Self-restraint behavior under COVID-19 through stigma: Theory and evidence based on mobility data

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Self-restraint behavior under COVID-19 through stigma: Theory and evidence based on mobility data*

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Abstract

This study conducts both theoretical and empirical analyses of how the non-legally-binding policies originating from COVID-19 affect people's going-out behavior. The theoretical analysis assumes that under a declared state of emergency, the individual going out suffers psychological costs arising from both the risk of infection and the stigma of going out. Thus, a hypothesis is derived that under a declared state of emergency, going out entails a strong psychological cost, and thus people refrain from going out. In the empirical analysis, this study estimates the model using a set of panel data from regional mobility data and from emergency declarations at the prefectural level to analyze self-restraint behavior under a non-legally binding emergency declaration. The results reveal that, compared with the pre-declaration of the state of emergency, going-out behavior under and after lifting of the state of emergency was suppressed even when the going-out behavior did not result in penalties, which is consistent with the theoretical analysis.

Keywords: COVID-19, Stigma, Self-restraint behavior, Non-legally binding policy, Regional mobility

JEL codes: D91, I12, I18

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1 Introduction

As of July 10, 2020, the coronavirus disease of 2019 (COVID-19) has become a global pandemic that has infected 12,102,328 people worldwide (WHO, 2020). To reduce the spread of this disease and the resultant number of deaths, countries around the world have adopted a variety of policies. In particular, as a strong measure to reduce infection, policies have been implemented to restrict people's activities, especially their ability to go out so as to decrease their chances of contact. Other policies have also been applied globally to protect people, such as social distancing, stay home, school closure, and protection measures at ports and airports. Yoo and Managi (2020) argue that such policies against COVID-19 will save lives and consequently minimize economic losses. Furthermore, Nakamura and Managi (2020) show that reducing air travel decreases the risk of the import and export. Policies that restrict behavior with the aim to prevent the spread of infectious diseases can be categorized into two types: enforceable behavioral restrictions that consider penalties using the legal system, and behavioral restrictions that do not use the legal system and are left to people's sense of self-restraint (unenforceable).

An example of the former is the behavioral limitation imposed by the policies of some European countries where the COVID-19 infection had spread rapidly. France imposes fines of between 135 and 3,700 euros if going out for purposes other than those authorized by the government, such as the purchase of daily necessities, under the Health Emergency Bill approved by lawmakers on March 22, 2020. In Italy, which has the world's fourth highest number of COVID-19-related deaths at 34,938 (as of July 10, 2020), a decree ordered a nationwide curfew on March 10, 2020, with fines of up to 3,000 euros for those who do not carry a "certificate" stating where they are going and why. Moreover, as of July 10, 2020, the United States has the highest number of cases in the world. New York State, with the highest number of cases in the country, issued a governor's decree on March 22, 2020, requiring 100% telecommuting. The decree imposes fines of up to 10,000 dollars if a company fails to comply and causes serious physical harm to its employees.

In contrast with these strict measures against the spread of infectious diseases that prohibit citizens from going out and impose severe private rights restrictions by the state with penalties for violations, some countries have a vague legal basis for restricting behavior. This refers to the second type of policy described above—a policy of curtailment based on people's decision-making, without enforcement. Sweden, which aims to get a certain number of people infected and immunized without strict restrictive measures, recommends working from home and only advocates avoiding unnecessary travel and social contact with high-risk older people. Japan, which has the lowest number of cases per million people among the 36 industrialized countries in the OECD, has a non-coercive, unenforceable policy with a vague legal basis, such as declaring a state of emergency and requesting that people refrain from leaving home unnecessarily to control the spread of COVID-19.

Thus, in Japan, the number of going-out actually decreased after the declaration of the state of emergency (The Japan Times, 2020a; Kyodo News, 2020). As a result, the number of infected people is considered to have been more successfully controlled compared with other OECD countries (Lu et al., 2020; Iwasaki and Grubaugh, 2020). However, although these reports of reduced going-out compare the going-out before and after the emergency declaration, they only focus on the situation in densely populated central metropolitan areas and do not control for public awareness of the increase in the number of people infected and the behavior reflected by it. Therefore, it is not possible to conclude from these reports whether the declaration of emergency actually reduced the number of going-out across the country, that is, the entire area within which the request for self-restraint was made.

In fact, the effect of these requests for self-restraint on the consciousness of the Japanese people can be seen in one phenomenon, the "self-restraint police" (*Jishuku Keisatsu* in Japanese). The self-restraint police are said to be members of the general public who conduct private policing of individuals and groups who do not comply with requests to refrain from going out or other activities under the emergency declaration. There have been incidents involving these self-restraint police, such as harassing phone calls, posts about restaurants that were operating under the declared state of emergency (The Japan Times, 2020c), slander of travelers because of their history of having COVID-19 (The Japan Times, 2020b), and damage to cars of travelers at tourist sites when their license plate number indicated that it was from another prefecture (The Japan Times, 2020b).

This phenomenon likely occurred because people have an aversion to those who do not refrain from going out, even in the case of non-legally binding declarations of a state of emergency. Thus, we suggest that even under unenforceable policies, people may refrain from going-out with the goal of avoiding the social stigma of going-out. Accordingly, this study focuses on people's restrictions from going out under such a decree that has an ambiguous legal basis, from both the theoretical and empirical perspectives.

Specifically for the theoretical analysis, we introduce a theoretical model that analyzes self-restraint behavior in the context of spreading infectious diseases from the perspective of stigma. First, statements such as the Japanese government's state of emergency are not legally binding. Thus, there are no fines or penalties for individuals who go out. Nevertheless, most Japanese citizens refrained from going outside under the state of emergency. A plausible reason why the declaration was valid is that most people were afraid of the risk of infection at that time. For example, Aum et al. (2020) assume that people accept the disutility of going out due to the risk of infection and conclude that people will stay home if they are at high risk of infection. If this is the only reason, then the effect of restraint should be consistent when the risk of infection is constant under the state of emergency and after it is lifted. Could this be true? What other important factors must be considered that affect people's self-restraint behavior? To address these questions, we analyze people's self-restraint behavior by introducing stigma into our theoretical model, as well as the risk of infection, in the following analysis.

The research on stigma has developed around social psychology Major et al. (2018), starting with discussion the by Goffman (1963). There are several studies on stigma in economics as well; Moffitt (1983); Besley and Coate (1992); Bhargava and Manoli (2015) study the stigma of accepting welfare benefits (Lindbeck et al., 1999; Kurita et al., 2020; Itaya and Kurita, 2020). Moreover, Kim (2003) analyzes the stigma related to tax evasion, and Rasmusen (1996) investigates the stigma for ex-convicts.

This study considers that stigma is important in analyzing the going-out behavior during the spread of infectious diseases since stigma can have a complementary role to infection risk in people's self-restraint behavior. In Japan, under the state of emergency, it was a social norm to refrain from going out. Public opinion was formed such that going out under the state of emergency was considered to be anti-social behavior. In other words, people who go out under the state of emergency are stigmatized as having inferior ethics in the society because they do not follow the social norms.

The theoretical analysis in this study supposes that the individual going out suffers psychological costs arising from both the stigma of going out and the risk of infection under the declared state of emergency. Specifically, we assume that infection risk and stigma have a complementary effect on the psychological cost to the player. As a result, the hypothesis is derived that under a declared state of emergency, people refrain more from going out as it entails a strong psychological cost.

For the empirical perspectives, several studies analyze the impact of Japan's non-legally enforceable emergency declarations on the population. For example, Kobayashi et al. (2020) use a statistical model based on a state-space model that combines the susceptible-infected-recovered models to predict the evolution of infectious diseases as well as includes the magnitude and timing of the peak of the epidemic, following interventions by the emergency declaration in Japan. They confirm that the issuance and extension of the state of emergency declaration has been successful in controlling the COVID-19 epidemic to some extent. Yamamoto et al. (2020), based on an online survey of prefectures where the spread of COVID-19 infection was significant, show that actions of self-restraint based on the declaration of a state of emergency cause psychological distress. Kawaguchi et al. (2020) use data obtained through an Internet survey with Japanese small and medium-sized enterprises to find that, in the short term, the state of emergency reduces both feasible and expected sales of firms. Qian and Yahara (2020) conduct a survey under the state of emergency and find that accuracy, morality, and ideology are changing people's behavior and mental health in response to COVID-19. Finally, Yamamura and Tsutsui (2020) construct panel data by conducting an Internet survey with the same respondents twice, before and after the emergency declaration, to analyze individual-level changes in preventive behavior and mental status due to the emergency declaration.

In contrast with studies analyzing the impact of non-legally-binding policies such as those described above, others analyze the impact of an enforceable lockdown on the economy (Acemoglu et al., 2020; Alvarez et al., 2020; Farboodi et al., 2020; Holtemöller, 2020; Eichenbaum et al., 2020; Gharehgozli et al., 2020; Mandel and Veetil, 2020; Martin et al., 2020). Martin et al. (2020) develop a microeconomic model to assess the socioeconomic impact of COVID-19 on individuals, estimating the direct impact of lockdown policy triggered by COVID-19 on household income, consumption, and poverty. Acemoglu et al. (2020) build a heterogeneous susceptible-exposed-infected-recovered model and conclude that a lockdown policy that focuses on at-risk older groups is optimal. Alvarez et al. (2020) discuss the optimal lockdown policy to minimize the deaths and economic costs attributable to COVID-19, using the formulation as an optimization problem. Mandel and Veetil (2020) estimate the costs of a lockdown in some sectors of the global economy due to COVID-19 using a multi-sector disequilibrium model that considers the buyer–seller relationship between agents in different countries. However, none of these studies consider stigma. In addition, lockdowns, unlike emergency declarations, have a legal basis with penalties. In other words, they do not consider the effects of looser emergency declarations that are not legally binding.

Based on the above research, this study contributes in the following ways: First, it develops a microeconomic theoretical model of people's going-out behavior in legally non-binding emergency declarations while considering the social stigma against going out. Second, we estimate a macro-panel data model that combines daily data on various outside behaviors covering all prefectures in Japan that are collected pre declaration, under declaration, and post declaration, as well as covariates to control for various confounding factors. We thus measure the effect of emergency declarations on the behavior of people outside the prefecture while considering factors that contribute to their behavior and the heterogeneity of emergency declarations in different prefectures with different dates of issuance. In addition, we compared the behavior of people who went out after the emergency declaration was lifted with that before the declaration.

The advantage of this study's contribution over existing studies on non-legally binding emergency declarations is as follows: First, there is little analysis in the literature on going-out actions associated with the issuance of emergency declarations based on ambiguous legal systems. Second, we build a theoretical model to explain going-out behavior under non-legally binding emergency declarations based on social stigma. Although Yamamura and Tsutsui (2020) analyze people's going-out behavior under a state of emergency in Japan, because their data set is based on a questionnaire survey, there is a possibility of measurement error due to personal memory differences and other factors. Moreover, because their study used a sample composed of two time points—before and after the declaration of an emergency—they did not consider changes in going-out activity after lifting of the state of emergency. In contrast, this study conducts an empirical analysis considering the three time points of pre-declaration, under-declaration, and post-declaration using data obtained from Google COVID-19 Community Mobility Reports, which provide more objective data compared with questionnaire survey data.

In the following, we briefly describe the results of this study. The theoretical analysis showed that the incentive to go out is reduced under the state of emergency compared with that after it is lifted through the stigmatization of going-out behavior. In other words, the number of people who go out under the state of emergency is lower than that after the emergency is lifted. Second, in the empirical analysis, we examined the going-out behavior under a declared state of emergency using daily mobility data for 47 prefectures in Japan.

After controlling for confounding factors that may vary by prefecture and time, we find that going-out behavior decreased under- and post-declaration of the state of emergency. Furthermore, this study finds that going-out behavior decreased the most during the under-declaration period.

The remainder of this paper is organized as follows: In Section 2, we present a theoretical analysis. Section 3 discusses the data, econometric methods, and analytical results. Finally, this study concludes in Section 4.

2 Theoretical Model

Let us start by explaining the model. Consider an economy in which the mass of the population is normalized to 1. The player chooses to go out or not. The player's gain is set as follows:

$$\begin{cases} u_{\text{out}} - \phi\left[\gamma c + \iota \sigma s\right]^{\delta} & \text{if going out,} \\ u_{\text{home}} & \text{if staying at home,} \end{cases} \tag{1}$$

where u_{out} is the utility from going out and u_{home} is the utility from staying at home. We assume that the utility from going out is higher than that from staying at home, that is, $u_{\text{out}} > u_{\text{home}}$.

$\phi\left[\gamma c + \iota \phi s\right]^{\delta}$ is the term of the psychological cost. This cost contains two components of the risk of infection of the virus (γc) and the stigma ($\iota \phi s$). This formulation indicates that the stigma and risk of infection are complementary in the psychological cost. Here, $\phi \in [0, \bar{\phi}]$ is the sensitivity to the psychological cost, $\gamma \in [0, 1]$ is the subjective probability of an individual being infected after going out, c is the cost of infection, s is the stigma cost, $\sigma \in (0, +\infty)$ is the parameter that indicates the size of the stigma cost relative to the cost of infection, $\delta \in (0, +\infty)$ is the parameter of cost to scale, and $\iota \in \{0, 1\}$ is the indicator variable that equals one if a state of emergency is declared and zero otherwise.

We assume that ϕ has distribution $\phi \sim F(\cdot)$, where $F'(\cdot) := f(\cdot)$ and $f(\phi) > 0$ for $\phi \in [0, \bar{\phi}]$. Then, we consider the critical level of the sensitivity to stigma cost as follows:

$$u_{\text{out}} - \hat{\phi}\left[\gamma c + \iota \sigma s\right]^{\delta} = u_{\text{home}}. \tag{2}$$

From Equation (2), individuals with sensitivities below (above) this threshold have an incentive to go out (stay home). Solving for $\hat{\phi}$, we obtain the following:

$$\hat{\phi} = \frac{\Delta}{\left[\gamma c + \iota \sigma s\right]^{\delta}}, \tag{3}$$

where $\Delta := u_{\text{out}} - u_{\text{home}} > 0$.

The proportion of individuals who go out, x, is as follows:

$$x = \Pr(\phi \leq \hat{\phi}) = F(\hat{\phi}). \tag{4}$$

We suppose that the stigma cost function is based on conformism as in Lindbeck et al. (1999, 2003). We assume that the stigma cost decreases with the proportion of individuals who go out, that is, $s = s(x)$, $s'(x) < 0$, and $s \in (0, +\infty)$.

We also assume that the difference of utility is higher than the expected cost of infection, that is, $\Delta > \gamma c$. When $\iota = 0$, all individuals choose going out since $u_{\text{out}} > u_{\text{home}}$. On the other hand, the case of $\iota = 1$ is analyzed as follows:

$$\begin{cases} \hat{\phi} &= \dfrac{\Delta}{\left[\gamma c + \iota \sigma s\right]^{\delta}}, \\ x &= F\left(\hat{\phi}\right), \\ s &= s(x), \end{cases} \tag{5}$$

$$x = F\left(\frac{\Delta}{\left[\gamma c + \iota \sigma s(x)\right]^{\delta}}\right) := \chi(x). \tag{6}$$

The fixed point of the mapping from x to x in Equation (6), x^*, is the equilibrium of this model[1]. Clearly, there is at least one equilibrium from the intermediate value theorem.

We present the following proposition:

Proposition 1 *There can exist multiple equilibria under a state of emergency. On the other hand, there exist the unique equilibrium when a state of emergency is lifted as follows:*

$$x^*_{\text{post}} = F\left(\frac{\Delta}{\left[\gamma c\right]^{\delta}}\right) \tag{7}$$

Proof. The slope of the mapping (6) is given as follows:

$$\frac{\partial \chi}{\partial x} = f\left(\frac{\Delta}{\left[\gamma c + \iota \sigma s(x)\right]^{\delta}}\right)\left[\frac{\Delta \delta \left[\gamma c + \iota \sigma s(x)\right]^{\delta - 1}}{\left[\gamma c + \iota \sigma s(x)\right]^{2\delta}}\right]\left[-\iota \sigma s'(x)\right]. \tag{8}$$

There is the possibility of multiple equilibria under a state of emergency since the sign of Equation (8) is positive.

On the other hand, the sign of Equation (8) is zero when a state of emergency is lifted. To confirm the equilibrium when a state of emergency is lifted, by substituting $\iota = 0$ into Equation (6), we get the following result:

$$\chi(x)|_{\iota = 0} = F\left(\frac{\Delta}{\left(\gamma c\right)^{\delta}}\right) \tag{9}$$

Clearly, Equation of (9) is fixed with respect to x. Therefore, the equilibrium when a state

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[1] The stability condition for equilibrium is $\partial \chi / \partial x < 1$.

of emergency is lifted (x^*_{post}) is unique as follows:

$$x^*_{\text{post}} = F\left(\frac{\Delta}{(\gamma c)^{\delta}}\right) \tag{10}$$

■

Proposition 1 suggests the possibility of multiple equilibria displayed in Figure 1 as an example. This figure shows a mapping from x to x, defined as $\chi(x)$: $\chi(x)|_{\iota=1}$ or $\chi(x)|_{\iota=0}$, where $\chi(x)|_{\iota=1}$ is the mapping under a state of emergency and $\chi(x)|_{\iota=0}$ is the mapping after a state of emergency. There exist an equilibrium with few going-out people ($x^*_{\text{under;L}}$) and equilibrium with many going-out people ($x^*_{\text{under;H}}$) as multiple equilibria under a state of emergency in Figure 1. We call $x^*_{\text{under;L}}$ "strictly self-restraint equilibrium" and $x^*_{\text{under;H}}$ "non-strictly self-restraint equilibrium," respectively. On the other hand, after the state of emergency is lifted, there exist and realize the unique equilibrium x^*_{post}. It is due to the existence of a certain complementarity that arises from the presence of externalities between people's behavior under the state of emergency. The Japanese case can be considered that under the emergency declaration, an equilibrium with fewer people out and about is achieved, i.e., strictly self-restraint equilibrium $x^*_{\text{under;L}}$, and after the emergency declaration, social norms are no longer in effect, i.e., x^*_{post}.

The following proposition presents the results for the difference in the number of citizens between the under the declaration of the state of emergency and its lifting.

Proposition 2 *The number of players going out under the state of emergency* (x_{under}) *is less than those going out after the state of emergency was lifted* (x_{post})*, ceteris paribus.*

Proof. Under the state of emergency ($\iota = 1$), by substituting $\iota = 1$ into (6), we get the following:

$$\chi\left(x\right)|_{\iota=1} = F\left(\frac{\Delta}{\left[\gamma c + \sigma s(x)\right]^{\delta}}\right). \tag{11}$$

We denote a fixed point for mapping (11) as x_{under}.

After the state of emergency is lifted, by substituting $\iota = 0$ into (6), we get the following:

$$\chi\left(x\right)|_{\iota=0} = F\left(\frac{\Delta}{\left(\gamma c\right)^{\delta}}\right). \tag{12}$$

We denote a fixed point for mapping (12) as x_{post}.

The difference between Equations (11) and (12) is given as follows:

$$\chi\left(x\right)|_{\iota=1} - \chi\left(x\right)|_{\iota=0} < 0. \tag{13}$$

Therefore, we get the following result:

$$x^{*}_{\text{under}} - x^{*}_{\text{post}} < 0 \tag{14}$$

for any $x \in [0, 1]$. ■

Proposition 2 shows that even in the condition with a fixed subjective probability of infection, the number of people going out under a request for self-restraint based on the declaration of a state of emergency is lower than those going out after the state of emergency is lifted. This implies that a non-legally binding policy—the state of emergency—can influence going-out behavior through stigma regardless of the fear of infection. Figure 1 underpins the mapping under the state of emergency $\chi(x)|_{\iota=1}$ is never above the mapping $\chi(x)|_{\iota=0}$. That is, we confirm the relationship, $x^{*}_{\text{post}} > x^{*}_{\text{under;H}} > x^{*}_{\text{under;L}}$.

The following proposition presents this interesting result.

Proposition 3 *Under the state of emergency, that is, $\iota = 1$, some players self-restrain from going out, even if all players expect the probability of infection to be zero, that is, $\gamma = 0$.*

Proof. By substituting $\iota = 1$ and $\gamma = 0$ into Equation (6), we get the following:

$$\chi(x)\,|_{\iota=1,\gamma=0} = F\left(\frac{\Delta}{[\sigma s(x)]^{\delta}}\right). \tag{15}$$

The sign of Equation (15) is positive since $\Delta > 0$, $\sigma > 0$, and $s(x) > 0$ for any $x \in [0, 1]$. Therefore, the fixed point for mapping (15) is positive, that is, $x^{*}_{\text{under}} > 0$. ■

Proposition 3 suggests that some individuals refrain from going out even if all of them thought the probability of infection was zero under the emergency declaration. This suggests that even in the absence of fear of infection, non-legally binding emergency declarations can influence behavior through stigma.

This section describes the theoretical analysis of individual behavior in situations where there is an infection risk and psychological cost due to stigma. We show that requests for self-restraint against going out based on non-legally binding emergency declarations are in effect in an equilibrium. Notably, Proposition 3 suggests that non-legally binding emergency declarations also affect the behavior of players with through stigma even in the condition with a fixed subjective probability of infection. In the following empirical analysis, we examine the results of Proposition 2[2].

3 Empirical Analysis

This section analyzes how Japan's unenforceable emergency declarations triggered by COVID-19 affected people's going-out behavior using daily prefectural population flow data from the Google COVID-19 Community Mobility Reports as well as several covariates. In addition,

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[2] Proposition 3 analyzes going-out behavior under the subjective infection probability of zero. However, since it is difficult to verify a situation wherein the subjective infection probability is zero in the real world, only Proposition 2 is tested in the empirical analysis.

we analyze how the behavior of people who went out after the state of emergency was lifted changed compared with that before it was issued, that is, whether the effects of the declaration continued after the emergency was lifted.

3.1 Methodology

In this study, we analyze the effects of emergency declarations on people's going-out behavior using a panel data model. Specifically, the following one-way error component model (Baltagi, 1984) is used:

$$
\begin{aligned}
y_{it} &= \mathbf{x}_{it}'\boldsymbol{\beta} + e_{it}, \\
e_{it} &= \alpha_i + \nu_{it},
\end{aligned} \tag{16}
$$

where y is the dependent variable on human flow, $i = 1, \dots, n$ is the index for the ith prefecture, $t = 1, \dots, T$ is the date, $\mathbf{x}$ is an explanatory variable vector containing covariates, $\boldsymbol{\beta}$ is an unknown parameter vector, and e is the disturbance term. Furthermore, as in Equation 16, the disturbance term can be decomposed into stochastic variability ν and prefecture-level heterogeneity α. Furthermore, focusing on the explanatory variable vector, it is decomposed as follows:

$$
\mathbf{x}_{it} := \left[\mathbf{d}_{it}', \mathbf{w}_{it}'\right]', \tag{17}
$$

where $\mathbf{d}_{it}$ is a vector of target variables consisting of two dummy variables, one for the date under the declaration and one for the date after the declaration, and $\mathbf{w}_{it}$ is a covariate vector.

The model in Equation (16) can be estimated using a one-way fixed-effect estimator (hereinafter, one-way FE) and the one-way random-effect estimator (hereinafter, one-way RE). The one-way FE presumes the binary dummy variable for α_i, whereas the one-way RE assumes that the individual effect is randomly determined. In this study, we estimate both and examine the estimates adopted as a result of the Hausman test.

3.2 Data

This study measures the impact of unenforceable emergency declarations on people's going-out behavior in Japan. For this purpose, we constructed a daily panel dataset at the prefecture level. In this section, we describe the contents of the data in detail.

First, we discuss the dependent variable y_{it} described in Section 3.1, namely, going-out behavior, which is the subject of the effects of policy interventions. This study uses the Google COVID-19 Community Mobility Reports[3] to evaluate the impact of the data on people's going-out behavior across Japan. Google collected these data to provide one piece of evidence on how public health authorities respond to COVID-19. These data are anonymized and aggregated with an emphasis on protecting people's privacy by using only location information from applications such as Google Maps[4]; in other words, the data are summarized by region. In Japan, about 90% of the people have used map applications at least once, and the number of Google Maps users is about 80% based on a survey[5]. Therefore, anonymized aggregate data obtained from users' Google Maps location data are considered reliable in terms of representing human flows in all prefectures of Japan. In addition, these data are divided into six categories according to the content of the going-out behavior: "Retail & recreation," "Grocery & pharmacy," "Parks," "Transit stations," "Workplaces," and "Residential." In this study, four of these six categories, "Retail & recreation" (`retail`), "Grocery & pharmacy" (`grocery`), "Parks" (`park`), and "Workplaces" (`workplace`), are used as dependent variables in terms of measuring the effect of emergency declarations based on the purpose of going out. According to the Google COVID-19 Community Mobility Reports, `retail` refers to going-out behavior consisting of entertainment and leisure-time purchases at restaurants, cafes, shopping centers, theme parks, museums, libraries, cinemas, and so forth. `grocery` refers to going-out behavior for activities related to purchasing daily necessities, such as visiting grocery stores, food wholesalers, fruit and vegetable markets, luxury grocery stores, drug

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[3] `https://www.google.com/covid19/mobility/`, accessed on July 10, 2020

[4] `https://www.google.co.jp/maps/`, accessed on July 10, 2020

[5] `https://www.value-press.com/pressrelease/215276`, in Japanese, accessed on July 10, 2020

stores, pharmacies, and so forth. `park` refers to an going-out to a park, such as a regional park, national park, public beach, marina, dog park, square, garden, and so forth. Finally, `workplace` refers to going-out behavior related to traveling to the workplace. In addition, it is important to note that these movement data are presented as percentage changes from the baseline value for each of the seven days of the week. These baseline values are defined by the median value for each of the seven days of the week during the five-week period from January 3 to February 6, 2020.

Second, we discuss variables that make up the target explanatory variable, $\mathbf{d}_{it}$. This vector comprises variables that measure the status of the emergency declaration. Therefore, we use the following variables as target variables in this study: the first is `under` that takes 1 on dates under the state of emergency and 0 otherwise, and the second is `post` that takes 1 on dates after the state of emergency lifted and 0 otherwise. The dates on which the state of emergency was declared and was lifted differ from prefecture to prefecture. In this study, we use date range data on the emergency declaration in Japan (Katafuchi, 2020) based on reports published by the Office for Novel Coronavirus Disease Control, Cabinet Secretariat, Government of Japan.

Third, we describe a covariate vector $\mathbf{w}_{it}$. As mentioned earlier, the dependent variable in this dataset is represented by the disparity from the seven reference values on each day of the week. Therefore, it is possible that there are seasonal differences between the five weeks within which those reference values are defined and the sample. In this study, two weather variables, daily precipitation (`precipitation`) and daily sunshine hours (`sunlight`), obtained from the Japan Meteorological Agency[6], are used to control for its seasonality. The positional attributes of these data are defined by a more detailed classification than at the prefecture level. Therefore, in this study, we treat meteorological data from the prefectural capitals as prefecture-level meteorological data to ensure representativeness. Furthermore, we consider that the impact of the spread of COVID-19, that is, the subjective probability of

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[6] `https://www.data.jma.go.jp/obd/stats/etrn/index.php`, in Japanese, accessed on July 10, 2020

contracting the disease, on people's going-out behavior is present, as also incorporated in the theoretical model in Section 2. Therefore, it is necessary to control the situation of infection at the prefecture level. This study thus incorporates a one-period lag of the increase in the number of infected people per million (`inc_positive_perm`) into the covariate vector. These data are calculated using the data from TOYO KEIZAI ONLINE (2020). However, since the data period begins from March 11, 2020, the data before that date were compiled based on press releases by the Ministry of Health, Labor and Welfare, Japan [7].

Finally, we discuss how to determine the sample period for this dataset. Table 1 shows when the state of emergency was declared (`emergency_start`) and lifted (`emergency_end`) for each prefecture, as well as the period during which the state of emergency was declared (`emergency_length`). The length of time under the emergency declaration varied from prefecture to prefecture—the shortest period was 28 days in about 80% of the prefectures. In this study, we use the mode value of the period under the emergency declaration to determine the length of the sample period under the state of emergency and after its lifting. Accordingly, this length is determined from the issuance to the cancellation of the state of emergency in large urban areas, such as Tokyo, Kanagawa, and Osaka, as these areas had longer emergency periods than most other regions. Therefore, we define the sample period from April 7 to 28 days prior to the declaration of the state of emergency in these metropolitan areas—that is, March 10, 2020, is the starting point of the entire sample period. On the other hand, this study defines the sample period from May 25 to 28 days after the lifting of the state of emergency for these metropolitan areas as the post-declaration sample period, with June 22, 2020 as the endpoint of the overall sample period. The sample is therefore composed of 47 prefectures, that is, $n = 47$; the sample period is from March 10 to June 22, 2020, that is, $T = 105$; and the sample size is $N = nT = 47 \times 105 = 4,935$.

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[7] `https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000121431_00086.html`, in Japanese, accessed on July 10, 2020

3.3 Result

First, we briefly look at the disparity between the going-out behavior in the pre-declaration, under-declaration, and post-declaration periods. It must be noted that each of these disparities is defined by the difference from representative value for the reference period defined by the Google COVID-19 Community Mobility Reports. Figure 2 shows the disparity for `retail`, that is, the difference from the reference value for the going-out purpose of purchasing activities related to entertainment and leisure, for the time period specified by the declaration of the state of emergency. To show the disparity more clearly by day of the week in this figure, we choose representative dates for each day of the week for each time period defined by the emergency declaration, so that the status of the emergency declaration is the same for all prefectures: March 28 (Saturday), March 29 (Sunday), and April 1 (Wednesday) for pre-declaration; April 25 (Saturday), April 26 (Sunday), and April 29 (Wednesday) for under-declaration; and May 30 (Saturday), May 31 (Sunday), and June 3 (Wednesday) for post-declaration. To further reflect the status of infection in each prefecture, this figure groups the samples by the date of the end of the state of emergency and shows the different shapes of the points. The three panels on the left compare the going-out behavior for `retail` between flows under and before the emergency declaration, and the three panels on the right compare the flows for `retail` under and after the emergency was lifted. The overall trend is that there is more flow of people pre- and post-declaration of a state of emergency compared with under-declaration. In other words, the flow of people for `retail` under a declared state of emergency is decreasing. This is because almost all of the points are to the left of the 45 degree line. However, a comparison between Sundays before and under the emergency declaration shows a slight increase in flows under the emergency declaration in some large cities such as Tokyo and Kanagawa in prefectures where the declaration was lifted the latest.

Next, we look briefly at the disparity in human flows for `grocery`. Figure 3 shows the same overall trend as for `retail`, although the number of prefectures where the flow of people is higher in the under-declaration than in the pre-declaration is higher here. As for parks, except for the Saturday after lifting the state of emergency and the Sunday before its lifting, the overall increase in the number of people going to parks under the emergency declaration can be seen in Figure 4. Finally, for `workplace`, the trend is the same as for `retail` and `grocery`. Figure 5 shows that the number of people going out for work decreased on any day of the week under a declared emergency situation. This can be attributed to the people's semi-compulsory decision of not going out for work in response to the government's telecommute requirements. With the exception of the going out for `park`, the going-out behavior in all categories decreased under the declared emergency situation. However, an analysis controlling for seasonality is necessary for `park`; furthermore, this analysis fails to account for prefecture-level heterogeneity in going-out behavior. In this study, we estimate the panel data model described in Section 3.1 and conduct in-depth analysis of how non-legally binding emergency declarations can affect going-out behavior.

Table 2 shows the results of estimating the panel data model introduced in Section 3.1 with the prefecture-level panel dataset created by this study. Each column represents a category of the dependent variable, the change in going-out behavior from the reference period of going out. Following the rule that a fixed-effect estimator is used if the results of the Hausman test are less than 5% statistically significant, a one-way fixed effect estimator is used in all categories except for `park`. This may be explained by the fact that heterogeneity at the prefectural level is randomly determined with respect to the going-out behavior for `park`, as seen in the scatter-plot analysis described above. The estimated coefficients are negative and statistically significant for all dependent variables, both `under` and `post`. Therefore, the results show that, comparing the periods before the emergency declaration and the reference value, going-out behavior decreased in both the under-declaration and post-declaration. Furthermore, looking at the estimated magnitudes of the coefficients, `under` is smaller than `post` for all dependent variables. This phenomenon suggests that under the state of emergency declaration, people may have been less likely to go out than post-declaration, based on the difference between their behaviors and the reference value before the emergency declaration.

To confirm the robustness of this relationship, this study conducts sensitivity analyses. First, results of the estimation with all covariates excluded are shown in Table 3. In this simpler estimation model, a one-way random effect estimator is used in the models for the three dependent variables except for `workplace`, following the rule that a fixed-effect estimator is used if the results of the Hausman test show that a statistical significance is less than 5%. Therefore, it is desirable that heterogeneity at the prefectural level is randomly determined when no covariates are incorporated into the model. The estimation results, however, show the same tendency as in Table 2, which presents the estimation result with all covariates. Second, the results of the estimation using estimators, which are not adopted based on the rule of using a fixed-effect estimator if the results of the Hausman test showed less than 5% statistical significance, are shown in Table 4 when all covariates are included and in Table 5 when all covariates are excluded. In these results, the coefficients are similar to those in Tables 2 and 3, that is, fewer going-out individuals at `under` and `post` declaration compared with the pre-declaration of the state of emergency. Moreover, the most self-restraint was shown under the declaration of the state of emergency. Third, Tables 6 and 7 show the results of each estimation in a sample of 47 prefectures divided into two subsets: one ($N = nT = 7 \times 105 = 735$) consisting of the seven prefectures where a state of emergency was declared the earliest on April 7, 2020 (Saitama, Chiba, Tokyo, Kanagawa, Osaka, Hyogo, and Fukuoka), as shown in Table 1, and the other ($N = nT = 40 \times 105 = 4,200$) consisting of the remaining 40 prefectures where the state of emergency was not issued on this date. The estimators used are based on the rule that a fixed-effect estimator is used if the results of the Hausman test show that a statistical significance is less than 5%. These results reinforce the findings that for both the seven prefectures with the earliest emergency declaration and the other 40 prefectures, there was less going-out behavior `under` and `post` declaration compared with before the declaration. Moreover, the most significant self-restraint behavior was observed under the declaration, except for the estimated result for the seven prefectures that there was less going-out behavior for `park` after the emergency was lifted than under the declaration. These sensitivity analyses indicate that the phenomenon of a statistically significant negative coefficient for `under` and `post` and a smaller coefficient for `under` than for `post` is robust.

This section confirmed the following: Going-out behavior was reduced both under the emergency declaration and after the emergency was lifted compared with the pre-declaration of the state of emergency; in addition, going-out behavior was most suppressed under the emergency declaration. This result clarifies two findings: First, people refrained from going out both under the declaration and after the lifting of the state of emergency. Second, despite the non-legally binding emergency declarations, people were more likely to refrain from going out under the declaration of a state of emergency than after it was lifted. Therefore, this second finding in the empirical analysis is consistent with Proposition 2 of the theoretical analysis in Section 2. This suggests that under a declared state of emergency, people may have acted because of the stigma of going-out as well as the risk of infection.

4 Conclusion

This study analyzes the effects of non-legally binding policies on curfews from two perspectives: the construction of a micro-theoretical model and an empirical analysis using panel data from the Google COVID-19 Community Mobility Reports.

A plausible reason for the declaration to be effective is that people considered the risk of infection to be high. If this were the only reason, then the effect of restraint should be consistent when the risk of infection is constant under the declaration of an emergency and after it is lifted. The theoretical analysis of this study assumes that under a declared state of emergency, the going-out individual suffers psychological costs arising from both the risk of infection and the stigma of going-out. As a result, a hypothesis is derived that under a declared state of emergency, going out entails a strong psychological cost and people refrain more from going out (Proposition 2).

The empirical analysis, using a panel dataset consisting of date data on the Japanese emergency declaration and daily human flow data as well as various covariates from Google COVID-19 Community Mobility Reports, revealed the following two points. First, the flow of people under the declaration of a state of emergency was suppressed. Second, although the effect of the restraint continued after the state of emergency was lifted, the degree of restraint was greater under the declaration of the state of emergency.

As the number of infected people in Japan is increasing again, there is a possibility that another state of emergency will be declared. In terms of policy action in such circumstances, the results of this study provide one policy implication by highlighting that non-legally binding policies can be effective in terms of reducing the number of people infected, that is, by curtailing their going-out behavior.

The theoretical analysis in this study suggests the possibility of multiple equilibria—strictly self-restraint equilibrium and not-strictly self-restraint equilibrium. In both equilibria, declaring a state of emergency has the effect of reducing the number of people going out, but the degree of effect may vary significantly. If multiple equilibria exist, while the strictly self-restraint equilibrium was realized in Japan in reality, the not-strictly self-restraint equilibrium could also have been realized.

Finally, there is no guarantee that the effect of the emergency declaration will always be the same. In the theoretical model of this study, the first and subsequent declarations of states of emergency had the same effect. On the other hand, from a social psychological point of view, the effect may be weakened as people become accustomed a declared state of emergency. Therefore, it is likely that the method and content of announcements would need to be revised as they are made more often.

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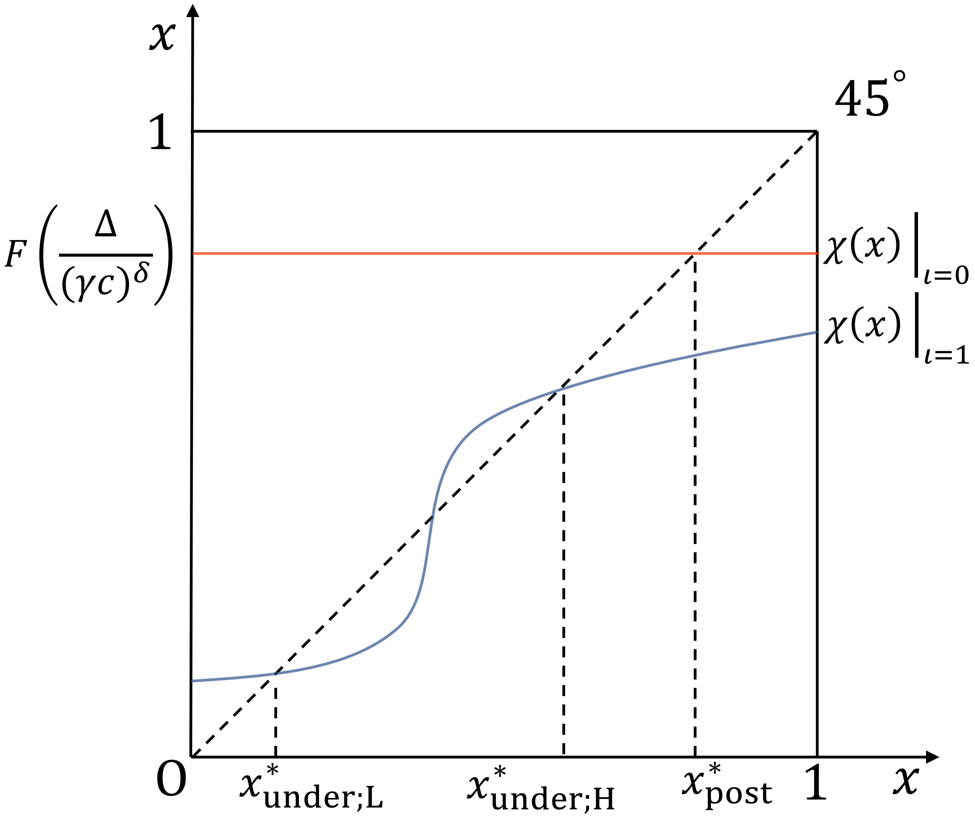

Figure 1: Example of multiple equilibria

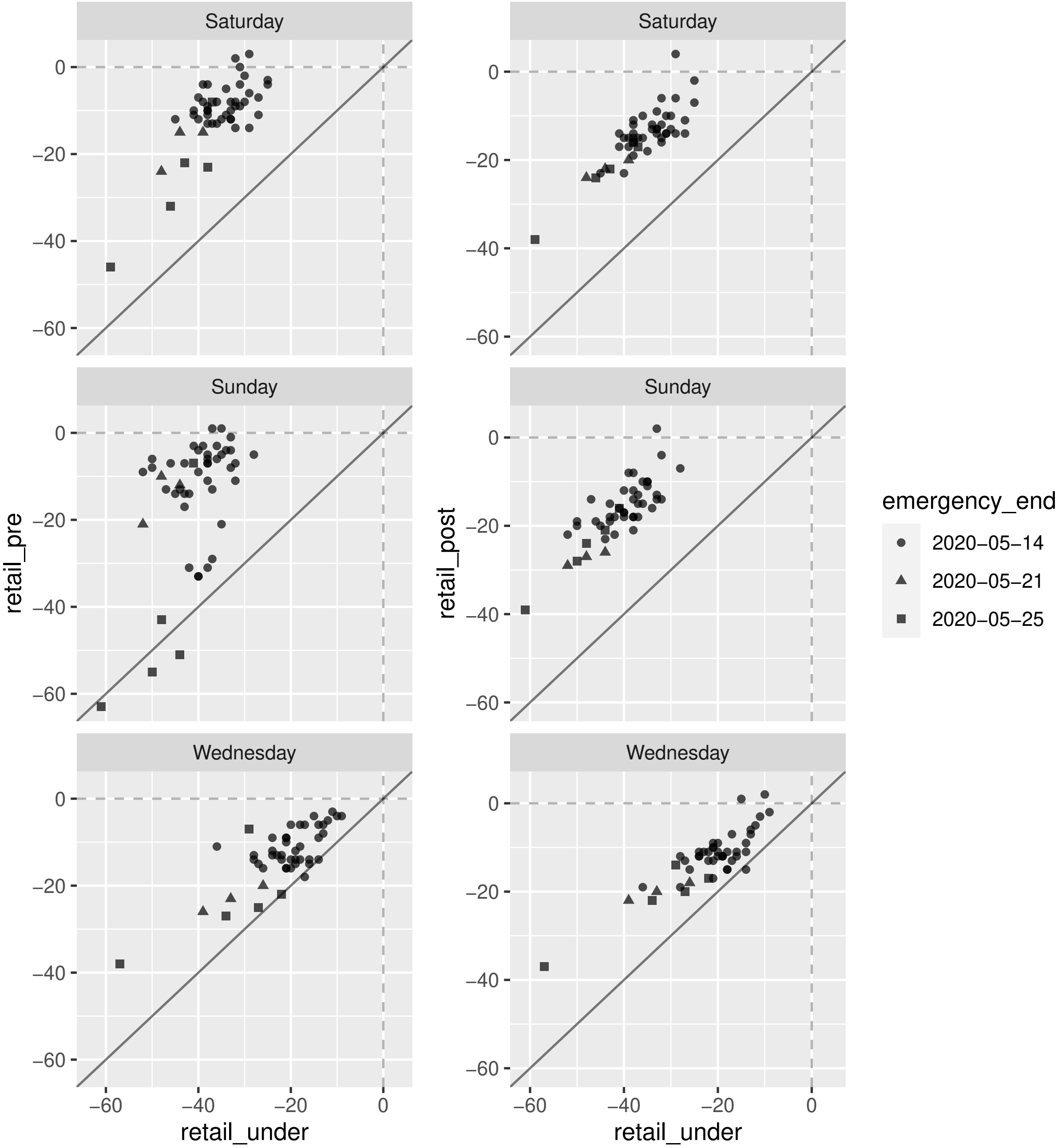

Figure 2: Comparison of going-out behavior in the prefectures of Japan: `retail`

Notes: The panels show the scatter plots of going-out behavior for `retail` between pre-declaration and under-declaration (left) and post-declaration and under-declaration (right) for three representative days: Saturday, Sunday, and Wednesday.

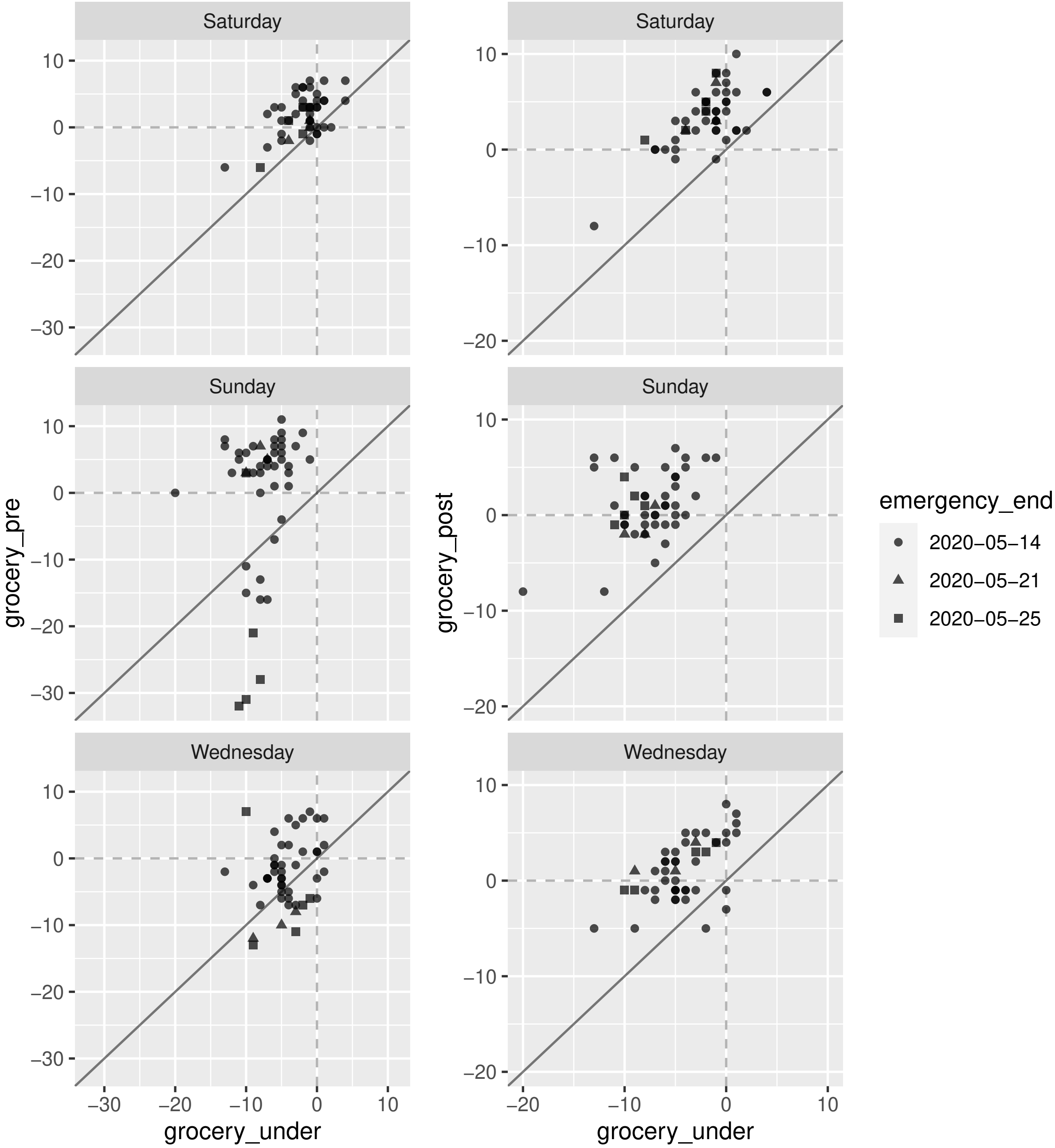

Figure 3: Comparison of going-out behavior in the prefectures of Japan: `grocery`
Notes: The panels show the scatter plots of going-out behavior for `grocery` between pre-declaration and under-declaration (left) and post-declaration and under-declaration (right) for three representative days: Saturday, Sunday, and Wednesday.

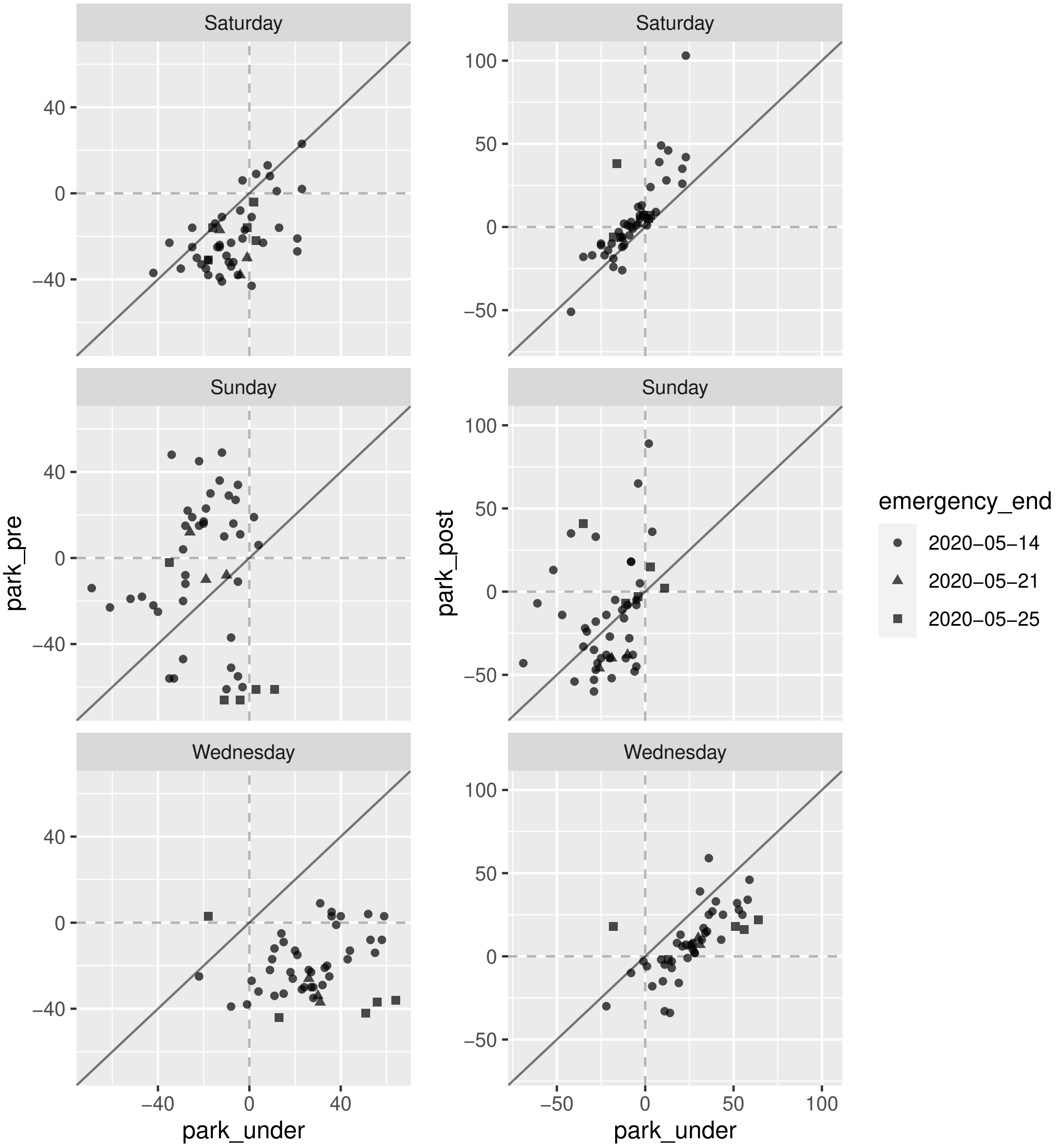

Figure 4: Comparison of going-out behavior in the prefectures of Japan: `park`

Notes: The panels show the scatter plots of going-out behavior for `park` between the pre-declaration and under-declaration (left) and post-declaration and under-declaration (right) for three representative days: Saturday, Sunday, and Wednesday.

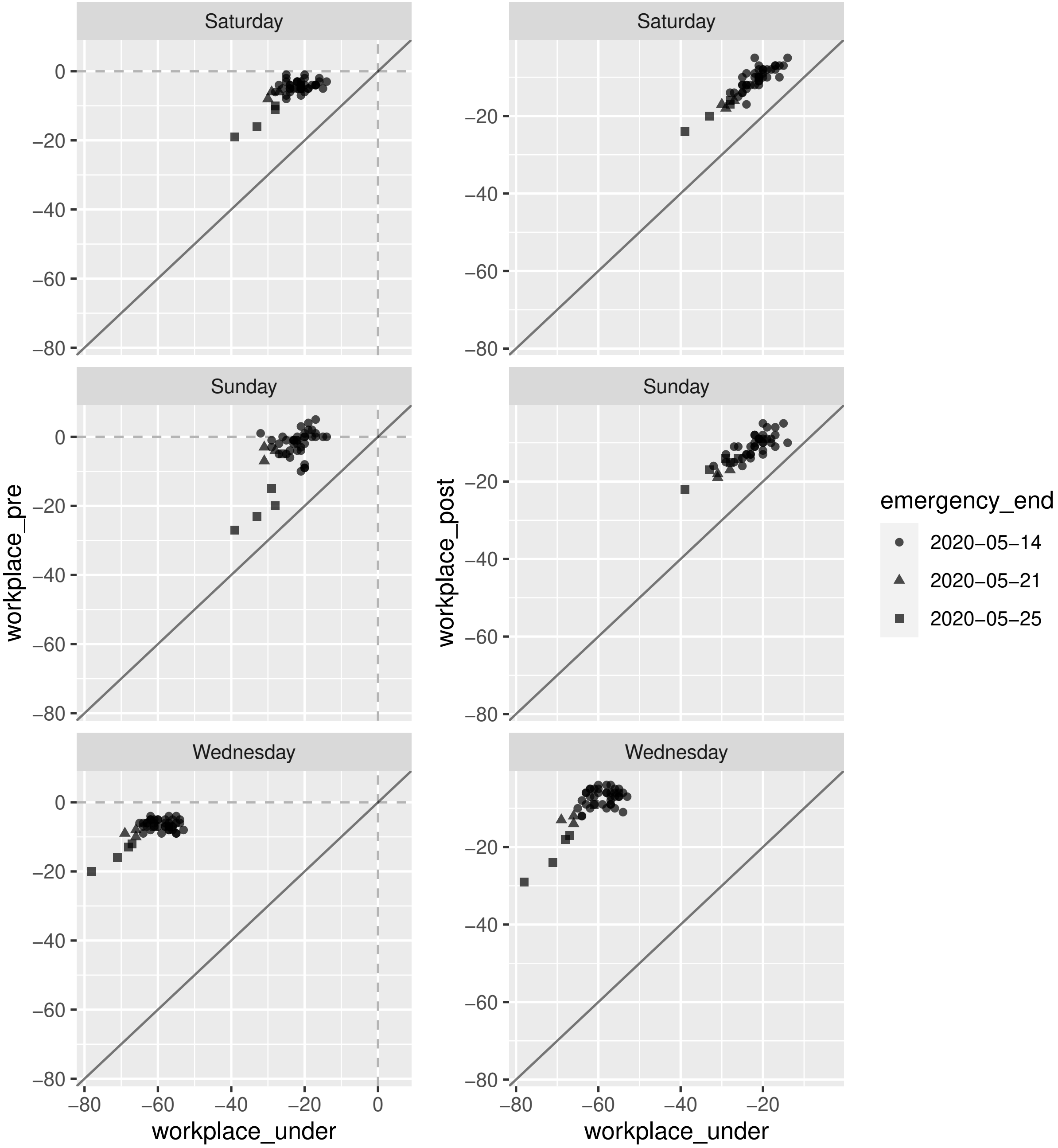

Figure 5: Comparison of going-out behavior in the prefectures of Japan: `workplace`
Notes: The panels show the scatter plots of going-out behavior for `workplace` between the pre-declaration and under-declaration (left) and post-declaration and under-declaration (right) for three representative days: Saturday, Sunday, and Wednesday.

Table 1: Date and length of state of emergency in the prefectures of Japan

prefecture	emergency_start	emergency_end	emergency_length
Hokkaido	2020-04-16	2020-05-25	39
Aomori	2020-04-16	2020-05-14	28
Iwate	2020-04-16	2020-05-14	28
Miyagi	2020-04-16	2020-05-14	28
Akita	2020-04-16	2020-05-14	28
Yamagata	2020-04-16	2020-05-14	28
Fukushima	2020-04-16	2020-05-14	28
Ibaraki	2020-04-16	2020-05-14	28
Tochigi	2020-04-16	2020-05-14	28
Gunma	2020-04-16	2020-05-14	28
Saitama	2020-04-07	2020-05-25	48
Chiba	2020-04-07	2020-05-25	48
Tokyo	2020-04-07	2020-05-25	48
Kanagawa	2020-04-07	2020-05-25	48
Niigata	2020-04-16	2020-05-14	28
Toyama	2020-04-16	2020-05-14	28
Ishikawa	2020-04-16	2020-05-14	28
Fukui	2020-04-16	2020-05-14	28
Yamanashi	2020-04-16	2020-05-14	28
Nagano	2020-04-16	2020-05-14	28
Gifu	2020-04-16	2020-05-14	28
Shizuoka	2020-04-16	2020-05-14	28
Aichi	2020-04-16	2020-05-14	28
Mie	2020-04-16	2020-05-14	28
Shiga	2020-04-16	2020-05-14	28
Kyoto	2020-04-16	2020-05-21	35
Osaka	2020-04-07	2020-05-21	44
Hyogo	2020-04-07	2020-05-21	44
Nara	2020-04-16	2020-05-14	28
Wakayama	2020-04-16	2020-05-14	28
Tottori	2020-04-16	2020-05-14	28
Shimane	2020-04-16	2020-05-14	28
Okayama	2020-04-16	2020-05-14	28
Hiroshima	2020-04-16	2020-05-14	28
Yamaguchi	2020-04-16	2020-05-14	28
Tokushima	2020-04-16	2020-05-14	28
Kagawa	2020-04-16	2020-05-14	28
Ehime	2020-04-16	2020-05-14	28
Kochi	2020-04-16	2020-05-14	28
Fukuoka	2020-04-07	2020-05-14	37
Saga	2020-04-16	2020-05-14	28
Nagasaki	2020-04-16	2020-05-14	28
Kumamoto	2020-04-16	2020-05-14	28
Oita	2020-04-16	2020-05-14	28
Miyazaki	2020-04-16	2020-05-14	28
Kagoshima	2020-04-16	2020-05-14	28
Okinawa	2020-04-16	2020-05-14	28

Table 2: Results of empirical analysis using mobility data

	Dependent variable			
	`retail`	`grocery`	`park`	`workplace`
`under`	-19.955^{***}	-5.578^{***}	-12.884^{***}	-18.182^{***}
	(0.513)	(0.235)	(1.544)	(0.507)
`post`	-6.410^{***}	-2.159^{***}	-7.231^{***}	-3.340^{***}
	(0.387)	(0.199)	(1.770)	(0.325)
Constant			-6.067^{***}	
			(1.296)	
Observations	4,935	4,935	4,935	4,935
R^2	0.588	0.488	0.533	0.335
Adjusted R^2	0.583	0.483	0.532	0.328
Hausman-test	1513.3^{***}	73.443^{***}	3.393	114.81^{***}
Estimator	FE	FE	RE	FE
Covariates	Yes	Yes	Yes	Yes

Notes: Numbers in parentheses stand for clustered-robust standard errors. *,**, and *** indicate statistical significance at the $10\%, 5\%$, and 1% levels, respectively. FE=fixed effect; RE=random effect.

Table 3: Results of empirical analysis using mobility data: sensitivity analysis without covariates

	Dependent variable:			
	`retail`	`grocery`	`park`	`workplace`
`under`	-20.143^{***}	-5.288^{***}	-10.972^{***}	-18.142^{***}
	(0.640)	(0.245)	(1.460)	(0.526)
`post`	-5.925^{***}	-2.600^{***}	-9.664^{***}	-3.368^{***}
	(0.391)	(0.215)	(2.071)	(0.311)
Constant	-7.482^{***}	3.005^{***}	8.421^{***}	
	(0.546)	(0.240)	(1.231)	
Observations	4,935	4,935	4,935	4,935
R^2	0.492	0.177	0.045	0.334
Adjusted R^2	0.492	0.177	0.045	0.327
Hausman-test	4.586	0.093	0.045	21.868^{***}
Estimator	RE	RE	RE	FE
Covariates	No	No	No	No

Notes: Numbers in parentheses stand for clustered-robust standard errors. *,**, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. FE=fixed effect; RE=random effect.

Table 4: Results of empirical analysis using mobility data: sensitivity analysis using other estimators with covariates

	Dependent variable:			
	`retail`	`grocery`	`park`	`workplace`
`under`	-19.991^{***}	-5.577^{***}	-12.891^{***}	-18.305^{***}
	(0.519)	(0.236)	(1.545)	(0.525)
`post`	-6.446^{***}	-2.162^{***}	-7.232^{***}	-3.452^{***}
	(0.392)	(0.199)	(1.773)	(0.347)
Constant	-8.138^{***}	1.685^{***}		-7.925^{***}
	(0.545)	(0.281)		(0.354)
Observations	4,935	4,935	4,935	4,935
R^2	0.585	0.486	0.536	0.336
Adjusted R^2	0.585	0.485	0.531	0.335
Hausman-test	1513.3^{***}	73.443^{***}	3.393	114.81^{***}
Estimator	RE	RE	FE	RE
Covariates	Yes	Yes	Yes	Yes

Notes: Numbers in parentheses stand for clustered-robust standard errors. *,**, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. FE=fixed effect; RE=random effect.

Table 5: Results of empirical analysis using mobility data: sensitivity analysis using other estimators without covariates

	Dependent variable:			
	`retail`	`grocery`	`park`	`workplace`
`under`	-20.101^{***}	-5.286^{***}	-10.977^{***}	-18.272^{***}
	(0.630)	(0.245)	(1.464)	(0.555)
`post`	-5.926^{***}	-2.600^{***}	-9.665^{***}	-3.364^{***}
	(0.390)	(0.215)	(2.070)	(0.310)
Constant				-7.572^{***}
				(0.300)
Observations	4,935	4,935	4,935	4,935
R^2	0.495	0.178	0.046	0.334
Adjusted R^2	0.490	0.170	0.036	0.333
Hausman-test	4.586	0.093	0.045	21.868^{***}
Estimator	FE	FE	FE	RE
Covariates	No	No	No	No

Notes: Numbers in parentheses stand for clustered-robust standard errors. *,**, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. FE=fixed effect; RE=random effect.

Table 6: Results of empirical analysis using mobility data: sensitivity analysis using a subset of the sample with the earliest state of emergency declaration

	Dependent variable:			
	`retail`	`grocery`	`park`	`workplace`
`under`	-25.005^{***}	-6.341^{***}	-9.888^{***}	-23.756^{***}
	(1.312)	(0.588)	(1.016)	(0.729)
`post`	-10.002^{***}	-2.826^{***}	-11.053^{***}	-7.739^{***}
	(1.051)	(0.590)	(0.830)	(0.846)
Constant	-12.034^{***}			
	(2.199)			
Observations	735	735	735	735
R^2	0.734	0.627	0.669	0.485
Adjusted R^2	0.733	0.621	0.664	0.477
Hausman-test	11.020^{*}	34.235^{***}	467.020^{***}	1083.000^{***}
Estimator	RE	FE	FE	FE
Covariates	Yes	Yes	Yes	Yes

Notes: Numbers in parentheses stand for clustered-robust standard errors. *,** , and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. FE=fixed effect; RE=random effect.

Table 7: Results of empirical analysis using mobility data: sensitivity analysis using a subset of the sample without the earliest state of emergency declaration

	Dependent variable:			
	`retail`	`grocery`	`park`	`workplace`
`under`	-19.195^{***}	-5.480^{***}	-13.666^{***}	-17.247^{***}
	(0.484)	(0.263)	(1.798)	(0.429)
`post`	-5.982^{***}	-2.124^{***}	-6.863^{***}	-2.715^{***}
	(0.389)	(0.213)	(2.037)	(0.232)
Constant	-7.342^{***}		-6.383^{***}	
	(0.419)		(1.404)	
Observations	4,200	4,200	4,200	4,200
R^2	0.552	0.487	0.513	0.308
Adjusted R^2	0.552	0.481	0.513	0.301
Hausman-test	4.315^{*}	29.896^{***}	0.2385	17.459^{***}
Estimator	RE	FE	RE	FE
Covariates	Yes	Yes	Yes	Yes

Notes: Numbers in parentheses stand for clustered-robust standard errors. *,**, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. FE=fixed effect; RE=random effect.