Supermarket Carryout Bag Policies and Bag Usage: Bans Versus Fees

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Using observational data on consumer carryout bag usage, we measure the effects of Disposable Bag Policies on bag demand. Our results show that a plastic bag ban and paper bag fee eliminate use of disposable plastic bags, increase use of reusable bags, and cause large increases in paper bag demand. We compare our results to a study on bag fees, and conclude that the types of bags stores choose to sell in lieu of single-use plastic bags, as well as the amount they sell them for, impact whether bag bans are more successful than bag fees in discouraging disposable bag demand. JEL code: H230, Q580

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I. INTRODUCTION

Single-use plastic bags bring convenience to the lives of supermarket customers, but at a significant 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,[2] it is no surprise that Disposable Bag Policies are gaining popularity among lawmakers in cities and counties across the county. Disposable Bag Policies prohibit grocery stores from providing customers with free single-use 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. Disposable Bag Policies come in four flavors: 1) bans on single-use plastic bags only, 2) bans on both single-use plastic and paper bags, 3) bans on single-use plastic and fees on paper bags, and 4) fees on both single-use plastic and paper bags.[3] While fees on both plastic and paper single-use bags have been adopted in several cities and counties on the east coast,[4] the most popular policy prescription on the west coast has been bans on plastic bags coupled with fees on paper bags. In California alone, over 75 plastic bag ban policies have already been passed at the city and county level,[5] and a

[2] 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 (Burnett, 2013). Given that approximately 100 billion plastic bags are consumed in the U.S. each year (Clapp and Swanston, 2009), municipalities across the U.S. together are spending up to $3.2 to 7.9 billion per year to clean-up plastic bags. This is a conservative estimate as city officials in San Francisco calculate that plastic bag clean-up, recycling and landfilling costs the city as much as 17 cents per bag, the equivalent of $8.5 million a year (Mirkarimi, 2007; Myer and Russo, 2012).

[3] Enacted fees have varied in magnitude between 5 and 25 cents.

[4] Washington, DC enacted a 5-cent fee on both single-use plastic and paper bags on January 1, 2010. Montgomery County Maryland introduced a similar 5-cent fee on January 1, 2012.

[5] Californians Against Waste. <http://www.cawrecycles.org/issues/plastic_campaign/plastic_bags/local>

statewide bag ban currently sits under debate in the California State Assembly.[6] And California is not the only state in this policy debate. As of February 2014, pending state legislation in the U.S. currently stands with 3 states considering laws that would ban disposable plastic bags—California, Massachusetts, and Washington, as well as Puerto Rico—and 8 states considering a fee or tax on all disposable bags[7]—California, Hawaii, Massachusetts, New York, Pennsylvania, Vermont, Virginia, and Washington (NCSL, 2014).[8]

The standard economic analysis, dating back to Pigou (1920), says that if disposable bags create externalities, they should be taxed. Yet in practice we often see governments choosing bans over taxes and fees. Given the policy debate between bag bans and bag fees, this paper investigates and compares whether these policies have their intended effects on the types of bags consumers use at checkout in supermarkets. To accomplish this, we first 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. 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

[6] California Senate Bill 270, which passed the California Senate on April 29, 2013, proposes to ban single-use plastic carryout bags and requires stores to sell paper and reusable bags for at least 10 cents each. If this bill clears the State Assembly's Committee on Appropriations on August 14, 2014, it will move to the floor of the State Assembly for a final vote. August 31, 2014 is the last day for the State Assembly to pass SB 270.

[7] Shoppers will have to pay these fees either directly when they purchase bags or indirectly in the price of their groceries. In the second case, retail stores will be taxed for providing disposable bags and it is assumed this additional cost will be passed onto customers in the total price they pay for groceries.

[8] The fees under consideration range from 1 to 15 cents per bag and depending on the state, the revenue from the fees that are not kept by stores would go to state parks, school districts, community improvement trusts or other public programs.

before and after the Disposable Bag Policies 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 Disposable Bag Policy change during our sample period.

With our unique panel dataset, we use a simple difference-in-differences empirical strategy to measure how disposable plastic bag bans and paper bag charges affect customers' demand for various types of disposable and reusable bags. We further measure whether changes in consumer behavior due to the policy shock are heterogeneous across: (1) the size of the fee—i.e. 5-cent fees versus 10-cent fees, (2) store type—i.e. national supermarket chain versus deep-discount chain, and (3) customer demographics—i.e. gender and race. 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 difference-in-differences analysis on each of these chains separately, we are able to compare how the types of bags that stores choose to sell in lieu of single-use plastic, as well as the prices of these alternative bags, influence consumer behavior.

Lastly, we investigate how outcomes under plastic bag bans and paper bag fees compare to outcomes under bag fees alone. We do this by relating our results

to that of Homonoff (2013). While there exist previous studies examining how Disposable Bag Policies affect consumer behavior (Convery, McDonnell, & Ferreira, 2007; Dikgang, Leiman, and Visser, 2012; He, 2010), 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. Homonoff (2013) studies a five cent single-use plastic and paper bag fee in Montgomery County Maryland and finds that the use of disposable bags drops 42 percentage points after the policy implementation. By using a similar methodology to 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.

To preview some of our results, we find that when comparing bag bans versus bag fees, both policies lead to remarkably similar increases in reusable bag usage and reductions in disposable bag usage at National Chain stores.[9] However, in comparing the Discount Chain to the National Chain, we find that charging 10 cents (instead of 5 cents) for paper bags and offering cheap, alternative reusable bags leads to even larger reductions in disposable bag demand. Specifically, after the policy change, paper bag demand only increased by 8.52 percentage points at Discount Chain stores, as compared to 46.51 percentage points at National Chain stores. In summary, the types of bags that stores decide to sell in lieu of single-use plastic bags, as well as the amount they sell them for, has significant impacts on the effectiveness of Disposable Bag Policies, especially in regards to disposable paper bag demand.

As the first study to 1) rigorously analyze consumer bag demand responses to plastic bag bans with paper bag fees and to 2) compare outcomes

[9] We refer to both paper and plastic carryout bags as disposable bags. Thus for customers facing a plastic bag ban, disposable bag use is completely comprised of paper bags and for customers facing a paper and plastic bag fee, it is a mix of paper and plastic bags.

under bag bans to those under bag fees, the results of this paper have the potential to shape current and future policy. Our results suggests that as further cities, counties, and states continue to design, adopt, and modify their own Disposable Bag Policies, they will want to consider not only their objectives for increasing reusable bag use, but also their objectives for paper bag consumption. The rest of the paper proceeds as follows. In Section II we review the background on single-use disposable bags. In Section III we describe the empirical setting, the policy changes that led to the experimental design, the data collection methodology, and the data. Section IV lays out the empirical strategy and Section V presents the results. Finally, Section VI compares our results to previous studies and discusses policy implications and Section VII concludes.

II. BACKGROUND ON DISPOSABLE BAG POLICIES

A. Environmental Costs of Disposable Carryout Bags

Standard disposable plastic bags cost retailers on average 3 cents each and paper bags cost 6 to 10 cents each[10]. 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.[11] Without seeing a price for single-use bags, customers are prone to use more bags than they would be willing to pay for at face-value, and this overuse of disposable plastic bags is costing municipalities millions in clean-up expenses annually. 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

[10] These bag cost estimates come from interviews with the store managers in our sample, but media articles also confirm these bag costs (Sweeney, 2014; Lewis and Lum, 2014). The cost of paper bags depend on bag size and whether bags have handles.

[11] The store owners we spoke with listed disposable bags as their 4th largest operating cost, after electricity, payroll, and credit card fees.

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 (Kauffman & Wolff, 2009). Furthermore, the 5.2 percent of plastic bags that do get recycled (USEPA, 2006) become a major problem for recyclers as the bags often clog the machines used to sort material (Millstein, 2007). San Francisco city officials calculate that plastic bag clean-up, recycling and landfilling costs the city as much as 17 cents per bag, the equivalent of $8.5 million a year (Mirkarimi, 2007; Myer and Russo, 2012). Similarly on the east coast, in New York City media articles report that transporting the 5.2 billion plastic bags disposed by the population costs the city $10 million annually (Foster, 2014).

Given the sizeable environmental costs of plastic bags, one might be tempted to answer the age-old 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: (i) paper bags are more energy intensive and more water intensive to manufacture than plastic bags, with paper bag production using 70 percent more energy and 17 times more water than the production of plastic bags of the same carrying capacity (Chaffee and Yaros, 2007), (ii) making paper uses trees that, instead, could be absorbing carbon dioxide, (iii) it takes about 91 percent more energy to recycle a pound of paper than a pound of plastic, and (iv) paper bags are heavier and bulkier than plastic bags and thus for every one truck that delivers plastic bags to a store, seven trucks are needed to deliver the same amount of paper bags (Lipscomb, 2008). Therefore, 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 no surprise that Disposable Bag Policies have in practice been more aggressive against plastic bag consumption that paper bag consumption.

B. Policies to Regulate Disposable Carryout Bags

Given the aforementioned costs of disposable bag usage, domestic and international governments began passing laws to regulate disposable bags in the early 2000's. Internationally it started with several countries, mainly in the global South, banning the use of plastic bags.[12] Ireland became the first country to impose a tax on customers for using plastic bags (Convery, McDonnell and Ferreira, 2007) while South Africa and China passed laws both banning the use of all plastic bags under a certain thickness as well as prohibiting stores from offering free plastic bags (Dikgang, Leiman, Visser, 2012; Hasson, Leiman and Visser, 2007; He, 2010). Domestically, 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. Several counties surrounding D.C. have since followed suit with similar laws and other cities (including New York City) are currently considering their own disposable bag fees (Hallock, 2014). These fees apply to all disposable paper and plastic bags at grocery stores, convenience stores and big-box stores such as Target and Walmart. Although the

[12]According to Clapp and Swanston (2009), "the first jurisdictions where anti-plastic bag norms emerged and regulatory action was taken were in the global South in the late 1990's and early 2000's. Northern industrialised countries saw attitudes shift only in more recent years, often with less stringent accompanying regulation. This South first, North second pattern of norm adoption is the opposite of the patterns typically seen with international norms."

fee magnitude has varied across municipalities (between 5 and 25 cents), in general retailers get to keep about 4 to 5 cents to cover the cost of implementation, while the city may keep any remaining cents of the fee 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 and paper bag fees instead of requiring fees for both. Furthermore, 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. This begs the question: Why has California chosen bans over fees? The answer lies in California Assembly Bill No. 2449. This bill, enacted statewide in 2006, requires grocery store operators to establish at-store recycling programs for customers to return clean plastic carryout bags to that store in easily viewed collection bins. All plastic carryout bags provided by the store must have displayed on the bag the words "PLEASE RETURN TO A PARTICIPATING STORE FOR RECYCLING." In addition, the 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, plastic bag fees have not been an available policy option for those California municipalities that did not feel recycling programs went far enough in addressing their disposable bag problems.

San Francisco was one such city. In 2007 San Francisco enacted a citywide ban on single-use plastic bags,[13] becoming the first government in the U.S. to do so. This sparked an exponential spread of Disposable Bag Policy adoption 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

[13] San Francisco amended this law in 2012, adding a 10-cent fee for paper bags.

in the summer of 2011—not only banning plastic bags but also charging a minimum of ten cents per paper bag. As of June 2014, over 75 Plastic Bag Policies have been adopted in California, including the populous cities of San Jose, Los Angeles, Long Beach and Oakland, as well as the counties of Alameda, Marin, Mendocino, Los Angeles, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz and Sonoma, to name a few. Interestingly, the requirements of California Assembly Bill No. 2449 were only operative until January 1, 2013. Thus any bills passed in California in and after 2013 could technically choose bag fees over bag bans. That being said, none of the more than 45 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 and paper bag fee and the other a plastic and paper bag fee.[14] Which will prevail and which should prevail?[15] Suppose the social cost of disposable bags is equal to their retail value. Then a policy that requires stores to make the price of bags transparent to customers would negate the pollution externality. What if the social cost of disposable bags is greater than their retail price? As Pigou (1920) would echo, a bag tax could be implemented to bring the price of the bag up to that of the social cost of the bag. Yet there are times when taxes are politically infeasible (such as in California between 2006 and 2013), and thus disposable bag bans can be used to eliminate the pollution externality. However, the loss of an item that consumers are willing to pay for, especially if there is no desirable alternative, may lead to a larger decline in consumer surplus than the decline in externality costs.

[14] Senate Bill 270 proposes to ban single-use plastic carryout bags and requires stores to sell paper and reusable bags for at least 10 cents each. Senate Bill 700 would instead require a retail establishment to charge 5-cents for both plastic and paper single-use carryout bag.
[15] Senate Bill 700 died in committee in February 2014 and is no longer under consideration. However, this question remains relevant for other governments across the country.

Several supermarket chains in areas affected by disposable 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, and they are made from 20% recycled materials and are recyclable themselves. While some believe these 15-cent bags are simply a loophole for stores and manufacturers to get around the intention of the plastic bag bans (Detz, 2014), others see them as a piece of the overall solution. The main issues with the current single-use plastic bags is that they were "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.

California Senate Bill 270—the bill calling for a statewide plastic bag ban and paper bag fee—also proposes the provision of $2 million in grant money from a California recycling fund to help plastic bag-making businesses start producing these types of reusable bags. However, some remain skeptical on whether 15-cent thick-plastic bags are in fact reused, and a handful of municipalities are considering upping their reusable bag requirement to 3 mils thick to prevent the use of these bags (Detz, 2014). 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 the thickness of reusable plastic bags to allow. Our paper addresses this policy debate, 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 be standard reusable totes bags, paper bags, backpack, boxes, or 15-cent alternative reusable bags. Consequently, the results of our research will inform policymakers of the

outcomes of the Disposable Bag Policies currently in place, as well as shape future policies under consideration.

III. 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.[16] 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, as seen in Figure I, 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.[17] For each transaction we collected data on the number and types of bags used, whether a

[16] In the two weeks leading up to the policy, several supermarkets in the affected cities began displaying signs by the entrance and in the check-out lanes, featuring the effective date and explaining what type of bags were affected.

[17] To avoid the "Observer Effect"—where people change their behavior when they are aware of being observed—research members did not interact with customers or the checkout process and stood in a way as to be the least noticeable by customers.

bagger is present, the length of the transaction and basic demographic data such as gender and race of the person paying.[18] 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.[19] 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.[20]

We visit a total of seven stores belonging to two different categories of grocery chains within the same treated and control cities.[21] The first retail 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, that in the pre-period offered only free single-use plastic bags and reusable tote bags for purchase of $0.99 to its consumers. Not only do these two chains

[18] Our methodology for data collection is roughly 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 the sub-categories of bags used. Sub-categories 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. Another difference is that we collect data on the presence of baggers, which may influence the number of types of bags customers use.

[19] While scanner data from these stores could have been used to understand paper bag purchases in the post-ban period at treated stores, scanner data cannot provide information about paper bag usage in the pre-ban period.

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

[21] Initially we wished to also visit a third chain that only offered paper and reusable bags in the pre-policy period, but this was not possible in the end, given that the chain did not allow us to collect the data in its stores.

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 adding the required 5-cent fee per paper bag.[22] Alternatively, the Discount Chain retains the $0.99 reusable tote bag it sold before the ban but additionally introduces a 10-cent paper bag and a 15-cent thick-plastic reusable bag. Interestingly, not only does the National Chain opt to charge the minimum amount for paper bags required by law, its paper bags are of a slightly better quality than the Discount Chain, whose paper bags do not have handles. Table I 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, and the number of transactions we observe at each store.[23]

At the National Chain, the policy change implies an infinite price on plastic, a five cent 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.[24]

[22] The price of the reusable tote bags does not change.

[23] 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.

[24] 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 hypothesize that Discount

Figure II(a) and II(b) plot the percentage of transactions using each of five types of bags—(i) thin single-use plastic, (ii) brought-from-home reusable bags, (iii) bought during checkout reusable bags, (iv) paper bags, and (v) 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 cases is further examined in two time periods: the PRE-ban period = Nov-Dec 2013 and the POST-ban period = Jan-Feb 2014.

Just by looking at the raw averages shown in Figure II(a) & II(b), 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. These similarities in distributions give us confidence in our belief that Concord and Berkeley are well-matched control cities for Richmond. The take-away of these graphs is that stores in cities with plastic bag bans and paper bag fees see a higher use of reusable bags and paper bags, a higher incidence of customers using no bags at all, and a complete eradication of newly-issued single-use plastic bags.

Next we examine at how the distributions of bag use vary across store type, for stores with bans and for stores without. At both the National and Discount Chain stores, nearly 100% of transactions use some sort of bag when there is no bag policy in place. Conversely, only ~85% of transactions use a bag

Chain stores have a higher proportion of low income and SNAP and WIC participants than the National Chain.

when there is a bag policy at National Chain stores, and only ~70% do likewise at Discount Chain stores. In regards to reusable bags, on average 40% 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 roughly 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 (no handles) 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 hints 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 a cheap and desirable alternative.

Next we use the pre-treatment period data to investigate whether the pre-period is balanced in terms of observable determinants of bag usage and pre-existing trends. As the match becomes less exact it is increasingly important to take advantage of the panel structure of the data. The panel allows one to control for (1) differences in treated and control stores and (2) differences in season. These controls are implemented with (1) store fixed effects that will control for observed and unobserved constant differences in determinants of bag usage at the store level and (2) by including seasonal week fixed effects that are common to all stores. Using data only for the pre-policy period, that is, until December 31, 2013, Table II presents summary statistics for the treated stores and control stores using observational data collected in the pre-ban period, including distribution of bags used, proportion of transactions with a bagger present, average number of registers open, and average transaction time measured in seconds.

The upper portion of Table II echoes numerically what we observe visually in Figure II(a) & (b). The last three rows in Table II show that National

Chain stores have baggers present for between 50-65% of transactions, approximately 4.6 registers open at a time, and transaction times ranging from 86-93 seconds. On average, the Discount Chain stores have baggers present less frequently (8-56% of transaction), fewer registers open (2.3 to 3.4 registers), and a wider variance of average transaction times (76-96 seconds).[25]

Table III presents demographic data from the pre-period. Reported at the top and bottom are the summary statistics of the observational data collected in-store for the proportion of customers that were Male, White, and Black at the National and Discount stores respectively. Sandwiched in the middle of Table III are 2012 census data, from the corresponding cities, for the proportion of the city population that is Male, White, Black, as well as the total population and the average salary in each city.[26] 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 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.

Overall, the sample averages for each variable compared within a store type are qualitatively similar, suggesting that the treatment and control stores share broadly similar patterns in the pre-period. In terms of the pre-policy period trends in the types of bags used, and number of bags used, we regress those variables on a time trend for the treatment and control stores and find the point estimates of the trend in treatment and control stores are not statistically different from each other. Looking at Figure III(a), which depicts the average number of

[25] The Berkeley Discount Chain store appears to be an outlier across these 3 measures in the pre-period. While this is partly because the Berkeley store had a bag policy during this time frame while the other stores did not, it is also partly due to the layout of the checkout lanes at the Berkeley store, which has very little standing room for baggers.

[26] 2008-2012 American Community Survey 5-Year Estimates. Richmond census values are population-weighted averages of Richmond, El Cerrito, and San Pablo.

bags used per shopping trip by week during the pre-period, we find there to be no difference in trends in treated compared to control stores. The same is true for the percent of transactions bringing reusable bags, shown in Figure III(b).

IV. DIFFERENCE-IN-DIFFERENCES EMPIRICAL STRATEGY

Following Homonoff (2013), 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 for each type of bag: 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 econometric estimation strategy. The reduced form specification boils down to the following empirical model of bag usage:

$$Y_{st} = \beta_0 + \beta_1(Treat * Post)_{st} + \beta_2 Treat_s + \beta_3 Post_t + \gamma X_{st} + \varepsilon_{st},$$

where Y_{st} is a measure of demand on the extensive or the intensive margin in store *s* during year *t*, $Treat_s$ 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 change, and X_{st} is a set of controls in store *s* during year *t*. The coefficient of interest is β_1, that is, the coefficient on the interaction of $Treat_s$ and $Post_t$, which measures the effect of the ban on demand in treated stores relative to changes in demand in control stores. We estimate the above specification for the probability of different types of bag usage (extensive margin) and also for the total number of bags used within bag types (intensive margin). The results are described in the following Section V and then compared to

previous findings in Section VI. All specifications use data from November to February, covering the PRE and POST policy change period.

V. RESULTS

A. Effect of Bag Ban: Extensive Margin

Table IV presents the results from the National Chain for the effect of the Richmond bag ban on one measure of consumption—demand for single-use plastic bags on the extensive margin. This is a linear probability model where the outcome variable is the probability of using a single-use plastic bag. The table shows four specifications of the model, with additional control variables added in each column as one moves from left to right. The model in column 1 includes the interaction of the TREAT*POST indicators (our variable of interest), the POST indicator, and store fixed effects. The results from this specification show that, at National Chain stores, the Richmond bag ban caused a 81.46 percentage point decline in the proportion of transactions using at least one disposable plastic bag. Column 2 adds fixed effects for the date of visit, hour of visit, week-in-month of visit (first, second, third, fourth), and observer. 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. For instance, studies have shown that as the day progresses, the average age of grocery shoppers declines, while their incomes rise (Goodman, 2008). If age and income are correlated with using reusable bags over disposable bags, differences in the hour of observation across locations could bias our results.[27] That being said, the inclusion of time fixed effects does not alter the point estimate on the effect of the ban. Column 3 adds further controls for whether the

[27] 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.

transactions occurred in an express lane, whether the visit was on a Sunday[28] (versus a Saturday), 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 differences across locations and time periods from biasing the results. We find the estimate of the effect of the ban is barely changed by the inclusion of these controls (i.e. the coefficient of interest β_1 doesn't change by much across the specifications). Lastly, column 4 clusters 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. Clustering the standard errors does not change the significance of the coefficient of interest.[29] Column 4 is our preferred specification and will be used in the remainder of this analysis.

Tables V & VI repeat the extensive margin analysis for the other types of bags, for each chain separately, using the preferred specification. In Table V we see that the ban at National Chain stores led to a decrease in disposable plastic bag use of 81.59 percentage points, an increase in paper bag use of 46.51 percentage points, an increase in bringing reusable bags of 26.03 percentage points and an increase in buying reusable bags of 4.25 percentage points. In addition, the percent of customers that use no bags increased by 9.26 percentage points. In Table VI we see that the imposition of the ban at Discount stores led to a decrease in disposable plastic bag use of 89.99 percentage points, an increase in paper bag use of only 8.52 percentage points, an increase in bringing reusable bags of 18.97 percentage points and an increase in buying 15-cent reusable bags

[28] According to Goodman (2008), shoppers on Sundays are noticeably younger than those on other days of the week.
[29] The fact that the robust clustered standard errors are smaller than the robust unclustered standard errors suggests that the intracluster correlations are negative.

of 28.74 percentage points. Lastly, the probability that customers use no bags increased by 31.20 percentage points.

In comparing the Discount and National Chain, 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,[30] 2) male customers at both chains are less likely to bring reusable bags and more likely to use no bags than female customers,[31] and 3) white customers are more likely to bring bags than those 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 5 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. Lastly, we note that customers at Discount stores choose to buy 15-cent reusable bags more often than 10-cent paper bags.[32]

B. Effect of Bag Ban: Intensive Margin

Table VII shows how disposable bag ordinances affect bag demand along the intensive margin. In column 3 we see that the average number of reusable bags used by reusable bag users at Discount stores per shopping trip increased by 0.513 bags after the policy change, yet, in column 2, the average number of reusable bags brought by reusable bag users at National Chain stores did not increase by a statistically significant amount. In column 1 we see that the bag ban caused the number of bags used by paper bag users to decrease by 2.286 bags at

[30] 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 transaction that need bags and the presence of baggers is endogenous with bag use.
[31] Anecdotally, male customers buying only a beverage often do not use a bag.
[32] This is true even though SNAP and WIC customers are allowed to use paper bags without charge.

the National Chain. Thus even though more National Chain customers use paper after the policy change (extensive margin), those who use paper bags use fewer paper bags per trip (intensive margin). Some other interesting findings in this table is that National Chain customers use fewer reusable and paper bags per transaction in express lanes (as one would expect) and customers use slightly more paper bags per transaction when a bagger is present (this could be because baggers float to transactions with larger purchases) and when the transaction is on a Sunday.

While we cannot look at how the bag ban affects the intensive margin of plastic bag demand, we can look at how the other control variables affect the intensive margin of plastic bags. Table VIII shows that at both chains, shopping in the POST period (only relevant for customers at the Concord store) has a significant and positive effect on the number of plastic bags used per transaction. Having baggers present also increases the number of plastic bags used, while customers use fewer bags if they are male. At National Chain stores, we also find that customers use fewer plastic bags on Sundays and when in express lanes.

C. Effect of Bag Ban over Time

Next, using the additional data we collected in March and April, we look at how and whether bag usage changes over time, as customers grow accustomed to Disposable Bag Policies. Using the same model specifications as in Table V and VI, we vary the length of the POST period over three scenarios. In scenario A we use the same POST period we've been using up until this point in the analysis, which includes all transactions in January and February 2014. In scenario B, we additionally include transactions in March 2014 in the POST period and in scenario C, we further include April 2014 transactions. Figure IV(a) plot the β_1 coefficients from these bag usage regressions for the National

Chain across the three time scenarios. Note that the probability of using paper bags and the probability of buying reusable totes remain relativity stable over time, however, the probability of bringing reusable bags decreases by almost 10 percentage points and the probability of using no bag increases by 10 percentage points. We believe these changes occur because customers learn that 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.[33]

Figure IV(b) repeats the analysis above for the Discount Chain. Comparing these figures reiterates the point that the treatment leads to very different bag usage patterns at the two grocery chains. Secondly, Discount Chain shoppers adjust differently to the bag ban over time than their National Chain counterparts. Unlike National Chain shoppers, the probability of Discount Chain shoppers bringing a reusable bag increases 7 percentage points over the three scenarios. Also, the probability of buying a 15-cent reusable bag decreases by 5 percentage points. We hypothesize that this change occurs in part because a fraction of customers begin reusing the 15-cent bags they purchase previously. We will discuss the reuse of the 15-cent bags further in Section VI on policy implications.

D. *Effect of Bag Ban: Heterogeneous Effects by Gender and Race*

Next we look at whether the treatment effects are heterogeneous across gender and race for paper, reusable, and no bag usage. To accomplish this we add interactions of the gender/race variables with the POST/TREAT variables to our preferred specification. Table IX & X present the results.[34] At the National

[33] All managers that we interviewed noted that shopping cart and shopping basket theft has increased since the implementation of the disposable bag bans.
[34] For these regressions, we include the additional observations collected in March and April in the POST period.

Chain (Table IX), we find that the bag ban treatment increases the probability of women bringing reusable bags 10.35 percentage points over that of men. However, we find no heterogeneous treatment effects by race. At the Discount Chain (Table X), we again find that during the bag ban treatment, women are more likely to bring reusable bags. Women are also 8.77 percentage points less likely to use paper bags. White customers are 10.87 percentage points more likely to bring reusable bags and 10.19 percentage less likely to go without a bag, and black customers are 14.34 more likely to use reusable bags and 7.16 percentage points less likely to use paper bags than customers of other minority races. Lastly, the treatment effects are not heterogeneous across gender and race for the 15-cent reusable bags. Together, these results indicate that Disposable Bag Bans increase the use of reusable bags the most among female and black customers.

VI. BAG BANS VERSUS BAG FEES AND POLICY IMPLICATIONS

How do single-use plastic bag bans compare with single-use plastic bag fees and which is the optimal policy prescription? If the objective of Disposable Bag Policies is to increase the use of reusable bags and decrease the use of disposable bags, do bag bans or bag fees do a better job in reaching this objective? The following figures 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. We first focus on the National Chain stores in our study since they are more comparable to the grocery chains used by Homonoff (2013). We also drop all January observations so that our

POST period is more similar to that used by Homonoff (2013).[35] As mentioned above, Homonoff (2013) 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 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. It is important to 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).

Figure V(a) plots the proportion of customers bringing reusable bags across stores and policy treatments. We see that bags ban and fees have very similar effects on encouraging customers to bring reusable bags. On average, 46% of customers facing a ban and 47% of customers facing a tax bring a reusable bag. Next, Figure V(b) plots the proportion of customers using disposable bags (either thin plastic or paper) across stores and policy treatments. What is interesting is that 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 point less than the proportion of bag fee customers. To summarize these figures, the Richmond and Berkeley bag bans and Montgomery County and DC bag fees have similar effects on reusable bag usage, while bans lead to slightly less disposable bag usage than fees. However, what is not shown here is that disposable bag use for bag ban customers is completely comprised of paper

[35] In Homonoff (2013), 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. All data was collected from Monday through Friday between the hours of eleven in the morning and eight at night.

while for bag fee customers it is a mix of paper and thin plastic.[36] Since paper bags have their own set of environmental costs, policymakers and citizens may be concerned by this increase in 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 reusable 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. Also, the thick plastic bags can hold double the volume of thin plastic bags[37] and they are sturdy enough to not need to be double bagged.[38] This begs the question: How does the proportion of customers using reusable and disposable bags under a bag ban with the 15-cent thick-plastic bag option compare to bag usage under Disposable Bag Policies without this alternative? To answer this question, we compare bag usage at our Discount stores to both those at our National Chain stores and those in Homonoff's sample. However, we want the reader to keep in mind that the clientele at Discount stores is very different than those at National Chain stores and thus this comparison should be considered within that context. Figures VI(a) and (b) are the same as V(a) and (b) but with the addition of bars for the Discount Chain in lighter shaded yellow. In Figure VI(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 use is stable across Disposable Bag Policies and store types. However, in Figure VI(a), we find that the presence of an alternative bag to purchase has a large effect on the proportion of customers using disposable

[36] 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.

[37] The standard thin plastic grocery bag holds 8 liters while the new thick plastic bags are required to at least hold 15 liters.

[38] Not a single customer we observed double-bagged the thick plastic bags. This is not true for paper bags, which are often double-bagged, even in the post-ban period.

bags. Only 11 percent of customers at Discount stores with bans use disposable bags, compared to 37 and 46 percent at stores without 15-cent thick plastic bags.

Thus 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 use. However, some environmental activists are concerned that the thick plastic bags are not actually reused by customers and are just a loophole to get around Disposable Bag Policies. These activists are lobbying for policymakers considering bag bans to increase the thickness of permissible reusable plastic bags from 2.25 to 3 mils. Fortunately, 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 Chain stores with a bag ban in place, forty-one percent of customers brought at least one reusable bag. Of those customers bringing reusable bags, 18 percent brought the 15-cent reusable bag. In comparison, only 6 percent of customers bringing reusable bags to the store brought old paper bags. Moreover, we find that two out of five customers that buy 15-cent reusable bags reuse them in future purchase. In conclusion, 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 (e.g. bag liners for small garbage bins).

Given these results, our main 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 thin plastic bags is nullified. Second, for cities and counties and states that opt for plastic bag bans and paper bag charges, we recommend incentivizing the production and sales 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.[39] Furthermore, we find that when Discount stores offer their price-sensitive customers 15-cent bags after the imposition of a plastic bag ban, they produce similar levels of reusable bag usage and smaller levels of paper bag usage than National Chain stores without these bags.

VII. CONCLUSION

This paper uses observationally recorded bag usage data (over bag type, time, and space) to measure shifts in bag demand in response to the introduction of a ban on plastic bags and a fee on paper bags. We find that this type of policy completely eliminates thin plastic bag use, increases paper bag use, increases reusable bag use, and increases the likelihood of foregoing bags all together. Comparing the two types of grocery chains in our sample, we find that during the bag ban, the probability of using paper increases more at the National Chain than at the Discount Chain while the reverse is true for the probability of using no bag at all. We hypothesize that this occurs for several reasons. First, Discount Chain shoppers may be more price sensitive than National Chain shoppers. Second, the National Chain store sells a higher quality paper bag for five cents less than the Discount stores. Third, Discount stores sell an alternative reusable bag for $0.15 as opposed to the National Chain, who only sell $1.50 reusable tote bags. We also find that not all consumer types react alike to the policy change, with women and black customers increasing their reusable bag usage after the policy more so than men and customers of other races. Perhaps women and black shoppers are

[39] Another problem with the typical reusable tote bag (made of cloth or woven plastic) that sells for a dollar or more is that customers don't always remember to clean them, making the a probable host to harmful bacteria such as e. coli. Klick and Wright (2012) find evidence that emergency room visits related to bacteria spike after the 2007 San Francisco Bag Ban. While customers may be no more likely to remember to clean 15-cent reusable bags, these bags are cheap enough to be thrown out if they have been exposed to bacteria (such as from holding raw chicken juices).

more price-sensitive than their counterparts or perhaps they are reacting more to the implicit environmental message of the ban.

Lastly, we compare bag demand outcomes under bag bans to those under bag fees. We find that both policies lead to similar patterns in reusable bag usage but that bag bans may lead to less disposable bag demand than bag fees, especially when stores offer a cheap reusable bag alternative to their customers and charge more for paper bags. Consequently, if the environmental costs of increased paper bag usage are a concern to policymakers and the public, these results suggest that Disposable Bag Policies should incentivize stores to sell cheap alternative reusable plastic bags as well as mandate that stores charge at least 10 cents or more for paper bags.

Future work focuses on other unintended effects on these policies, such as on cashier productivity, which is a topic of a companion paper by Taylor and Villas-Boas (2014) building on previous work by Taylor (2013) who studied productivity effects of Disposable Bag Policy in another setting.[40] Additionally, in future work we aim to merge the bag usage data with actual transaction level panel scanner data to measure whether the bag policies led not only to bag usage behavioral changes but also to changes in the composition of the shopping baskets in each shopping trip. In particular, if the effect of such policies would be to cause a consumer to shop smaller amounts and more frequently, due to the higher cost of bagging items, this would imply that bag policies could indirectly affect the environment in terms of fuel and transportation costs to go more often to supermarkets. Lastly, we will continue to compare outcomes under bag bans versus bag fees. While bag bans and bag fees were found to be similar in their effects on reusable bag usage in this study, they may differ along other

[40] Taylor (2013) studies checkout productivity effects of the 2010 District of Columbia five-cent bag fee.

dimensions, such as their effects on store productivity, consumer health, and the composition of shoppers' baskets.

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Table I: Bag Ordinances and Number of Transactions Observed

National Chain

	Bag Ban Start Date	Paper Bag Fee	—Number of Trans. Observed— 2013 Dec	——2014—— Jan-Feb	Mar-Apr	Total
Berkeley	January 1, 2013	10 cents	226	276	199	701
Richmond	January 1, 2014	5 cents	200	272	194	666
Concord	No Ban	"Free"	254	324	200	778
Total Obs.			680	872	593	2145

Deep-Discount Chain

	Bag Ban Start Date	Paper Bag Fee	—Number of Trans. Observed— 2013 Nov-Dec	——2014—— Jan-Feb	Mar-Apr	Total
Berkeley	January 1, 2013	10 cents	156	163	202	521
Richmond[1]	January 1, 2014	10 cents	435	345	388	1168
Concord	No Ban	"Free"	201	185	230	616
Total Obs.			792	693	820	2305

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

Table II: Summary Statistics, Pre-Ban

	National Chain			Discount Chain		
	Berkeley	Richmond	Concord	Berkeley	Richmond	Concord
Plastic Bag	0.000	0.810	0.902	0.000	0.894	0.900
	(0.000)	(0.393)	(0.298)	(0.000)	(0.308)	(0.301)
Paper Bag	0.376	0.050	0.0354	0.115	0.000	0.000
	(0.485)	(0.218)	(0.185)	(0.321)	(0.000)	(0.000)
Bought Reus. Bag	0.022	0.000	0.000	0.186	0.002	0.000
	(0.147)	(0.000)	(0.000)	(0.390)	(0.048)	(0.000)
Brought Reus. Bag	0.482	0.150	0.055	0.513	0.062	0.075
	(0.501)	(0.358)	(0.229)	(0.501)	(0.242)	(0.264)
No Bags	0.186	0.055	0.063	0.244	0.062	0.050
	(0.390)	(0.229)	(0.243)	(0.431)	(0.242)	(0.218)
Bagger Present	0.535	0.650	0.512	0.077	0.429	0.560
	(0.500)	(0.478)	(0.501)	(0.267)	(0.495)	(0.498)
Ave. No. Register Open	4.673	4.585	4.681	3.404	2.276	2.945
	(0.676)	(0.752)	(0.411)	(1.409)	(0.373)	(0.378)
Trans. Time (seconds)	92.98	88.92	86.62	95.56	75.53	85.89
	(55.97)	(59.30)	(51.58)	(64.13)	(48.24)	(56.02)

Standard deviations in parentheses. Table reports mean values of each variable in the pre-ban period.
Bag variables: Probability of customers using bag type.

Table III: Demographics, Pre-Ban

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)

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	$38,644	$27,211	$28,801

Discount Chain - Observed Data

	Berkeley	Richmond	Concord
Male	0.532	0.406	0.440
	(0.501)	(0.492)	(0.498)
White	0.449	0.293	0.615
	(0.499)	(0.456)	(0.488)
Black	0.308	0.346	0.145
	(0.463)	(0.476)	(0.353)

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, and San Pablo.

Table IV: Effect of Bag Ordinance on Disposable Plastic Bags - Extensive Margin (National Chain)

	(1)	(2)	(3)	(4)
	Prob. Plastic	Prob. Plastic	Prob. Plastic	Prob. Plastic
Post x Treat	-0.8146***	-0.8201***	-0.8159***	-0.8159***
	(0.0307)	(0.0338)	(0.0341)	(0.0074)
Post	0.0046	0.1502*	-0.0288	-0.0288***
	(0.0131)	(0.0811)	(0.0308)	(0.0089)
Express			-0.0052	-0.0052
			(0.0193)	(0.0235)
Sunday			-0.0286	-0.0286**
			(0.0351)	(0.0124)
Bagger Present			0.0275**	0.0275*
			(0.0126)	(0.0147)
Male			-0.0046	-0.0046
			(0.0118)	(0.0153)
White			-0.0212*	-0.0212
			(0.0121)	(0.0147)
Mean of Dep Variable	0.4417	0.4417	0.4425	0.4425
Num of Obs.	1551	1551	1548	1548
R squared	0.7916	0.7957	0.7964	0.7964
Standard Errors	Robust	Robust	Robust	Cluster
Store Fixed Effects	Yes	Yes	Yes	Yes
Observation Fixed Effects[1]	No	Yes	Yes	Yes

Robust and Clustered standard errors are in parentheses. Clusters are at the store-day level.

Outcome variable: probability of using at least one disposable bag. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

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

Table V: Effect of Plastic Bag Ban on Bag Demand - Extensive Margin (National Chain)

	(1) Prob. Plastic	(2) Prob. Paper	(3) Prob. Brought Reus.	(4) Prob Buying Reus.	(5) Prob No Bags
Post x Treat	-0.8159***	0.4651***	0.2603***	0.0425***	0.0926***
	(0.0074)	(0.0267)	(0.0272)	(0.0050)	(0.0187)
Post	-0.0288***	-0.0844***	0.1330***	-0.0180***	-0.0475
	(0.0089)	(0.0280)	(0.0288)	(0.0063)	(0.0287)
Sunday	-0.0286**	0.0268	0.1339***	0.0293***	-0.1013***
	(0.0124)	(0.0247)	(0.0282)	(0.0064)	(0.0266)
Express	-0.0052	0.0330	-0.0718*	0.0008	0.0164
	(0.0235)	(0.0335)	(0.0399)	(0.0059)	(0.0253)
Bagger Present	0.0275*	0.0718***	0.0086	0.0016	-0.0704***
	(0.0147)	(0.0238)	(0.0308)	(0.0034)	(0.0237)
Male	-0.0046	0.0322	-0.0864***	-0.0098**	0.0514***
	(0.0153)	(0.0209)	(0.0255)	(0.0045)	(0.0167)
White	-0.0212	0.0020	0.1031***	0.0009	-0.0578***
	(0.0147)	(0.0217)	(0.0225)	(0.0043)	(0.0172)
Mean of Dep Variable	0.4425	0.2119	0.2668	0.0071	0.1195
Num of Obs.	1548	1548	1548	1548	1548
R squared	0.7964	0.2258	0.2386	0.0296	0.1229
Standard Errors	Cluster	Cluster	Cluster	Cluster	Cluster
Store Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observation Fixed Effects[1]	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. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

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

Table VI: Effect of Plastic Bag Ban on Bag Demand - Extensive Margin (Discount Chain)

	(1) Prob. Plastic	(2) Prob. Paper	(3) Prob. Brought Reus.	(4) Prob. 15 cent Bag	(5) Prob No Bags
Post x Treat	-0.8999***	0.0852***	0.1897***	0.2874***	0.3120***
	(0.0233)	(0.0159)	(0.0230)	(0.0257)	(0.0227)
Post	0.0136	0.0012	0.0389	-0.0297	-0.0038
	(0.0233)	(0.0165)	(0.0253)	(0.0231)	(0.0234)
Sunday	-0.0212	-0.0155	0.0132	-0.0714***	0.0974***
	(0.0194)	(0.0137)	(0.0196)	(0.0206)	(0.0181)
Bagger Present	0.0516***	0.0061	-0.0045	0.0169	-0.0585**
	(0.0175)	(0.0183)	(0.0177)	(0.0145)	(0.0219)
Male	0.0103	-0.0237*	-0.0666***	0.0116	0.0448**
	(0.0100)	(0.0122)	(0.0226)	(0.0146)	(0.0208)
White	-0.0273*	-0.0310**	0.1119***	-0.0349*	-0.0048
	(0.0155)	(0.0121)	(0.0272)	(0.0171)	(0.0224)
Mean of Dep Variable	0.4929	0.0515	0.2169	0.0875	0.1844
Num of Obs.	1475	1475	1475	1475	1475
R squared	0.7955	0.1077	0.2122	0.1586	0.1719
Standard Errors	Cluster	Cluster	Cluster	Cluster	Cluster
Store Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observation Fixed Effects[1]	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. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

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

Table VII: Effect of Plastic Bag Ban on Bag Demand - Intentive Margin

	National Chain		Discount Chain
	# Paper	# Brought Reus.	# Brought Reus.
Post x Treat	-2.2861***	0.1994	0.5126***
	(0.1672)	(0.3264)	(0.1743)
Post	0.4624***	0.2721	0.3918**
	(0.1344)	(0.2285)	(0.1502)
Sunday	1.1930***	-0.4576	(0.1468)
	(0.1091)	(0.5593)	(0.1468)
Express	-0.3990*	-0.6280**	
	(0.2145)	(0.2575)	
Bagger Present	0.5557**	0.2554	0.3854*
	(0.2128)	(0.1885)	(0.2263)
Male	0.1405	0.2123	-0.1981
	(0.1809)	(0.1308)	(0.1542)
White	0.0908	0.4742***	0.1441
	(0.1869)	(0.1597)	(0.1097)
Mean of Dep Variable	2.1341	2.1816	1.7469
Num of Obs.	328	413	320
R squared	0.1892	0.1271	0.1165
Standard Errors	Cluster	Cluster	Cluster
Store Fixed Effects	Yes	Yes	Yes
Observation Fixed Effects[1]	Yes	Yes	Yes

Clustered standard errors are in parentheses. Clusters are at the store-day level.

Outcome variables: demand among users for paper and reusable bags. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

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

Table VIII: Determinants of Single-use Plastic Bag Demand - Intentive Margin

	National Chain # Single-use Plastic	Discount Chain # Single-use Plastic
Post	2.4471***	0.3306***
	(0.0658)	(0.0682)
Sunday	-1.9011***	0.0033
	(0.1642)	(0.1640)
Express	-1.7604***	
	(0.4790)	
Bagger Present	1.4507***	1.3450***
	(0.4375)	(0.3482)
Male	-0.0984	-0.7006**
	(0.3139)	(0.2751)
White	0.9498***	0.0664
	(0.2776)	(0.3102)
Mean of Dep Variable	4.6248	3.8226
Num of Obs.	685	727
R squared	0.1698	0.0773
Standard Errors	Cluster	Cluster
Store Fixed Effects	Yes	Yes
Observation Fixed Effects[1]	Yes	Yes

Clustered standard errors are in parentheses. Clusters are at the store-day level.

Outcome variables: demand among users for single-use plastic bags. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

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

Table IX: Heterogenous Effects of Plastic Bag Ban on Bag Demand - Extensive Margin (National Chain)

	(1)	(2)	(3)	(4)
	Prob. Paper	Prob. Brought Reus.	Prob Buying Reus.	Prob No Bags
Post x Treat	0.4102***	0.1913***	0.0171**	0.1979***
	(0.0545)	(0.0657)	(0.0072)	(0.0538)
Post	-0.0864	0.1609**	-0.0327**	-0.0650
	(0.0552)	(0.0773)	(0.0137)	(0.0649)
Post x Treat x Male	0.0196	-0.1035**	0.0001	0.0677
	(0.0612)	(0.0497)	(0.0099)	(0.0425)
Post x Male	0.0604*	0.0145	0.0119	-0.0401
	(0.0315)	(0.0461)	(0.0080)	(0.0263)
Male	-0.0051	-0.0802**	-0.0155*	0.0554**
	(0.0154)	(0.0371)	(0.0078)	(0.0222)
Post x Treat x White	0.0250	0.0118	0.0146	-0.0517
	(0.0615)	(0.0572)	(0.0087)	(0.0472)
Post x White	0.0186	-0.0558	0.0118	-0.0148
	(0.0436)	(0.0560)	(0.0093)	(0.0380)
White	0.0045	0.1007**	-0.0105	-0.0444
	(0.0263)	(0.0498)	(0.0090)	(0.0267)
Post x Treat x Black	-0.0257	0.0907	0.0049	-0.0491
	(0.0763)	(0.0957)	(0.0167)	(0.0843)
Post x Black	0.0496	-0.0348	0.0098	0.0353
	(0.0617)	(0.0869)	(0.0215)	(0.0669)
Black	0.0441	-0.0893*	0.0009	-0.0448
	(0.0408)	(0.0524)	(0.0183)	(0.0325)
Mean of Dep Variable	0.2214	0.2844	0.0061	0.1298
Num of Obs.	2141	2141	2141	2141
R squared	0.2045	0.2347	0.0278	0.1182
Standard Errors	Cluster	Cluster	Cluster	Cluster
Store Fixed Effects	Yes	Yes	Yes	Yes
Observation Fixed Effects[1]	Yes	Yes	Yes	Yes

Clustered standard errors are in parentheses. Clusters are at the store-day level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

Outcome variables: probability of using at least one bag or no bags.

Control variables not included in table due to space constraints: Sunday, Express, and Bagger Present.

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

Table X: Heterogenous Effect of Plastic Bag Ban on Bag Demand - Extensive Margin (Discount Chain)

	(1)	(2)	(3)	(4)
	Prob. Paper	Prob. Brought Reus.	Prob. 15 cent Bag	Prob No Bags
Post x Treat	0.0445	0.2340***	0.2263***	0.3210***
	(0.0306)	(0.0473)	(0.0370)	(0.0444)
Post	0.0793**	0.0592	-0.0116	-0.1361***
	(0.0322)	(0.0578)	(0.0382)	(0.0395)
Post x Treat x Male	0.0877***	-0.0828*	-0.0118	0.0594
	(0.0303)	(0.0458)	(0.0464)	(0.0426)
Post x Male	-0.0545**	-0.0823**	0.0369	0.0861**
	(0.0224)	(0.0388)	(0.0364)	(0.0347)
Male	-0.0050	-0.0149	-0.0045	-0.0139
	(0.0078)	(0.0237)	(0.0071)	(0.0182)
Post x Treat x White	-0.0482	0.1087*	0.0371	-0.1019*
	(0.0310)	(0.0562)	(0.0490)	(0.0604)
Post x White	0.0008	0.0031	-0.0122	-0.0023
	(0.0154)	(0.0503)	(0.0231)	(0.0395)
White	-0.0037	0.0448	-0.0152	0.0102
	(0.0064)	(0.0431)	(0.0115)	(0.0288)
Post x Treat x Black	-0.0716*	0.1434**	-0.0026	-0.0422
	(0.0398)	(0.0574)	(0.0425)	(0.0554)
Post x Black	0.0452	-0.0808	0.0563**	-0.0074
	(0.0414)	(0.0538)	(0.0266)	(0.0393)
Black	0.0374	-0.0555	0.0073	-0.0105
	(0.0269)	(0.0342)	(0.0101)	(0.0242)
Mean of Dep Variable	0.0594	0.2457	0.0982	0.2213
Num of Obs.	2291	2291	2291	2291
R squared	0.0945	0.2071	0.1270	0.1783
Standard Errors	Cluster	Cluster	Cluster	Cluster
Store Fixed Effects	Yes	Yes	Yes	Yes
Observation Fixed Effects[1]	Yes	Yes	Yes	Yes

Clustered standard errors are in parentheses. Clusters are at the store-day level. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

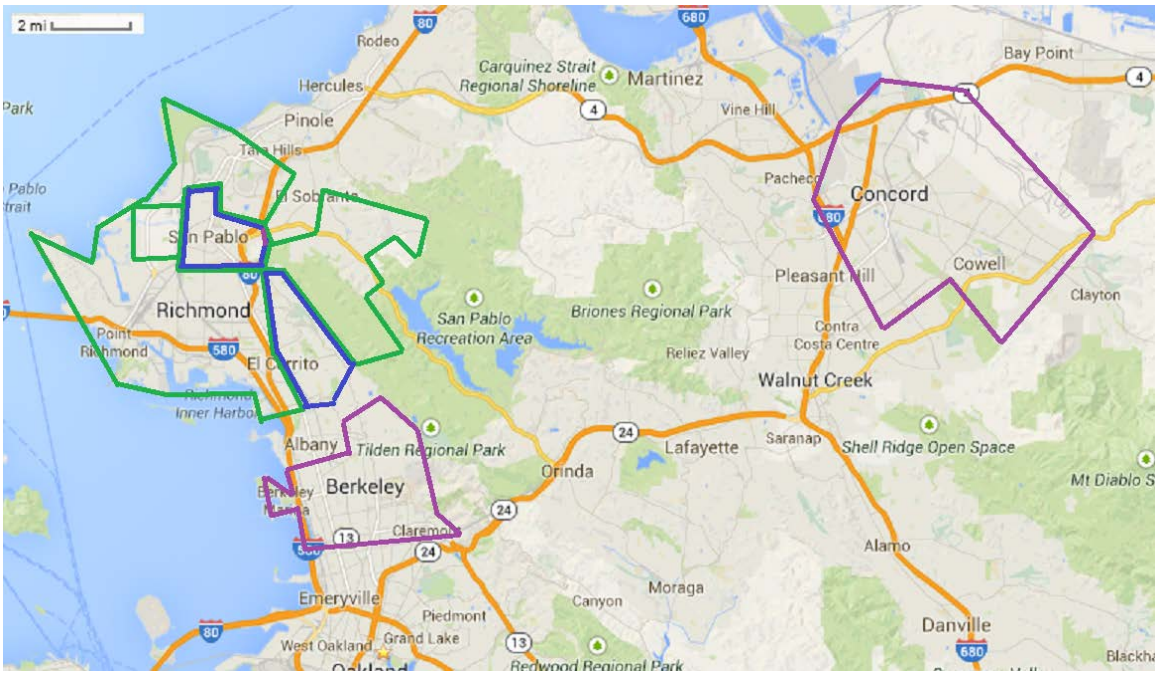
Outcome variables: probability of using at least one bag or no bags.

Control variables not included in table due to space constraints: Sunday and Bagger Present.

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

Figure I

Map of Contra Costa and Alameda County



Source: Google Maps. City borders added by authors.

Figure II(a)

Percent of Transactions Using Bag Type (National Chain)

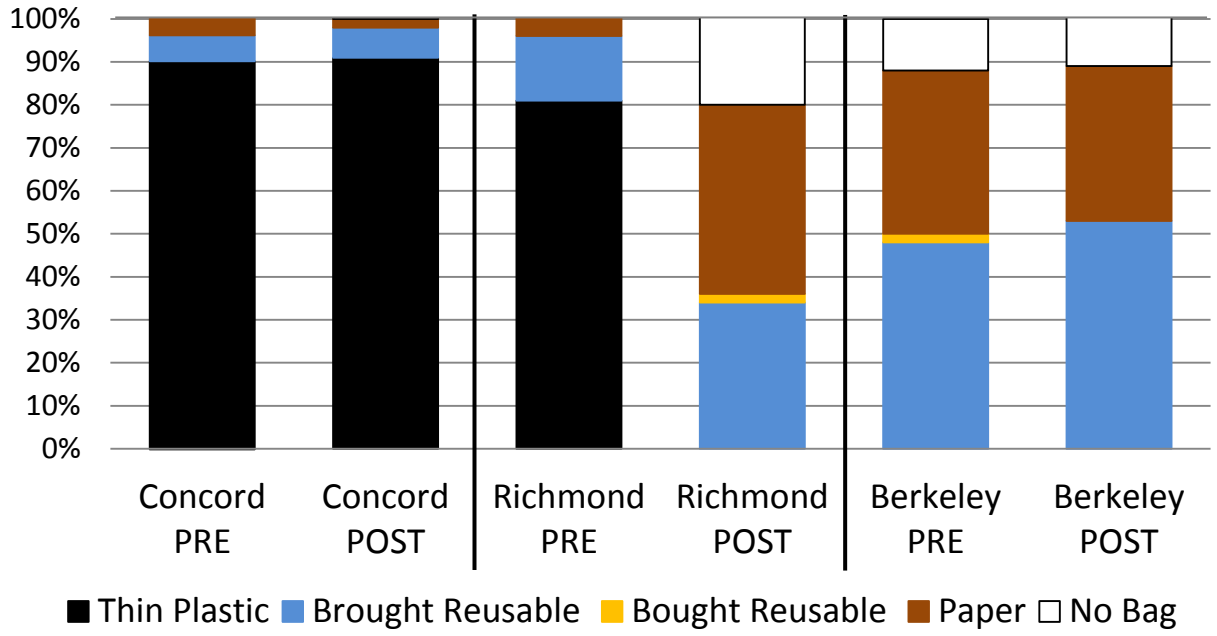


Figure II(b)

Percent of Transactions Using Bag Type (Discount Chain)

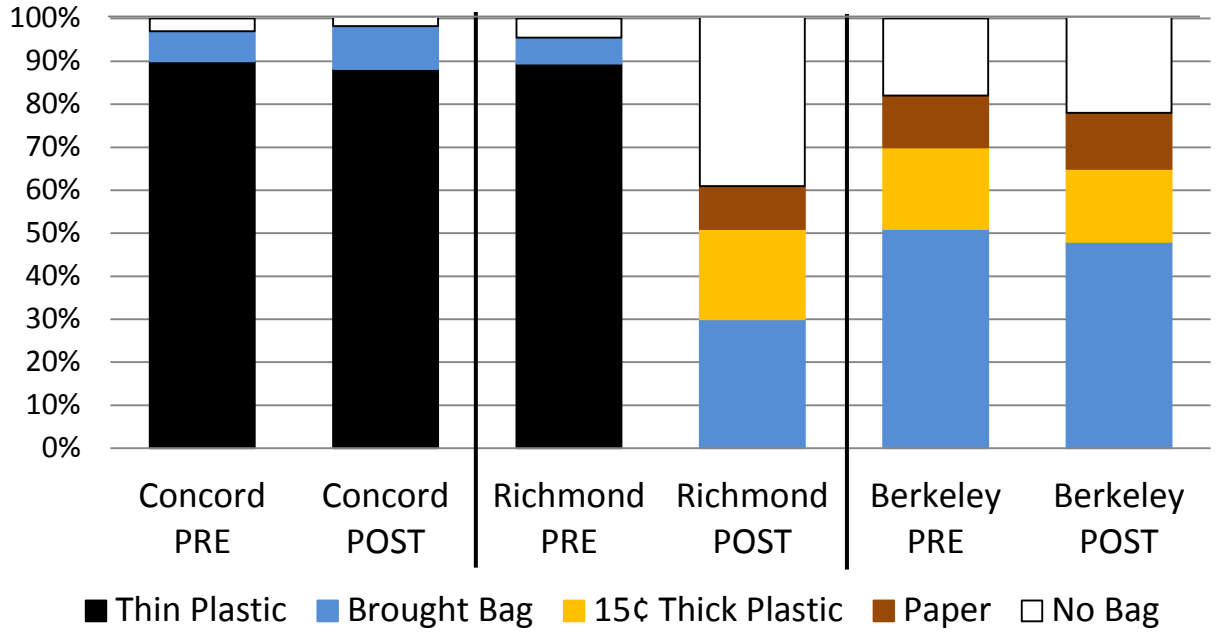


Figure III(a)

Average Bags Used Per Transaction (PRE)

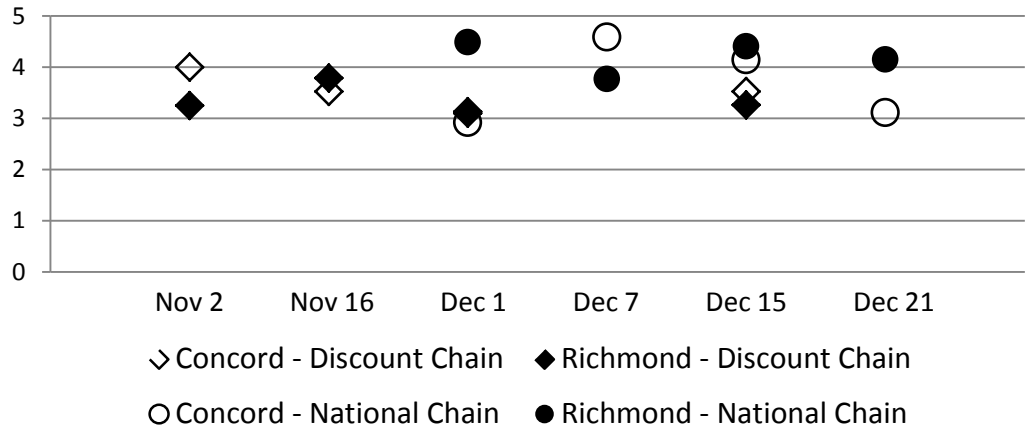


Figure III(b)

Percent of Transactions Bringing Reusable Bags (PRE)

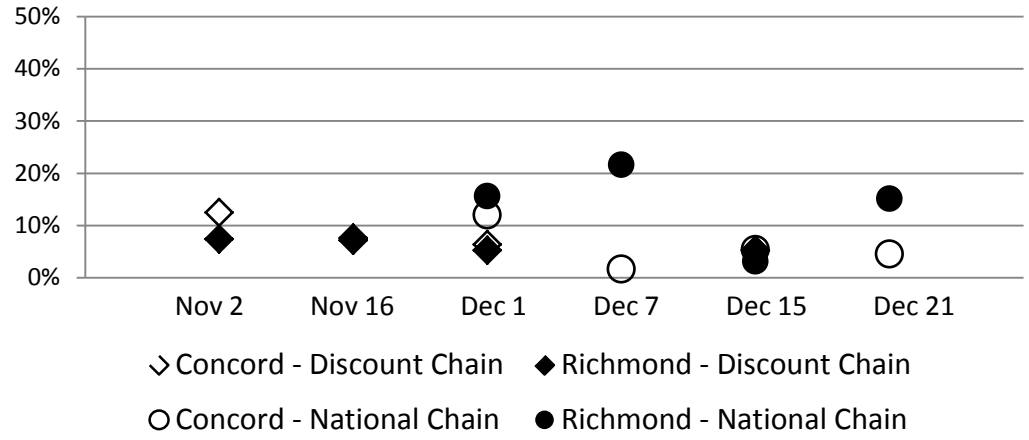


Figure IV(a)

Changes in Bag Demand Over Time by Bag Type (National Chain)

*(A) POST = January-February. (B) POST = January-March. (C) POST = January-April.

Figure IV(b)

Changes in Bag Demand Over Time by Bag Type (Discount Chain)

*(A) POST = January-February. (B) POST = January-March. (C) POST = January-April.

Figure V(a)

Proportion of Customers Bringing a Reusable Bag (National Chain)

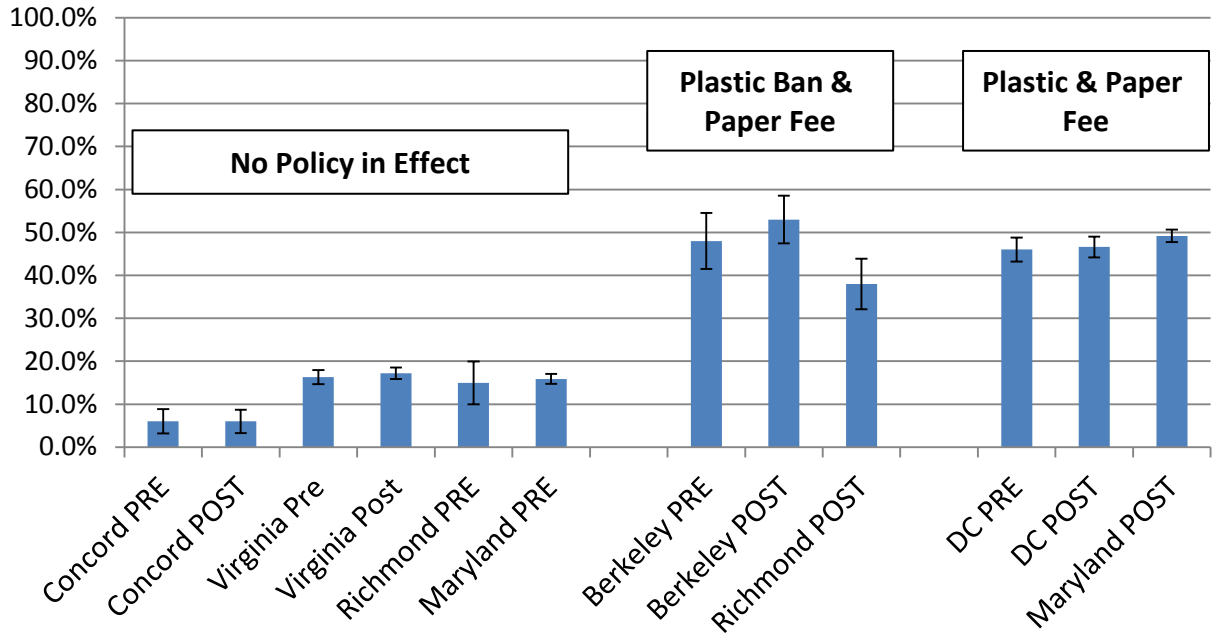


Figure V(b)

Proportion of Customers Using Disposable Bags (National Chain)

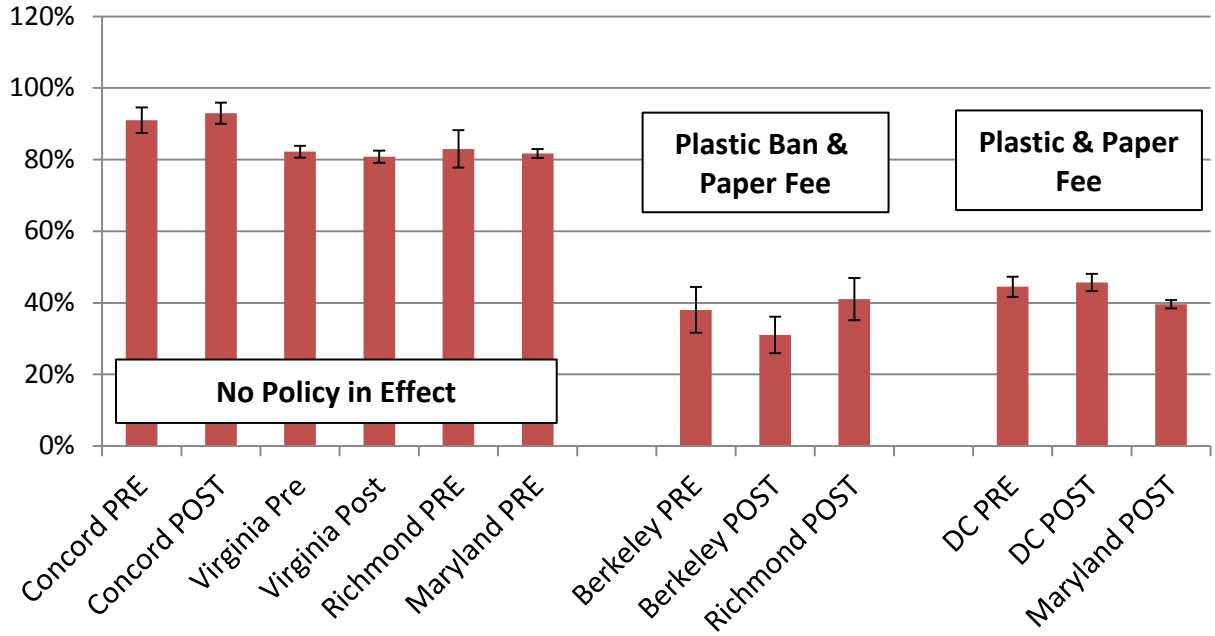
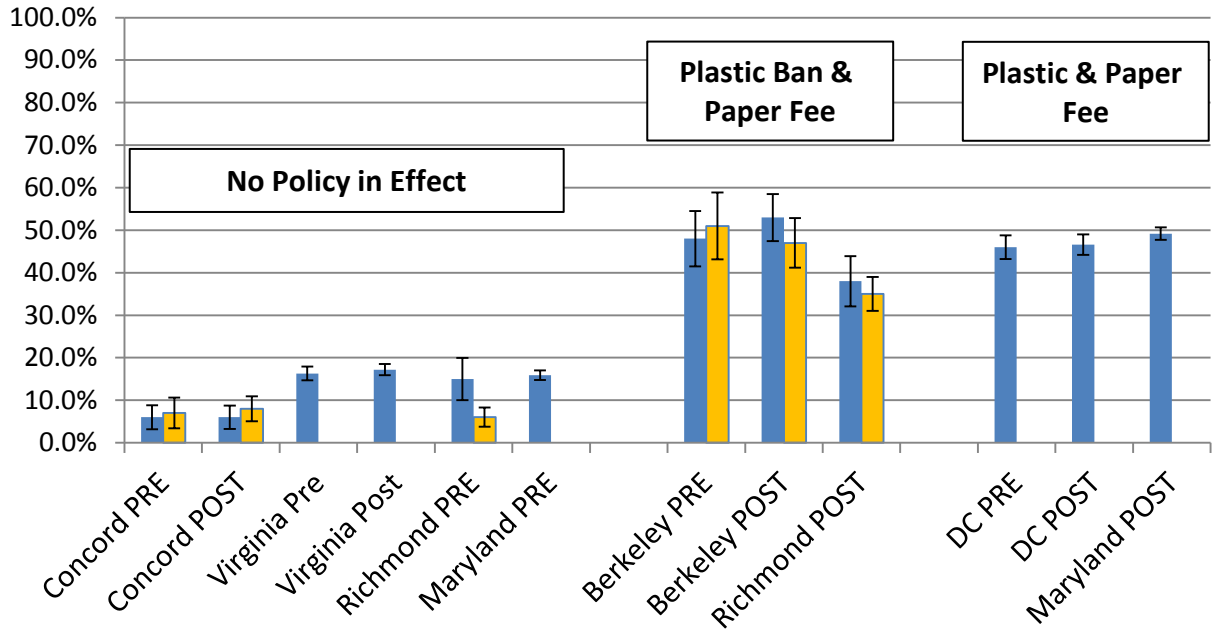


Figure VI(a)

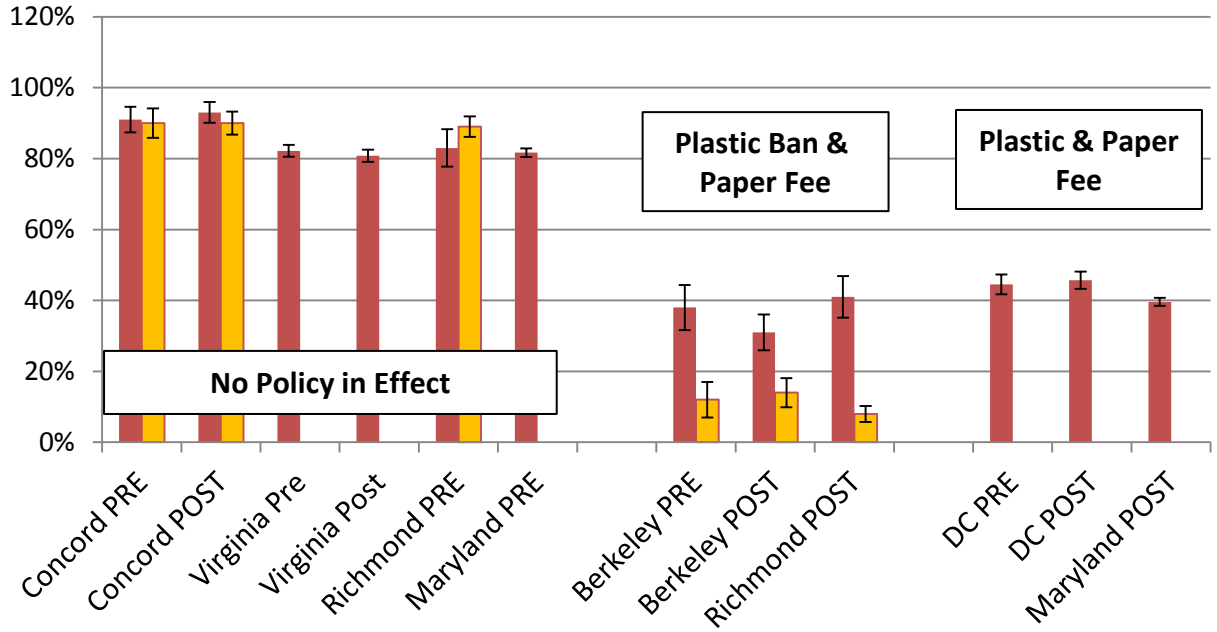
Proportion of Customers Bringing Reusable Bags



*National Chain = dark shaded bars. Discount Chain = light shaded bars.

Figure VI(b)

Proportion of Customers using Disposable Bags



*National Chain = dark shaded bars. Discount Chain = light shaded bars.