Bans *vs*. Fees:
Disposable Carryout Bag Policies and Bag Usage

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Abstract *Using observational data on consumer carryout bag usage, we measure the effects of Disposable Bag Policies on disposable and reusable bag demand. Our results show that plastic bag bans coupled with paper bag fees—while decreasing total disposable bag demand—lead to significant increases in paper bag consumption. We compare our results to a study on bag fees and find that both policies lead to similar increases in reusable bag usage. However, the success of bans versus fees in discouraging disposable bag usage is contingent upon the types and prices of bags stores choose to sell in lieu of disposable plastic*.[2]

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Bans *vs.* Fees: Disposable Carryout Bag Policies and Bag Usage

Abstract *Using observational data on consumer carryout bag usage, we measure the effects of Disposable Bag Policies on disposable and reusable bag demand. Our results show that plastic bag bans coupled with paper bag fees—while decreasing total disposable bag demand—lead to significant increases in paper bag consumption. We compare our results to a study on bag fees and find that both policies lead to similar increases in reusable bag usage. However, the success of bans versus fees in discouraging disposable bag usage is contingent upon the types and prices of bags stores choose to sell in lieu of disposable plastic*.
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Disposable carryout plastic bags bring convenience to supermarket customers, but at a substantial cost to the environment and to municipalities trying to keep their streets and waterways clean. With plastic bag clean-up, recycling, and land-filling costing cities and local governments millions of dollars per year, Disposable Bag Policies are gaining popularity among lawmakers across the county. Disposable Bag Policies prohibit retail stores from providing customers with free carryout bags at checkout. The ultimate goal of these policies is to alter consumer behavior—curbing the consumption of single-use bags and encouraging the use of reusable bags. Yet, while all Disposable Bag Policies share this common goal, in practice they differ in their policy prescriptions, dividing into two competing approaches: (1) Bag bans—a command-and-control approach to regulate behavior directly and (2) Bag fees—a market-based approach to incentivize individuals to change their own behavior.

The adoption of both types of policies has been widespread in the U.S.[1] At the local level, fees on both plastic and paper carryout bags have been adopted by several cities and counties on the east coast, while the most popular policy prescription on the west coast has been bans on plastic bags coupled with fees on paper bags. At the state level, as of August 2015

[1] For lists of Disposable Bag Policies by city, county, and state (adopted and rejected), we recommend the following online resources: BagLaw.com and Californians Against Waste.

legislation stood with two states having already banned plastic bags,[2] at least fifteen states having considered bag bans, and at least eighteen states having considered bag fees.[3] In light of the pervasiveness of both policies, this paper asks: *Does the policy tool matter with respect to changing consumer behavior?*

The standard economic analysis, dating back to Pigou's work in the 1920's, has emphasized the efficiency advantages of economic incentive (EI) mechanisms, such as fees and taxes, over command-and-control (CAC) approaches, such as bans (Sandmo 1978). When polluters (i.e. plastic bag users) differ in their costs of abatement (i.e. forgoing plastic carryout bags), the flexibility offered by EI approaches reduces the aggregate cost of achieving a given level of pollution reduction in comparison to uniformly-applied CAC policies. However, the cost of information and monitoring also underlie the choice between taxes and bans. Compliance with bans may be relatively cheaper to monitor, which could account for the occurrence of these forms of regulation (Christiansen and Smith 2012). Moreover, as Weitzman (1974) illuminates in his seminal work "Prices *vs.* Quantities," when there is significant uncertainty about the costs of pollution abatement, the outcomes from regulations which set a pollution quantity (or cap) can differ from those which set a pollution price, and conditions for one to dominate depend on the sensitivity of marginal abatement costs and marginal pollution damages to the pollution level. Therefore, if policymakers do not know consumers' demand elasticity for disposable carryout bags or the pollution damages from an additional bag, economic theory is ambiguous about whether bans or taxes should be chosen.

[2] Hawaii and California. All four counties in Hawaii have banned plastic bags, making it a statewide ban in effect. In California, a statewide ban on plastic bags passed the state legislature and was signed into law by the governor on September 30, 2014. However, opponents secured enough signatures to put the ban to a public vote, meaning the ban is effectively on hold until November 2016.

[3] In addition, a handful of states are considering laws which would ban cities from banning plastic bags.

Given the theoretical uncertainty and the growing prevalence of both types of policies, it is imperative to compare outcomes under each regulation tool. With this objective in mind, we (1) empirically investigate whether a bag ban has had its intended effects on the types of bags consumers use at checkout, and (2) compare and contrast outcomes under this bag ban to those of a bag fee. To accomplish the first task, we take advantage of a policy change in the neighboring Californian cities of El Cerrito, Richmond, and San Pablo. Starting January 1, 2014, these cities began to prohibit retail stores from providing customers with plastic single-use bags at checkout. Any retail establishment that provides a recycled paper carryout bag or reusable bag to a customer must charge a minimum of five cents per bag. Using this policy change as a natural experiment, we collect observational data on customers' bag choices at a set of stores in these cities, both before and after the policy took effect. We observe customers during checkout and record the number and types of bags used, the length of transaction times, whether a bagger was present and basic customer demographic information. Besides collecting counterfactual data in the pre-policy period, we also collect data at stores in the control cities of Berkeley and Concord, where there was no bag policy change during our sample period.

With our unique panel dataset, we use a difference-in-differences empirical strategy to measure how plastic bag bans with paper bag fees affect customers' demand for various types of disposable and reusable bags. We also measure whether changes in consumer behavior due to the policy shock are heterogeneous across fee size and store type. In particular, we collect data at two markedly different grocery chains within the same treated and control cities. Not only do these chains attract a different clientele within the same city—as evidenced by the demographic data we collect—their management also chose different responses to the same Disposable Bag Policy. The first chain, which we refer to as the National Chain, chose to charge the minimum

required 5 cents per paper bag. Alternatively, the second chain—referred to as the Discount Chain—chose to charge 10 cents per paper bag and introduced a 15-cent thick-plastic reusable bag. By running the same analysis on each of these chains separately, we are able to compare how the types and prices of bags offered influence consumer behavior.

For our second objective, we investigate how outcomes under plastic bag bans compare to outcomes under bag fees, by juxtaposing our analysis with a study on a concurrent bag fee. Homonoff (2013) investigates the 5-cent plastic and paper bag fee in Montgomery County, Maryland. While there exist previous studies examining how Disposable Bag Policies affect consumer behavior (Dikgang et al. 2012), Homonoff (2013) was the first to collect data on bag usage in both the pre- and post-policy period and at treated and control stores. By replicating the methodology of Homonoff (2013) on our sample of stores, we are able to directly compare results, and consequently, draw conclusions on the effectiveness of bag bans versus bag fees.

The empirical literature comparing outcomes under bans and fees is limited, especially with respect to consumption-driven externalities. Adda and Cornaglia (2010) analyze these two policies on passive smoking and find that excise taxes are more effective at reducing exposure to tobacco smoke than smoking bans in public places. The reason is that bans displace smokers to private places where they contaminate non-smokers, especially young children. Although disposable bags and cigarettes are very different commodities in many respects, our analysis likewise finds that bans displace consumption in unintended ways in which taxes do not.[4]

To preview some of our results, at the National Chain we find that both policies lead to remarkably similar increases in reusable bag usage and reductions in disposable bag usage.[5]

[4] Other empirical studies have compared EI instruments versus CAC approaches in reducing air pollutants (Oates et al. 1989) and in incentivizing the production of higher fuel economy vehicles (Greene 1990).

[5] We refer to both paper and plastic bags as disposable bags. Thus for customers facing a plastic bag ban, disposable

However, under a plastic bag ban, the eradication of plastic bag consumption is offset by a 46.50 percentage point increase in paper bag consumption. In comparing the Discount Chain to the National Chain, we find that charging 10 cents (instead of 5 cents) for paper bags and offering inexpensive, 15-cent reusable bags leads to larger reductions in total disposable bag usage. In particular, after the policy change paper bag demand increases by only 10.12 percentage points at Discount Chain stores. Thus the types of reusable bags that stores decide to sell in lieu of single-use plastic bags—as well as the price of these alternatives—has significant impacts on the effectiveness of ban versus fees, especially with respect to paper bag demand.

This study uniquely contributes to the literature by being the first to rigorously analyze consumer responses to plastic bag bans and the first to compare outcomes under bag bans to those under bag fees. We also extend the analyses of previous studies by measuring the use of all subcategories of carryout bags—as opposed to broad categories—and by investigating the heterogeneity of effects by store type. As such, the results of this paper have the potential to shape current and future policy—and not just policies regulating disposable bags but also the regulation of other disposable products (ex. Styrofoam containers and plastic bottles). Our results suggest that as cities, counties, and states continue to design and adopt Disposable Bag Policies, they will want to consider not only their objectives for reusable and plastic bag usage, but also their objectives for paper bag consumption. The rest of the paper proceeds as follows. Section 2 reviews the background on disposable carryout bags. Section 3 describes the empirical setting, the policy changes that led to the experimental design, and the data collection methodology. Section 4 lays out the empirical strategy and presents the results. Section 5 compares our bag ban results to a study examining a bag fee and discusses policy implications. Section 6 concludes.

bag usage is only comprised of paper bags. For customers facing a paper and plastic bag fee, it is a mix of both.

Background on Disposable Bag Policies

Standard single-use plastic bags cost retailers on average 3 cents each and paper bags cost 7 to 10 cents each.[6] However, customers do not directly see the price of the disposable bags they use, as the majority of grocery stores roll the price of these bags into the total cost of the transaction. Without seeing a price, customers are prone to use more plastic bags than they would be willing to pay for at face-value, and this overuse is costing municipalities millions in clean-up expenses. Each year Americans are estimated to consume 100 billion single-use plastic bags (Clapp and Swanston 2009)—approximately 325 bags per person per year—the vast majority of which are eventually landfilled or littered. When not kept in landfills, plastic bags end up in storm drains, rivers and oceans—degrading water quality, harming birds and aquatic life, clogging waterways, and becoming a general eyesore. Even when properly disposed of in a receptacle, plastic bags are easily blown away due to their light weight and aerodynamics. Moreover, the 13.5 percent of plastic bags that do get recovered (EPA 2015) become a major problem for recyclers as the bags often clog the machines used to sort material.[7] A study of the budgets of 6 major cities in the U.S. finds that the litter control of plastic bags costs between 3.2 and 7.9 cents per bag.[8] Given that approximately 100 billion plastic bags are consumed in the U.S. each year, municipalities across the U.S. together spend up to $3.2 to $7.9 billion per year to clean up plastic bags.

In light of the sizeable costs of plastic bags, one might be tempted to answer the age-old

[6] Bag cost estimates come from interviews with the store managers in our sample, but media articles also confirm these estimates ("Plastic Ban Means Higher Costs are in the Bag." *Crain's Chicago Business*. May 3, 2014. Online). The cost of paper bags depend on bag size and the presence of handles. Store owners list disposable bags as their fourth largest operating cost, after electricity, payroll, and credit card fees.

[7] "Which Bag is Best: Paper or Plastic?" *The Oregonian*. May 17, 2007. Online.

[8] "Do Bans on Plastic Grocery Bags Save Cities Money?" *National Center for Policy Analysis*. Dec. 2013. Online.

question “Paper or Plastic?” with a resounding “Paper!” However, single-use paper bags are not without their own environmental costs and thus may not be an adequate alternative to plastic. The negative environmental impacts of paper bags include: (1) paper bags are more energy and water intensive to manufacture than plastic bags, (2) paper bag production generates 70 percent more air and 50 times more water pollutants than the production of plastic bags, (3) it takes 98 percent less energy to recycle a pound of plastic than a pound of paper, and (4) paper bags are 9 times heavier than plastic bags, requiring more space in transportation trucks and landfills.[9] By switching from plastic to paper, society is simply trading one set of environmental costs for another. However, the important take-away is that the environmental costs of single-use plastic bags are felt acutely in the budgets of local municipalities, especially those along waterways, whereas the environmental cost associated with paper bags are more broadly spread across all people in a population. Therefore it is unsurprising that in practice Disposable Bag Policies have been more aggressive against plastic bag consumption than paper bag consumption.

Policies to Regulate Disposable Carryout Bags

Given the aforementioned costs of disposable bag usage, governments in the U.S. began passing laws to regulate disposable bags in the mid to late 2000’s.[10] On January 1, 2010 the District of Columbia became the first city in the U.S. to require a fee, charged at checkout, for using single-use plastic and paper bags. This law—which passed in response to a District Department of Environment study that found plastic bags comprised 47 percent of trash in D.C.’s rivers and tributaries (DDOE 2008)—had the joint goals of changing consumption of bags and

[9] “Graphic: Paper or Plastic?” *The Washington Post*. Oct. 3, 2007. Online.

[10] Internationally, disposable bag regulations started earlier, with several countries banning the use of plastic bags in the global South, where the externalities of plastic bags are exacerbated by less established municipal waste collection and recycling. Policies later spread to the global North, with Ireland becoming the first industrialized country to impose a tax on customers for using plastic bags in 2002 (Convery et al. 2007).

raising revenue for watershed clean-up. Several counties surrounding D.C. have since followed suit with similar laws. Although the fee magnitude has varied across municipalities (between 5 and 25 cents), in general retailers get to keep a portion of the fee to cover the cost of implementation, while the municipality may keep any remaining cents to be used for funding clean-up and recycling programs.

Unlike many of their east coast counterparts, Californian cities and counties have passed plastic bag bans with paper bag fees instead of requiring fees for both. In California, the charges for paper bags are kept completely by the retailers and none of the revenue is collected by the local government implementing the law. Why has California chosen bans over fees? The answer lies in California Assembly Bill 2449. This bill, enacted in 2006, began as a plastic bag fee bill, but—due to pressure from the plastic industry—transformed into a plastic bag recycling bill. Moreover, a last minute change to this law prohibits "a city, county or other public agency from adopting, implementing, or enforcing an ordinance, resolution, regulation or rule that imposes a plastic carryout bag fee upon a store." Consequently, a plastic bag fee was not an available policy option for California municipalities that did not feel recycling programs went far enough in addressing their disposable bag problems.[11]

San Francisco was one such city. In 2007 San Francisco enacted a citywide ban on single-use plastic bags, becoming the first government in the U.S. to do so. This sparked the spread of Disposable Bag Policies in California, with the cities of Malibu and Palo Alto adopting similar laws in 2008 and 2009 and Los Angeles County passing even stronger legislation in the summer of 2011—not only banning plastic bags but also charging a minimum of ten cents per paper bag. By the time the Richmond bag ban—the primary policy in our analysis—went into

[11] "The Plastic Bag Ban Epic." *LA Observed*. Sep. 6, 2014. Online.

effect in 2014, over 55 city and county bans had been implemented in California.[12] While the requirements of CA Bill 2449 were only operative until January 1, 2013 and any bills passed in California in and after 2013 could technically choose bag fees over bag bans, interestingly none of the ordinances passed in 2013 or 2014 opted for a plastic bag fee.

Yet plastic bag fees are not completely out of the picture. In 2013 two bills were introduced in the California Senate—one of them a plastic bag ban with a paper bag fee and the other a fee on both plastic and paper bags.[13] Furthermore, several supermarket chains in areas affected by plastic bag bans have found a way to satisfy customers willing to pay for plastic bags—selling 15-cent thick-plastic reusable bags at checkout. These bags meet all the requirements of current Californian Disposable Bag Policies: they are at least 2.25 mils thick, they are capable of carrying 22 pounds for 125 uses, they have handles and are made from materials that can be cleaned or disinfected, they are made from 20% recycled materials and are recyclable themselves. The main issues with the current single-use plastic bags are that they are "free"—leading them to be excessively overused—and lightweight—making them difficult to landfill and recycle. Selling a bag that is neither free nor lightweight solves both of these issues, while also providing utility to customers willing to pay for them.[14]

However, some view these 15-cent bags as a loophole for stores and manufacturers to get around the intention of the plastic bag bans. Skeptical on whether 15-cent thick-plastic bags are in fact reused, a handful of municipalities are considering upping their reusable bag requirement

[12] Another 50 local bag bans were adopted by the time the statewide ban was signed into law in September 2014.

[13] Senate Bill 270—the bill signed into law—bans single-use plastic carryout bags statewide and requires stores to sell paper and reusable bags for at least 10 cents each. Senate Bill 700—which died in committee—would have instead required stores to charge 5 cents for both plastic and paper carryout bags.

[14] Senate Bill 270 also provides $2 million in grant money from a California recycling fund to assist plastic bag-making businesses in producing these types of reusable bags.

to 3 mils thick to prevent the use of these bags. Therefore, not only do governments considering Disposable Bag Policies have to decide between bag bans versus bag fees, they must also decide on the types and thickness of reusable bags to allow. Our paper addresses both policy debates, first, by comparing consumer demand outcomes under bag bans to those under bag fees, and second, by examining the various types of bags consumers reuse—whether they are standard reusable totes bags, paper bags, backpack, boxes, or alternative 15-cent reusable bags.

Data Collection and Summary Statistics

To assess the effectiveness of single-use plastic bag bans, we take advantage of a policy change in the neighboring Californian cities of El Cerrito, Richmond, and San Pablo. Starting January 1, 2014, these cities began to prohibit retail stores from providing customers with plastic single-use bags at checkout. Any retail establishment that provides a recycled paper carryout bag or reusable bag to a customer must charge the customer a minimum of five cents for each bag provided, a fee that goes entirely to the retailer collecting it. Using this policy change as a natural experiment, we collect observational data on customers' bag choices at a set of grocery stores, including three treated stores located in the cities of El Cerrito, Richmond, and San Pablo, two control stores in the city of Berkeley (where a Disposable Bag Policy had already been imposed a year prior to the new policies), and two controls stores in the city of Concord (where no Disposable Bag Policy has been enacted). Since the city of Richmond geographically envelopes the cities of San Pablo and El Cerrito, we group all three cities together as one region (Richmond) for the remainder of this paper.

The data were obtained through direct observation of transactions by members of our research team stationed near checkout lanes. For each transaction we collected data on the number and types of bags used, whether a bagger is present, the length of the transaction and

basic demographic data such as gender and race of the person paying. This type of transaction specific information can only be gained from in-store observations, and is not included in the scanner datasets from these stores. Four visits per store occurred in November and December 2013, before the Richmond Disposable Bag Policy went into effect, and 4-6 visits occurred in January and February 2014, after the ban was in place. We also made an additional 4 visits in March and April 2014 to collect follow-up data. Each visit lasted 1-2 hours and was made on either Saturday or Sunday between 11am-7pm—high foot-traffic hours for grocery shopping.[15]

Our methodology for data collection is based on that of Homonoff (2013) in that we collect data by direct observation at treated and control stores in the pre- and post-policy period. However, while Homonoff (2013) collected data on bag usage in broad categories (disposable bags versus reusable bags), we go further and collect data on all subcategories of carryout bags. Subcategories of disposable bags include: single-use plastic and single-use paper. Sub-categories of reusable bags include: reusable tote bags, 15-cent thick-plastic bags, reused disposable paper and plastic bags, backpacks, purses, boxes, suitcases, and other. We do this in order to measure changes in bag usage within reusable and disposable categories (i.e. plastic versus paper bags, 15-cent versus one-dollar reusable bags), which are an important consideration for both store operators and policymakers evaluating consumer behavior and policy success. This paper also extends the work of Homonoff (2013) by collecting data on the presence of baggers—which may influence the number and types of bags customers use—and by collecting data at two distinct types of grocery chains—which allows us to examine whether the effects of Disposable Bag Policies are heterogeneous by store type.

We visit a total of seven stores belonging to two different categories of grocery chains

[15] To prevent potential biases, we randomized the order in which we visited the stores on each observation date.

within the same treated and control cities. The first chain is a large National Chain, offering high and low prices in many products, located in very diverse demographic regions, and that, in the pre-period, offered to its consumers at checkout free plastic bags, free paper bags, and reusable tote bags for purchase of $1.50. The other chain we collect data from is a regional Discount Chain, which in the pre-period offered only free single-use plastic bags and reusable tote bags for purchase of $0.99. Not only do these two chains offer different types of bags in the pre-period, their managements also respond differently to the same policy change. The National Chain reacts to the ban by continuing to offer the same paper and reusable tote bags as before the policy, but adds the required 5-cent fee per paper bag. The Discount Chain also retains the reusable totes it sold before the ban, but alternatively introduces a 10-cent paper bag and a 15-cent thick-plastic reusable bag.[16] Besides charging the minimum amount for paper bags required by law, the National Chain's paper bags are of a slightly better quality than the Discount Chain, whose paper bags do not have handles. Table 1 reports background information on the seven stores in our sample—three from the National Chain and four from the Discount Chain—including when the policy went into effect at each store, what stores charge for paper bags in the post-policy period, the number of transactions we observe at each store, and pre-ban store characteristics (average number of lanes open, percent of transactions with baggers present, and average length of transaction time in seconds).[17]

At the National Chain, the policy change implies an infinite price on plastic, a five cent

[16] The price of the reusable tote bags does not change after the policy implementation at either chain. While the Discount Chain sells $0.99 reusable totes before and after the ban, our team never witness a purchase of these bags.

[17] More observations were made at National Chain stores on average over the sample period because data collection occurred at the National Chain stores on two dates more than at the Discount stores. Also, since the Richmond area has two locations of the Discount Chain, we decide to make observations at both in order to increase our total number of observations and statistical power.

price on paper, and the usual price on reusable tote bags available. In this case we can see how consumers react to the differential relative price changes of the bag options available to them. At the Discount Chain, we instead measure how consumers suddenly adjust behavior to new bag alternatives that have a positive price as compared to the free plastic option. Moreover, by measuring the effects on consumer behavior in the Discount Chain separately from the National Chain, we are able to focus on what we hypothesize to be a very price sensitive population.[18]

Plotting the raw means of the bag usage data speaks volumes. Figure 1 (a) and (b) plot the percentage of transactions using each of six types of bags—(i) thin single-use plastic, (ii) paper bags, (iii) bought during checkout reusable bags, (iv) brought reusable bags, (v) a combination of multiple bag types and (vi) no bags—for the National Chain and for the Discount stores respectively. The summary statistics are separated into the three policy regions—(1) Concord: control stores with no ban ever, (2) Richmond: treated stores with a policy change, and (3) Berkeley: control stores with a ban pre-dating the sample period. Each of these cities is further examined in two time periods: the PRE-ban period (Nov-Dec 2013) and the POST-ban period (Jan-Feb 2014). In Figure 1, we see stark changes in the distribution of the type of bags used that are contemporaneous with the bag policies across the treatment and control groups. The first thing to note is that only the treated Richmond stores see a noticeable change in bag usage between the PRE and POST period. Second, while the Richmond stores have similar bag use distributions to their Concord counterparts in the PRE period, they switch to a distribution more similar to that of their Berkeley counterparts in the POST period. The take-away of these graphs is that stores in cities with plastic bag bans and paper bag fees see total disposable bag usage

[18] While we cannot measure the income of customers in our sample, based on our conversations with managers and anecdotal evidence at the Discount Chain stores, we conjecture that Discount Chain stores have a higher proportion of low income customers and SNAP and WIC participants than the National Chain.

decrease (plastic plus paper), however, paper bag usage increases markedly. The policy also leads to higher use of reusable bags and higher incidence of customers using no bags at all.

We also examine how the distributions of bag usage vary across store type, for stores with bans and for stores without. At both the National and Discount Chain stores, roughly 95% of transactions use some sort of bag when there is no bag policy in place. Conversely, only 80% of transactions at National Chain stores use a bag when there is a bag policy, and only 70% do likewise at Discount Chain stores. In regards to reusable bags, between 30% and 50% of transactions bring reusable bags to stores that have bag policies in effect. This is true for both chains. In terms of purchasing bags, at National Chain stores with bans, 40% of transactions pay the 5 cents per paper bag with handles and only 1% pay $1.50 for a reusable tote bag. At Discount stores, only 30% of transactions pay for bags at checkout, with approximately 10% paying 10 cents for paper and 20% paying 15 cents for thick-plastic reusable bags. Interestingly, the 15-cent bag is more popular than the 10-cent paper bag at Discount stores. This preliminary surveillance of the raw data suggests that plastic bag bans cause a large increase in paper bag demand; however, this increase in paper demand may be mitigated if customers are charged more for paper bags or offered an inexpensive and desirable alternative.

Next we use the pre-treatment period data to investigate whether the pre-period is balanced in terms of observable determinants, such as customer demographics and bag usage within and across chains. Since we employ a difference-in-difference strategy, a critical assumption is the appropriate selection of the treatment and control groups. Our selection rules for the control and treated cities were (1) the presence of both retail chains within the city, (2) proximity—only cities within one hour travel of the research team, (3) accessibility by public transit, and (4) most importantly, the two control cities best matched Richmond in terms of

average demographics characteristics, based on available census data. To verify whether the control and treatment cities are well matched, table 2 presents demographic and income summary statistics from the pre-period. Reported in the top panel are 2012 census data for the proportion of each city's population that is male, white, black, as well as the total population and the average salary in each city. Richmond has a larger proportion of minority residents and a lower average salary than either Berkeley or Concord. To understand whether our selected stores are representative of the entire city, the middle and bottom panel present the summary statistics of the observational data collected for the proportion of customers that were male, white, and black at the National and Discount stores respectively. Compared to the census data, the clientele of the National Chain stores appear to be fairly representative of the cities in which they live. On the other hand, the percentage of black and minority clientele at the Discount stores are 10-20 percentage points greater than representative of the census data, and this is true across all cities. We feel this is strong evidence that the National and Discount chains attract a very different clientele, even within the same city.

The other critical identification assumption is that of parallel trends—where, had it not been for the Disposable Bag Policies, Richmond would have had the same change in bag usage over time as Berkeley and Concord. To validate this assumption, we use the pre-policy data and regress each of the bag usage variables on a time trend, an indicator for treatment, and their interaction. We find the point estimates of the time trend are not statistically different between treatment and control stores, with the exception of paper bags at the treated National Chain, which see a downward trend before the ban went into effect. Since the hypothesis is that plastic bag bans lead to an increase in paper bag usage, we would be more concerned if the opposite were true—i.e. an upward trend in paper bag usage in the treatment stores before the policy.

In regards to other observable characteristics, the last three columns of table 1 show that, in the pre-period, National Chain stores have baggers present for between 51-65% of transactions, approximately 4.6 registers open at a time, and transaction times ranging from 86-93 seconds. Conversely, the Discount Chain stores have baggers present less frequently (8 to 56% of transaction), fewer registers open (2.3 to 3.4 registers), and a wider variance of average transaction times (76-96 seconds). Overall, the sample averages for these variables compared within each chain are similar, suggesting that the treatment and control stores share broadly equivalent patterns in the pre-period.[19]

Difference-in-Differences Empirical Strategy and Results

We use a regression framework to evaluate the effect of the Richmond bag ban on measures of bag demand controlling for various individual- and store-level covariates. We consider two measures of bag demand: demand on the *extensive margin* (the percent of customers using each type of bag) and demand on the *intensive margin* (how many bags each customer uses given they use a particular type of bag). We exploit the quasi-experimental panel design to perform a difference-in-differences estimation strategy. The reduced form specification is:

$$Y_{st}^{B} = \beta_1(Richmond * Post)_{st} + \beta_2 Post_t + \alpha_s + \gamma X_{st} + \varepsilon_{st}, \qquad (1)$$

where Y_{st}^{B} is a measure of demand on either the extensive or the intensive margin in store s during year t for type of bag B = {plastic, paper, bought reusable, brought reusable, no bag}, $Richmond_s$ is an indicator for observations at stores in Richmond, $Post_t$ is an indicator for observations in 2014, which are after the implementation of the policy, α_s represents store fixed

[19] The Berkeley Discount store appears to be an outlier across these 3 measures in the pre-period. This is partly because the Berkeley store already had a bag policy during the pre-period and partly due to the layout of the checkout lanes at the Berkeley store, which has very little standing room for baggers.

effects, and X_{st} is a set of controls. The coefficient of interest is β_1, that is, the coefficient on the interaction of $Richmond_s$ and $Post_t$, which measures the effect of the ban on demand in treated stores relative to changes in demand in control stores in Berkeley and Concord. We estimate the above specification for each chain and bag type separately.

Tables 3 & 4 present the results—from the National and Discount Chain respectively—for the effects of the Richmond bag ban on bag demand for the various types of bags, along both the extensive and intensive margins. To estimate demand on the extensive margin, we use a linear probability model where the outcome variable is the probability of using a particular type of bag.[20] To estimate demand on the intensive margin, we use OLS where the outcome variable is the total number of bags used among those that use them. Each specification includes—in addition to the interaction of the Richmond*POST indicators, the POST indicator, and store fixed effects—fixed effects for the date of visit, hour of visit, week-in-month of visit (first, second, third, fourth), and observer. We include these fixed effects since the profile of the average grocery shopper is not constant over the course of a day, day of the week, or week in the month.[21] We also control for whether the transactions occurred in an express lane, whether a bagger was present for at least part of the transaction, whether the customer paying was male, and whether the customer paying was white. These controls are added to further prevent

[20] We found that a probit model produces similar results.

[21] Studies have shown that as the day progresses, the average age of grocery shoppers' declines while the average income rises, and that shoppers on Sundays are noticeably younger than those on other days of the week. ("Grocery Shopping: Who, Where, and When." *The Time Use Institute*. Oct. 2008. Online). Another way in which customers' profiles are not constant over time is that SNAP and WIC participants are more likely to use their benefits in the first weeks of the month. According the Food and Nutrition Service of the USDA (2012), 80 percent of SNAP benefits are used within the first 2 weeks of issuance. Therefore, if age and income are correlated with using reusable bags over disposable bags and we don't include these time fixed effects, differences in the timing of observations across locations could bias our results.

differences across locations and time periods from biasing the results. Lastly, we cluster the standard errors at the store-day level to account for the possibility that the errors are correlated within a given store on a particular day, but not across stores or dates.

In table 3 we find that, in regards to the extensive margin, the ban at National Chain stores led to a decrease in plastic bag consumption of 81.57 percentage points, an increase in paper bag use of 46.50 percentage points, an increase in bringing reusable bags of 26.03 percentage points and an increase in buying reusable bags of 4.24 percentage points. In addition, the percent of customers using no bags increased by 9.25 percentage points. Adding the β_1 coefficients from column (1) and (2) shows that total usage of disposable bags (paper plus plastic) decreased by approximately 35 percentage points.[22] With respect to the intensive margin, in column 6 we see that the bag ban caused the number of paper bags used per transaction by paper bag users to decrease by 2.08 bags. Thus even though National Chain customers use paper bags 46.50 percentage points more often after the policy change (extensive margin), those who use paper bags use fewer paper bags per trip (intensive margin). In column 7 we find that the average number of reusable bags brought by reusable bag users at the National Chain did not increase by a statistically significant amount due to the ban. Thus while the ban led more people to bring reusable bags, it did not alter the number of reusable bags used per trip. Lastly, we can combine the extensive and intensive margin estimates in a two-part model to approximate the overall effect of the Disposable Bag Policy on reusable and paper bag demand (McDonald and Moffitt 1980; Homonoff 2013).[23] The combined estimates indicate that the policy increased the

[22] Since it is possible for National Chain shoppers to use both plastic and paper during a transaction, we also run equation (1) with the percent of customers using either paper or thin plastic as Y_{st}^{B}. In this specification, the estimated β_1 is -33.20 percentage points, which is very close to what we obtain by simply adding the coefficients in column (1) and (2).

[23] The conditional expectation of demand can be decomposed into its extensive and intensive components as

number of paper bags used by 1.76 bags and increased the number of reusable bags by 0.64 bags per customer per shopping trip.[24]

Table 4 presents the results for the Discount Chain, where the imposition of the ban led to a decrease in disposable plastic bag use of 89.05 percentage points, an increase in paper bag use of only 10.12 percentage points, an increase in bringing reusable bags of 18.32 percentage points and an increase in buying 15-cent reusable bags of 28.57 percentage points. The probability that customers use no bags increases by 29.67 percentage points. Adding the β_1 coefficients from column (1) and (2) shows that total usage of disposable bags decreased by approximately 79 percentage points. On the intensive margin, column 6 shows that the average number of reusable bags used by reusable bag users increased by 0.4041 bags after the policy change. As above, we combine the extensive and intensive margin estimates to approximate the overall effect of the Disposable Bag Policy on reusable bag demand. We find that the policy increased the overall number of reusable bags by 0.28 bags per customer per shopping trip.

Comparing the Discount and National Chain results, we find that at both chains (1) the presence of a bagger is correlated with an increase in the probability in customers using disposable bags and a decrease in the probability of customers using no bags,[25] (2) male customers are less likely to bring reusable bags and more likely to use no bags than female

follows: $E[y|x] = E[y|x, y > 0] * P(y > 0|x)$, where y represents demand and x represents the covariates. The total effect on bag demand of a change in one of the covariates is given by:

$$\frac{\partial E[y|x]}{\partial x} = \frac{\partial E[y|x, y > 0]}{\partial x} * P(y > 0|x) + \frac{\partial P(y > 0|x)}{\partial x} * E[y|x, y > 0].$$

For this exercise, we evaluate $P(y > 0|x)$ and $E[y|x, y > 0]$ at the sample means of the treated stores, pre-policy.

[24] Given that the number of bags used of any given bag type is zero censored, we also estimate bag demand under a Tobit model. We find that the estimates are larger but qualitatively similar under a Tobit model compared to the combined demand model used above.

[25] Baggers are instructed to keep busy and float to checkout lanes where there are groceries to bag. Thus the correlation between bag use and baggers may be due to baggers moving to larger transactions that need bags.

customers, and (3) white customers are more likely to bring bags than customers of other races. When contrasting the Discount Chain and the National Chain, it is interesting to note that the increase in paper bag usage is more than 4 times larger at National Chain stores than at Discount stores. Also, Discount store customers are 3 times more likely to use no bags than National Chain store customers. Finally, customers at Discount stores choose to buy 15-cent reusable bags more often than 10-cent paper bags. We suggest that these difference between chains occur for several reasons: (1) the National Chain stores sell paper bags for 5-cents less than the Discount stores, (2) Discount stores sell an alternative reusable bag for $0.15 as opposed to the National Chain, which only sells $1.50 reusable tote bags, and (3) Discount Chain shoppers may be more price sensitive than National Chain shoppers.

Analysis of Bag Demand over Time

Using the additional data collected in March and April, we look at whether bag demand changes over time, as customers grow accustomed to the Richmond bag ban. Using the same model specifications as in Table 3 and 4 for demand on the extensive margin, we vary the length of the POST period over two scenario. In scenario A we use the same POST period we have been using up until this point in the analysis, which includes all transactions in January and February 2014. In scenario B we instead use transactions in March and April 2014 in the POST period. Figure 2 (a) plots the β_1 coefficients from these regressions for the National Chain across the two time scenarios. Note that the effect of the Disposable Bag Policy on paper bag consumption remains relatively stable over time, however, when using the later months the increase in the probability of bringing reusable bags is roughly 20 percentage points lower and the increase in the probability of using no bag is 20 percentage points higher. The differences in point estimates between the early and later scenarios are statistically significant at the 5% level

for all bag types except paper. One hypothesis for why these changes occur is that customers learn they can repack their cart item by item without bags and then bring the cart out to their vehicle (where they may or may not have bags) to unload it again.[26]

Figure 2 (b) repeats the analysis above for the Discount Chain. Comparing the panels reiterates the point that the treatment leads to dissimilar bag usage patterns at the two grocery chains. Unlike National Chain shoppers, the increase in the probability of Discount Chain shoppers bringing a reusable bag is 20 percentage points higher in the later months. Also, the increase in the probability of buying a 15-cent reusable bag is 13 percentage points lower in the later months. The differences in point estimates between the scenarios are only significant at the 5% level for brought bags and bought 15-cent bags. We hypothesize that these changes occur in part because a fraction of customers begin reusing the 15-cent bags they purchased previously. We will discuss the reuse of the 15-cent bags further in the next section on policy implications.

Bag Bans *vs.* Bag Fees and Policy Implications

If the objective of Disposable Bag Policies is to increase the use of reusable bags and decrease the use of disposable bags, how do bag bans and bag fees compare in reaching this objective? To answer this question we compare the proportion of customers using reusable bags and disposable bags in Homonoff's (2013) sample to the proportion of customers using reusable and disposable bags in our sample. As mentioned above, Homonoff studied the 2012 Montgomery County Maryland Disposable Bag Policy which imposed a 5-cent fee on both disposable plastic and paper bags. In Homonoff's study, stores in Virginia were without a Disposable Bag Policy and thus are comparable to our Concord store. Stores in Washington, DC had a 5-cent bag fee for two years when the Montgomery County Maryland Disposable Bag

[26] Many interviewed managers noted that shopping cart and shopping basket theft increased after the policy change.

Policy went into effect and thus are comparable to the Berkeley stores in our sample. Lastly, the Maryland stores are the ones treated in Homonoff's study and thus are comparable to the Richmond stores in our sample. Note that while Maryland and Richmond customers face very different prices for thin plastic bags (5 cents versus infinity) both face the same magnitude of fee for paper bags (5 cents).

We first focus on the National Chain stores in our study since they are more comparable to the grocery chains used by Homonoff (2013).[27] The darkly shaded bars in Figure 2 (a) plot the proportion of customers bringing reusable bags and 2 (b) the proportion of customers using disposable bags (either thin plastic or paper) at National Chain stores across policy jurisdictions and treatment periods. In panel (a) we see that bag bans and fees have very similar effects on encouraging customers to bring reusable bags—with 46% of customers facing a ban and 47% of customers facing a fee choosing to bring reusable bags. In panel (b) disposable bag usage is also similar under both types of policies, though on average the proportion of bag ban customers using disposable bags is 6 percentage points less than the proportion of bag fee customers.

In summary, at National Chain stores bans and fees have similar effects on reusable bag usage, while bans lead to slightly less disposable bag usage than fees. Yet what is not shown here is that disposable bag use for ban customers is completely comprised of paper whereas for fee customers it is a mix of paper and thin plastic.[28] Since paper bags have their own set of environmental costs, policymakers and citizens may be concerned by the significant increase in

[27] We also drop all January observations so that our POST period is more similar to that used by Homonoff (2013), whose data in the pre-period was collected from late September to early November of 2011 while data in the post-period was collected from late February to early March of 2012.

[28] Homonoff (2013) does not decompose disposable bag usage into paper and plastic because "almost all customers chose to use plastic bags when they were offered." Looking at our pre-period data, we also find that the vast majority of customers chose plastic bags over paper bags when given the option.

paper bag usage under plastic bag bans.

However paper is not the only alternative type of bag that grocery stores can offer. The 15-cent thick-plastic bags are an alternative to thin plastic bags and they do not have as large of side-effects of being easily blown around or clogging recycling equipment. This begs the question: How does the proportion of customers using reusable and disposable bags under a bag ban with the 15-cent bag option compare to bag usage under policies without this alternative? To answer this question, we compare bag usage at our Discount stores to bag usage at both our National Chain stores and those in Homonoff's sample.[29] Focusing now on the lighter shaded bars, in panel (a) we see that having an alternative type of bag to buy doesn't significantly alter the proportion of customers bringing reusable bags. In other words, reusable bag usage is stable across Disposable Bag Policies and store types. However, in panel (b), we find that the presence of an alternative bag to purchase has a large effect on the proportion of customers using disposable bags. Only 10 percent of customers at Discount stores with bans use disposable paper bags, compared to roughly 40 percent of customers at stores without 15-cent thick-plastic bags. Therefore 15-cent thick-plastic bags seem like desirable alternatives to thin plastic bags, especially for those who worry that bag bans lead to an increase in paper bag consumption.

In light of concerns that the thick-plastic bags are not actually reused by customers, our unique experimental design allows us not only to measure the number of customers buying the thick plastic bags, but also the number reusing them as well. At Discount stores with a bag ban in place, thirty-nine percent of customers brought at least one reusable bag. Of those customers bringing reusable bags, 17 percent brought the 15-cent reusable bag. In comparison, only 6 percent of customers bringing reusable bags brought old paper bags. Moreover, comparing the

[29] When making this comparison, we want to keep in mind the caveat that the clientele at Discount stores is very different than at National Chain stores.

percentages of customers buying and bringing 15-cent bags indicates that 2 out of 5 customers that buy 15-cent bags reuse them in future purchases. Therefore, a large percentage of Discount Chain customers do reuse the 15-cent thick-plastic bag for future purchases. And this is just a lower bound for the reuse of these bags, which may be reused in other ways by customers (ex. bag liners for small garbage bins).

Given these results, our first policy recommendation for municipalities considering Disposable Bag Policies is that retailers should be required to make the price of all types of bag they offer transparent to their customers at purchase. Just by having a salient price, much of the externality of the overuse of disposable bags is eliminated. Second, for cities, counties and states that opt for plastic bag bans with paper bag fees, we recommend incentivizing the production and sale of 15-cent thick-plastic reusable bags. The thickness of these bags makes them less likely to blow out of garbage systems and into water-ways. Plus they are both recyclable and reusable. Furthermore, we find that when Discount stores offer their price-sensitive customers 15-cent bags, it produces similar levels of reusable bag usage and smaller levels of paper bag usage than at National Chain stores without these bags.

Conclusion

This paper adds empirical insight to the "prices *vs*. quantities" debate by being the first to compare the effect of bans versus fees on consumer disposable and reusable bag demand. We collect observational bag usage data (over bag type, time, and space) to measure shifts in bag demand in response to the introduction of a plastic bag ban coupled with a paper bag fee. We then compare our analysis to a study on a plastic and paper bag fee. Our main results are threefold. First, bag bans—while decreasing total disposable bag consumption and increasing reusable bag usage—lead to significant increases in paper bag demand. At the National Chain,

the percent of customers using paper bags climbs from less than 5% before the policy to over 40% afterwards. However, the fee for paper bags is effective in that those who choose to buy paper use fewer paper bags per transaction after the policy change. Second, we find that the two Disposable Bag Policies produce remarkably similar increases in reusable bag usage. Third, bans and fees also have similar effects in terms of reducing total disposable bag consumption, that is, unless stores offer inexpensive reusable bags and charge more for paper bags, in which case bans may be more effective than fees. In particular, the percent of customers using paper only increases to 10% at Discount stores where 15-cent reusable bags were sold. Thus, if the environmental costs of both plastic *and* paper bag consumption are a concern to policymakers and the public, these results suggest that Disposable Bag Policies should also regulate the types and prices of the reusable bags stores choose to sell instead of, or alongside, disposable bags.

Our results are not only relevant for the regulation of disposable bags, but can also inform policies regulating other disposable products, such as Styrofoam containers and plastic bottles. Future work will focus on other unintended effects of Disposable Bag Policies. We aim to merge our observational bag usage data with corresponding transaction-level scanner data to measure whether bag policies lead to changes in the composition of shopping baskets and in the time necessary for checkout. While bans and fees were found to have similar effects on reusable bag usage in this study, these policies may differ along other dimensions.

References

Adda, J. and F. Cornaglia. 2010. The Effect of Bans and Taxes on Passive Smoking. *Amer. Econ. J.: Appl. Econ*. 2(1):1-32.

Clapp, J. and L. Swanston. 2009. Doing Away with Plastic Shopping Bags: International Patterns of Norm Emergence and Policy Implementation. *Environ. Politics*. 18(3): 314-332.

Convery, F., S. McDonnell, and S. Ferreira. 2007. The Most Popular Tax in Europe? Lessons from the Irish Plastic Bags Levy. *Environ. Resource Econ*. 38 (1): 1-11.

Christiansen, V. and S. Smith. 2012. Externality-Correcting Taxes and Regulation. *Scand. J. Econ.* 114(2): 358-383.

DDOE, District of Columbia Department of the Environment. 2008. Anacostia Watershed Trash Reduction Plan.

Dikgang, J., A. Leiman, and M. Visser. 2012. Elasticity of Demand, Price and Time: Lessons from South Africa's Plastic-Bag Levy. *Appl. Econ*. 44 (26): 3339-3342.

EPA, Environmental Protection Agency, United States. 2015. Advancing Sustainable Materials Management: Facts and Figures.

FNS, Food and Nutrition Service. 2012. Building a Healthy America: A Profile of the Supplemental Nutrition Assistance Program. Alexandria, VA: USDA, FNS.

Greene, D. 1990. CAFE or Price?: An Analysis of the Effects of Federal Fuel Economy Regulation and Gasoline Price on New Car MPG, 1978-89. *Energy J*. 11(3): 37-57.

Homonoff, T. 2013. Can Small Incentives Have Large Effects? The Impact of Taxes vs. Bonuses on Disposable Bag Use. Industrial Relations Section Working Paper 575, Princeton Univ.

McDonald, J. and R. Moffitt. 1980. The Uses of Tobit Analysis. *Rev. Econ. Statist*. 62(2):318 321.

Oates, W., P. Portney, and A. McGartland. 1989. The Net Benefits of Incentive-Based Regulation: A Case Study of Environmental Standard Setting. *Amer. Econ. Rev*. 79(5): 1233-1242.

Sandmo, A. 1978. Direct versus Indirect Pigovian Taxation. *Europ. Econ. Rev.* 7(4):337-349.

Weitzman, M. 1974. Prices *vs.* Quantities. *Rev. Econ. Stud*. 41(4): 477-491.

Table 1: **Bag ordinances, number of transactions observed, and average pre-ban transaction characteristics**

National Chain

	Bag Ordinances		Number of Trans. Observed				Pre-Ban Statistics		
	Bag Ban Start Date	Paper Bag Fee	2013 Dec	2014 Jan-Feb	2014 Mar-Apr	Total	Ave. Lanes Open	% Trans. w/Baggers	Ave. Trans. Time (seconds)
Berkeley	January 1, 2013	10 cents	226	272	199	697	4.67	0.54	92.98
Richmond	January 1, 2014	5 cents	200	271	194	665	4.59	0.65	88.93
Concord	No Ban	"Free"	254	321	199	774	4.68	0.51	86.62
Total Obs.			680	864	592	2136			

Discount Chain

	Bag Ordinances		Number of Trans. Observed				Pre-Ban Statistics		
	Bag Ban Start Date	Paper Bag Fee	2013 Nov-Dec	2014 Jan-Feb	2014 Mar-Apr	Total	Ave. Lanes Open	% Trans. w/Baggers	Ave. Trans. Time (seconds)
Berkeley	January 1, 2013	10 cents	156	163	201	520	3.40	0.08	95.56
Richmond[1]	January 1, 2014	10 cents	433	341	384	1158	2.28	0.43	75.52
Concord	No Ban	"Free"	199	183	228	610	2.95	0.56	86.11
Total Obs.			788	687	813	2288			

1. We observe transactions at two Discount Stores in the Richmond Area.

Table 2: **Demographics, pre-ban**

2012 Census Data			
	Berkeley	Richmond	Concord
Male	0.489	0.489	0.498
White	0.627	0.497	0.704
Black	0.088	0.212	0.038
Under 18	0.130	0.243	0.226
Population	122,662	157,176	122,683
Ave. Salary	$42,332	$28,365	$33,511
National Chain - Observed Data			
	Berkeley	Richmond	Concord
Male	0.469	0.410	0.461
	(0.500)	(0.493)	(0.499)
White	0.690	0.580	0.764
	(0.463)	(0.495)	(0.426)
Black	0.106	0.250	0.0433
	(0.309)	(0.434)	(0.204)
Discount Chain - Observed Data			
	Berkeley	Richmond	Concord
Male	0.532	0.406	0.442
	(0.501)	(0.492)	(0.498)
White	0.449	0.293	0.613
	(0.499)	(0.456)	(0.488)
Black	0.308	0.346	0.146
	(0.463)	(0.476)	(0.354)

Standard deviations in parentheses. Table reports mean values of each variable in the pre-period. Sources: In-store observational data & U.S. Census Bureau, 2008-2012 American Community Survey 5-Year Estimates. Richmond census values are population weighted averages of Richmond, El Cerrito, & San Pablo.

Table 3: **Effect of plastic bag ban on bag demand - extensive margin and intensive margin (National Chain)**

	Extensive Margin					Intensive Margin	
	(1) Plastic	(2) Paper	(3) Brought Reus.	(4) Buying Reus.	(5) No Bags	(6) Paper	(7) Brought Reus.
Post x Richmond	-0.8157***	0.4650***	0.2603***	0.0424***	0.0925***	-2.0765***	0.1999
	(0.0074)	(0.0268)	(0.0272)	(0.0050)	(0.0187)	(0.0850)	(0.3260)
Post	0.0774***	-0.1195**	-0.2693***	-0.0538***	0.2114***	-1.2558***	0.7731
	(0.0152)	(0.0497)	(0.0434)	(0.0110)	(0.0410)	(0.2433)	(1.1818)
Express	-0.0052	0.0331	-0.0720*	0.0008	0.0164	-0.3990*	-0.6286**
	(0.0235)	(0.0335)	(0.0398)	(0.0059)	(0.0253)	(0.2145)	(0.2578)
Bagger Present	0.0274*	0.0721***	0.0082	0.0016	-0.0701***	0.5557**	0.2560
	(0.0148)	(0.0239)	(0.0308)	(0.0034)	(0.0237)	(0.2128)	(0.1885)
Male	-0.0046	0.0324	-0.0870***	-0.0098**	0.0517***	0.1405	0.2243*
	(0.0154)	(0.0210)	(0.0256)	(0.0045)	(0.0167)	(0.1809)	(0.1297)
White	-0.0210	0.0004	0.1056***	0.0008	-0.0591***	0.0908	0.4776***
	(0.0147)	(0.0227)	(0.0233)	(0.0043)	(0.0174)	(0.1869)	(0.1622)
Num of Obs.	1544	1544	1544	1544	1544	328	411
Store Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observation Fixed Effects[1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors are in parentheses. Clusters are at the store-day level. Outcome variables: probability of using at least one bag or no bags (extensive) and bag demand among users (intensive). $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

[1] Fixed Effects for Date-of-Visit, Hour, Week-in-Month, Observer, and Day-of-Week.

Table 4: **Effect of plastic bag ban on bag demand - extensive margin and intensive margin (Discount Chain)**

	Extensive Margin					Intensive Margin
	(1) Plastic	(2) Paper	(3) Brought Reus.	(4) 15 cent Bag	(5) No Bags	(6) Brought Reus.
Post x Richmond	-0.8905***	0.1012***	0.1832***	0.2857***	0.2967***	0.4041**
	(0.0215)	(0.0167)	(0.0223)	(0.0276)	(0.0170)	(0.1827)
Post	-0.0504	-0.0188	0.1281***	-0.0138	-0.0735**	0.7524
	(0.0389)	(0.0346)	(0.0389)	(0.0466)	(0.0308)	(0.4847)
Bagger Present	0.0518***	0.0064	-0.0046	0.0169	-0.0588**	0.3969*
	(0.0175)	(0.0183)	(0.0178)	(0.0144)	(0.0218)	(0.2302)
Male	0.0103	-0.0237*	-0.0666***	0.0116	0.0448**	-0.1990
	(0.0100)	(0.0122)	(0.0226)	(0.0146)	(0.0208)	(0.1544)
White	-0.0276*	-0.0316**	0.1121***	-0.0348*	-0.0043	0.1451
	(0.0155)	(0.0121)	(0.0271)	(0.0172)	(0.0225)	(0.1091)
Num of Obs.	1475	1475	1475	1475	1475	320
Store Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observation Fixed Effects[1]	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors are in parentheses. Clusters are at the store-day level. Outcome variables: probability of using at least one bag or no bags (extensive) and bag demand among users (intensive). $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

[1] Fixed Effects for Date-of-Visit, Hour, Week-in-Month, Observer, and Day-of-Week.

Figure 1(a): Percent of transactions using each bag type (National Chain)

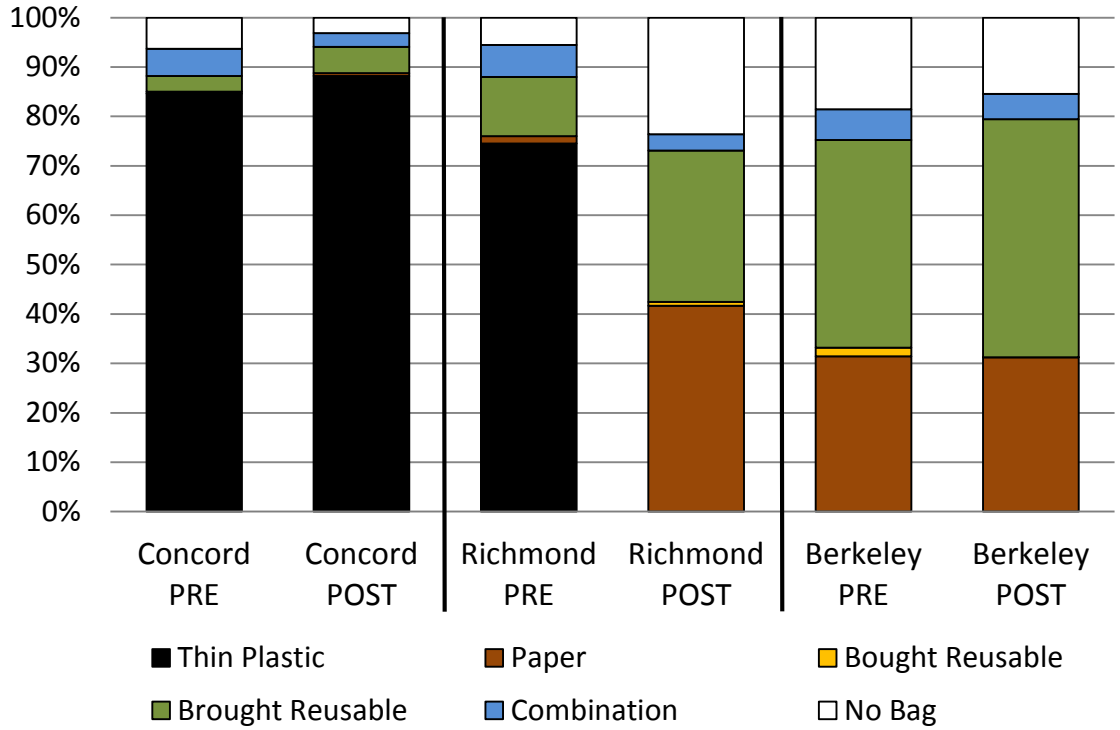


Figure 1(b): Percent of transactions using each bag type (Discount Chain)

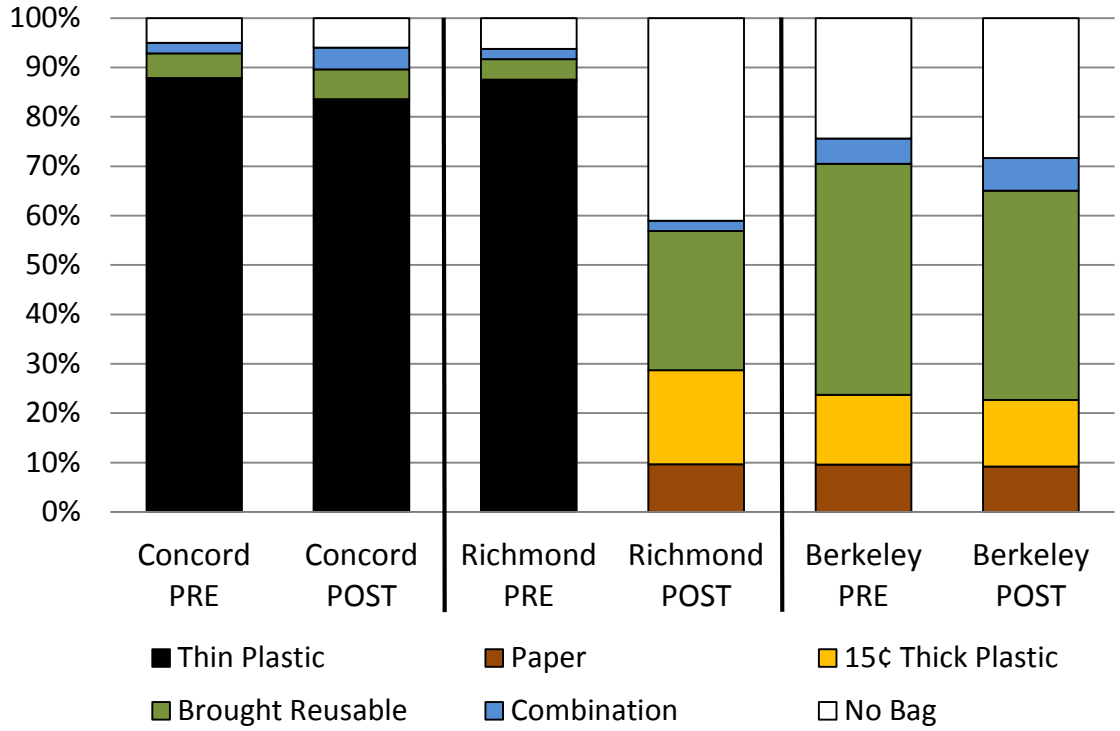


Figure 2(a): Effect of Plastic Bag Ban on Bag Demand over Time (National Chain)

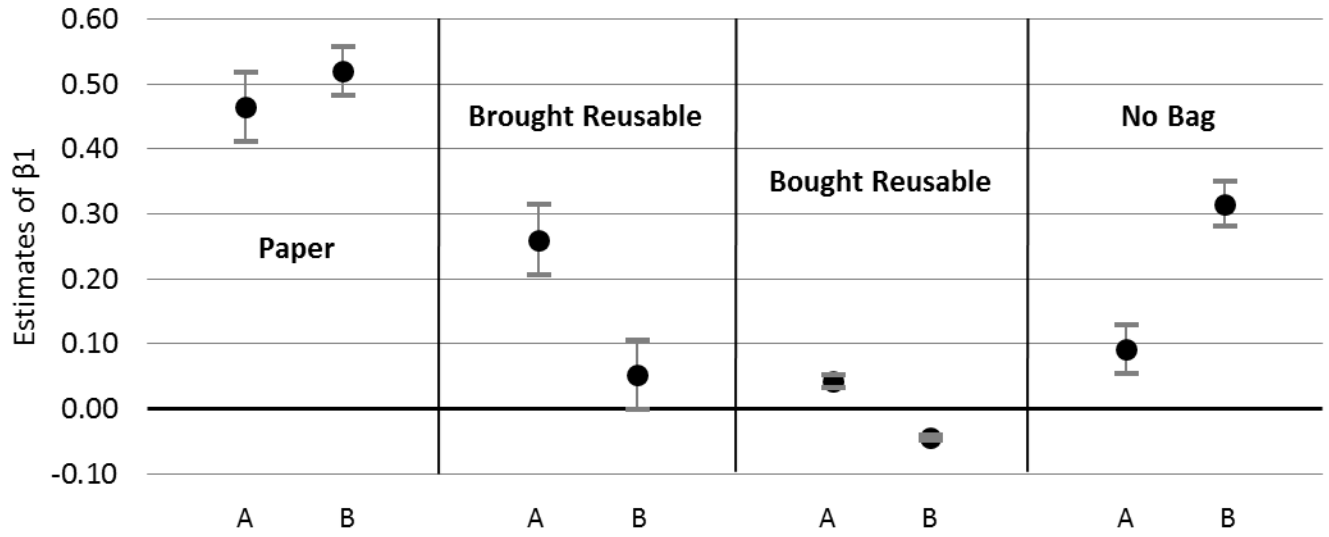
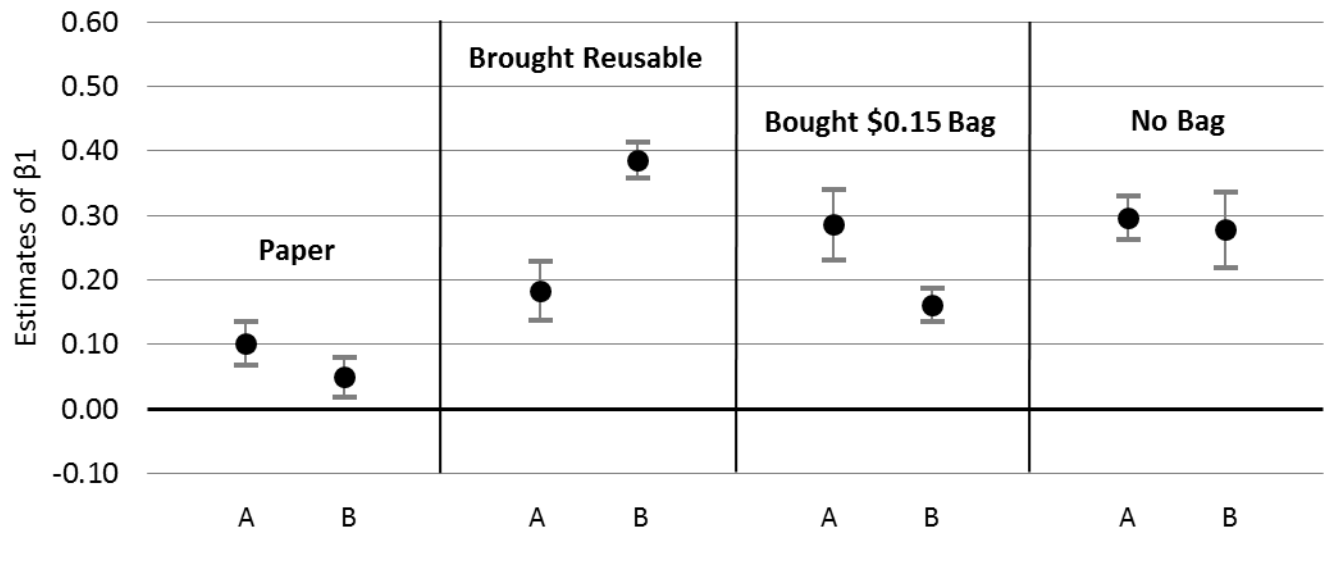


Figure 2(b): Effect of Plastic Bag Ban on Bag Demand over Time (Discount Chain)



95% confidence intervals are calculated using clustered standard errors. β_1 is the coefficient on the interaction of Richmond*POST. Using the model specifications for bag demand on the extensive margin, we vary POST over two scenarios: (A) POST = January-February. (B) POST = March-April.

Figure 3(a): Proportion of customers bringing reusable bags, across policy jurisdictions

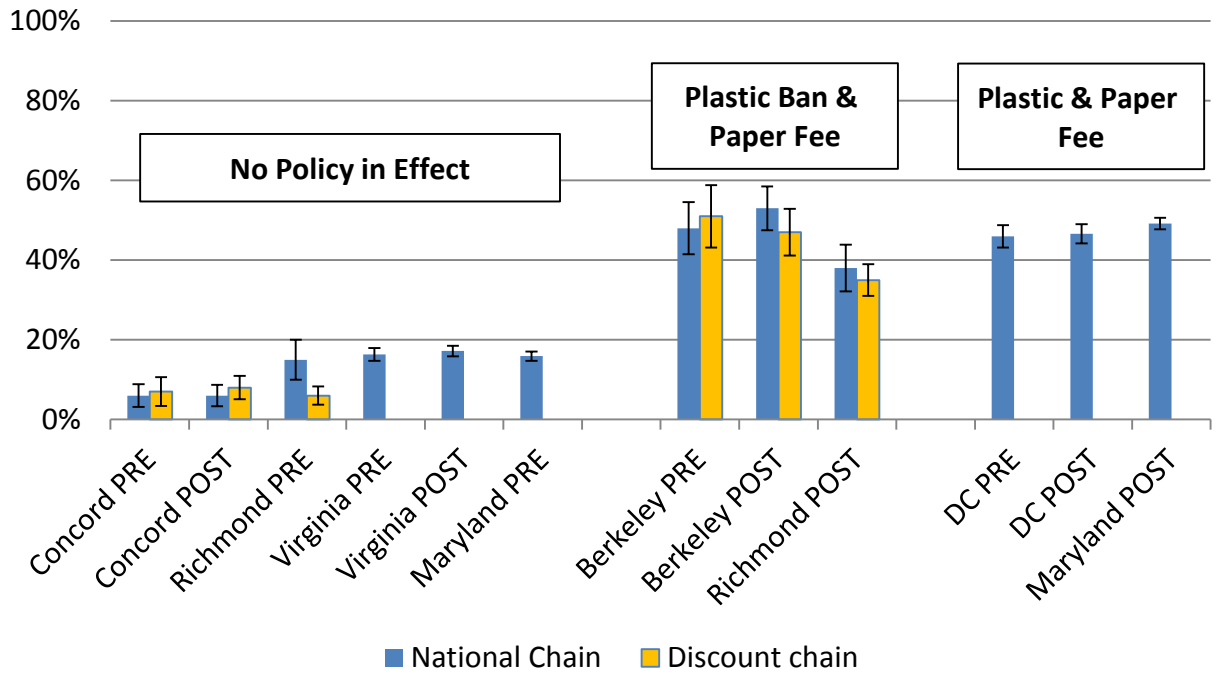
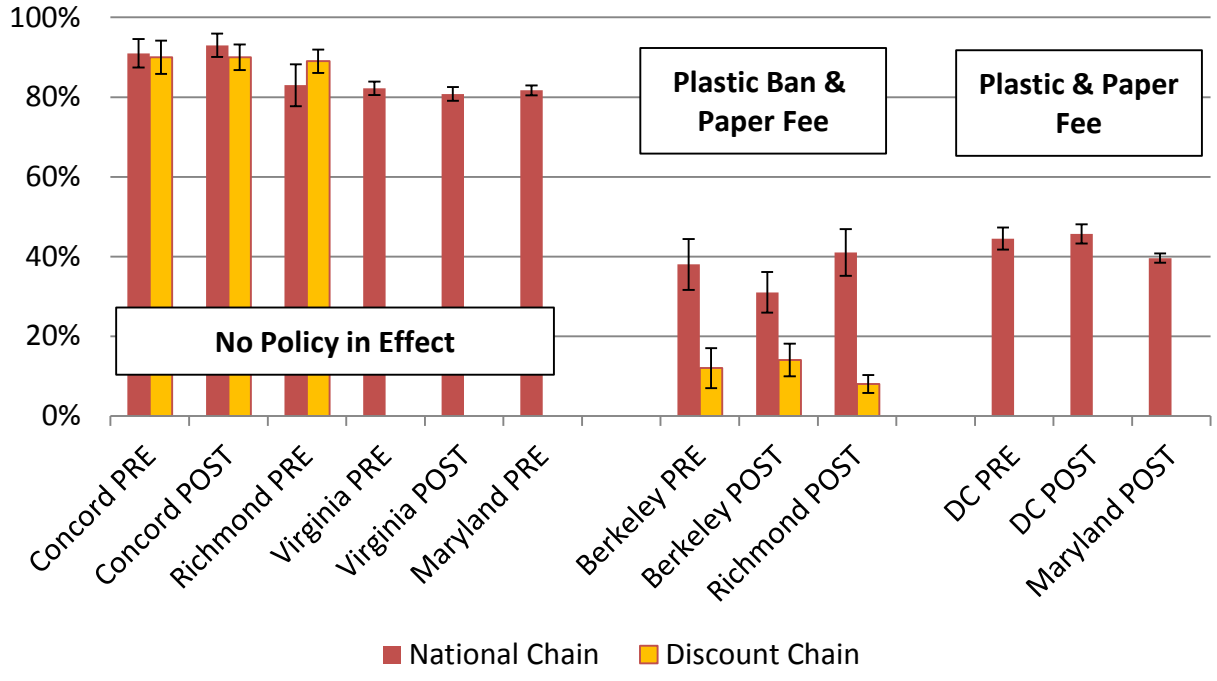


Figure 3(b): Proportion of customers using disposable bags, across policy jurisdictions



* 95% confidence intervals.