Identifying leakage of incomplete environmental regulation

– Evidence from Japanese plastic bag fee –

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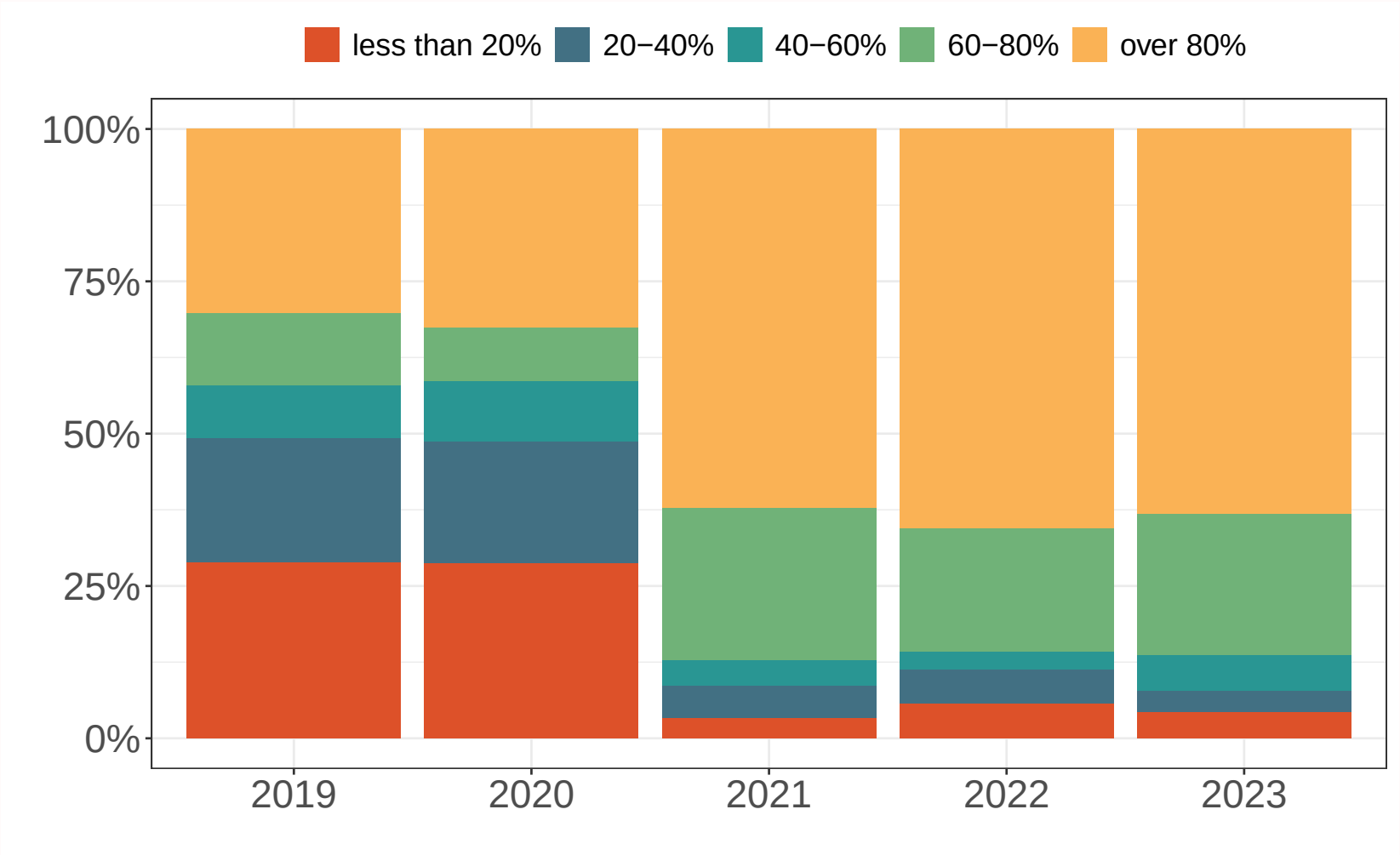
Motivation

- It is very difficult for environmental policy to comprehensively regulate all targeted entities (e.g., small businesses, imported products.)
- Pollution emissions that escape from the coverage of environmental policy are referred to as 'leakage' (see Fowlie (2009)).
- The most discussed example of pollution leakage is the issue in trade between EU countries and non-EU countries under the EU ETS.
  - $\rightarrow$ Soon introducing CBAM:Carbon Border Adjustment Mechanism).
- This study analyzes the leakage issue in the plastic bag charging policy, which was uniformly implemented nationwide on July 1, 2020 in Japan.

The changes of plastic bag refusal rates in Japan

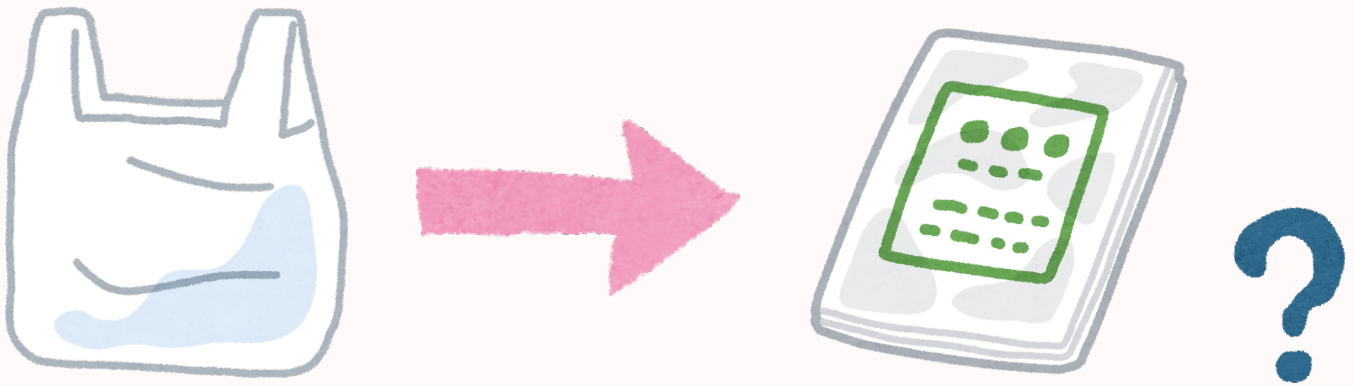


Source: National Supermarket Association of Japan Website

Hypothesis

Leakage into trash bags due to the plastic bag fee policy

Has the plastic bag charge led to an increase in the purchase of paid trash bags by those who previously used plastic bags as liners for trash bins, such as for burnable waste?



Literature Review (1)

- Taylor (2019) used the example of the municipal level ban on plastic bag in California to demonstrate leakage, concluding that there was an increase in trash bag purchases equivalent to about 30% of the plastic bags that were no longer distributed."
- Taylor (2020) analyzed the loss of customers due to increased checkout times, and Taylor (2022) examines leakage, such as the shift in consumption from supermarkets to eat-in spaces as a result of the plastic bag ban.

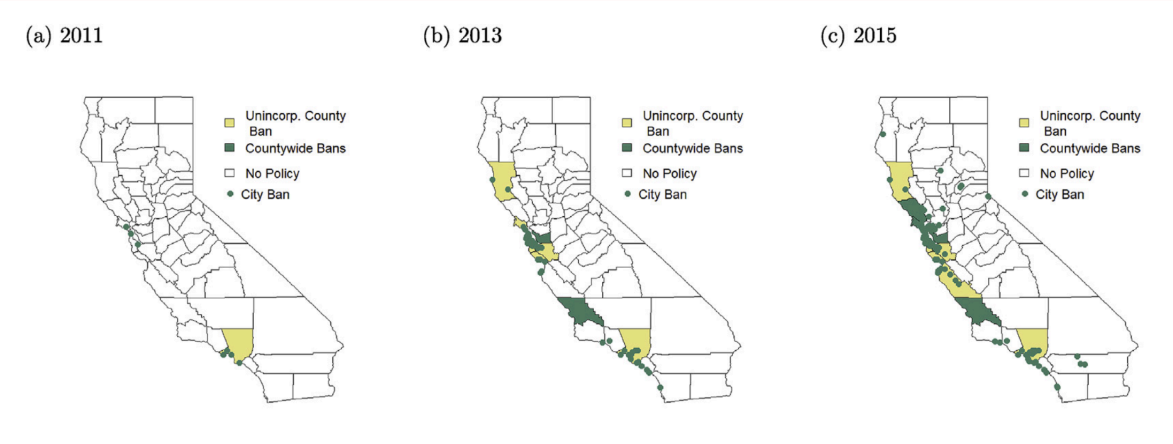


Figure 1: Changes in plastic ban in California (Taylor, 2019)

Literature Review (2)

- The City of Chicago banned the distribution of plastic bags thinner than 57 microns in 2015. As a result, the number of retailers making and distributing thicker plastic bags increased.
  - → The policy was changed to a 7-cent fee in 2017.
  - → Homonoff et al. (2021) analyzed this policy change and found that the fee reduced plastic use.

- Rivers et al (2017) and Homonoff (2018) analyzed, from a behavioral economics perspective, the difference between a 5-cent fee policy and a 5-cent point distribution for plastic bags refusal in Washington, DC and Toronto, respectively.
  - → The results show that pay-as-you-go is more effective than point rebate.

Literature Review (3)

- Bharadwaj et al. (2021) and Wang and Li (2021) evaluate plastic bag charging for Nepal and China, respectively.
- Bharadwaj et al. (2021) showed that, in fact, demand is moving outside of regulation.
- Wang and Li (2021) found that the plastic bag fee reduced the demand for plastic bags, but in some cases increased the consumption of roll-type plastic bags distributed free of charge by supermarkets, which in turn increased the total amount of plastic use.

Literature Review (4)

- Nakatani et al. (2020) analyzed Japan's plastic use by input-output table and conclude that to meet the ambitious reduction goal by the government is difficult to achieve without the effort through the entire supply chain.

- Seo and Kudo (2022) conducted a survey to reveal the factors that induce the behaviral change after the plastic bag fee.

- Nihijima and Nakatani (2024) verified the impact of plastic bag fee. They conclude that the fee decreased the plastic bag about 30% and municipalities introduced designated trash bags tend to refuse the plastic bag and discard fewer.

$\rightarrow$ As far as authros know, there is no previous research analyzing the leakage in Japan directly.

Japan's new policy

- Japan revised the Containers and Packaging Recycling Law to make it mandatory to charge for plastic shopping bags.
- The price and use of the bags were to be determined freely by the retailer, except the following

The cases of fee exemption

1. plastic film with a thickness of 50 micrometers or more (because it can be used repeatedly)
2. those containing 100% marine biodegradable plastic
3. containing more than 25% of biomass materials

Notes

- Our foucs is on the introduction of plastic bag fee from July 1st, 2020.
- It is nationwide regulation but there are several municipalities which have introduced plastic bag fee only within its jurisdiction before the introduction of the nationwide plastic bag fee policy.
- For example, all municipalities in Toyama prefecture are under plastic bag fee regulation since 2008.

Spatial Distribution of treatment

Whole Japan (left) and Kanto Region (right)

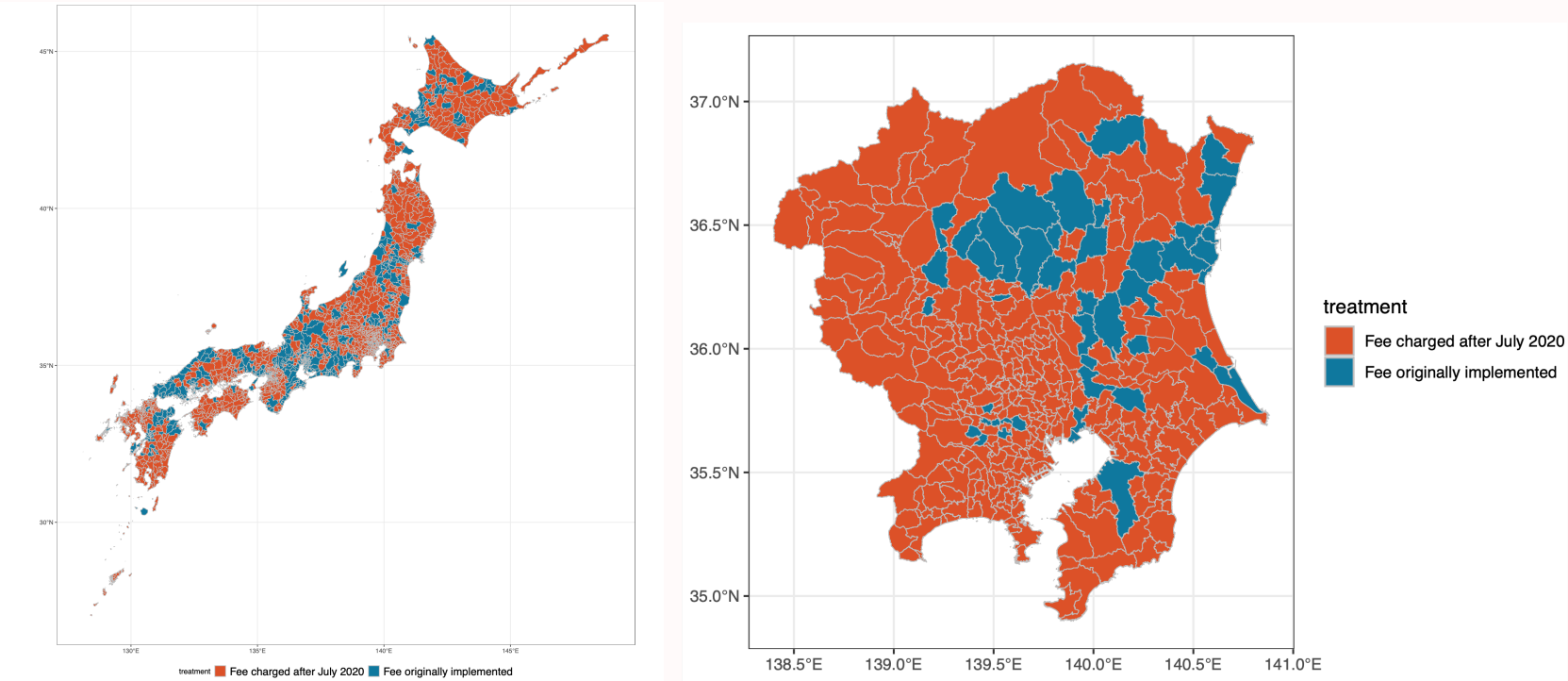
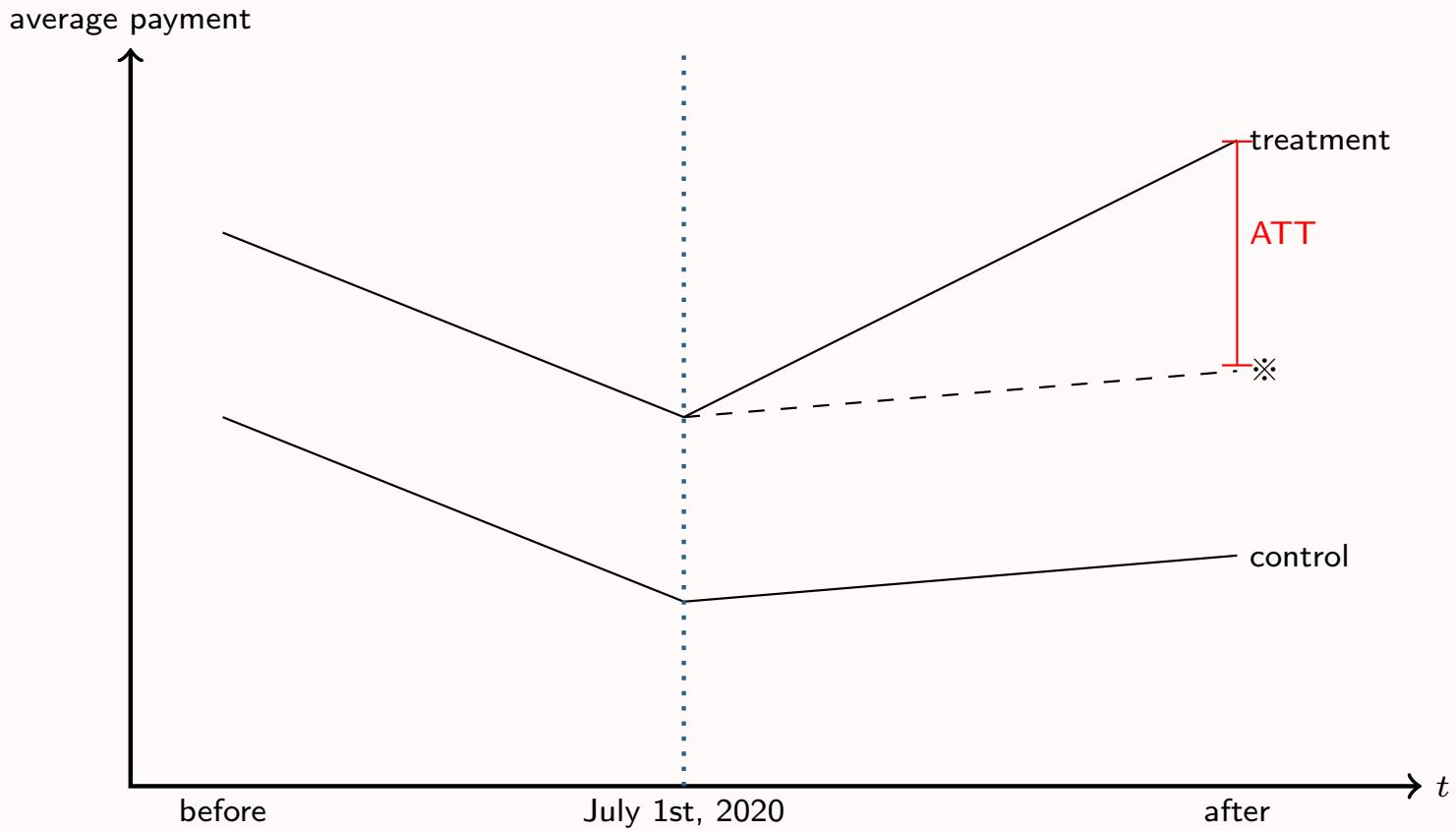


Figure 2: Geographical Distribution of Treatment Group

Method: Difference-in-Differences (DID)

Treatment: Individuals living in municipalities where fees were first introduced in July 2020
Control: Individuals living in the other areas



※ The average outcome that would have been observed if the treatment group had not received the treatment.

The Model

- Our outcome variable is Y_{it} which denotes the expenditure on garbage bag by respondent i in month t.
- We also denote that M_t is a month dummy variable which takes unity if t is after July 1, 2020 (otherwise zero).

$$Y_{it} = treat_{it}\beta + \alpha_i + \mu_t + \epsilon_{it}, \tag{1}$$

- In (1), $treat_{it}(\equiv M_t \times T_i)$ here takes unity if a municipality respondent i lives had not introduced plastic bag fee before AND if t is after July 1st in 2020.
- Note that α_i is individual effect while μ_t denotes time fixed effect.

Data

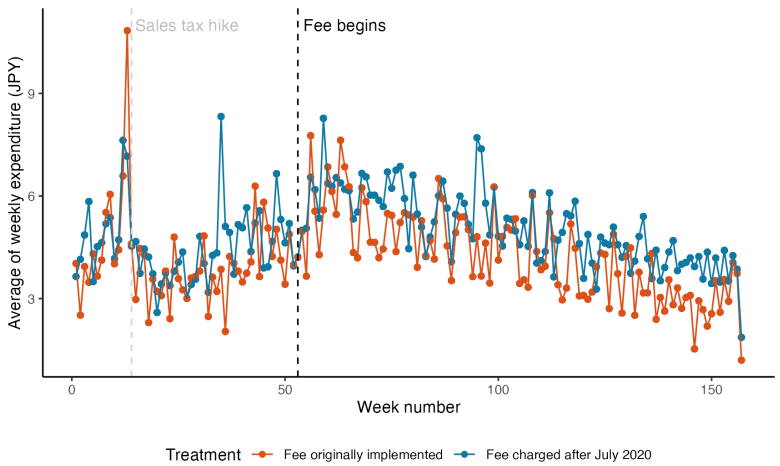
We are using the results of a consumer survey conducted by Macromill, Inc. The data covers the period from July 2019 to June 2021.

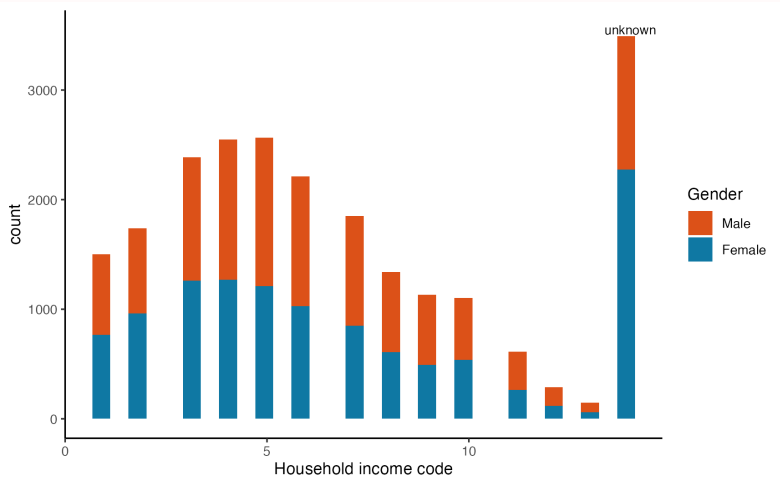
Table 1: Descriptive statistics

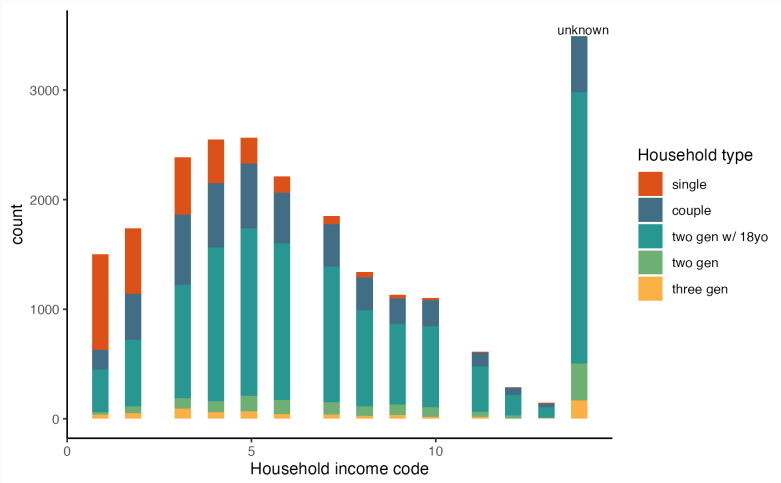
Treatment	Time		N	average	s.d.	min.	max.
1	0	Monthly expenditures (JPY)	51204	19.94	90.12	0.00	3892.00
		Household income code	51204	6.50	3.86	1.00	14.00
		Family code	51204	2.63	0.85	1.00	5.00
	1	Monthly expenditures (JPY)	102408	22.06	95.44	0.00	6444.00
		Household income code	102408	6.50	3.86	1.00	14.00
		Family code	102408	2.63	0.85	1.00	5.00
0	0	Monthly expenditures (JPY)	29880	17.91	87.27	0.00	4174.00
		Household income code	29880	6.37	3.90	1.00	14.00
		Family code	29880	2.62	0.86	1.00	5.00
	1	Monthly expenditures (JPY)	59760	18.60	85.27	0.00	3480.00
		Household income code	59760	6.37	3.90	1.00	14.00
		Family code	59760	2.62	0.86	1.00	5.00

- Treatment dummy takes 1 for individuals in municipalities without fee before July 2020, and 0 otherwise.
- Time dummy takes 0 before July 2020, and 1 otherwise.
- Household income codes starts from 1 for 2 mil. yen or less, increasing in increments of 1 million yen, then 10 represents 10 to 12 mil. yen; 11 for 12 to 15 mil. yen, 12 for over 15 million yen, and 14 for 'unknown'.
- Family code: 1 for single, 2 for couples, 3 for two families, 4 for three families, 5 for others

Data visualization







Source: Authors' own calculation

Subsample patterns

1. Household income level
   - 13 categories starting from 2 million Japanese Yen / year, plus unknown.
2. Family types
   - Single, Couple, Two generation with children under 18 years old, Two generation with children over 18 years old, Three generation, others.
3. Trash bag sizes
   - Under 3L, 3-10L, 10-15L, 15-30L, 30-45L, and Over 45L.

Results (1)

- The results with all individuals and all types of trash bags together did not show significance.

	base	single	couple	family child under 18	family child over 18	low income	high income
treat_d	1.428	−0.094	2.063	1.951	2.437	1.673	0.755
	(1.059)	(1.762)	(2.257)	(1.744)	(1.827)	(3.017)	(3.584)
Num.Obs.	243 252	27 360	61 956	69 876	64 980	15 372	23 148
R2	0.111	0.084	0.094	0.094	0.145	0.120	0.099
R2 Adj.	0.085	0.056	0.068	0.067	0.120	0.093	0.072
R2 Within	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R2 Within Adj.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	85.76	67.91	84.49	86.08	95.28	77.71	105.85
FE: monitor_ID	X	X	X	X	X	X	X
FE: month_number	X	X	X	X	X	X	X

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Cluster robust standard errors by monitor and by month

Results (2): subsample analysis

- Focusing only on those who have purchased trash bags after the fee introduction, a couple of household types show statistically significant positive effects.

	base	single	couple	family child under 18	family child over 18	low income	high income
treat_d	2.112**	0.990	1.012	3.414*	3.489*	1.104	4.716+
	(0.671)	(1.271)	(1.301)	(1.378)	(1.641)	(1.999)	(2.496)
Num.Obs.	119 412	15 192	30 528	31 608	32 328	7524	11 304
R2	0.061	0.058	0.058	0.056	0.070	0.060	0.058
R2 Adj.	0.034	0.029	0.030	0.028	0.042	0.029	0.028
R2 Within	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R2 Within Adj.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	62.90	53.14	61.69	69.08	62.18	53.93	71.87
FE: monitor_ID	X	X	X	X	X	X	X
FE: month_number	X	X	X	X	X	X	X

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Cluster robust standard errors by monitor and by month

Take-home message

- The leakage into trash bags due to the introduction of plastic bag fee has been observed worldwide, but no such evidence was found in Japan.
  - → In the full sample, significance at the 10% level was only found for "two-person households with 10-15L bag sizes" and "low-income households with bags of 3L or less".

- Unlike in the United States where plastic bag distribution is completely banned, those who want to use plastic bags as cheap liner in the trash bins continue to buy a plastic bag at the checkout?

- Compared to prior studies, Japan's plastic bag fee policy contributes to the reduction of plastic use much more than other countries.

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Thank you for your attention

See you soon in Yokohama!