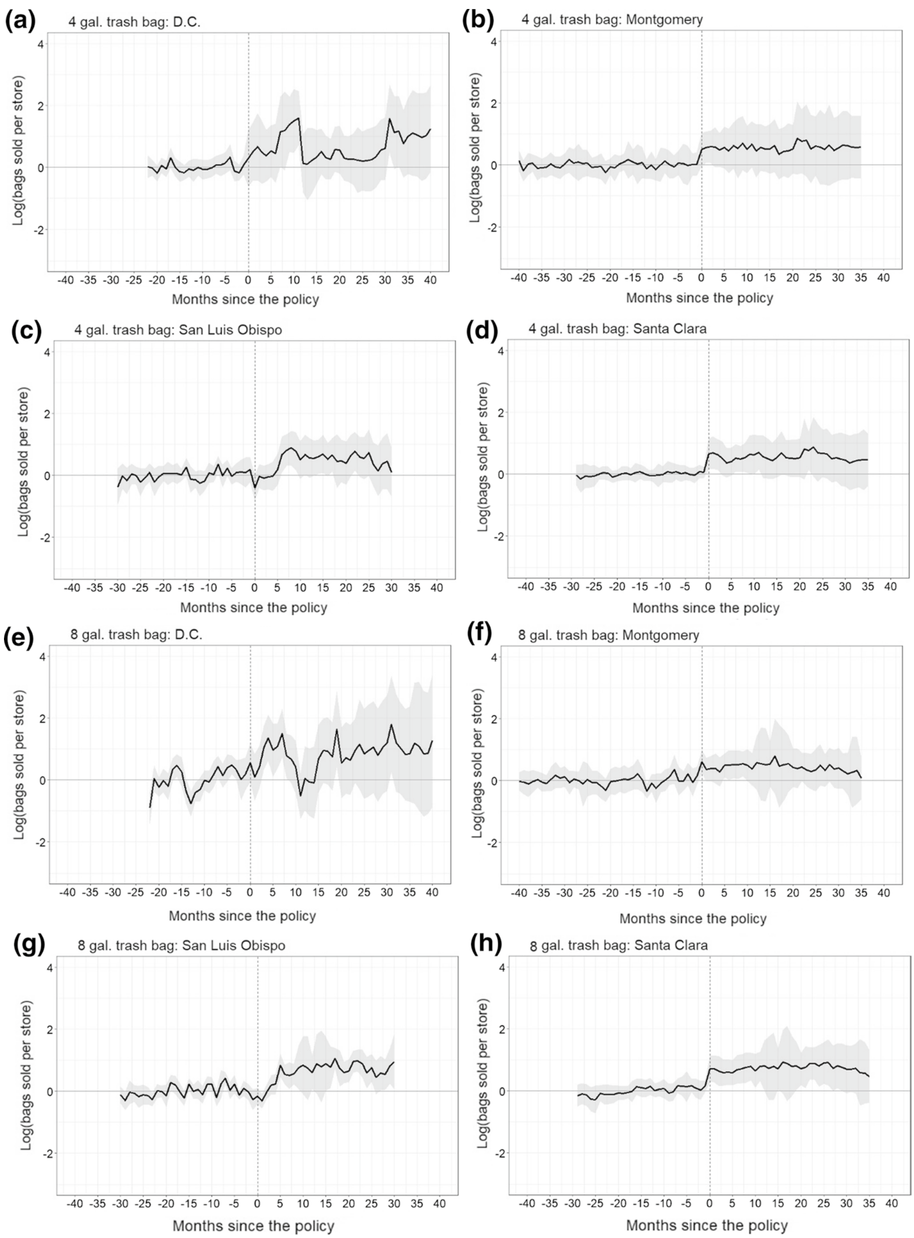

Fig. 2 Policy effect on 4 and 8 gallon trash bag sales. *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 4 and 8 gallon trash bags increase in each study area due to the implementation of the CGB regulations

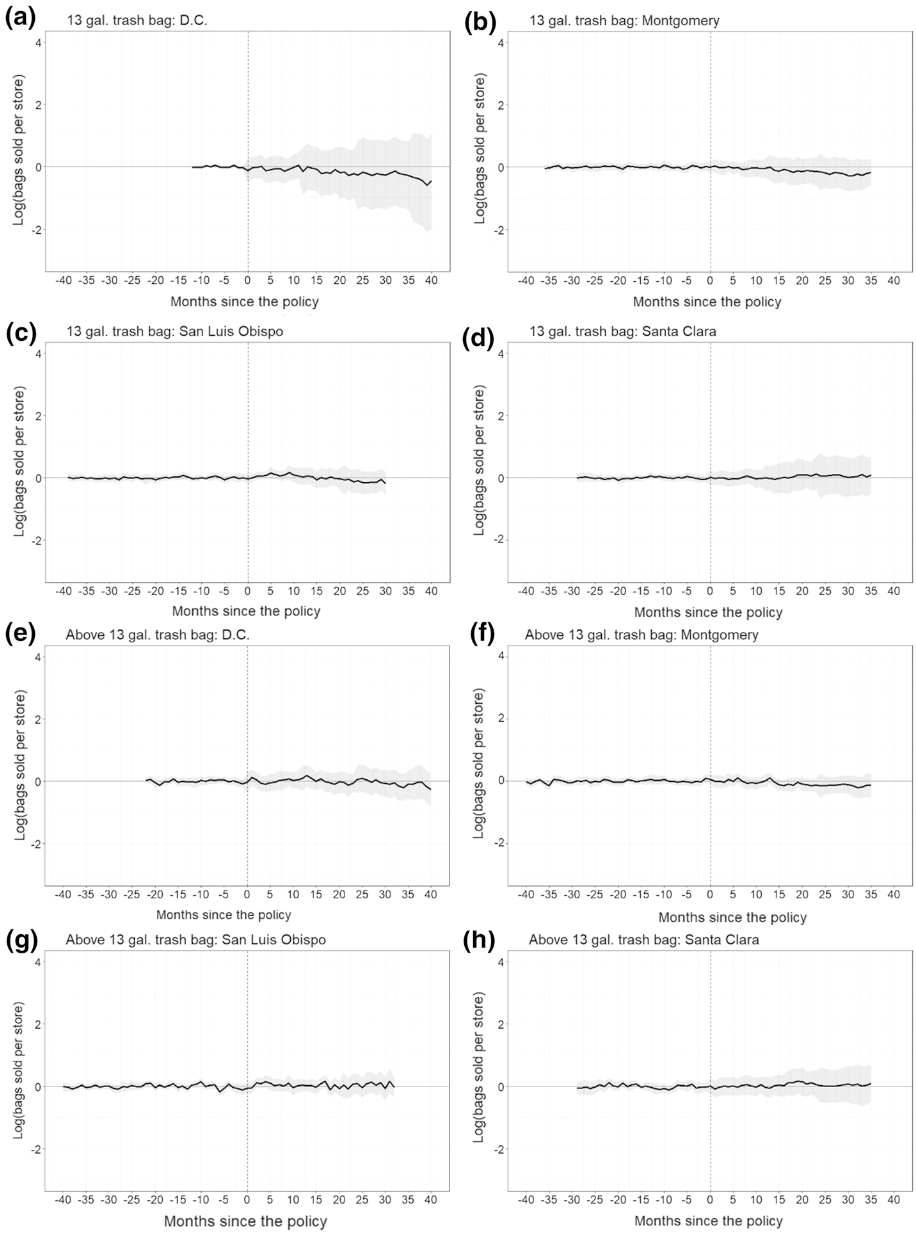

Fig. 3 Policy effect on 13 and above 13 gallon trash bag sales. *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 13 and above 13 gallon trash bags are not significantly affected by the implementation of the CGB regulations

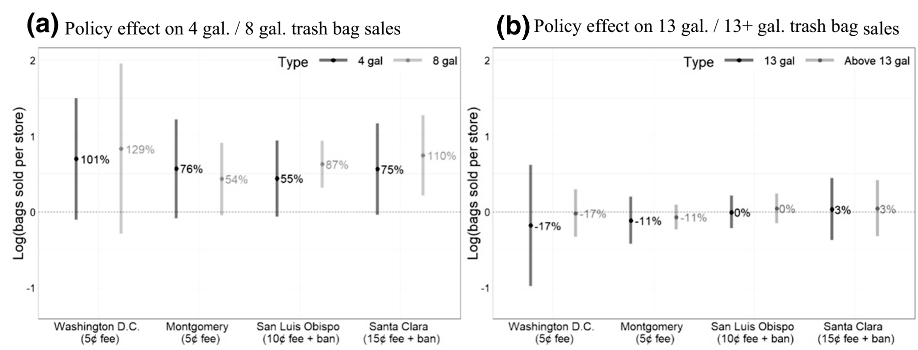

Fig. 4 Effect of the CGB regulations on trash bag sales. *Note* The average policy effects on trash bag sales are estimated by Eq. (1). The length of error bars indicates a 95% confidence interval produced by bootstrapped standard errors with the and estimated by Eq. (1). The vertical axis indicates the average treatment effect on treated over time, measured in the log of bags sold per store. Panel a. shows that the sales of 4 gallon trash bags significantly increase in Washington D.C., Montgomery County, San Luis Obispo County, and Santa Clara County by 101%, 76%, 55%, and 75%, respectively. The sales of 8 gallon trash bags significantly increase in Washington D.C., Montgomery County, San Luis Obispo County, and Santa Clara County by 129%, 54%, 87%, and 110%, respectively. On the other hand, Panel b. shows that there are no similar increases in the sales of 13 gallon or above trash bags

4.2 Effects of the CGB Legislation from Regulated Bags to Unregulated Bags

Figure 4 shows the average causal impact of the CGB regulations on trash bag sales using the general synthetic control model. Since the original estimation unit in Figs. 2 and 3 is in a log form, the log of the number bags sold per store in each treated county is further converted in a change rate by calculating $\left[exp(\delta_{it}) - 1\right] \times 100$, where δ_{it} is the average treatment effect as denoted in Eq. (1). Figure 4a shows that CGB regulations lead to an average increase in sales of 4 gallon trash bags by 101% in Washington D.C., 76% in Montgomery County, 55% in San Luis Obispo County, and 75% in Santa Clara County. Similarly, the regulations increase 8 gallon trash bag purchases by 54–129%. In contrast, Fig. 4b shows no statistically significant effect of the regulations on the sales of larger bags. This finding clearly indicates that the CGB regulations have an unintended effect on purchases of smaller trash bags, for which the free CGBs were probably reasonably good substitutes. The fact that we find no effect for larger bags strengthens our conclusion since there would be little logical reason for large bags to be affected by the CGB regulations.

4.3 Test for Price Endogeneity

Economic theory would suggest that CGB regulations may lead to an increase in trash bag prices induced by rising trash bag sales due to the CGB policies. If the policy effect on trash bag prices is statistically significant, then the estimated treatment effect in Sect. 4.2 would be an underestimated. To examine this possible policy effect on trash bag prices, we conducted the same synthetic control model but switched the price variable and bag sale variable (i.e., price becomes the dependent variable, and bag sale becomes one of the independent variables in Eq. (1).

The estimated policy effects on unit prices are presented in Fig. 5a (4 and 8 gallon bags) and Fig. 5b (13 and 13+ gallon bags). No statistically significant effects on bag prices are found. Hence, we conclude that the prices of garbage bags in treated areas were not

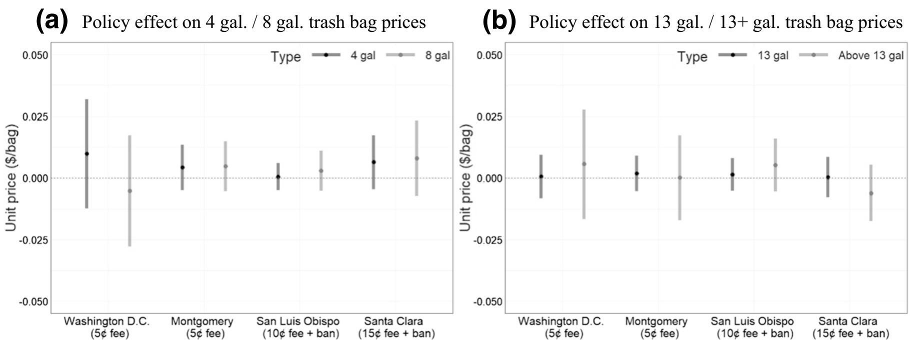

Fig. 5 Test for price endogeneity. *Note* The average policy effects on trash bag prices are estimated by Eq. (1) with unit prices as the dependent variable and sales as the independent variable. The length of error bars indicates a 95% confidence interval produced by bootstrapped standard errors. The result shows that the policy does not have a significant effect on trash bag prices for all types of trash bags in each study area

affected by the CGB policies given the selected study period and therefore, the estimated treatment effects on bag purchase in Sect. 4.2 were not diminished by the demand response. Nevertheless, note that it is advisable to have sufficient pre-/post-intervention information to ensure the credibility of a synthetic control estimator (Abadie 2021), so the estimation result may not be robust to a shorter length of study periods ("Appendix B").

4.4 Test of Equality for Policy Effects

As shown in Fig. 4a, there is substantial overlap in 95% confidence intervals for the average treatment effects in all four treated study area. To examine whether or not distinct types of CGB regulations lead to statistically different increases in 4 and 8 gallon trash bag sales, this subsection presents tests of equality for the treatment effect estimated in Sects. 4.1 and 4.2. We conducted the test of equality following the below procedure:

> *Step 1* we first performed a Shapiro–Wilk normality test for the estimated treatment effect over the post-treatment period across the four study areas. The test results suggest that the study areas show a deviation from the theoretical normal distribution, implying the resulting monthly treatment effects are not normally distributed.
> *Step 2* since most of the study areas show a deviation from the theoretical normal distribution, we applied a pairwise Mann–Whitney–Wilcoxon nonparametric test for examining whether a difference in policy effects on bag sales is statistically significant between a treated county and synthetic control within selected post-period durations. To have reliable statistical inference results, we chose to compare treatment effects between areas with the bag fee policies and with bag fee + bag ban policies within 24 and 30 months of the post-period to ensure a sufficient sample size to carry out the pairwise two-sample Mann–Whitney–Wilcoxon test. The null hypothesis for testing two independent sample means can express as $H_0 : \mu_{(fee)} - \mu_{(fee+ban)} = 0$.

The test results are presented as 95% nonparametric confidence intervals in Fig. 6a and show that mean differences in 4 gallon trash bag sales are not statistically different between the bag fee policies and bag fee + bag ban policies. On the other hand, there is a marginally significant difference in mean 8 gallon trash bag sales between the bag fee policies and bag

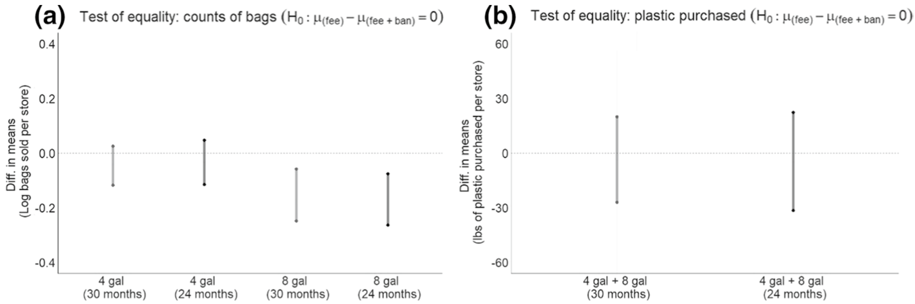

Fig. 6 Test of equality for policy effects in different study areas. *Note* The intervals are 95% nonparametric confidence intervals were estimated using pairwise two-sample Mann–Whitney–Wilcoxon test. The null hypothesis is that there is no difference in bag sales and plastic purchased between the bag fee policies ($\mu_{(fee)}$) and the bag fee + ban policies ($\mu_{(fee+ban)}$)

fee + bag ban policies. Nevertheless, when we combined both 4 gallon and 8 gallon and examined the impact of the policy types on the total plastic purchased, the test result indicates an insignificant difference in means between the bag fee policies and bag fee + bag ban policies (Fig. 6b)..

5 Discussion

5.1 Revisit Taylor (2019)

This study validates and extends the work of Taylor (2019), with different methods and additional policy types. Specifically, for the study scope and data, Taylor (2019) uses Nielsen retail scanner data from 2007 through 2015 to investigate CGB policies effect on sales of 4, 8, and 13 gal trash bags in 139 Californian cities and counties along with observational data at checkout while this paper also uses Nielsen retail scanner data but focuses on jurisdictions in Washington D.C., Maryland, and California from 2006 to 2014 in order to study different types of CGB policies. Both papers use California policies to study bag bans and both use San Luis Obispo County. Taylor (2019) uses San Jose which is part of Santa Clara County used in this paper. Methodologically, Taylor (2019) investigates the policy effect on trash bag using event study methods while this paper uses the synthetic control method.

Taylor (2019) finds that CGB policies increase sales of 4, 8, and 13 gallon trash bags and by 120%, 64%, and 6%, respectively. We find that CGB policies in our Californian study areas lead to an increase in sales of 4 and 8 gallon trash bags by 55%–75% and 87%–110%, respectively (Table 2), but no significant effect on 13 gallon trash bags is found in this study. Although (Taylor 2019) finds CGB policies also affect the sale of 13 gallon trash bags, the effect size is relatively small. Because of the distinct study scopes and estimation methods used in the two studies, there are slight differences in results between both papers. Nevertheless, the two papers have the same key message: CGBs were substituted for similar sizes of trash bags before implementing the CGB regulations. After the regulations came into effect, consumers' plastic bag demand switch from regulated plastic bags (i.e., free plastic/paper CGBs) to unregulated plastic bags (i.e., plastic trash bags).

Table 2 Estimated effects of the CGB regulations

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
4 gal				
Baseline sales prior to the policy[1]	3817	10,942	5385	17,652
Avg. increase in sales[2]	7655 (3875, 11,435)	19,310 (10,837, 27,784)	8345 (5265, 11,424)	30,965 (18,485, 43,444)
Change in plastic[3]	38.77 (0.59, 76.95)	84.52 (− 1.07, 170.1)	29.89 (− 1.21, 61)	134.46 (8.42, 260.5)
8 gal				
Baseline sales prior to the policy[1]	3950	9497	2271	10,855
Avg. increase in sales[2]	9059 (3083, 15,034)	14,629 (9508, 19,750)	4243 (3471, 5016)	22,842 (16,247, 29,437)
Change in plastic[3]	95.53 (− 16.21, 207.27)	95.96 (0.2, 191.72)	36.88 (22.43, 51.32)	224.16 (100.83, 347.49)

[1] Baseline sales (count/store-month) prior to the policy is from the scanner data. [2] Average increase in sales (count/store-month) over the post-period is calculated by $[1] \times exp(\delta_{it})$, where δ_{it} is the average treatment effects (ATE) from Eq. (1). The detail ATE estimation results are presented in the Appendix. Values in the parentheses indicate 95% confidence intervals. [3] Increases in plastic (lb/store-month) is computed by $([2] - [1]) \times$ (plastic unit weight), which were collected from Taylor (2019) and are 0.0101 lb/bag and 0.0187 lb/bag for 4 and 8 gallon trash bags, respectively. Values in the parentheses indicate 95% confidence intervals

5.2 Policy Implications

The unintended growth in trash bag sales induced by the regulations can be further investigated in terms of actual plastic weight. The result shows that CGB legislation can increase plastic usage in the form of purchased 4 gallon trash bag sales of 30–135 pounds per store per month in each treated county, and an increase in plastic consumption through 8 gallon trash bag sales of 37–224 pounds per store in each treated county. Using the mid-point estimates,[4] this would imply that the regulation led to an average increase in purchased plastics of 127 pounds per store per month. Using an estimated weight of a disposable plastic CGB of 0.013 lbs per bag, this would mean that as long as the policies led to a reduction in CGBs of at least 9769 bags per store per month or about 326 bags per day, the policy has a net negative effect on plastic generated.

As seen in Sect. 4.4, the magnitude of the effect on sales of plastic trash bags does not vary much by type of grocery regulations; taxing plastic CGBs or banning them entirely leads to almost comparable levels of plastic leakage from CGBs to plastic trash bags. The fact that these effects are barely different is somewhat surprising. The fee per CGB in Washington D.C. and Montgomery County, MD, is 5¢ per bag, and in the two California counties, the ban on plastic bags is accompanied by a fee of 10 or 15¢ per paper bag. For comparison, the average price for purchased trash bags ranges from 6¢ per bag for the 4 gallon size to 9¢, 17¢, and 27¢ for larger sizes (Table 1). One might expect, therefore, that the effect on 4 gallon trash bags would be different across the counties—plastic CGBs are certainly better substitutes for 4 gallon bags than for the other sizes and, at 5¢ per bag, they are cheaper than trash bags.

There are several plausible reasons why consumers respond no differently to fees than to bans. First, trash bags and CGBs are clearly not identical in quality or size; if their costs are nearly the same, trash bags are probably the preferred product. Second, there is price salience and loss aversion—while consumers are accustomed to paying cost per box of 20–100 trash bags, they may experience regret or even anger when charged a fee for something that has always been free. Finally, any regulation, whether a fee or a ban, carries with it a message about what is societally appropriate behavior. Hence, when making the choice of whether to pay a fee for a CGB or buy a box of trash bags, the former carries with it a social cost that may outweigh any savings that the consumer may experience. We cannot determine the extent to which these factors play a role in the effects that we find, but this question does have implications for the design of policies that might be employed elsewhere.

Our finding also shows that the resulting plastic leakage is not significantly different from distinct policies. The effect of a 5¢ fee for either paper or plastic CGBs is essentially the same as that of a ban on plastic bag and a fee of 10 or 15¢ on paper bags. While policy makers may choose fees over bans in order to soften the blow, our results suggest that the overall effect on consumers is little different. The implication of this result is that policy makers should be aware that banning or charging fees on disposable CGBs probably have comparable effects.

Our results clearly suggest that some consumers reuse free CGBs, and when such bags are banned or taxed, they will seek other alternatives to fulfill their essential plastic bag demand. Such policies, therefore, have an unintended growth in unregulated plastic bags. This fact provides important information for policy makers, and they should be aware of this unintended consequence before implementing a CGB regulation.

[4] The lower and upper bound of the increase in plastic from both 4- and 8-gallon trash bag is 30 to 224 lb/store-month. Its mid-point estimate is 127 lb/store-month. The weight of a 12″×7″×22″ disposable GCBs is 0.013 lb/bag retrieved from https://www.uline.com/Product/Detail/S-3632/Plastic-Shopping-Bags/. Accessed February 28, 2021.

6 Conclusions

This study aims to investigate the impact of different carryout grocery bag (CGB) regulations on the sales of alternative plastic bag products. The effects of charging and banning CGBs on trash bag sales are estimated using the general synthetic control method with Nielsen retailer scanner data. The results show that CGB legislation in four jurisdictions significantly increased monthly 4 gallon plastic trash bags' sales by 30–135 pounds per store and 8 gallon trash bag sales by 37–224 pounds per store. In contrast, there is no evidence of a similar effect on sales of larger 13 gallon or above 13 gallon trash bag products.

An increase in 4 and 8 gallon plastic trash sales suggests that some people reused free grocery carryout plastic bags to pack their trash before the CGB regulation came into effect. After implementing the policy, people do not have those free CGBs but still have a demand to dispose of trash. Therefore, they need to purchase additional plastic trash bags from grocery stores. The policy implication of this study suggests that when policy makers regulate a particular waste source, they may also need to consider unintentional policy effects on other unregulated waste sources. This study's further implication is that the magnitude of the increasing plastic consumed from purchased plastic trash bags is not significantly different across distinct types of grocery regulations. Namely, either taxing CGBs or banning plastic carryout bags will lead to plastic leakage from CGBs to plastic trash bags. While we are unable to tell the net effect on plastic consumption, because of the heavier weight of purchased trash bags, it is possible that a bag ban could even lead to an increase in total plastic waste, and this is without taking into account any plastic content in purchased CGBs that consumers buy, and eventually discard, as a result of the ban. On the other hand, as noted in our motivation, an especially important concern is waste that finds its way into the environment in general and oceans in particular; it is possible that free CGBs are more likely to end up there than the replacement purchased trash bags.

A number of questions remain about the real environmental effect of CGB regulations. There are some county-wise bag bans in California and North Carolina, but the retailer scanner data is not available for those counties at the time of conducting this study. Thus, the selected study areas in this study do not include a policy type where plastic bag bans are not coupled with a paper bag fee at the county level. Since the ban incorporates a fee on paper bags—which might also be a substitute for bin liners, it would be worth comparing the different magnitudes of bag fees without a bag ban to a bag ban policy alone. In addition, we are unable to explore the relationship between these policies and household characteristics and behavior. For instance, are the effects of the policies a direct result of the change in access or price, or is the main effect the result of a social "nudge" that encourages consumers to adhere to pro-social norms? Do bans or different magnitudes of bag fees affect grocery shopping frequency or store choice? How do different magnitudes of bag fees affect households' expenditures per trip? Finally, there is an important distributional concern in that low-income consumers may be more affected by these regulations than high-income consumers, suggesting that the policies may be regressive. These and other questions should be investigated if bag ban regulations are to be used more widely.

Appendices

Detailed estimation results and the policy effect on unit prices of trash bags are presented in this section.

Appendix A: Endogeneity Checks and Estimation Results

See Figs. 7 and 8 and Tables 3, 4, 5 and 6.

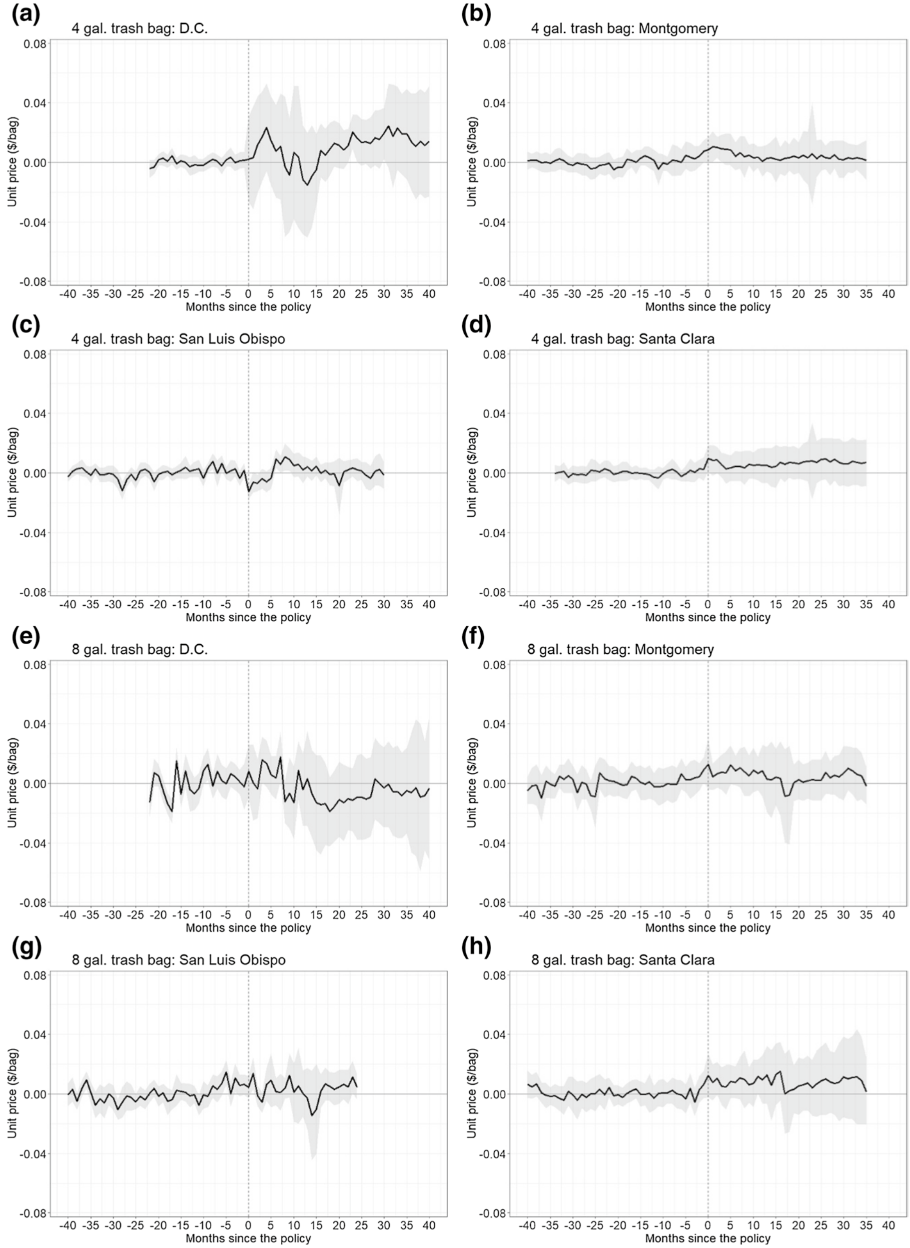

Fig. 7 Policy effect on 4 and 8 gallon trash bag unit prices. *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 4 gallon trash bags increase in each study area due to the implementation of the CGB regulations

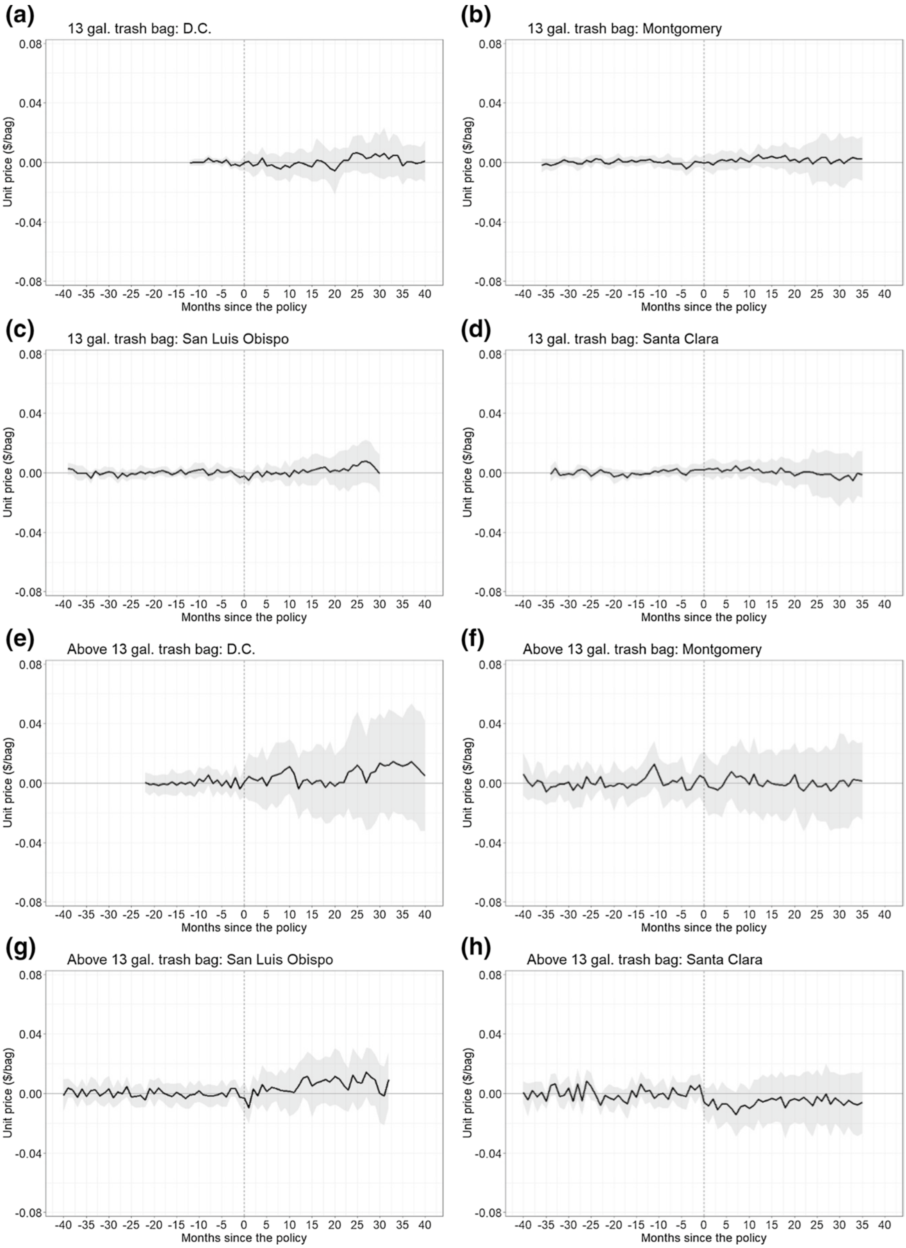

Fig. 8 Policy effect on 13 and above 13 gallon trash bag unit prices. *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 13 gallon trash bags are not significantly affected by the implementation of the CGB regulations

Table 3 Effect of the CGB regulations on 4 and 8 gallon trash bag sales

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
4 gal				
Average policy effect	0.696*	0.568**	0.438**	0.562**
	(0.423)	(0.451)	(0.267)	(0.424)
Price	−23.524***	−23.117***	−26.664***	−13.768***
	(3.219)	(3.953)	(3.852)	(3.328)
Income	0.052***	0.033**	0.036*	−0.006
	(0.013)	(0.017)	(0.026)	(0.015)
Population density	0.013	−0.042	0.111	0.072
	(0.073)	(0.167)	(0.779)	(0.391)
8 gal				
Average policy effect	−0.830*	0.432*	0.625***	0.744**
	(0.624)	(0.225)	(0.292)	(0.326)
Price	−12.27***	−8.395***	0.509	0.767
	(1.732)	(2.033)	(2.516)	(2.749)
Income	−0.004	0.014	−0.011	−0.007
	(0.015)	(0.012)	(0.016)	(0.016)
Population density	0.025	−0.007	0.142	0.114
	(0.125)	(0.085)	(0.293)	(0.407)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is the logarithm of bags sold per store. The unit of the price variable is $/bag. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

Table 4 Effect of the CGB regulations on 13 and 13+ gallon trash bag sales

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
13 gal				
Average policy effect	−0.181	−0.114	−0.005	0.033
	(0.436)	(0.193)	(0.126)	(0.203)
Price	−5.246***	−2.119**	−1.895	−4.615***
	(1.229)	(1.104)	(1.357)	(1.456)
Income	0.013*	0.002	−0.004	0.004
	(0.006)	(0.006)	(0.012)	(0.010)
Population density	0.012	0.003	0.168	0.088
	(0.072)	(0.064)	(0.274)	(0.278)
13+ gal				
Average policy effect	−0.020	−0.069	0.044	0.043
	(0.168)	(0.089)	(0.093)	(0.201)
Price	−4.768***	−4.264***	−3.916***	−4.151***
	(0.611)	(0.569)	(0.655)	(0.935)
Income	0.005	0.009	0.014	0.001
	(0.006)	(0.005)	(0.009)	(0.011)
Population density	−0.004	−0.004	−0.024	0.000
	(0.034)	(0.021)	(0.111)	(0.192)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is the logarithm of bags sold per store. The unit of the price variable is $/bag. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

Table 5 Effect of the CGB regulations on 4 and 8 gallon trash bag unit prices

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
4 gal				
Average policy effect	0.010	0.004	0.000	0.006
	(0.011)	(0.005)	(0.003)	(0.006)
Sale	−0.007***	−0.008***	−0.009***	−0.012***
	(0.001)	(0.000)	(0.000)	(0.001)
Income	0.000	0.000**	0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.001	0.000	−0.002	−0.002
	(0.001)	(0.001)	(0.005)	(0.005)
8 gal				
Average policy effect	−0.005	0.005	0.003	0.008
	(0.013)	(0.005)	(0.010)	(0.007)
Sale	−0.005***	−0.008***	−0.007***	−0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
Income	0.000	0.000**	−0.001**	−0.001
	0.000	0.000	(0.000)	(0.000)
Population density	0.000	0.000	0.001	0.003
	(0.002)	(0.001)	(0.008)	(0.007)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is $/bag. The sale is the logarithm of bags sold per store. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

Table 6 Effect of the CGB regulations on 13 and 13+ gallon trash bag unit prices

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
13 gal				
Average policy effect	0.001	0.002	0.001	0.000
	(0.004)	(0.004)	(0.004)	(0.005)
Sale	−0.002***	−0.01***	−0.008***	−0.001*
	(0.001)	(0.000)	(0.001)	(0.001)
Income	0.000***	0.000***	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.000	0.000	0.001	−0.001
	(0.000)	(0.000)	(0.005)	(0.005)
13+ gal				
Average policy effect	0.006	0.000	0.005	−0.006
	(0.012)	(0.009)	(0.006)	(0.007)
Sale	−0.028***	−0.022***	−0.01***	−0.011***
	(0.003)	(0.004)	(0.002)	(0.001)
Income	0.001**	0.001	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.000	−0.001	−0.003	−0.005
	(0.002)	(0.003)	(0.007)	(0.006)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is $/bag. The sale is the logarithm of bags sold per store. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

Appendix B: Synthetic Control Model Estimated with Less Observations

See Figs. 9, 10, 11, 12, 13 and 14 and Tables 7, 8, 9 and 10.

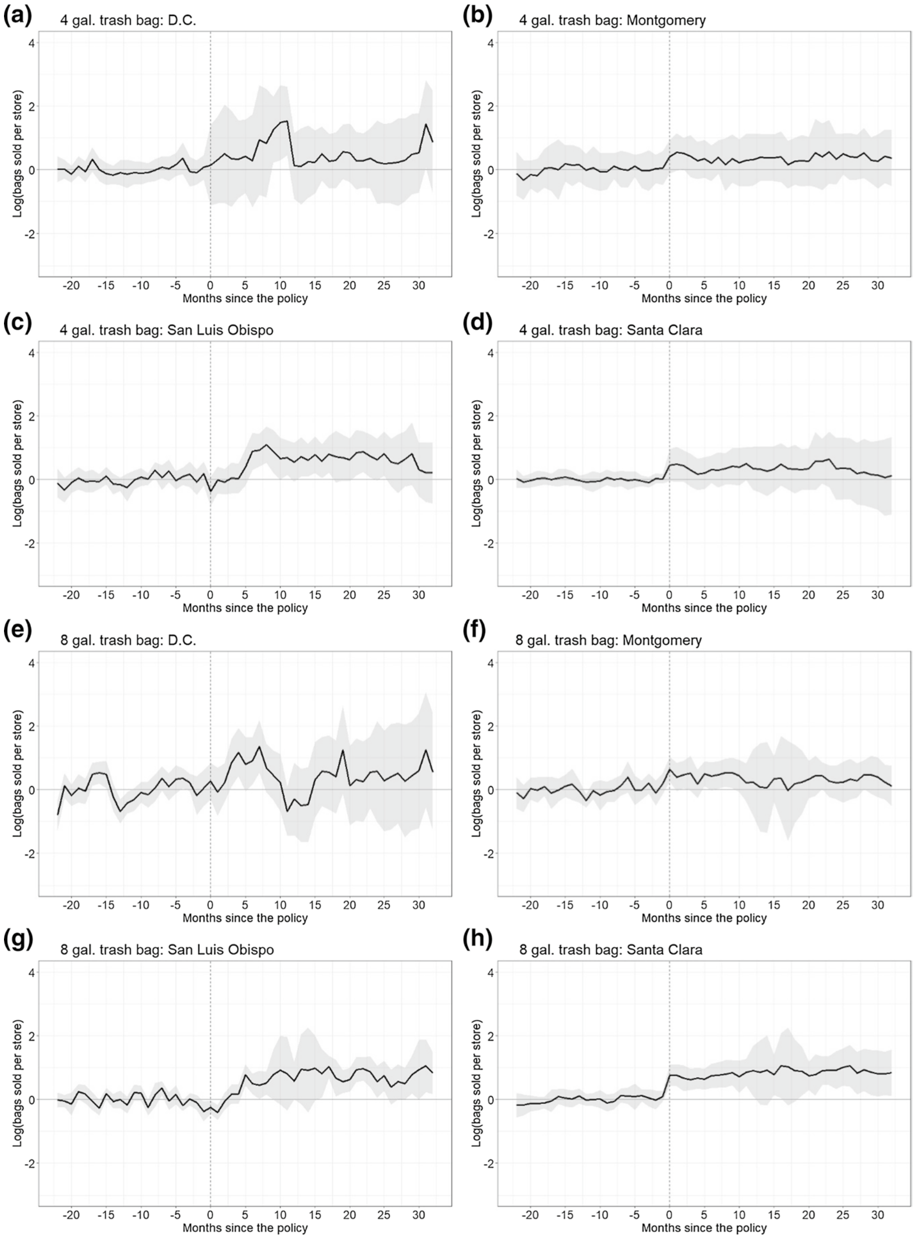

Fig. 9 Policy effect on 4 and 8 gallon trash bag sales (shorter period). *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 4 and 8 gallon trash bags increase in each study area due to the implementation of the CGB regulations

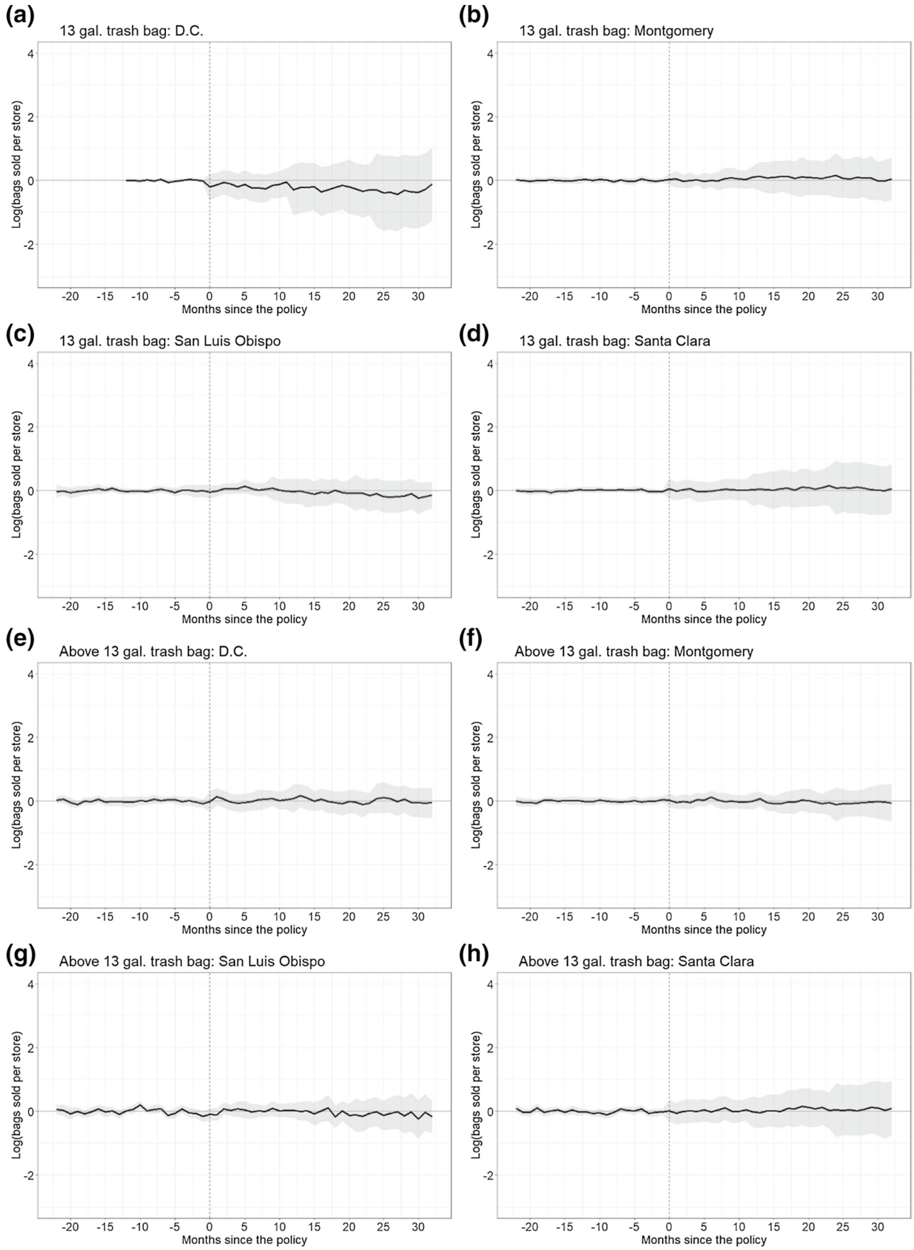

Fig. 10 Policy effect on 13 and above 13 gallon trash bag sales (shorter period). *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 13 and above 13 gallon trash bags are not significantly affected by the implementation of the CGB regulations

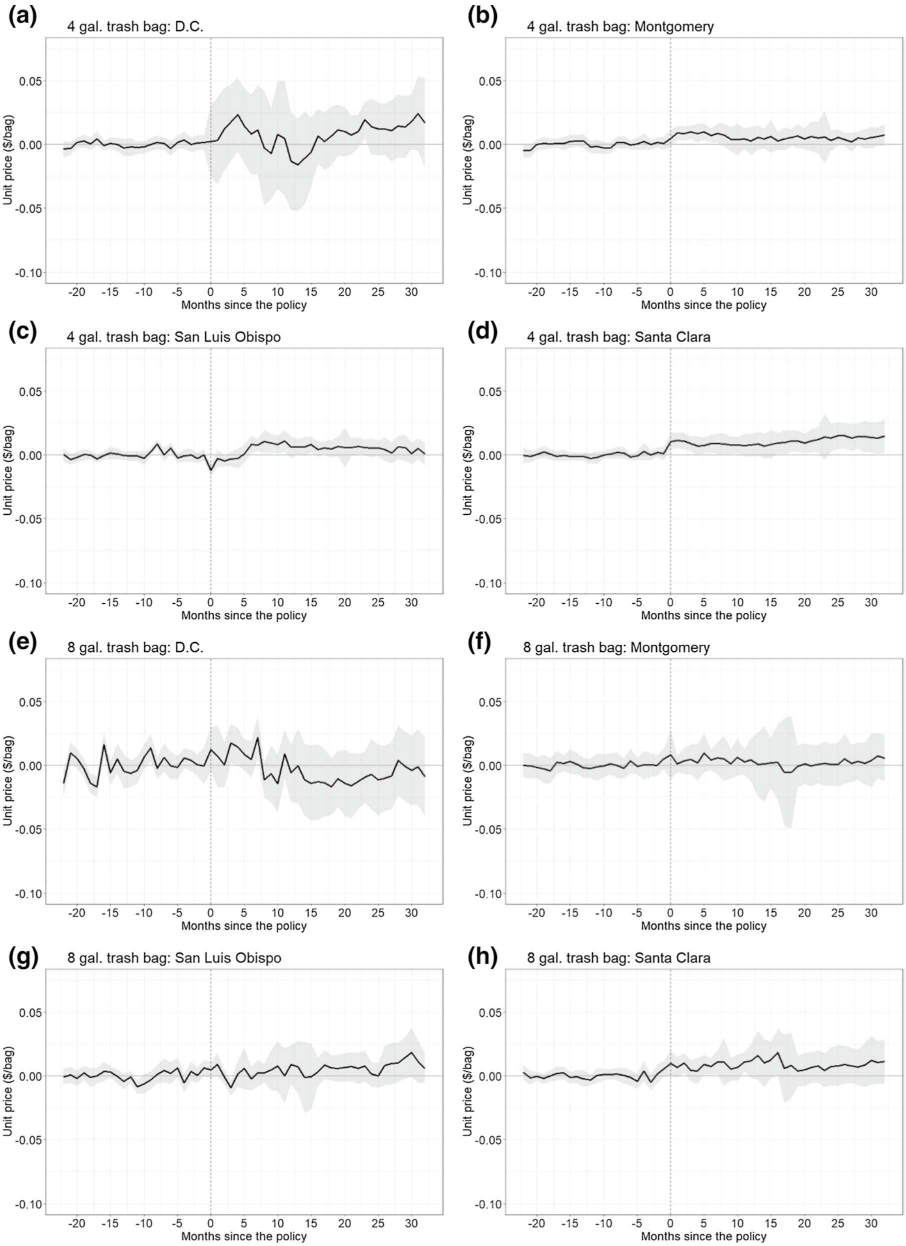

Fig. 11 Policy effect on 4 and 8 gallon trash bag unit prices (shorter period). *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 4 gallon trash bags increase in each study area due to the implementation of the CGB regulations

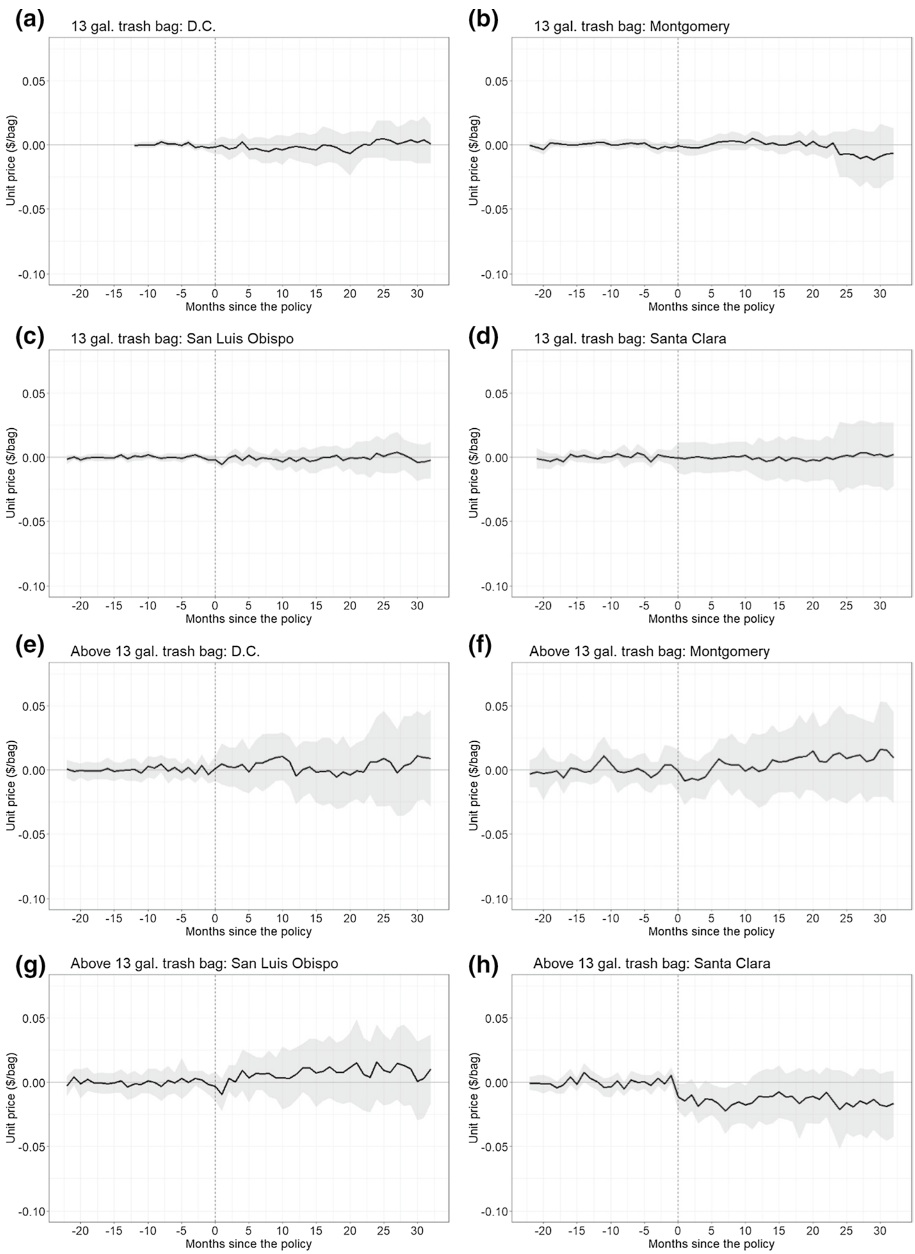

Fig. 12 Policy effect on 13 and above 13 gallon trash bag unit prices (shorter period). *Note* The figures depict differences in trash bag sales between a treated county and synthetic control over time. The x-axis is a rescaled time horizon (in months), where Month 0 is the month implementing the policy. The policy effects on trash bag sales are estimated by Eq. (1). The intervals in gray indicate 95% confidence intervals constructed by bootstrapped standard errors. The result shows that the sales of 13 gallon trash bags are not significantly affected by the implementation of the CGB regulations

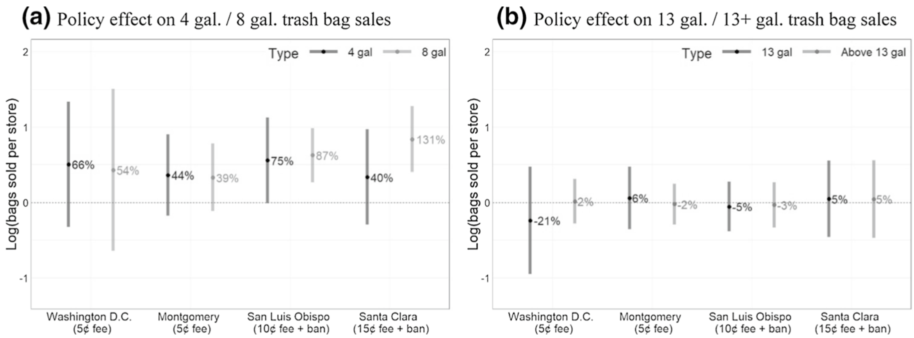

Fig. 13 Effect of the CGB regulations on trash bag sales (shorter period). *Note* The average policy effects on trash bag sales are estimated by Eq. (1). The length of error bars indicates a 95% confidence interval produced by bootstrapped standard errors with the and estimated by Eq. (1). The vertical axis indicates the average treatment effect on treated over time, measured in the log of bags sold per store. Percentage numbers indicate converted change rates of increasing sales calculated by $\left[exp(\delta_{it}) - 1\right] \times 100$, where δ_{it} is the average treatment effect as denoted in Eq. (1)

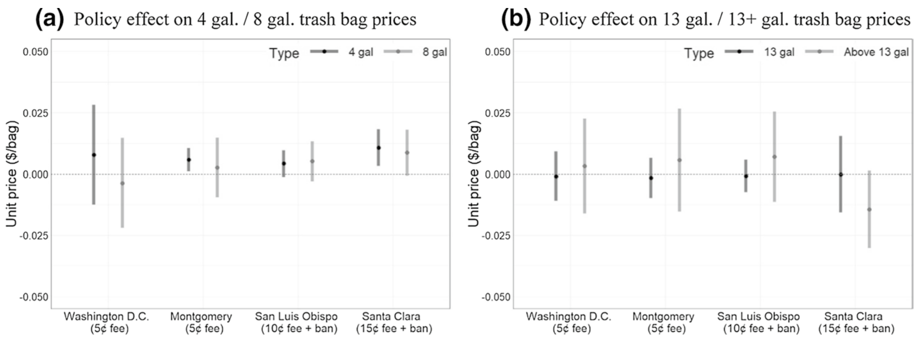

Fig. 14 Test for price endogeneity (shorter period). *Note* The average policy effects on trash bag prices are estimated by Eq. (1) with unit prices as the dependent variable and sales as the independent variable. The length of error bars indicates a 95% confidence interval produced by bootstrapped standard errors. The result shows that the policy does not have a significant effect on trash bag prices for all types of trash bags in each study area

Table 7 Effect of the CGB regulations on 4 and 8 gallon trash bag sales (shorter period)

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
4 gal				
Average policy effect	0.505	0.363	0.557**	0.337
	(0.424)	(0.275)	(0.289)	(0.323)
Price	−28.277***	−26.921***	−34.935***	−14.084***
	(2.966)	(3.637)	(3.068)	(3.019)
Income	0.051***	0.104***	0.059*	0.016
	(0.017)	(0.029)	(0.032)	(0.024)
Population density	0.031	0.025	0.088	0.064
	(0.106)	(0.095)	(0.632)	(0.506)
8 gal				
Average policy effect	0.429	0.333	0.627***	0.839***
	(0.548)	(0.228)	(0.182)	(0.223)
Price	−8.61***	−6.716**	4.068	0.866
	(1.335)	(2.832)	(2.592)	(1.934)
Income	−0.001	0.009	−0.009	−0.023
	(0.012)	(0.026)	(0.021)	(0.015)
Population density	0.084	−0.021	0.215	0.225
	(0.138)	(0.085)	(0.356)	(0.282)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is the logarithm of bags sold per store. The unit of the price variable is $/bag. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

Table 8 Effect of the CGB regulations on 13 and 13+ gallon trash bag sales (shorter period)

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
13 gal				
Average policy effect	−0.238	0.060	−0.054	0.048
	(0.364)	(0.211)	(0.169)	(0.258)
Price	−4.982***	−4.338***	−3.628***	−4.374***
	(1.141)	(0.917)	(1.493)	(1.126)
Income	0.019***	0.005	0.006	0.000
	(0.008)	(0.006)	(0.011)	(0.013)
Population density	0.01	−0.016	0.100	0.116
	(0.082)	(0.052)	(0.262)	(0.402)
13+ gal				
Average policy effect	0.016	−0.021	−0.033	0.045
	(0.152)	(0.139)	(0.154)	(0.262)
Price	−4.759***	−4.535***	−4.34***	−3.685***
	(0.719)	(0.652)	(1.133)	(0.855)
Income	0.003	−0.002	−0.011	−0.004
	(0.008)	(0.009)	(0.015)	(0.014)
Population density	−0.007	−0.012	0.052	0.077
	(0.031)	(0.036)	(0.288)	(0.352)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is the logarithm of bags sold per store. The unit of the price variable is $/bag. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

Table 9 Effect of the CGB regulations on 4 and 8 gallon trash bag unit prices (shorter period)

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
4 gal				
Average policy effect	0.008	0.006**	0.004	0.011***
	(0.010)	(0.002)	(0.003)	(0.004)
Sale	−0.008***	−0.010***	−0.011***	−0.011***
	(0.001)	(0.000)	(0.000)	0.000
Income	0.000	−0.001***	−0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.001	0.000	0.001	0.000
	(0.002)	0.000	(0.003)	(0.004)
8 gal				
Average policy effect	−0.004	0.003	0.005	0.009*
	(0.009)	(0.006)	(0.004)	(0.005)
Sale	−0.008***	−0.006***	−0.005***	−0.008***
	(0.001)	0.000	(0.001)	0.000
Income	0.000	−0.001**	−0.001	−0.001***
	0.000	0.000	(0.000)	(0.000)
Population density	0.000	0.000	0.000	0.001
	(0.002)	(0.001)	(0.006)	(0.006)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is $/bag. The sale is the logarithm of bags sold per store. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

Table 10 Effect of the CGB regulations on 13 and 13+ gallon trash bag unit prices (shorter period)

	Washington D.C.	Montgomery	San Luis Obispo	Santa Clara
13 gal				
Average policy effect	−0.001	−0.002	−0.001	0.000
	(0.005)	(0.004)	(0.003)	(0.008)
Sale	−0.003***	−0.005***	−0.015***	−0.015***
	(0.001)	(0.000)	(0.001)	(0.004)
Income	0.000***	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.000	0.000	0.003	0.003
	(0.000)	(0.000)	(0.005)	(0.011)
13+ gal				
Average policy effect	0.003	0.000	0.007	−0.014*
	(0.010)	(0.011)	(0.009)	(0.008)
Sale	−0.027***	−0.018***	−0.015***	−0.020***
	(0.003)	(0.004)	(0.004)	(0.001)
Income	0.001**	0.001	0.001	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Population density	0.000	0.004	0.001	−0.005
	(0.002)	(0.003)	(0.022)	(0.011)

The significance levels are marked as follows: ***p-value < 0.01, **p-value < 0.05, and *p-value < 0.1. All estimates control for county and month fixed effects. The unit of the dependent variable is $/bag. The sale is the logarithm of bags sold per store. Income is the average adjusted gross income in each county measured in USD 1000 per capita. Population density is in 100 people/sq. miles

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