Is Awareness Converted into Practice? Local Berkeley Restaurants' Perception on Plastic Pollution

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ABSTRACT

Plastic pollution is a global issue that has exponentially grown in concern and magnitude over the years. It can be said that most people generally understand the detrimental effects of using plastic, but it remains an indispensable part of our lives. Research to-date focuses on measures taken to reduce plastic and consumer perceptions relating to plastics, while not enough attention is paid to firm-side opinions. To bridge this knowledge gap, I distributed a three-page survey containing Likert-scale and numerical fill-in-the-blank questions to restaurants adjacent to the UC Berkeley campus. The questionnaire collected data on awareness relating to plastic pollution, plastic usage, and thoughts on how much a consumer should be charged extra per plastic item. Then, I conducted correlation tests and constructed scatterplots displaying the association between the variables of interest. My results showed that though statistically insignificant, plastic pollution awareness and plastic foodware usage are negatively correlated. In other words, higher consciousness translates to lower usage of plastic in three metrics that I evaluated: utensils, to-go containers, and bags. Additionally, there was much variation when it came to how much restaurants thought consumers should be charged extra for plastic foodware. All in all, the results do not point to a robust conclusion regarding the variables I tested for, but there is still much to be learned from my study. First, it is the first of its kind to study firm-side perceptions, and my study may even inspire similar research to be done, thus filling the existing knowledge gap.

KEYWORDS

firm-side attitudes, social cost of marine plastic, Single Use Disposable Foodware and Litter Reduction Ordinance (SUDFLRO), single-use plastic foodware, correlation tests and statistics

INTRODUCTION

An Introduction to Plastic Pollution

Plastic pollution (PP) is undoubtedly one of the biggest problems of our generation and generations to come. Synthetic plastics have only been used since 1907, after the invention of a material called Bakelite (Cole et al. 2011); however, it is only in the last few decades that people have realized the consequences of using a material that can take upwards of 500 years to biodegrade (WWF Australia).

When discussing the gravity of marine plastic pollution (MPP), it is essential to define the concept of planetary boundaries (PB). According to *Planetary Boundaries: Exploring the Safe Operating Space for Humanity*, the PB concept is a human-determined framework that establishes thresholds related to large-scale Earth System processes, the crossing of which may trigger large-scale changes in the functioning of the Earth System (Rockström et al. 2009). In other words, we must restrain these environmental thresholds from being crossed in order to prevent abrupt or irreversible change on possibly a planetary scale. Of the nine PBs, the one most relevant to the plastics crisis is the chemical pollution planetary boundary threat, which covers pollutants ranging from synthetic organic compounds to heavy metals (Rockström et al. 2009). Plastics, little to our knowledge, often consist of the substances that fall under the PB threat as chemical pollutants. In fact, the chemical ingredients of more than 50% of plastics are hazardous, and some hazardous chemicals widely used as specific targeted additives are composed of heavy metals (Tang et al. 2015).

To be classified as a chemical pollution planetary boundary threat, an issue must meet the essential conditions, delineated by three questions: (1) Is the pollution irreversible or poorly irreversible? (2) Are effects only detectable when the problem is planetary-scale? (3) Is there a disruptive effect on Earth system processes? So far, MPP has already met two conditions, relating to its irreversibility and global ubiquity. Though a quantitative boundary level does not yet exist for chemical pollution (i.e. scientists have not yet quantified what threshold must be passed for large-scale change to take place), MPP has already become dire enough to warrant being included as a PB (Villarubia-Gomez et al. 2018).

An instance of this concern is when plastic resin pellets are ingested by seabirds and other marine organisms. Because of the high accumulation potential of one of its components polypropylene, pellets are thought to serve as both a transport medium and a potential source of toxic chemicals in the marine environment (Mato et al. 2001). Equivalently, it was found that animals exposed to compounds such as phthalates and bisphenol-A showed adverse impacts on reproductive functionality, particularly during developmental stages (Vegter et al. 2014).

"Innovation Offsets," "Social Cost," and An Overview of Existing Policy

Examples like those mentioned above are precisely why research, policy, and awareness must be advanced and streamlined in order to tackle the plastics crisis. Much like the uncertainty surrounding the extent of global chemical pollution, there is uncertainty regarding the effectiveness of solutions tackling chemical pollution, specifically PP.

Traditionally, environmental goals and industrial competitiveness have been believed to clash—there must exist a trade-off between social benefits and private costs. However, over the past 20 to 30 years, there has been an emerging school of thought. This paradigm shift is centered around dynamic competitiveness and "innovation offsets," which can be described as firm decisions that may lower the net cost of meeting environmental standards and potentially lead to absolute advantages over other firms facing less stringent regulations. For instance, firms that volunteered to participate in the Environmental Protection Agency's 1991 "Green Lights" program agreed to closely monitor their entire electrical energy consumption in exchange for advice on energy efficiency improvements. The data collected by the EPA show that nearly 80 percent of the projects had paybacks of two years or less (Porter and van de Linde 1995). By joining this program, participating firms were able to experience "innovation offsets" that ultimately benefitted them along with the environment.

One example applicable to plastics is what is known as the "early-mover advantage." Because Germany enacted recycling standards earlier than in most other countries, German firms were able to develop less packaging-intensive products, which have been warmly received in the marketplace (Porter and van de Linde 1995). However, one drawback of the early-mover advantage, as well as innovation offsets in general, is that it can often be limited

by countries' eagerness to impose environmental regulations. A country's willingness to enforce environmental standards depends on its attitudes regarding the "social cost" of the externality. In our scenario, it is clear that MPP is the result of a market failure, in which the price of making and using things made out of plastic does not reflect the full cost of disposing of that plastic (Carr 2019).

In economic terms, the social cost is the sum of private and external costs, and reflecting the full "social" cost means including the additional economic damages created by mismanaged plastic debris that wind up in the ocean. As explained earlier in this section, marine wildlife is heavily damaged by marine plastic debris, but coastal municipalities and ocean users are also harmed. It is predicted that the current stock of marine plastic approximates to between $500 billion to $2.5 trillion USD annually in social costs (Wahlén 2019). General economic theory suggests that a simple yet efficient way to correct externalities is by making polluters "internalize" the externality, often through command-and-control policies and economic instruments. In this paper, we will focus on economic instruments: market-based interventions aimed to encourage good behavior or discourage bad behavior.

There are many reviews that assess the general effectiveness of different government-initiated economic instruments, such as the paper *Economic instruments and marine litter control*. Oosterhuis consolidates existing policies, including penalties, taxes, deposit-refund schemes, and subsidies, into a table and weighs the strengths and weaknesses of each. What is immediately obvious in their findings is that effectiveness is incredibly heterogeneous. Many policies were limited by a variety of factors, like weak political support, corruption, and consumer preference/demand. Even of the policies that were labeled as "high" effectiveness, additional constraints existed (Oosterhuis et al. 2014). Overall, authors in this subject area have found that bans and taxes, among other measures, are hard to implement, harder to enforce, and even harder to assess efficacy. In addition, bans across North America have been implemented inconsistently, further complicating the issue across state and national borders (Xanthos and Walker 2017). Moreover, many reviews summarizing bans and taxes attempt to give solution recommendations in their conclusion sections. Numerous studies stress the importance of consumer behavior, education campaigns, and the involvement of multiple key

stakeholders in society—policymakers, civil society actors, the scientific community, and the private sector—in mitigating PP (Lohr et al. 2017, Xanthos and Walker 2017).

Results of Plastic Reduction Policies

Aside from holistic reviews, much of the literature are experimental studies that assess the before- and after-effects of a policy implementation. There are many novel instruments that have been tested in different municipalities and regions that aim to reduce single-use plastic (SUP) usage and waste, and analyzing these instruments gives us a better idea of what works and what does not. One particular economic instrument that seeks to encourage recycling is container-deposit legislation (CDL), colloquially known as "bottle bills." How the CDL system works is a retailer buys beverages from a distributor, and a deposit is paid to the distributor for each can/bottle purchased. The consumer pays the deposit to the retailer when buying the beverage, and when the consumer returns the empty beverage container to the retail store, a redemption center, or a reverse vending machine, the deposit is refunded (Bottle Bill Resource Guide).

In the reviews that I looked into, CDL has had varying degrees of success. In Oosterhuis's review, effectiveness has either been "conditional" or "limited" by factors including consumer demand, corruption and low pricing of SUPs (Oosterhuis et al. 2014). Conversely, Schuyler's review states that there is little scientific research that has demonstrated the effectiveness of CDL in reducing mismanaged waste, but then cites multiple cases in which CDL has proven practical. As an example, in the U.S. and Australia, data collected from the Ocean Conservancy International Coastal Clean-up showed that the mean proportion of containers found in coastal debris surveys in states with a CDL is approximately 40% lower than non-CDL states (Schuyler et al. 2018). This undertaking is a success story that demonstrates the influence that a well-designed approach can have on the desired area of effect.

CDL is one of the many economic instruments designed to reduce waste generation, but Disposable Bag Policies are another type of policy more closely related to my study. The research that I will introduce involves pre- and post-policy measurement of SUP usage on a more localized level. Although my research topic is considerably different from the

Disposable Bag Policies that I was able to examine, they are nonetheless useful in formulating my scope and methodology. For example, the city of Aspen, Colorado implemented its Waste Reduction Ordinance in 2012, which banned single-use check-out bags and instituted a $0.20 fee for single-use paper bags. The study gathered three types of data—the total number of paper bags purchased, observations of in-store shopper behavior, and surveys of consumer perceptions and attitudes towards the ban. After the ban, the purchase of paper bags increased, and almost 85% of people leaving Aspen supermarkets chose to either carry their groceries by hand or use reusable bags, with 45% of shoppers leaving the market with no bags (Armstrong and Chapman 2018). What we can learn from this study is that bag bans presumably lead to more consciousness regarding bag use, if not direct decreases in usage. Additionally, data gathered from surveys and interviews with store representatives indicate that initial frustration and opposition to this type of measure is normal, but over time, communities will adapt to it.

Interestingly, when juxtaposing the effectiveness of incentives (rewards) with disincentives (fees) in decreasing bag use, it was found that the tax policy of $0.05, implemented in Montgomery County, Maryland, reduced the overall demand for disposable bags by over half and prompted consumers to substitute to reusable alternatives. Likewise, the large effect of the tax is also striking given that the bonus (the incentive) of $0.05 had almost no impact on bag use. This study lends support to policies that aim to tax a "bad" rather than incentivize a "good," which the authors found consistent with a model of loss aversion (Homonoff 2013). The next example of Disposable Bag Policies, *Bans vs. Fees: Disposable Carryout Bag Policies and Bag Usage*, borrows Homonoff's methodology from the aforementioned study and applies it to a different setting: Concord, Richmond, and Berkeley, California. In this study, Concord served as the control (stores with no ban ever), Richmond served as the treatment (stores with a policy change), and Berkeley served as the other control (stores with a ban pre-dating the sample period). Like the other two studies, this one also takes down largely quantitative data from pre- and post-ban periods and reinforces Homonoff's conclusion that bag bans lead to significant increases in paper bag. Furthermore, it was found that bans and fees produce remarkably similar increases in reusable bag usage. Lastly, bans and fees also have similar effects in reducing total disposable bag consumption, unless stores

offer inexpensive reusable bags and charge more for paper bags, in which case bans may be more effective than fees (Taylor and Villas-Boas 2015).

The next subsections delve into a chronological history of bans in Berkeley and adjacent municipalities, which is integral to understanding the potential of Berkeley's new ordinance with respect to future policies aiming to reduce waste from SUPs.

Berkeley's early plastic bans

In 1987 when the world faced the ozone depletion crisis, Berkeley became the first city to ban foam plastic food containers manufactured with chlorofluorocarbons (CFCs), which were found to have a significant adverse impact on the ozone layer (L.A. Times 1987). In particular, the halocarbon CFC-11, used to blow polyurethane (PUR) foams for insulation, posed an especially large environmental threat due to its volatile nature. When the foam wastes are disposed of, much of the released CFC-11 gas found in the air pore space of the landfilled waste is emitted with the biogas produced in the landfill (Kjeldsen and Jensen 2001). The city of Berkeley immediately recognized the gas's capability for ozone destruction and swiftly banned CFC-containing plastics, reflecting its environmental awareness and readiness to take a stance against pollution. A year later, Berkeley banned all polystyrene, including nearly all foam cups, plates and hamburger holders (L.A. Times 1988). The law required that 50% of takeout food packaging be recyclable or compostable, way ahead of most other municipalities (Californians Against Waste). Moving on from these two initiatives, there is little literature documenting the changes between 1988 and 2012, but in 2012, Alameda County adopted two ordinances, which will be discussed more in detail—the Mandatory Recycling Ordinance and the Single-Use Bag Ordinance.

Alameda County leads California to take a stand against plastics

In 2011, the Alameda County Waste Management Authority (ACWMA) board voted unanimously to ban single-use checkout bags under the Single-Use Bag Ordinance. Under another law rolled out at the same time, the board also voted to introduce the Mandatory Recycling Ordinance, requiring businesses and managers of multi-family buildings to recycle

(Oakland North). For the city of Berkeley, from July 1, 2012 onwards, the ACWMA mandated recycling for businesses and institutions with 4 or more cubic yards of weekly garbage as well as multi-family properties with 5 or more units. Phase 2 of this ordinance, implemented from July 1, 2014 onwards, added food scraps and compostable paper to the "Covered Materials" list and expanded to include *all* businesses (Recycling Rules Alameda County).

The bag ordinance, the one more pertinent to my study, was a sweeping measure tackling the issues of bags in landfills and widespread litter in Alameda County. In fact, plastic bags comprised 9.6 percent of litter collected during coastal cleanup days in 2008, which emphasizes the magnitude of the problem (StopWaste 2008). The next notable legislation after the two 2012 bills were passed in 2014 and 2016—Senate Bill 270 (SB 270) and Proposition 67, respectively—a statewide bill prohibiting the distribution of single-use grocery bags and requiring that all paper and reusable bags be charged a minimum of 10 cents and meet specific requirements (California Legislative Information). With these two passages, California made history by becoming the first state to enact legislation imposing a state-wide ban on single-use bags at large retail stores (National Conference of State Legislatures).

The trend of these laws shows that not only specific cities (e.g. Berkeley) or counties (e.g. Alameda), but also the entire state of California, were unified in wanting to ban certain SUPs and uphold environmental health for residents. The last, and most recent, development to the ban was an adjustment to the ACWMA-enforced Single-Use Bag Ordinance—as of May 1, 2017, all retail stores that sell perishable or nonperishable goods (including, but not limited to, clothing, food, and personal items) were now included under the ordinance. As of November 1, 2017, restaurants and take-out food establishments, including food trucks and vendors who distribute food in bags, were added to the list of those encompassed by the law (ACWMA).

The Single Use Disposable Foodware and Litter Reduction Ordinance

The Single Use Disposable Foodware and Litter Reduction Ordinance (SUDFLRO), also known as the Disposable-Free Dining Ordinance, became a groundbreaking piece of legislation aimed at reducing the use and disposal of SUPs. There are three phases of this new law—with each phase effective March 29, 2019 (Phase I); January 1, 2020 (Phase II); and

July 1, 2020 (Phase III). The first phase mandated that "Accessory Disposable Foodware Items," including but not limited to cups, lids, utensils, straws, and clamshells, among others, were to be provided only upon request or at self-serve stations. Additionally, "Prepared Food Vendors" (PFVs) (which include bakeries, drive-ins, food products stores, and bars, among others) that allow self-bussing must provide color-coded receptacles, with clear signage, for separation of recyclables, compostables, and landfill waste. In Phase II, PFVs are required to use compostable foodware certified by the Biodegradable Products Institute for to-go orders and must charge customers 25 cents for each disposable cup provided. Lastly, for Phase III, all PFVs will be required to use only durable, washable foodware for dine-in meals (City of Berkeley), though there will be some allowable compostable and recyclable products such as straws, foil wrappers, tray liners and napkins (Waste360). Surprisingly, most people were onboard with the idea of SUDFLRO. As Martin Bourque, the executive director of the Ecology Center, a Berkeley-based environmental non-profit, explains, "Everyone we talked to thought there was a problem that needs solving. They understood it's not just about moving materials from waste bins to recycling or compost bins" (Waste360).

Opposition to the ordinance

In January 2019, the City Council of Berkeley voted unanimously to approve SUDFLRO, but as with any legislation, there was bound to be dissent from the public. Points of opposition submitted by the public and key stakeholders regarding SUDFLRO were released in a City Council Report (CCR) compiled by Berkeley's Zero Waste Commission (ZWC). To begin with, Kate O'Neill, associate professor at UC Berkeley's Department of Environmental Sciences, Policy & Management, raised concern over whether the city of Berkeley is equipped with the proper infrastructure to process compostables (Waste Dive). This is an important topic that O'Neill introduces, as without the necessary infrastructure to manage the waste products, the ordinance would be counterproductive to the end goal of improving waste diversion and wasteful of the time and resources dedicated to drafting the ordinance in the first place.

Besides Berkeley's capacity to handle compostables, a few expressed concern over how much responsibility belongs to the firm vs. the customer. As the report states, "If SUDs

are required to be compostable or recyclable, it is still likely these items will end up in landfill, based on consumer behavior and availability of recycle/compost collection containers." In response to this, the ZWC recommends that the city "fund city-wide program to educate consumers on proper sorting of waste and ordinance, improve collection through increased service and quantity of city bins…[and] require customer-facing in-store compost bins for collection" (CCR). Akin to the earlier point about poorly sorted waste streams, Berkeley resident Michael Katz claims, "It's not practical to expect people to have the forethought or carrying space to bring their own takeout containers to restaurants...slapping a $.25 charge on compostable containers strikes me as the kind of action that exposes Berkeley to ridicule rather than respect: It would change hardly anyone's behavior, except to perhaps discourage patronizing Berkeley restaurants" (CCR).

Lastly, on the topic of sanitary concerns, Alison Piccoli of the California Restaurant Association explains, "If a customer were to bring in a reusable cup, straw, or Tupperware container to a restaurant that isn't properly sanitized, it encourages the transfer of foodborne illnesses through these products and can spread throughout the entire restaurant" (CCR). In a time of global pandemic under COVID-19, this concern magnifies what is on everyone's minds—the increased transmission risks behind consumers bringing in their own foodware. Even if the pandemic subsides, there will be at least some period during which worried consumers will blatantly oppose this aspect of the ordinance.

It is clear that despite unanimous approval from the City Council and widespread support of the bill, there are still concerns with many aspects of SUDFLRO, spanning from the role that consumers play, to sanitary concerns caused by discontinuing SUPs. The opposition detailed above is not to say that the ordinance is by any means unnecessary or inadequate; it simply shines light on the fact that there are many moving components that must be simultaneously taken into consideration when navigating through policy design. All in all, the ordinance still represents a huge step in the right direction for PP mitigation and for Berkeley's role as an environmental trailblazer.

Objectives

One notable knowledge gap in this subject's literature and existing Berkeley environmental policy is how much firms and businesses actually care about the issues surrounding PP, and whether these values translate into less (or more) usage and disposal of SUPs. While the three Disposable Bag Policies discussed above do not directly relate to my methodology, which involves testing for correlation using survey data, they help to educate my own process by helping to determine which types of questions to ask during data collection. I plan to answer the following question: in local Berkeley restaurants, is there a correlation between their levels of plastic pollution awareness and their levels of plastic consumption? I hypothesize that there is no correlation between awareness and practices—restaurants' knowledge on PP and related issues does not necessarily translate into their everyday operation.

Besides my central research question, I also have two subquestions that I aim to answer: (1) does the type of cuisine of the restaurant have any bearing on its level of PP awareness and/or plastic consumption? (2) Do restaurants that have higher levels of PP awareness tend to want to charge higher prices for plastic food packaging?

My methodology is influenced by a study that measured the extent of managers' beliefs influencing corporate environmental responsiveness. The results demonstrated that managers who are aware of the consequences of human-nature interaction and feel compelled to take actions, view organizations (e.g. firms) as a field to materialize their environmental concerns by making appropriate strategic decisions (Papagiannakis and Lioukas 2012). From this study, I decided I would need to target managers to complete the survey, as they are the ones able to make impactful future decisions for their restaurants.

METHODS

Study site

For my study, I selected local Berkeley restaurants adjacent to the UC Berkeley campus in order to make my findings more relevant to the student demographic. The study

site, shown in Appendix A (on page 27), included restaurants from five regions of Berkeley—Southside, Elmwood/North Oakland, Central Berkeley/Berkeley Downtown, Northside, and North Berkeley. I attempted to sample roughly an equal number of restaurants from each region to ensure that all regions are weighted equally during data analysis. One criterion of my sampling was that the restaurant cannot be part of a chain and/or large franchise, as it is generally more difficult to obtain managerial or bureaucratic permission to conduct my research. I also took into consideration the diversity of cuisines in my samples, as one of my subquestions involves the relationship between certain cuisines and their associated levels of SUP consumption.

Unfortunately, I was unable to collect complete data from the five regions listed above due to the Spring 2020 COVID-19 epidemic, which caused many restaurants in my proposed study system to close. I originally planned to sample approximately 8-10 restaurants from each region, equating to a sample size of approximately 40-50 restaurants; however, I managed to finish only the region of Elmwood and a portion of Southside Berkeley—as a result, my revised sample size is 10. Of the ten, three were Japanese, two were American, and the rest were one of each: French, Thai, Italian, Indian, and Chinese.

Data collection methods

For my study, I required a three-page questionnaire that my mentor David Law and graduate student instructor Jessica Heiges helped me revise and improve. It was structured primarily with scaled *Likert* ("on a scale from 1-10...") and short numerical *fill-in-the-blank* (e.g. "What is your restaurant's consumption of all plastic utensils in a given week?") questions. The survey, attached as Appendix B (pages 28-30), was designed to be completed in less than five minutes for the restaurant's convenience. The sections of the survey questions are as follows: "General Restaurant Information," "Restaurant Plastic Usage," "Plastic Pollution Awareness," "Looking Forward: What Can and Should Be Changed," and "Berkeley's New 2020 Plastic Ordinance."

As explained in the Introduction section, my methodology required the manager or owner of the restaurant to fill out the survey. Thus, my data collection methods consisted of walking store-to-store and asking to speak with the manager. If he or she were present at the

time of visit, I introduced myself, gave a brief explanation on the purpose of my research, and handed out the survey. If the manager or owner were not present, I would ask the employee for an appropriate time or day to return. I collected the questionnaire between one to three days after distribution.

Data analysis methods

Once the survey results were collected, I coded and inputted them into Microsoft Excel, with each quantitative question corresponding to a column and each observation corresponding to a row. My CRQ focused on the correlation between PP awareness and usage, but my subquestions involved other variables, such as type of cuisine (*CUISINE*) or perceptions on charging consumers for plastic foodware.

To conduct my data analysis, I employed RCommander's statistical and graphical methods (Fox 2005). For my central research question, I juxtaposed the restaurant's awareness on plastic pollution (*AWARE_PP*) with three metrics of plastic usage: weekly consumption of plastic utensils (*PERCENT_UTENSILWK*), to-go containers (*PERCENT_TOGOWK*), and bags (*PERCENT_BAGWK*). Then, I called the "Correlation Test" function under the conditions: Pearson's product-moment and two-sided alternative hypothesis—for *AWARE_PP* vs. *PERCENT_UTENSILWK*, *AWARE_PP* vs. *PERCENT_TOGOWK*, and *AWARE_PP* vs. *PERCENT_BAGWK*. For each pair, I noted the correlation coefficient *r*, *t*-value, *p*-value, and the 95% confidence interval. Additionally, I called the "Scatterplot" function—including "jitter both x- and y-variables" and "least-squares line"—for the same three relationships in order to visually observe the correlation.

Regarding subquestion one, I called "Scatterplot" again, this time utilizing "Plot by groups" to classify restaurants by *CUISINE*; I was able to discern the variations in awareness and consumption across different cuisines. Lastly, to answer subquestion two, I employed "Correlation Test," this time comparing *AWARE_PP* to how much the restaurant thought a consumer should be charged extra per utensil (*CHARGE_UTENSIL*), to-go container (*CHARGE_TOGO*), and bag (*CHARGE_BAG*).

For all tests in my analysis, I used a two-tailed, 5% significance level to determine statistical significance.

RESULTS

From my RCommander data analysis, I found that restaurants' awareness on plastic pollution (*AWARE_PP*) is negatively correlated with the three metrics of plastic usage: weekly consumption of utensils (*PERCENT_UTENSILWK*), to-go containers (*PERCENT_TOGOWK*), and bags (*PERCENT_BAGWK*). However, using a two-tailed, 5% significance level, I found that none of these negative correlations are statistically significant—for all three relationships, the *p*-values are greater than 0.05, and the confidence intervals contain zero, meaning that it is uncertain whether or not there is a true correlation. Table 1 shows the correlation coefficient *r*, *t*-value, *p*-value, and the 95% confidence interval for the three relationships. Figure 1 shows the same relationships using scatterplots with "least-squares lines," and from the scatterplots, it is clear that the data points are not tightly focused around the least-squares line; the residuals are relatively large.

Table 1. Correlation statistics for awareness vs. consumption. I ran correlation tests in RCommander to determine the sign, size (magnitude), and significance of correlation for the variables below.

***AWARE_PP* vs...**	**Correlation coefficient *r***	***t*-value**	***p*-value**	**95% confidence interval bounds**
PERCENT_UTENSILWK	-0.2931311	-0.86719	0.4111	[-0.7789855, 0.4126563]
PERCENT_TOGOWK	-0.1395699	-0.39867	0.7706	[-0.7070618, 0.5372700]
PERCENT_BAGWK	-0.4617951	-1.4726	0.1791	[-0.8455660, 0.2366347]

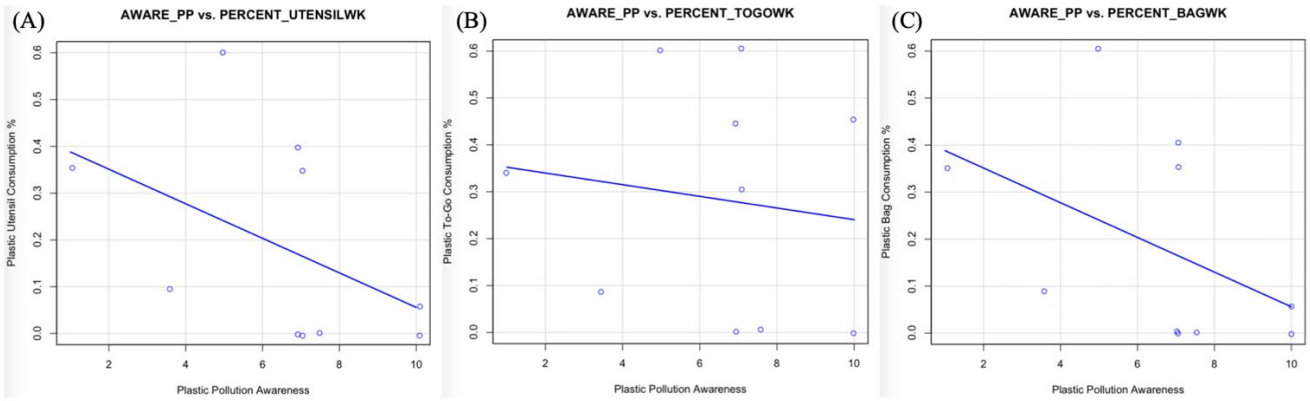

Figure 1. Level of plastic pollution awareness vs. percent of weekly consumption of (A) plastic utensils, (B) to-go containers, and (C) bags. The x-axis is based on the scaled question: "On a scale from 1 to 10, how aware are you on the issue of plastic pollution in general terms?" The y-axis is based on the numerical fill-in-the-blank question: "What is your restaurant's consumption of all plastic (A) utensils, (B) to-go containers, and (C) bags in a given week? (Units = count (#) or percentage)"

As for my first subquestion, I found that American restaurants tended to have the highest PP awareness and lowest SUP consumption out of the seven cuisines, as shown in Figure 2. Additionally, Japanese restaurants had high amounts of variation; while all of them answered between 3.5 and 7 on their level of awareness, their percent plastic used ranged from 0%, the sample minimum, to 60%, the sample maximum. Because the other types of cuisine each had only one sample, I was unable to draw notable conclusions about them.

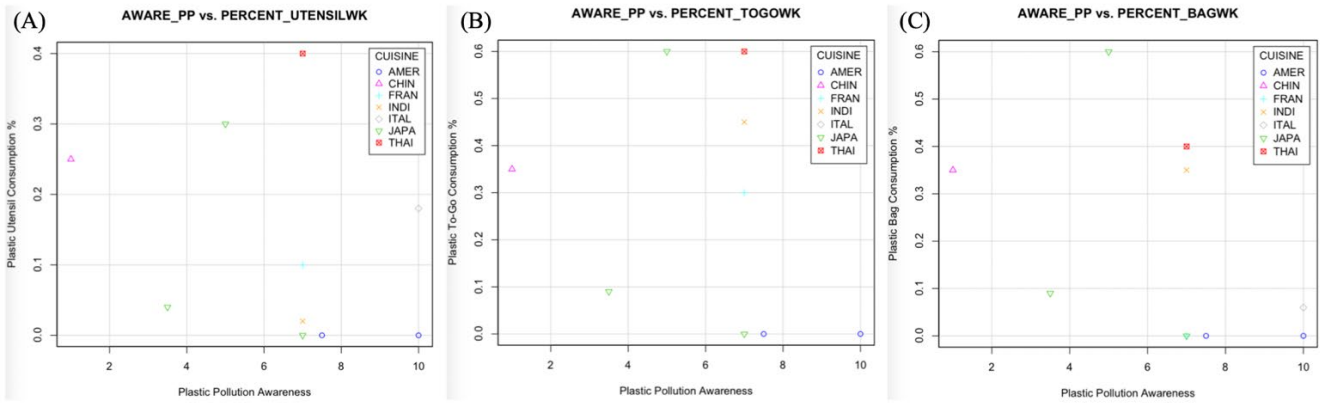

Figure 2. Level of plastic pollution awareness vs. percent of weekly consumption of plastic (A) utensils, (B) to-go containers, and (C) bags, grouped by type of cuisine. In Panel (A), the French-cuisine (*FRAN*) data point is difficult to see, but it is at (*AWARE_PP* = 7, *PERCENT_UTENSILWK* = 0.1). In Panel (B), the *FRAN* data point is at (7, 0.3). In Panel (C), the *FRAN* data point is at (7, 0.0).

Lastly, I ran two-tailed, 5% significance correlation tests on *AWARE_PP* vs. how much the restaurant thought a consumer should be charged extra per utensil (*CHARGE_UTENSIL*), to-go container (*CHARGE_TOGO*), and bag (*CHARGE_BAG*). I found little to no correlation between the variables. The correlation coefficients I found were 0.04007904, 0.02538503, and 0.07113182, respectively, and are depicted in Table 2. Though all positive, these coefficients were far from being significant, as all of them had *p*-values greater than 0.80—extremely far from a significance level of 0.05. Figure 3, which are scatterplots showing these associations, convey visually that no correlation exists between the variables.

Table 2. Correlation statistics for awareness vs. ideal charge for a customer. I ran correlation tests in RCommander to determine the sign, size (magnitude), and significance of correlation for the variables below.

***AWARE_PP* vs...**	**Correlation coefficient *r***	***t*-value**	***p*-value**	**95% confidence interval bounds**
CHARGE_UTENSIL	0.04007904	0.11345	0.9125	[-0.6048095, 0.6532214]
CHARGE_TOGO	0.02538503	0.071823	0.9445	[-0.6140558, 0.6447069]
CHARGE_BAG	0.07113182	0.2017	0.8452	[-0.5846802, 0.6707190]

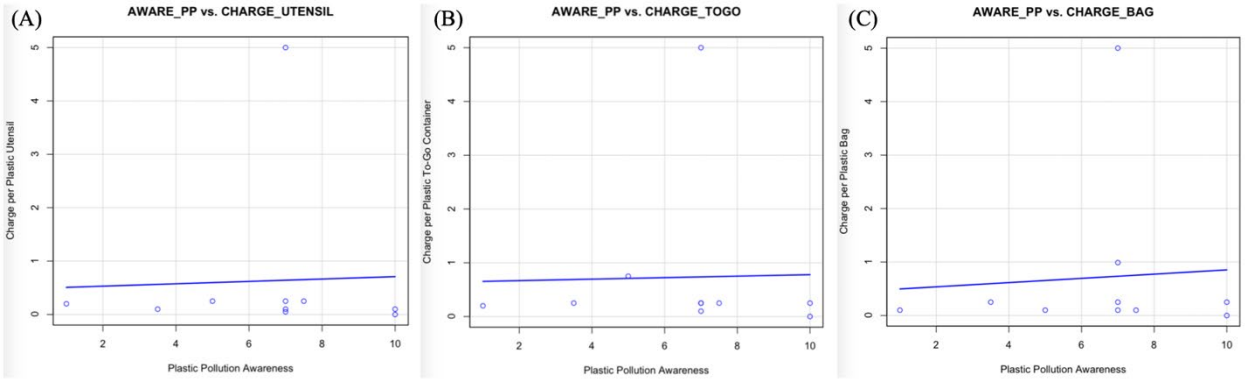

Figure 3. Level of plastic pollution awareness vs. ideal charge to a customer per plastic (A) utensil, (B) to-go containers, and (C) bag. The x-axis is based on the scaled question: "On a scale from 1 to 10, how aware are you on the issue of plastic pollution in general terms?" The y-axis is based on the numerical fill-in-the-blank question: "How much, if anything, do you think a consumer should be charged ***extra*** per plastic (A) utensil, (B) to-go container, and (C) bag?"

During this analysis, I noticed an outlier due to one restaurant inputting $5.00 for all three metrics—*CHARGE_UTENSIL*, *CHARGE_TOGO*, and *CHARGE_BAG*. Most other restaurants had amounts ranging from 0¢ to 50¢, so I speculated that the correlation coefficients found above are downward-biased. Specifically, the inclusion of the outlier could have led to not only lower correlation coefficients, but also lower *t*-values, higher *p*-values, and generally a lower tenacity in my results. This source of bias reflects that correlation between the variables could potentially be stronger but is currently being stifled by the outlier. Consequently, I removed the outlier to see how it would impact my results, and after manipulating the data, I found much different correlation statistics, as shown in Table 3. The outlier-excluding scatterplots are represented in Figure 4. I found that while none of the new correlation coefficients are statistically significant, they became much more significant than in the previous test. The new coefficients and p-values are as such: r = -0.4007904 / p = 0.11345 for utensils, -0.2976074 / 0.4367 for to-go containers, and 0.04562971 / 0.9072 for bags.

Table 3. Correlation statistics for awareness vs. how much a customer should be charged, outlier removed. I ran correlation tests in RCommander to determine the sign, size (magnitude), and significance of correlation for the variables below. ***The outlier of $5.00 for plastic utensil, to-go container, and bag was removed and tests were rerun.***

***AWARE_PP* vs...**	**Correlation coefficient *r***	***t*-value**	***p*-value**	**95% confidence interval bounds**
*CHARGE_UTENSIL**	-0.4082064	-1.1831	0.2754	[-0.8436230, 0.3510973]
*CHARGE_TOGO**	-0.2976074	-0.82477	0.4367	[-0.8030152, 0.4567996]
*CHARGE_BAG**	0.04562971	0.12085	0.9072	[-0.6378203, 0.6888759]

* Outlier of $5.00 was removed from this correlation analysis (n=9).

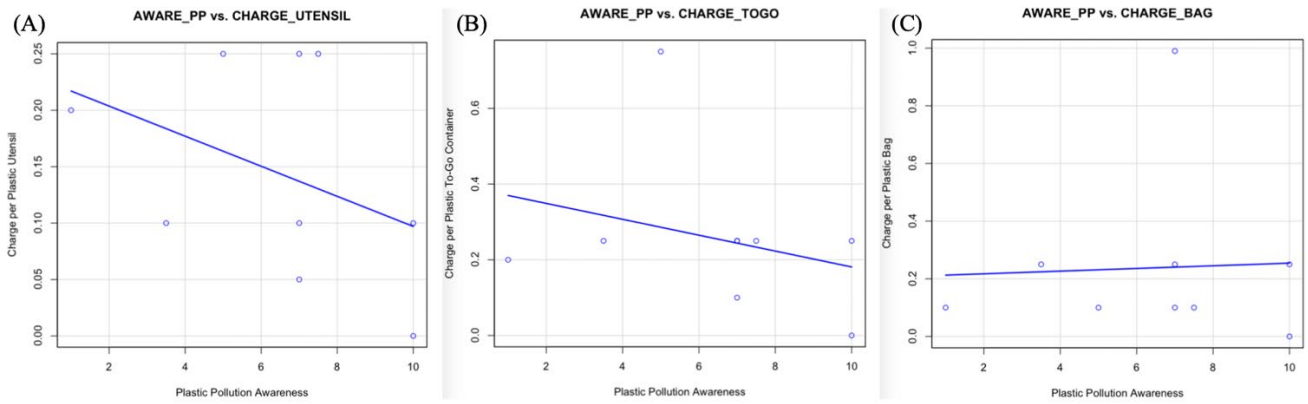

Figure 4. Level of plastic pollution awareness vs. ideal charge to a customer per plastic (A) utensil, (B) to-go container, and (C) bag, outlier removed. Figure 4 is identical to Figure 3, respectively, except the outlier of $5 (5.0) for plastic utensil, to-go container, and bag was removed.

Interestingly enough, the correlation became weaker for *AWARE_PP* vs. *CHARGE_BAG* after removing the outlier. The *r* decreased from 0.07113182 to 0.04562971, and the *p*-value increased from 0.8452 to 0.9072, indicating that the outlier surprisingly corroborated the original analysis for this one relationship only.

DISCUSSION

With my scientific inquiry, I aimed to observe whether awareness of plastic pollution translated into a change in the amount of SUP foodware consumption in local Berkeley restaurants. The insights gathered from surveying restaurants and more generally businesses, have meaningful application towards policy design; it may educate future legislation that can both highlight the importance of educating firms on PP and assist restaurants (or firms) in tangibly reducing their amounts of SUPs used. In the analysis of my central research question and subquestions, I found that none of the correlations between different variables that I tested for were significant at the 5% level. Statistically, there were varying degrees of significance, with *p*-values ranging from 0.1791 to 0.9445. Graphically, my findings followed the same trend—some lines-of-best-fit closely modeled the scatterplot, while others, especially the plots of awareness vs. charge (outlier included), modeled the data very weakly. In the rest of this section, I plan to synthesize my results from each of my analyses, highlight some limitations of my project, and explore potential future applications of my research. For the most part, my methodology and research sufficiently addressed a gap in knowledge in this

field. As mentioned in the Introduction section, many of the papers in the literature review have been focused heavily on *consumer*, rather than *firm*, perceptions on PP and related issues. Especially given the context of Berkeley's ongoing implementation of SUDFLRO, the inclusion of firm perspectives will shed light on the importance of including firms' awareness and willingness to comply with environmental legislation. The restaurant attitudes in question ultimately tie back to innovation offsets that can advance both firm profit and sustainability efforts, and on a larger scale, the paradigm shift desperately needed for our society to lessen our reliance upon SUPs.

Trends in type of cuisine vs. plastic awareness and consumption

American restaurants tended to have both the highest levels of awareness and the lowest levels of consumption, indicating an understanding of the issue's magnitude and a willingness to take steps to combat it. In the context of global sustainability, the United States was one of the first countries to recognize the repercussions of reliance upon SUPs. Since this realization, we have seen a trend in American companies (restaurants included) becoming increasingly conscious of their own impact as well as to consumer outlooks regarding plastics. For example, the dominant literature revolves around U.S.-based efforts aimed at reducing waste from SUPs, but this awareness may not be as prominent in other cultures, especially in "throwaway societies" such as China, India, and much of Southeast Asia. "Throw-away societies" are usually developing countries that are highly dependent upon short-lived, disposable items and their cost-effectiveness relative to other materials. Corroborating this idea, the Chinese restaurant featured the lowest awareness across the board (1's in all awareness questions) and relatively high consumption. The Japanese data points were more varied—while their awareness ranged between 3.5 and 7, their percent plastic used ranged from 0%, the sample minimum, to 60%, the sample maximum. This implies either heterogeneity in the awareness of Japanese restaurants, or homogeneity in awareness but a differing magnitude in actions taken to reduce waste.

A possible justification is that many Asian cuisines, Japanese included, feature soup noodles as a staple food item, which inherently requires more packaging than dishes from other cuisines. The components of the dish are usually separated for take-out orders—a plastic

deli container for the soup and another container (plastic or not) for the noodles. Other Japanese dishes, such as sushi or rice bowls, may require less packaging, and the variety among dishes may perhaps explain the large variation within SUP consumption in Japanese restaurants. Nevertheless, this is only one explanation for the spread of data points, and with a larger number of Japanese samples, I would have arrived at a more definitive outcome.

Variation in how much to charge consumers extra for plastic

My tests on restaurants' awareness vs. perception on charging consumers for plastic foodware (from here on called "consumer charge") also presented a mixed story. The results suggest that restaurants have some degree of understanding on the "social cost" of plastic, which was briefly explained in the Introduction section. The majority of survey responses ranged between 0¢ and 25¢, whether it be for a utensil, to-go container, or bag. For the discussion on this analysis, I will focus first on the case where the outlier of $5.00 (per utensil, to-go container, and bag) was not removed.

Even though the robustness for this set of tests is much lower, indicated by much higher *p*-values, the direction of correlation shows a positive relationship. Logically, with higher levels of awareness, restaurants would place a higher cost (internalizing the "social cost") on SUPs. In the first analysis with the outlier, there is a slight positive correlation, though statistically insignificant, between awareness and consumer charge for all three metrics of consumption. As with all of my data analysis, my results were hindered by my diminished sample size, resulting in lower *t*-values and higher *p*-values. With a greater number of restaurants surveyed, statistical power would have increased regardless of the direction of association (positive vs. negative). However, because the correlation for consumer charge is positive in all three types of foodware, it is reasonable to assume that a greater level of power could lead to a stronger and more positive association for consumer charge.

In my analysis without the outlier, the direction of correlation for awareness vs. charging consumers for utensils and to-go containers changes from positive to negative, while the relationship remains positive for bags. In other words, for utensils and to-go containers, higher levels of awareness are associated with a lower consumer charge. This somewhat

counterintuitive finding reveals that some restaurants in my sample have not fully grasped the concept of the "social cost" of marine plastic.

Interestingly, in both analyses (with and without the outlier) for consumer charge, correlation remains positive for the category of bags. Moreover, when the outlier is removed, association becomes weaker (outlier included: $r = 0.07113182$ / p-value = 0.8452; excluded: $r = 0.04562971$ / p-value = 0.9072). A possible explanation for this occurrence is the longer history of awareness and action around single-use bags—measures attempting to correct the externality created by bags are among the first mechanisms developed to tackle PP. Consequently, the long fight against bags, which created societal awareness, could explain why consumer charge increases with rising awareness both with and without the outlier. If single-use utensils and to-go containers are expected to follow the same trajectory as bags, then we can expect a much quicker societal understanding, in the near future, of the gravity in solving the plastics crisis.

The central research question: awareness vs. consumption

Ultimately, the correlation between levels of PP awareness and percent weekly consumption of utensils, to-go containers, and bags are negative, albeit statistically insignificant. I hypothesized that there exists no correlation between awareness and consumption, and formally, my study confirmed that in all three cases, conclusions concerning correlation cannot be drawn. My results do not suggest a clear-cut verdict, and in fact, imply a variety of possibilities.

Despite the uncertainty of the results in relation to my central research question, my findings suggest that with a more robust and thorough investigation, the true population correlation between awareness and consumption could be negative and statistically significant. A true negative correlation is a promising indication that SUP usage and disposal indeed decrease with rising understanding of the problem at hand.

An intriguing discovery substantiates my earlier point regarding bags; of the three categories, the correlation for bags is the most negative and the closest to significance at the 5% level. As discussed in the Results section, the correlation coefficient r is -0.4617951 with a p-value of 0.1791. The value of r establishes a moderate (and negative) degree of association

between the variables, while the *p*-value expresses that, assuming *r* is equal to zero (i.e. no correlation), there is only a 17.91% probability of obtaining results as extreme as what was found during my analysis. I infer that the logic applied in an earlier subsection also applies here—due to the well-established battle to ban single-use bags, people are more aware of the "social cost" of using single-use bags. As the data reveal, restaurant managers are among those who are conscious of the environmental and social stigma behind bags. This interpretation is reflected in my analysis as a noticeable decrease in usage, especially as awareness increases. Echoing my earlier point, it may be possible to see similar trends in utensil and to-go container consumption as society eventually stigmatizes all disposable food packaging. In the context of our current digital age, there is much potential for the transmission of environment-related news and even greater potential to take action against PP, including mobilizing individuals to clean up public spaces, pushing legislators to draft beneficial policies, and purchasing from eco-friendly and socially conscious businesses.

Limitations and future directions

The first limitation of my study is that it lacks both internal and external validity. To begin the discussion on internal validity, my methodology excludes restaurant franchises, leading to both undercoverage and volunteer bias. Undercoverage bias occurs when members of the larger population are inadequately represented in the sample, and my study, restricted by time and resources, certainly omitted restaurants that would have influenced my results. Additionally, my study suffers from volunteer bias, as no restaurant is mandated to complete my survey—naturally, some restaurants refused to participate, meaning that the remaining sample is not entirely representative of the greater population. Related to undercoverage bias, restaurant shutdowns due to COVID-19 reduced my sample size substantially, greatly weakening the robustness of my research. Had I collected my intended sample size of 40-50, I conceivably would have been able to draw more definitive conclusions from my analyses, and some of them might even have been significant at the 5% level. With a sample size of only ten, it is extremely difficult to discuss notable results and broader implications.

Furthermore, there should have been more pre-pilot inquiry into survey design prior to distribution of the final version. For instance, my original intention was for the "consumption

of all plastic (utensils / to-go containers / bags) in a given week" response to be in units of count (#) rather than in percentage (%). Analyzing the usage of foodware in count form would have made comparing observations much simpler (e.g. sample 1: 700 utensils/week vs. sample 2: 850 utensils/week), so giving restaurants the option to fill out either count or percentage introduced a variable of ambiguity into my analysis. Typically, "count of weekly consumption of plastic" is more straightforward than "percent of weekly consumption of plastic" to the general reader. As a unit of measurement, it may not be immediately apparent what the percent form measures, while the count form is instantly understandable. During my data collection, this vagueness translated into often having to return to the restaurant and ask for a conversion of the answers into the correct form. A recommendation on how to improve future research is to continually revise the survey (or data collection instrument), with advice from multiple credible sources, until only the most essential questions with the right units are asked.

Another limitation of my design is its cross-sectional nature. Cross-sectional studies ordinarily result in weaker outcomes, whereas executing a cohort study would allow for measurement of not only the variables of interest at a given time, but also potential trends in those variables over time. This particularly makes sense given the timing of SUDFLRO. As a result, one recommendation that I would give for a future reiteration of this study is to gather both pre- and post-ordinance data—employing a methodology analogous to the single-use bag study conducted in Aspen, Colorado by Armstrong and Chapman.

Moreover, I found that tracking down restaurant managers, along with requiring them to complete the survey on their own time, proved quite difficult. A future research recommendation is a prolonged period of data acquisition and possibly an incentive for the restaurant to participate, which would make obtaining the necessary data points more doable.

Lastly, my study lacks external validity, in that my results are not entirely applicable anywhere outside the Bay Area, if not only Berkeley. Few cities or municipalities could boast such a sweeping, progressive ordinance, and even fewer could situate a study during or right after its implementation to measure its effects on the variables of interest. Thus, the results of this study are limited mainly by the history and future of existing laws on SUPs and the level of collective PP understanding. For example, it is improbable to expect in the near future, any other city outside of the Bay Area to implement a law as comprehensive as SUDFLRO.

Legislation is created in a piece-by-piece manner, and there have been plenty of Berkeley-wide laws that have laid the groundwork for SUDFLRO, several of which have been discussed in the Introduction section. On a similar note, because of Berkeley's history of tough stances on environmental affairs, the average level of awareness among residents and firms is presumably skewed upwards. Assuming this has a relevant impact on my data, then I would expect that my findings have an upward bias as well, compared with if this same study were conducted anywhere else.

Broader implications

This is the first study aiming to study the correlation between a restaurant's extent of awareness on plastic pollution and its extent of plastic consumption. All things considered, despite setbacks during data collection, my experimental design adequately addressed my central research question and the knowledge gap in the literature relating to the disparity in research between what firms vs. consumers believe. Although this study focuses on circumstances specific to Berkeley, the lessons learned from my study have worthwhile application towards policy design that can integrate firm-side sustainability education and legislature directed at helping firms transition away from SUPs. It is not unreasonable to conclude that more research on firms' perceptions can result in useful policy, which can eventually produce tangible and potentially groundbreaking waste reduction improvements for both the private sector and consumers. Understanding these pain points of restaurants, and more generally, businesses, can lead to a paradigm shift in how corporate operations and sustainability can synergize.

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of my thesis mentor David Law, who helped me design and revise my questionnaire and improve the rest of my paper. In particular, I received a lot of valuable advice from him on different ways to interpret my results and expand upon future research recommendations in my Discussion section. My peer reviewer Eileen Williams also provided great feedback on drafts of my different sections at every step of the way, and my friend (Class of 2019 Environmental Sciences major!) Roxi Shiu was instrumental in revising each of my sections, along with helping me completely restructure my Introduction section.

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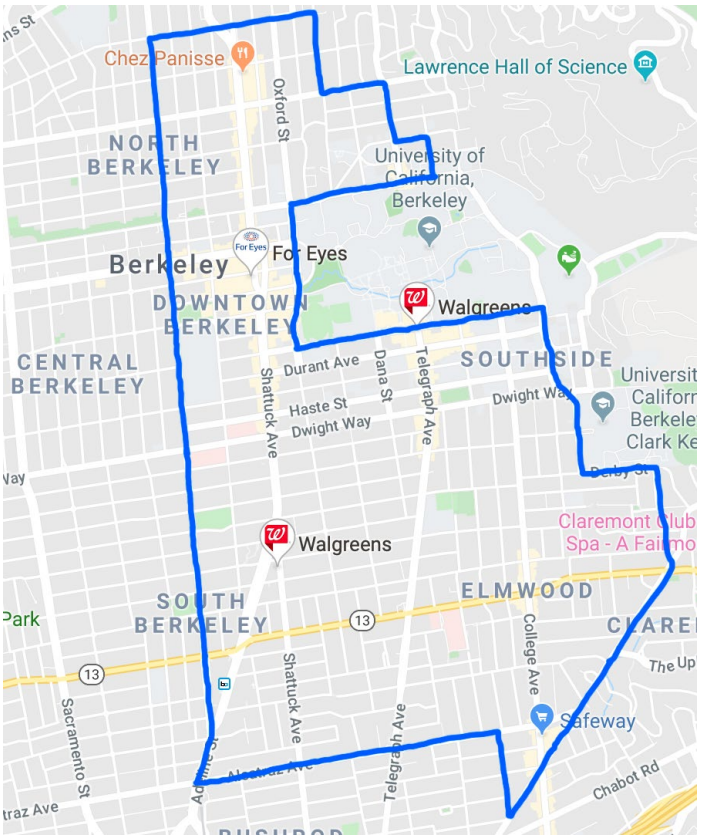
APPENDIX



Appendix A. Map of my intended study site. I selected local Berkeley restaurants adjacent to the UC Berkeley campus to make the study more relevant to the student demographic. My study site includes restaurants from the regions of Southside, Elmwood (North Oakland), Central Berkeley (Berkeley Downtown), North Berkeley, and Northside. I originally planned to sample approximately 8-10 restaurants from each region, equating to a sample size of approximately 40-50 restaurants; however, I managed to finish only the region of Elmwood and a small portion of Southside Berkeley—as a result, my revised sample size is 10.

Appendix B. The three-page questionnaire that I distributed to local Berkeley restaurants.

To whom this may concern,

My name is Ansel Deng and I am a senior at UC Berkeley studying Environmental Sciences. I am currently working on my senior thesis, which focuses on how aware local Berkeley restaurants are of plastic pollution and related environmental issues, and their current plastic usage behaviors.

I understand that some of the answers to the below questions contain private firm data, so the name of your establishment will be kept confidential; only data collected, excluding the name of the establishment, will be used for analysis and publication.

For example, Gypsy's (2519 Durant Ave, Berkeley, CA 94704) would be discussed in my senior thesis as "an Italian restaurant in Southside Berkeley," but the name "Gypsy's" would never appear in order to maintain confidentiality.

If you have any other questions, feel free to contact me at ansel.deng@berkeley.edu or (626) 636-7578. If you would like more time to fill out the survey, please let me know. Again, thank you in advance for helping me out with my senior thesis project!

General Restaurant Information

1) How many customers would you say your restaurant has in a given *week*?

   _____ (Units = count (#))

2) What *percentage* of total transactions at your restaurant are take-out? (A *ratio* of dine-in's : carry-out's would also work.)

   _____ (Units = % or ratio)

Restaurant Plastic Usage

3) What is your restaurant's consumption of all **plastic utensils** in a given *week*? (This includes plastic spoons, forks, sporks, and knives. This does not include compostable plastics.)

   _____ (Units = count (#) or percentage)

4) What is your restaurant's consumption of **plastic to-go containers** in a given *week*? (This includes clamshells - "hinged take-out containers", cylinders - "deli containers and lids", etc.)

   _____ (Units = count (#) or percentage)

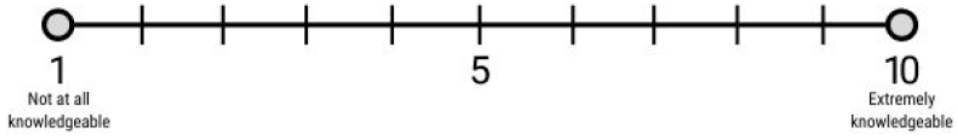
5) What is your restaurant's consumption of **plastic bags** in a given *week*? (This includes both reusable and single-use bags.)

   _____ (Units = count (#) or percentage)

Plastic Pollution Awareness

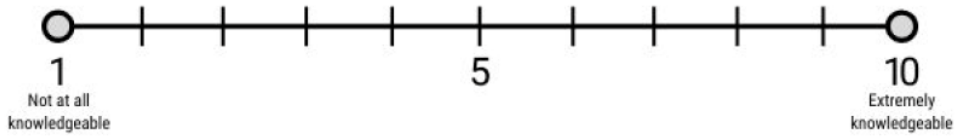
On a scale from 1 to 10, how aware are you on the issue of...

6) Plastic pollution in general terms? (A 1 means you know very little about the issue, and a 10 means you are extremely knowledgeable.)

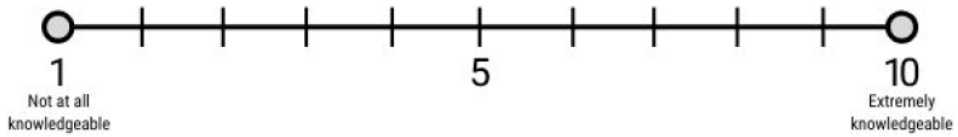


7) Marine plastic pollution and its effect on marine wildlife? (A 1 means you know little to nothing about the issue, and a 10 means you are extremely knowledgeable.)

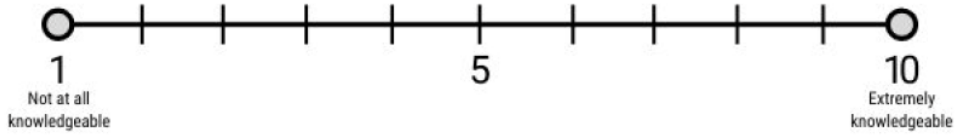
8) Microplastics and their effect on global ecosystems and food chains? (A 1 means you know very little about the issue, and a 10 means you are extremely knowledgeable.)



9) Greenhouse gas emissions resulting from landfill management practices? (A 1 means you know very little about the issue, and a 10 means you are extremely knowledgeable.)



10) Groundwater pollution from landfill leachate and landfill management practices? (A 1 means you know very little about the issue, and a 10 means you are extremely knowledgeable.)



Looking Forward: What Can and Should Be Changed

How much, if anything, do you think a consumer should be charged ***extra*** per...	Cost (in ¢)
Plastic utensil (e.g. plastic spoon, fork, spork, knife)?	
Plastic bag (e.g. reusable bag, single-use bag)?	
Plastic container (e.g. clamshell - "hinged take-out container", cylinder - "deli container and lid")?	

11) What is the largest barrier preventing your restaurant from switching from single-use plastic to biodegradable/reusable material?

_____

_____

12) What are your considerations from transitioning away from single-use plastic to biodegradable material? Check all that apply.

- ☐ Economic Benefits
- ☐ Economic Costs
- ☐ Consumer Demand
- ☐ Retention Rates
- ☐ Social
- ☐ Convenience
- ☐ Indifference
- ☐ Infrastructure
- ☐ Legislation
- ☐ Other: _____

Berkeley's New 2020 Plastic Ordinance

13) "Under the new law, disposable compostable straws, lids, stirrers, cup spill plugs, napkins and utensils for take-out will now be provided only on **request** or at **self-serve stations**. Starting in 2020, there will also be a **25-cent charge for disposable cups** to get customers to bring their own. By 2020, all dine-in foodware will be **reusable**, and all take-out foodware will be **compostable**."

	Yes	Somewhat	No	Unsure
Are you aware of this new law?				
Were you given prior notice for the enactment of this law?				
Do you think that this new law is reasonable?				

14) What steps have you taken or plan to take in order to comply with this new law?

_____

_____