Supplementary Information

In this online appendix, we first present our data. We then demonstrate the robustness o

A Data

Our data used for control variables come from multiple sources. We will list them one by one.

A.1 COVID-19 policy dummies

The emergency declaration dummy was created based on the progress of the government's response as summarized by Tottori Prefecture on its website for new coronavirus infections. The site lists the prefectures that are subject to the issuance, change, and cancellation of emergency declarations in chronological order. Based on this information, we determined whether each prefecture was under a state of emergency declaration at a certain time. School closure dummies were created based on information of school closures for the national government and each prefecture in the time-series news archives on NHK's special website for new coronaviruses. The variable was set to 1 only when schools were closed in the entire prefecture. For municipality or school-level closure, the variable is set to be 0. Large-scale assembly dummies were created based on the governor's press conferences and updates on coronavirus in each prefecture. The criterion for variable 1 was defined as an event capacity of 5,000 people or less and a capacity ratio of 50% or less in each prefecture, and was set to 0 if either of these criteria was not met. In cases where the prefectural criteria were based on the guidelines of the respective industry, dummies were created based on the common guidelines of event-related industries.

A.2 COVID-19 test cases

In the analysis of the infection prevention effect, the number of COVID-19 test cases in each prefecture was added as a control variable. As of 2020, the number of tests in each prefecture varies in Japan, especially because of the capacity of each municipality to test. If the number of tests itself is small, the number of new infection cases may be underestimated. We referred to the data on the number of tests published on the website of each prefecture.

A.3 Restaurant website views

The rate of increase in the number of restaurant website views per week was also used as another indicator to capture the business conditions of restaurants. This data is available on V-RESAS, published by the Cabinet Office. In this data, the rate of increase or decrease in the restaurant website views compared to the same week in 2019 is disclosed for each prefecture. The original data is held by Retty, Japan's largest word-of-mouth gourmet service operated by Retty, Inc..

A.4 Mobility by residential type

In addition to the number of visitors to restaurants, we also used the human flow data published by V-RESAS to examine the impact on human flow in and across the prefectures. The weekly data shows the rate of increase or decrease in the mobility by residential type (within the municipality, within the prefecture, or from outside the prefecture) compared to the same week in 2019 for each prefecture.

A.5 Mobility inflow and outflow by prefecture

We used Agoop's paid data for the human flow within each prefecture and the human flow from outside the prefecture into each prefecture. Agoop's human flow data is the aggregate data of users' GPS information held by Agoop. Agoop's human flow data is the aggregate data of GPS information of users held by Agoop, and it is the data that estimates the population of the entire human flow from a sample of the number of people who existed at a certain coordinate at a certain time. Therefore, it is possible to grasp not only the total number of people in a prefecture, but also the movement of people from a specific prefecture to a specific prefecture/municipality. This data was used to estimate the number of potentially infected people coming from other prefectures as shown in the SIR model above, rather than as an objective variable.

A.6 Mobility by facility type

For the mobility data, we also deployed the "COVID-19: Community Mobility Report" published by Google. The data reveals the rate of increase or decrease in human flow in six types of locations ("retail and entertainment," "grocery stores and pharmacies," "parks," "transfer stations," "workplaces," and "residences") by country and region/prefecture. The median value for each day of the week for the five-week period from January 3 to February 6, 2020 is used as the baseline for the rate of change. Thus, the daily data is the rate of change from the base values for each day of the week.

A.7 Weather data

For the weather data of temperature and precipitation, we used the daily weather observation data of observatories in each prefecture using the “Past Weather Data Search” of the Japan Meteorological Agency. When extracting the data from the database, several municipalities with observatories were chosen from several municipalities with the top population. In detail, Yamanashi Prefecture is represented by Kofu and Kawaguchiko; Nagano Prefecture by Nagano, Matsumoto, Ueda, and Iida; Shizuoka Prefecture by Hamamatsu, Shizuoka, and Fuji; Gunma Prefecture by Maebashi and Isesaki; Ibaraki Prefecture by Tsukuba, Mito, and Hitachi; and Tochigi Prefecture by Utsunomiya and Oyama. The average values of these municipalities was set as the representative location for each prefecture. For the values, the weekly precipitation total and the weekly average temperature was used as the representative respectively.

B Estimation equation

The epidemiological analysis is based on the SIR-applied fixed effect model. This section shows the process of how the equation is derived from the SIR model.

The SIR model is the most basic mathematical model that captures the epidemic dynamics of infectious diseases that spread directly from person to person. The model estimates the infection status in three stages: Susceptible, Infectious, and Removed.

dI(t)dt= StIt- I(t)

denotes infectivity, and denotes recovery rate. The above ordinary differential equation is a model that represents the number of population increases in the stage of infection, and can be rewritten as follows when estimating the number of newly infected people.

COVID= SI

This multiplication can be converted into addition in logarithmic form.

ln COVID =ln +lnS+lnI

Previous studies have shown that the coefficients of the variables on the right-hand side of the equation tend not to be equal to one when the two sides are logarithmic. In addition, it has been shown that it is appropriate to add the infectivity common to all regions and time points as the intercept. Therefore, we transform the model by adding coefficients to the variables and the intercept as follows

ln COVID =0+1ln +2lnS+3lnI

In order to adapt this basic estimation equation to changes in external circumstances that affect the infection cases, we add control variables such as economic activity variables and weather conditions. In addition, the purpose of the GZ certification policy that we want to estimate is to reduce the infectivity ( ) that can be transferred from one infected person to another. Therefore, we redefine the infectivity ( ) as follows to derive the main estimation model.

ln =1lnGZ+u ln COVID =0+1lnGZ+2lnS+3lnI+4ln Control +u

C Statistical Testing

D Treatment Effect

D.1 Comparison of Treatment and Control prefecture

D.2 Comparison of policies in Treatment and Control prefecture

D.3 List of Business suspension request

E Robustness Check

E.1 Infection Prevention

E.2 Economic Effects

E.3 1 week lag analysis

E.4 Resview

E.5 Google Mobility data

E.6 Self-restraint rate

E.7 V-RESAS

E.8 Summary statistics

E.9 Cumulative GZ linear

E.10 Yamanashi and Other prefectures

Table 1: The COVID-19 new infection cases (2 week lag) and the Green Zone certification

	Dependent variable:			
	log(nofcases + 1)			
	(1)	(2)	(3)	(4)
Cumulative GZ-certified restaurants, log	-0.103^{***}	-0.119^{***}	-0.115^{***}	
	(0.013)	(0.024)	(0.024)	
Cumulative GZ-certified restaurants and hotels, log				-0.111^{***}
				(0.022)
Infectious, log	0.573^{***}	0.583^{***}	0.581^{***}	0.581^{***}
	(0.038)	(0.034)	(0.031)	(0.031)
Susceptible (two-week lag), log	0.947	5.272	11.647	−5.903
	(72.294)	(87.204)	(76.274)	(71.014)
State of Emergency	0.065	0.160	0.115	0.125
	(0.232)	(0.203)	(0.171)	(0.173)
Tests (two-week lag), log	0.009	0.009	0.009	0.009
	(0.014)	(0.015)	(0.014)	(0.014)
Customers per restaurant, log		0.472	0.437	0.501
		(0.406)	(0.434)	(0.432)
Average temperature, log			0.036	0.037
			(0.046)	(0.041)
Average rainfall, log			−0.106	−0.103
			(0.058)	(0.058)
School closure				
Gathering restriction				
Prefecture FE	X	X	X	X
Week FE	X	X	X	X
Observations	396	396	393	393
R^2	0.929	0.929	0.929	0.929
Adjusted R^2	0.912	0.912	0.912	0.912

Note: *p<0.1; **p<0.05;

Table 2: Restaurants' sales and customers (POS) and the Green Zone certification

	Dependent variable:							
	Sales per restaurant, log				Customers per restaurant			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Cumulative GZ-certified restaurants, log	0.016***	0.014***	0.014**	0.014***	0.036***	0.033***	0.033***	0
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)	(
State of Emergency	−0.273***	−0.271***	−0.262***	−0.257***	−0.223***	−0.220***	−0.213***	−
	(0.014)	(0.013)	(0.012)	(0.017)	(0.028)	(0.026)	(0.027)	(
The number of new COVID-19 cases, log		−0.011	−0.012	−0.011		−0.015	−0.017	−
		(0.009)	(0.010)	(0.011)		(0.012)	(0.013)	(
Average temperature, log			0.013*	0.012*			0.011**	0
			(0.005)	(0.005)			(0.004)	(
Average rainfall, log			−0.001	−0.001			−0.001	−
			(0.001)	(0.001)			(0.001)	(
School closure				0.090				−
				(0.115)				(
Gathering restriction				−0.008				−
				(0.019)				(
Prefecture FE	X	X	X	X	X	X	X	
Day FE	X	X	X	X	X	X	X	
Observations	5,472	5,472	5,472	5,472	5,472	5,472	5,472	
R^2	0.926	0.926	0.927	0.927	0.943	0.943	0.943	
Adjusted R^2	0.911	0.911	0.912	0.912	0.931	0.931	0.932	

Note: *p<0.1; **p<0.05; ***

Table 3: TABLE: COVID-19 new cases (1 week lag) and the Green Zone certification

	Dependent variable:			
	log(nofcases + 1)			
	(1)	(2)	(3)	(4)
log(cumGZ + 1)	-0.098^{***}	-0.107^{***}	-0.104^{***}	
	(0.013)	(0.019)	(0.019)	
log(cumGZ(Hotel included) + 1)				-0.101^{***}
				(0.018)
log(infected_lag1 + 1)	0.577^{***}	0.588^{***}	0.587^{***}	0.587^{***}
	(0.038)	(0.034)	(0.031)	(0.031)
emergency	−66.241	−58.903	−53.992	−69.757
	(76.537)	(84.503)	(78.279)	(72.203)
log(noftestst.1 + 1)	0.041	0.098	0.093	0.103
	(0.202)	(0.211)	(0.221)	(0.225)
log(customers_per)	0.010	0.010	0.010	0.011
	(0.014)	(0.015)	(0.015)	(0.015)
log(avg_temp_q)		0.286	0.249	0.304
		(0.377)	(0.377)	(0.382)
log(rain + 1)			0.043^{**}	0.043^{**}
			(0.013)	(0.012)
log(susceptible)			−0.008	−0.005
			(0.112)	(0.111)
Intercept	962.052	853.986	782.72	1011.178
	(1127.962)	(1155.183)	(1077.895)	(908.959)
Prefecture FE	X	X	X	X
Week FE	X	X	X	X
Observations	402	402	402	402
R^2	0.931	0.932	0.932	0.932
Adjusted R^2	0.915	0.915	0.915	0.915
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4: Restaurant View (percentage change) and the Green Zone certification

	Dependent variable:		
	Restaurant View (percentage change)		
	(1)	(2)	(3)
log(cumGZ + 1)	1.530***	1.533***	2.546**
	(0.261)	(0.258)	(0.684)
log(newcaseday + 1)	−1.703**	−1.701**	−1.407*
	(0.460)	(0.469)	(0.679)
emergency	−3.519**	−3.549**	−3.811***
	(1.197)	(1.207)	(0.903)
avg_temp_q		−0.005	−0.000
		(0.016)	(0.018)
rain		0.052	0.042
		(0.062)	(0.062)
log(cumGZ + 1):log(newcaseday + 1)			−0.314*
			(0.124)
Restraurant View Yamanashi mean		-21.052	
Restraurant View Control mean		-22.641	
Prefecture FE	X	X	X
Week FE	X	X	X
Observations	408	408	408
R^2	0.949	0.949	0.950
Adjusted R^2	0.937	0.937	0.938
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 5: Mobility type (Google Mobility) the Green Zone certification

	Dependent variable:											
	retail and recreation		grocery and pharmacy		parks		transit stations		workplaces		residential	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
log(cumGZ + 1)	0.354***	0.534***	0.085	0.113	3.008***	3.515***	0.515***	0.780**	−0.015	−0.025	−0.053***	−0.046***
	(0.039)	(0.079)	(0.052)	(0.081)	(0.225)	(0.440)	(0.119)	(0.264)	(0.059)	(0.063)	(0.010)	(0.009)
log(newcase_day + 1)	−0.151*	−0.046	0.146	0.163	0.930	1.219	0.240	0.396	0.065	0.060	0.041	0.045
	(0.070)	(0.169)	(0.109)	(0.135)	(0.807)	(1.093)	(0.445)	(0.607)	(0.077)	(0.084)	(0.037)	(0.042)
emergency	−4.081***	−4.154***	−0.370	−0.381	3.708	3.510	−2.308	−2.415	−1.449***	−1.445***	1.003***	1.000***
	(0.502)	(0.513)	(0.398)	(0.398)	(3.540)	(3.366)	(2.259)	(2.167)	(0.321)	(0.324)	(0.241)	(0.245)
tempq	−0.008*	−0.008*	−0.003	−0.003	−0.013	−0.012	−0.018	−0.017	−0.001	−0.001	−0.000	−0.000
	(0.003)	(0.003)	(0.002)	(0.002)	(0.022)	(0.021)	(0.013)	(0.012)	(0.002)	(0.002)	(0.000)	(0.000)
avg_rain	−0.072***	−0.073***	−0.094***	−0.094***	−0.231***	−0.233***	−0.063***	−0.064***	−0.027***	−0.027***	0.024***	0.024***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.040)	(0.040)	(0.016)	(0.016)	(0.004)	(0.004)	(0.003)	(0.003)
log(cumGZ + 1):log(newcase_day + 1)		−0.123**		−0.019		−0.347*		−0.182		0.006		−0.005
		(0.043)		(0.022)		(0.169)		(0.095)		(0.012)		(0.008)
Prefecture FE	X	X	X	X	X	X	X	X	X	X	X	X
Date FE	X	X	X	X	X	X	X	X	X	X	X	X
Observations	2,646	2,646	2,646	2,646	2,627	2,627	2,646	2,646	2,646	2,646	2,646	2,646
R^2	0.967	0.968	0.909	0.909	0.841	0.842	0.901	0.902	0.991	0.991	0.986	0.986
Adjusted R^2	0.960	0.961	0.891	0.891	0.808	0.809	0.881	0.882	0.989	0.989	0.983	0.983

Note: *p<0.1; **p<0.05; ***p<0.01

Table 6: The night-time self-restraint rate and the Green Zone certification

	Dependent variable:		
	Night_selfrest		
	(1)	(2)	(3)
log(cumGZ + 1)	-0.003^{**}	-0.003^{**}	-0.004^{***}
	(0.001)	(0.001)	(0.001)
log(newcase_day + 1)	0.005	0.005	0.005
	(0.003)	(0.003)	(0.003)
emergency	0.085^{***}	0.084^{***}	0.085^{***}
	(0.014)	(0.014)	(0.014)
avg_temp_q		-0.000	-0.000
		(0.000)	(0.000)
sum_rain		0.001^{***}	0.001^{***}
		(0.000)	(0.000)
log(cumGZ + 1):log(newcase_day + 1)			0.001^{***}
			(0.000)
Prefecture FE	X	X	X
Day FE	X	X	X
Observations	2,724	2,724	2,724
R^2	0.947	0.948	0.948
Adjusted R^2	0.937	0.937	0.937
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 7: The self-restraint rate by male age group and the Green Zone certification

	Dependent variable:						
	M15	M20	M30	M40	M50	M60	M70
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log(cumGZ + 1)	0.005**	−0.001	−0.001	−0.001**	−0.001*	−0.002	−0.001
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
log(newcase_day + 1)	0.003	0.004**	0.004*	0.003**	0.003**	0.000	0.006*
	(0.004)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)
emergency	0.034*	0.016**	0.031***	0.021***	0.018***	0.039***	−0.000
	(0.016)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.008)
avg_temp_q	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
sum_rain	0.001**	0.000**	0.000**	0.000***	0.000***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log(cumGZ + 1):log(newcase_day + 1)	0.000	−0.000	−0.001***	−0.001***	−0.001**	0.000	−0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Prefecture FE	X	X	X	X	X	X	X
Day FE	X	X	X	X	X	X	X
Observations	2,694	2,694	2,694	2,694	2,694	2,694	2,694
R^2	0.924	0.930	0.949	0.963	0.964	0.957	0.942
Adjusted R^2	0.908	0.916	0.939	0.955	0.956	0.949	0.930
Note:					*p<0.1; **p<0.05; ***p<0.01		

Table 8: The self-restraint rate by female age group and the Green Zone certification

	Dependent variable:						
	F15	F20	F30	F40	F50	F60	F70
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log(cumGZ + 1)	−0.001	−0.002	−0.002	−0.001	−0.000	−0.001**	−0.002*
	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
log(newcase_day + 1)	0.004	0.002	0.003	0.003**	0.002	0.004**	0.005*
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
emergency	0.031	0.014*	0.021**	0.022***	0.027***	0.025***	0.040***
	(0.018)	(0.006)	(0.007)	(0.005)	(0.006)	(0.002)	(0.009)
avg_temp_q	−0.000	−0.000*	−0.000	−0.000	−0.000	−0.000*	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
sum_rain	0.001**	0.000*	0.000***	0.000***	0.000***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log(cumGZ + 1):log(newcase_day + 1)	0.001	0.000	−0.000**	−0.000*	−0.000	−0.000	−0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Prefecture FE	X	X	X	X	X	X	X
Day FE	X	X	X	X	X	X	X
Observations	2,694	2,694	2,694	2,694	2,694	2,694	2,694
R^2	0.934	0.941	0.959	0.966	0.965	0.961	0.945
Adjusted R^2	0.921	0.929	0.950	0.958	0.958	0.953	0.934
Note:				*p<0.1; **p<0.05; ***p<0.01			

Table 9: Interregional Mobility and the Green Zone certification

	Dependent variable:								
		incity			inpref			outpref	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
log(cumGZ + 1)	−0.117***	−0.107***	−0.011	0.242**	0.174*	−0.128	1.055***	1.125***	2.0
	(0.022)	(0.026)	(0.045)	(0.070)	(0.081)	(0.136)	(0.164)	(0.138)	(0
log(newcaseday + 1)		0.049	0.076		−0.251	−0.337*		0.401	0
		(0.052)	(0.063)		(0.178)	(0.148)		(0.478)	(0
emergency		0.566**	0.535*		−5.098***	−5.000***		−0.684	−
		(0.200)	(0.212)		(0.542)	(0.556)		(2.382)	(2
avg_temp		−0.091	−0.094		0.188	0.199		−0.811	−
		(0.056)	(0.055)		(0.162)	(0.164)		(0.788)	(0
rain		0.003	0.002		−0.037	−0.033		0.043	0
		(0.012)	(0.012)		(0.054)	(0.050)		(0.069)	(0
log(cumGZ + 1):log(newcaseday + 1)			−0.030***			0.094*			−0
			(0.007)			(0.040)			(0
Mean of Mobility in Yamanashi		5.49			-7.079			-27.778	
Mean of Mobility in Control		5.165			-7.584			-27.881	
Prefecture FE	X	X	X	X	X	X	X	X	
Week FE	X	X	X	X	X	X	X	X	
Observations	408	408	408	408	408	408	408	408	
R^2	0.980	0.980	0.980	0.960	0.963	0.964	0.942	0.943	0
Adjusted R^2	0.975	0.975	0.976	0.951	0.955	0.955	0.930	0.930	0

Note: *p<0.1; **p<0.05; ***p

Table 10: Summary Statistics

Statistic	N	Mean	St. Dev.
New cases per day	408	76.061	122.493
Number of customers per restaurant	408	254.371	86.767
Sales per restaurant	408	585,798.500	174,182.800
Average temperature	408	13.646	7.837
Amount of rainfall	408	3.926	5.531
Infectious mobility	408	172.859	260.401
Number of COVID-19 tests	408	9,705.902	16,030.830