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Ángel Fernández Pérez; Ángela Mesa Pedrazas and

Alessio Gaggero

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Shutting Down to Save Lives: A Regression Discontinuity Analysis of Non-Essential Business Closure

Ángel Fernández Pérez[1], Ángela Mesa Pedrazas[2], and Alessio Gaggero[*3]

[1]Dpt. Applied Economics, University of Granada
[2]Dpt. Sociology, University of Granada
[3]Dpt. Quantitative Methods for Economics and Business, University of Granada

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Abstract

We quantify the effect of the non-essential business closure policy in the Spanish region of Andalusia. Exploiting that municipalities were assigned a two-week closure of the non-essential business on the basis of the exact 14-day infection rate (per 100,000 inhabitants) being above a cut-off value of 1,000, we use a regression discontinuity design to estimate the causal impact of the policy on new COVID-19 cases and deaths. Using weekly administrative data, our estimates suggest that, on average, the policy reduced new COVID-19 cases and deaths by 63 and 1, respectively. Notably, our heterogeneity analysis highlights that while the policy was extremely effective in urban areas, its effect was not statistically different from zero in rural areas, namely, municipalities with population less than 5,000. Our results imply that roughly 700 lives have been saved by this policy. Overall, this study provides compelling evidence that shutting down businesses has been an effective tool to counter the COVID-19 pandemics.

JEL Codes: I1, I18, H12.
Keywords: COVID-19; non-essential business closure; Spain; 14-day infection rate; infection; mortality; regression discontinuity.

* Corresponding author: Alessio Gaggero. Department of Quantitative Methods for Economics and Business, University of Granada. Campus Universitario de Cartuja, 18071 Granada, Spain. E-mail: alessiogaggero@go.ugr.es. We are grateful to participants at the XLI edición de las Jornadas de la Asociación de Economía de la Salud (AES) as well as participants of the II Workshop in Economics and Management UGR. This article has been screened to ensure no confidential information is revealed. All errors are our own.

1 Introduction

Since its emergence in late 2019, the Coronavirus disease 2019 (COVID-19) pandemic has presented an unprecedented challenge to healthcare systems worldwide. Given the highly lethal and contagious nature of the virus, and the absence of vaccines, national governments have been forced to implement prompt and extreme non-pharmaceutical interventions (NPIs) to slow the spread of the disease and reduce its impact on population health, including social distancing, mask mandates, travel restrictions, lockdowns, and closure of the non-essential business (Apel et al., 2023; Brauner et al., 2021; Cho, 2020; Ciminelli & Garcia-Mandicó, 2022). While these measures were used to reduce the spread of the virus and preventing unnecessary deaths, they seem to have had a significant impact on the mental health (Gaggero et al., 2022; García-Prado et al., 2022; Hyland et al., 2020; Serrano-Alarcón et al., 2022), subjective well-being (Cheng et al., 2020), domestic violence (Bullinger et al., 2021), substance use (Emery et al., 2021), unemployment (Fairlie et al., 2020), and performance of healthcare systems (Mesnier et al., 2020). Given the ongoing debate about the efficacy of non-pharmaceutical interventions, it is crucial to provide empirical evidence to inform decisions about their use. This is particularly important for future pandemics and new COVID-19 variants, as understanding the effectiveness of NPIs in reducing infections and deaths can help guide policymakers in implementing effective and efficient responses to these outbreaks.

In this paper, we evaluate the effectiveness of one the most commonly implemented NPIs during the COVID-19: the non-essential businesses closure (NEBC). While at some level it is obvious that shutting down the businesses can help to reduce the spread of the virus, there is a lack of reliable estimates quantifying the population-level effects of this intervention. This is crucial from a policy perspective, given the significant economic and social costs associated with business closures.

In an ideal experiment, we would randomly force certain municipalities to shut down the non-essential business while allowing other similar municipalities to continue business as usual. Our empirical design mimics this ideal experiment by exploiting the NEBC policy implemented in the Spanish region of Andalusia from January 17, 2021, which mandated a two-week shutdown of non-essential businesses based on the exact indicator of the 14-day infection rate per 100,000 inhabitants exceeding the cut-off of 1,000 cases. Accordingly, we can retrieve reliable estimates of the NEBC policy by comparing municipalities just below and just above the predetermined cut-off in a regression discontinuity (RD) design approach.

Using weekly administrative data on the 785 municipalities of the Spanish region of Andalusia, spanning from January to May 2021, our findings suggests that the NEBC policy significantly reduced new COVID-19 cases and deaths. Specifically, our RD estimates imply that, on average, a two-week closure of the non-essential businesses avoided 63 new COVID-19 cases and 1 new COVID-19 death. These results imply that roughly 700 lives have been saved by the NEBC policy between January and May 2021. Next, we investigate the effect of heterogeneity and analysed whether, and the extent to which, the estimated effects depend on population size. We find that the NEBC policy was extremely effective in urban areas (municipalities with more than 5,000 inhabitants) but had no significant effects in rural areas. Specifically, our RD estimates suggests that in urban areas, a two-week closure of the non-essential businesses avoided roughly 100 new COVID-19 cases and 1.5

new COVID-19 death.

This paper has several key strengths that are worth noting. Firstly, to the best of our knowledge, this is the first study examining the effectiveness of the NEBC policy in Spain, as well as one of the few analysing this kind of NPIs in the literature. Mendez-Brito et al. (2021) conducted a systematic review of empirical studies on NPIs and discovered that out of 34 studies found, only six examined the effectiveness of closing business or venues on variables such as the COVID-19 reproduction number, incidence, or mortality rates. Most of them are focused on measuring the impact of the school closing, the lockdowns, or the social gathering restrictions. Our study is unique in that it examines the effectiveness of non-essential business closure at a granular level that is not often explored in the literature. As a result, our findings make a significant contribution to the understanding of the effectiveness of NPIs in controlling the spread of COVID-19. Secondly, this study could provide policymakers with empirical evidence that can inform evidence-based decision-making regarding the implementation or continuation of COVID-19 measures in a context in which dealing effectively with new waves/variants or, most in general, new pandemics, has become a major policy goal, both at the local and the national level. According to a recent editorial of The Lancet journal, the COVID-19 pandemic is far from over (Lancet, 2023). Data provided by the COVID-19 weekly epidemiological report of the World Health Organisation (WHO) suggest that several countries in the Western Pacific Region such as China, Japan, or Republic of Korea that have reported a high increase of new cases per 100,000 in last 28-day period (WHO, 2023). Finally, the design of the intervention analysed allows us to estimate more accurate causal effects of the policy by overcoming some limitations pointed out by the previous literature, such as the lack of counterfactuals with which compare the treated units, as well as the impossibility to isolate the effects of the different NPIs (Bongaerts et al., 2021; Cho, 2020; Ciminelli & Garcia-Mandicó, 2022). Our use of regression discontinuity design is a powerful tool for addressing issues of confounding factors and reverse causation that can hinder causal inference in observational studies. To ensure the validity of our approach, we performed several tests to evaluate the assumptions of the testing framework. The remainder of the paper proceed as follows. Section 2 reviews the literature. Section 3 outlines the institutional setting. Section 4 describes the data, variables and the empirical strategy. Section 5 reports the results, whereas Sections 6 and 7 provide, respectively, the discussion and conclusions of the paper.

2 Literature Review

This paper contributes to the literature evaluating the effectiveness of several NPIs, such as lockdowns, school and business closures, night-time curfews or use of masks, on COVID-19 cases and deaths. Alfano & Ercolano (2020) analysed the role played by the lockdown measures when it comes to reducing the number of new COVID-19 infections by using data of 202 countries around the world. They find that those countries that implemented the lockdowns had significantly fewer new COVID-19 cases than countries that did not. These results are in line with those found by Born et al. (2021) and Orea & Álvarez (2022) for the case of Sweden and Spain, respectively. Born et al. (2021) estimated that if Sweden had implemented a 9-week lockdown during the first wave of

COVID-19 pandemic, the number of infections and deaths would have reduced by around 75% and 38%, respectively. Orea & Álvarez (2022) observed that the lockdown implemented in Spain during the first wave of pandemic prevented by about 600,000 infections by COVID-19. Alfano (2022) also studied the effectiveness of the school closures policy at a European level on the number of new COVID-19 infections by finding a positive impact mainly 40 days after the intervention. Hansen & Mano (2023) and Chernozhukov et al. (2021) analysed the effect of state-wide mask mandates in the United States during the first wave of the pandemic. They estimate that mandating face masks seems to have reduced the rate of infections, hospital admissions, and deaths by saving around 87,000 lives. The impact of the night-time curfews was also analysed by Apel et al. (2023). They find that the banning of leaving the home between 9 p.m. and 5 a.m. implemented in the Hamburg city between April and May 2021 avoided the infection of around 3,000 people during that period.

Our study is most closely related to the small literature evaluating the closure of the non-essential business. Bongaerts et al. (2021) and Ciminelli & Garcia-Mandicó (2022) analysed the effectiveness of these measures in Italy in 2020 during the first wave of the pandemic. They find a clear positive effect of the NEBC policies on the reduction of deaths by COVID-19, with an estimated 9,500 lives saved in just 24 days (Bongaerts et al., 2021). Additionally, they observe that the effectiveness of these measures is higher when applied in places with lower infection rates, suggesting that early action is crucial to mitigate the spread of the virus (Ciminelli & Garcia-Mandicó, 2022). In the United States (US), Courtemanche et al. (2020) find that the closure of restaurants dining rooms, bars or entertainment centres significantly reduced the growth rate of COVID-19 cases in 3,138 US counties from March 1, 2020 to April 27, 2020. Since business closure was mandated across the entire country simultaneously, these studies face a potential limitation in that there is no true control group to compare against (Ciminelli & GarciaMandicó). Thanks to our uniquely appropriate institutional setting, in our study we can identify a control group that can be used as a counterfactual outcome in the absence of the policy. [1]

3 Institutional Setting

As in other countries in the world, the COVID-19 outbreak has shaken Spain in several waves, prompting the Spanish central government to declare a state of alarm on March 14, 2020, just three days after the WHO declared COVID-19 a global pandemic (BOE, 2020a). From that day, strong restrictions were adopted nationwide, including stay-at-home orders, school and business closures, mandatory use of masks, and cessation of non-essential activities, until the curve of infections and deaths flattened in June. However, due to a surge in daily infections and worsening epidemiological indicators, the second state of alarm was enacted on October 25, 2020 (BOE, 2020b). However,

[1] Despite the positive effects reported by these authors, recent studies suggest that NEBC policies might not be the most effective NPIs. After analysing several NPIs in 41 countries during the first wave of the pandemic, the results of Brauner et al. (2021) suggest that the closure of face-to-face businesses such as restaurants, bars, and nightclubs, as well as other non-essential businesses delivering personal services were not the most effective measures in reducing the COVID-19 transmission. Instead, limiting the number of people in gatherings, or closing schools and universities appear to be more effective interventions. Similar conclusions were also reached by other authors, including Banholzer et al. (2021), Dreher et al. (2021), and Hunter et al. (2021). Other studies suggest that a combination of NPIs could be the most appropriate way for a more effective reduction of the reproduction number of COVID-19 (Haug et al., 2020; Wibbens et al., 2020).

Table 1: COVID-19 restrictions in Andalusian municipalities, by incidence level

Measures implemented to contain the spread of SARS-CoV-2 virus	14-day Infection Rate	
	$\leq \mathbf{1,000}$	$> \mathbf{1,000}$
NEBC policy	**No**	Yes
Curfew	Yes	Yes
Worship places restrictions	Yes	Yes
Groups restrictions	Yes	Yes
Regional lockdown	Yes	Yes
Provincial lockdowns	Yes	Yes
Schedule restrictions	Yes	Yes
Municipal lockdown	Yes	Yes

Note: The Tables outlines the COVID-19 restrictions in Andalusian municipalities implemented on January 17, 2021.

in this case, the management of the pandemic was devolved to the regional authorities (Angelici et al., 2023). They were allowed to impose restrictions such as curfews, regional, provincial, and municipal lockdowns, limits on group size, and restrictions on worship places. Additionally, they could adopt any other restrictions allowed by regional laws, including economic restrictions and healthcare measures.

From October 25, 2020, to May 9, 2021, the Andalusian government faced two COVID-19 waves. The first occurred between October and December 2020, during which the government established a curfew from 11 pm to 6 am and limited group gatherings to six people. Additionally, a municipal lockdown prevented individuals from leaving their municipality of residence except for justified reasons. These measures were applied in all the territory until its relaxation during the Christmas holidays. However, in response to an increase in COVID-19 cases and deaths, and in the absence of vaccines, the January 17, 2021, the government re-implemented the same set policies but, in this occasion, the closure of the non-essential business was carried out according to each municipality's epidemiological situation. Specifically, municipalities with a 14-day infection rate exceeding 1,000 were required to close non-essential businesses for a period of two weeks.[2] This policy, known as NEBC, is summarized in Table 1. The Table highlights that while NEBC was only mandated to municipalities exceeding the 14-day infection rate of 1,000, a set of NPIs was also in place for all municipalities, namely (a) a curfew between 10 pm and 6 am; (b) regional, provincial, and municipal lockdowns; (c) restrictions on group sizes to no more than four people in public or private places; and (d) a mandatory limitation of 50 percent capacity in worship places.

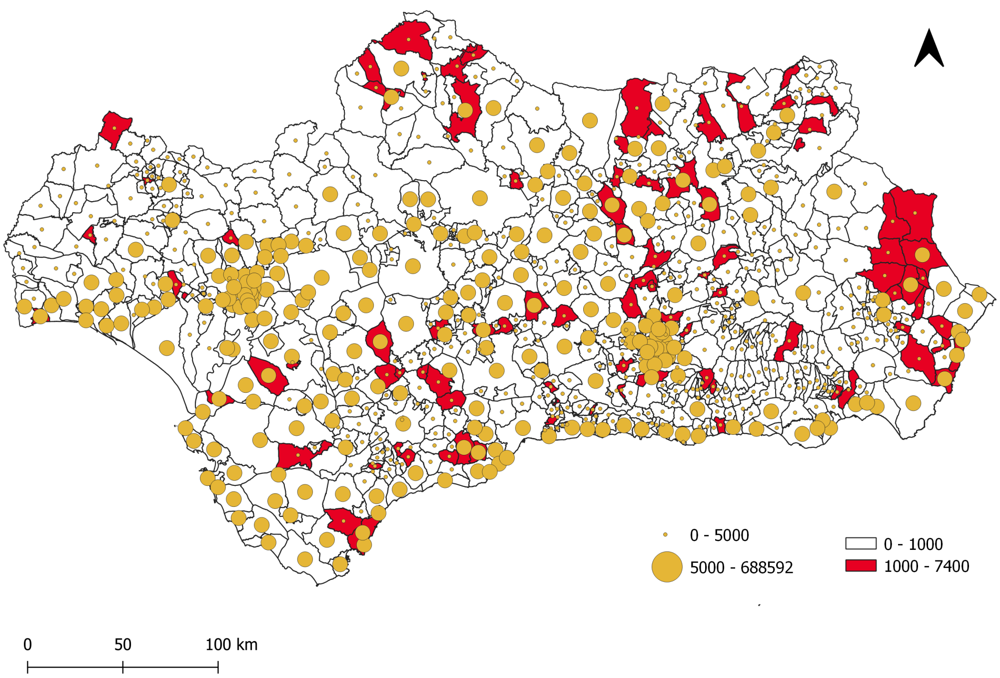
[2]Table A.1, in Appendix A1, provides the full list of essential businesses allowed to stay open regardless of the 14-day infection rate.

4 Methods

4.1 Data

We use the administrative data provided by the Institute of Statistics and Cartography of Andalusia (ISCA) along with the Health and Consumption Department of Andalusia related to the COVID-19 situation in the region.[3] We collected weekly data for every Friday from January 15 to May 7, 2021, for a total of 17 weeks, from all 785 municipalities composing the region of Andalusia. This gives us a sample of 13,242 observations. [4] The dataset contains detailed information by municipality on: (1) the accumulated number of confirmed COVID-19 cases since February 26, 2020; (2) accumulated number of confirmed COVID-19 deaths since February 26, 2020; (3) the 14-day infection rate per 100,000 inhabitants, which is calculated by dividing the accumulated number of confirmed COVID-19 cases in the last 14 days by the population size of the municipality and multiplying by 100,000.[5] A person is considered as infected or deceased from COVID-19 if it has been confirmed through a positive polymerase chain reaction (PCR) test or rapid antigen test.

Figure 1: Map of Andalucia.



Source: Authors own calculation using spatial data of Andalusia, published by the Institute of Statistics and Cartography of Andalusia (ISCA). *Note:* The Figure shows the 785 Andalusian municipalities with their 14-day infection rate (per 100,000 inhabitants) on the 17 of January 2021, by population size

[3]In Appendix A2 we provide an extensive description and political background of Spain and the region of Andalusia.

[4]For the municipalities of the province of Málaga, we do not have information for the week of the March 5, 2021. Therefore, we only have data of 16 weeks for municipalities in this province.

[5]Although we use the official variable provided by the ISCA, we confirmed the accuracy of our results by independently creating the 14-day infection rate variable.

In order to analyse the heterogeneous effects by population size, we divide the municipalities in two groups: 1) urban areas (those municipalities with more than 5,000 inhabitants), and 2) rural areas (municipalities with less than 5,000 inhabitants). There exist different approaches to classify to a municipality as urban or rural. We have followed the approach of the Ministry of Agriculture, Fisheries and Food, which sets as rural those municipalities with less than 5,000 inhabitants in its demographic report of the rural population of 2020 (MAFF, 2021). In this way, by 67% of Andalusian municipalities (527 out of 785) would be considered as rural, which comprise about 900,000 inhabitants.

Figure 1 shows the Andalusian municipalities with their 14-day infection rate (per 100,000 inhabitants) on the January 17, 2021, by population size.[6] The Figure shows that on January 17, 93 municipalities had the 14-day infection rate greater than 1,000 and hence mandated a two-week NEBC. Table 2 shows descriptive statistics for the sample of interest.[7] It shows that average weekly number of COVID-19 cases is roughly 600 per municipality, while the average number of COVID-19 deaths is 10, reaching a maximum of 744 when the pandemic was at its peak. On average, the 14-day infection rate is 356 and the average population size is 10,730. In the section that follows, we layout the econometric model employed to estimate the policy impact.

Table 2: Summary Statistics

	(1) Mean	S.D.	Min	Max
Total COVID-19 Cases	600.88	2203.07	0	41511
Total COVID-19 Deaths	10.51	40.48	0	744
14-day Infection Rate (per 100,000 people)	356.54	579.45	0	9416
Population	10731.67	39494.74	51	691395
N^o of Municipalities	115.87	37.64	51	179
Observations	13242			

Note: The Tables shows the summary statistics of the main variables of interest.

4.2 Econometric Model

In this study we employ an RD design exploiting the discontinuity caused by the NEBC policy assignment rule. This type of design, which was first introduced by Thistlethwaite & Campbell (1960), has now emerged as one of the most credible non-experimental strategies for the analysis of causal effects in observational settings (Cattaneo et al., 2019). In the RD design, all units have a running variable, and treatment is assigned to those units with a value of the running variable above a certain cut-off point. The key feature of the design is that the probability of being assigned to the treatment changes abruptly at the known cut-off value of the running variable. It mimics a randomised evaluation since treatment can be assumed as good as random for units in an arbitrarily close neighbourhood of the cut-off value. The RD design is perfectly suited for our context, since all municipalities have a 14-day infection rate, our running variable, but only those with a value greater than 1,000 were assigned to the NEBC policy. Accordingly, thanks to the discontinuous change in

[6]In Table A.2, in Appendix A1, we report basic statistics of the region of Andalusia, by population size.

[7]In Table A.3 in Appendix A1, we report statistics for the entire sample (from October 30, 2020 to May 7, 2021) and in Table A.4 we report statistics by province.

the probability of being assigned to the NEBC policy we can gauge at the (local) causal effect, by using municipalities with a score of the running variable barely below the cut-off as counterfactuals for those with a score barely above it.

Formally, let $Z_{i,t}$ be the running variable which identifies the 14-day infection rate for municipality i at time t. Let the cut-off point of interest be $z_0 = 1,000$, since municipalities with a 14-day infection rate greater than 1,000 were assigned to the NEBC policy. Finally, let us denote an indicator variable, denoted $P_{i,t}$, which takes the value of one for municipalities with infection rate greater than 1,000 and hence assigned to the NEBC policy, namely $P_{i,t} = 1\left[Z_{i,t} \geq z_0\right]$. In our case, since the NEBC policy was strictly assigned on the basis of the 14-day infection rate, we use the simplest version of an RD design, which is known as the sharp design.[8] In the spirit of Hahn et al. (2001), a regression framework for a sharp RD design is as follows:

$$\Delta Y_i = \alpha + \beta P_{i,t} + \phi Z_{i,t} + \delta P_{i,t} \cdot Z_{i,t} + \boldsymbol{X}'_{i,t}\gamma + \varepsilon_{i,t},$$

where ΔY_i is a two-week difference in the variables of interest, namely, the number of COVID-19 infections and deaths. $P_{i,t}$ and $Z_{i,t}$ are the variables described above; we follow the recommendations of Gelman and Imbens (2018) and employ a linear function of the running variable in our baseline specification. Additionally, we include in the baseline model an interaction term between the policy indicator and the running variable, denoted $P_{i,t} \cdot Z_{i,t}$, to allow the function to have different slopes at the two sides of the cutoff, a standard assumption in RD design. X_i is a vector of control variables, namely, date and province fixed effects (FE), and γ is the vector of associated coefficients. Finally, $\varepsilon_{i,t}$ is a random disturbance. β is the main parameter of interest which, represents the effect of NEBC policy around the cut-off point.[9] We cluster standard errors on the running variable based on the recommendation of Lee & Card (2008).[10]

5 Results

5.1 Primary Results

We first examine graphically the effect of the NEBC policy on new COVID-19 cases and deaths. Figure 2 presents clear evidence of a discontinuity at the cut-off of the running variable, both on new COVID-19 cases and deaths. Specifically, the plots imply that municipalities with a 14-day infection rate value just above the cut-off exhibit a lower increase in the number of COVID-19 cases and deaths than their counterparts just below the cut-off. We next test the statistical significance

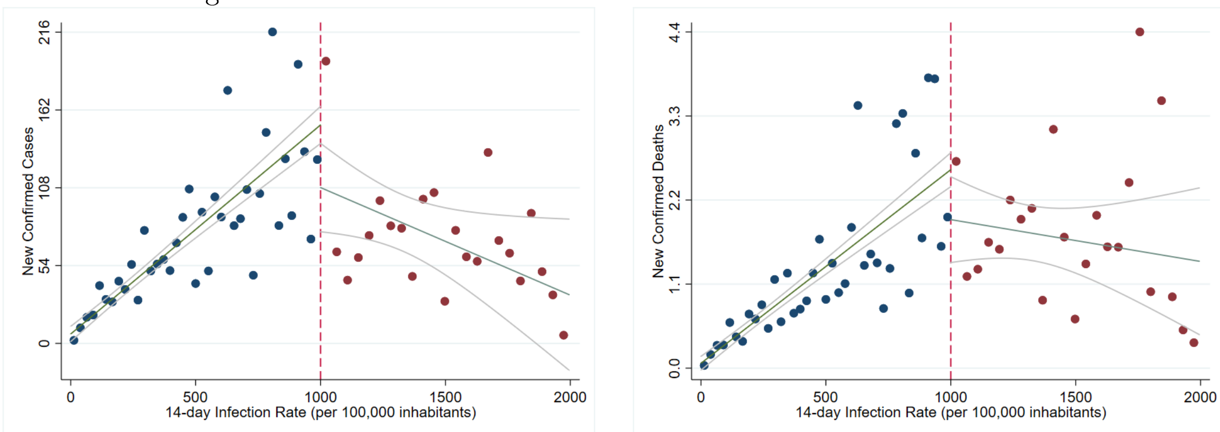
[8] Alternatively, in the fuzzy design the probability of receiving the treatment is known to be discontinuous in the cut-off point, but not in a deterministic fashion.

[9] Our analysis is based on weekly data, collected each Friday of the week. However, there is a possibility that the NEBC status of municipalities may have changed within the week, which could lead to the misclassification of the actual treatment status. As a result, our presented results should be interpreted as intention-to-treat estimates of the NEBC policy. This means that our estimates represent the effect of the policy assignment rule rather than the effect of the actual non-essential business closure.

[10] Following Kolesár & Rothe (2018), we also estimate our models using Eicker-Huber-White (EHW) heteroskedasticity-robust standard errors. These are recommended when the number of support points around the cut-off is sufficiently large and are based on a smaller bandwidth. Results are very similar and available upon request.

of these findings in a regression framework while controlling for a number of potential confounding factors, as described above.

Figure 2: Effect of the NEBC policy around the Cut-off.



Note: The figure shows local polynomial estimates of the NEBC policy on COVID-19 cases and death as a function of the running variable, namely the 14-day infection rate (per 100,000 inhabitants).

In Table 3 we report the main findings of this paper are presents the robustness of the results including a battery of specifications. In Column (1) we present the basic specification RD specification, which only includes, as a covariate, the running variable. Column (2) includes the interaction term between the policy indicator and the running variable, to allow for the functional form of the running variable to have different slopes at the two sides of the cut-off. In Column (3) we control for a linear time trend. In Column (4), we replace the linear time trend with time fixed effect (FE), namely a full-set of weekly dummies. Finally, in Column (5), we present our preferred specification which also controls for province FE in order to account for provinces time-invariant characteristics, both observable and unobservable. In Panel A and B, we present RD estimates of the NEBC policy on new COVID-19 cases and deaths, respectively.

The results presented in Panel A exhibit that the NEBC policy had a statistically significant and beneficial effect on new COVID-19 cases. Specifically, the estimated coefficient in Column (5), our preferred specification, implies that, on average, municipalities assigned to a two-week closure of the non-essential business had the number of new COVID-19 cases reduced by 63. While the adjusted R-square increase considerably, the average effect remains positive and relatively stable. Similarly, the estimates in Panel B suggest a significant and beneficial effect of the NEBC policy on the number of COVID-19 deaths. Specifically, the estimated coefficient in Column (5) suggests that, on average, municipalities assigned to a two-week closure of the non-essential business reported roughly one fewer COVID-19 death then their counterpart. To strengthen the validity of this findings in Table A.3, in the Appendix, we show the results obtained by estimating the sharp RD design when employing different polynomial orders of the running variable, ranging from a polynomial of order 1 (Column (1), or baseline estimates) to a polynomial of order 4 (Column (4)). Once again, allowing for different flexibility of the running variable, estimates are qualitatively the same. Overall, the RD estimates confirm the findings displayed in Figure 2 and provide compelling evidence of the significant and beneficial effects of the NEBC policy on new COVID-19 cases and deaths.

Table 3: RD Estimates of the NEBC Policy on COVID-19 Cases and Deaths

	(1)	(2)	(3)	(4)	(5)
Panel A: COVID-19 Cases					
NEBC Policy [0,1]	-66.765***	-60.809***	-57.347***	-61.048***	-63.038***
	(21.647)	(17.455)	(17.404)	(17.233)	(17.009)
$\boldsymbol{Z_{i,t}}$	✓	✓	✓	✓	✓
$\boldsymbol{P_{i,t} \cdot Z_{i,t}}$		✓	✓	✓	✓
Linear Time Trend			✓		
Time FE				✓	✓
Province FE					✓
Observations:	9816	9816	9816	9816	9816
Adjusted R^2:	0.016	0.034	0.036	0.048	0.060
Panel B: COVID-19 Deaths					
NEBC Policy [0,1]	-0.867**	-0.770**	-0.714**	-0.717**	-0.774***
	(0.358)	(0.302)	(0.301)	(0.302)	(0.297)
$\boldsymbol{Z_{i,t}}$	✓	✓	✓	✓	✓
$\boldsymbol{P_{i,t} \cdot Z_{i,t}}$		✓	✓	✓	✓
Linear Time Trend			✓		
Time FE				✓	✓
Province FE					✓
Observations:	9816	9816	9816	9816	9816
Adjusted R^2:	0.021	0.038	0.040	0.039	0.053

Note: In Panel A and B we present RD estimates of the NEBC policy on new COVID-19 cases and deaths, respectively. Key regressor: NEBC Policy [0,1]. This is a dummy for whether a municipality as a 14-day infection rate (per 10000 inhabitants) greater than 1000. In Column (1) we present the basic specification RD specification, which only includes, as a covariate, the running variable. Column (2) includes the interaction term between the policy indicator and the running variable, to allow for the functional form of the running variable to have different slopes at the two sides of the cut-off. In Column (3) we control for a linear time trend. In Column (4), we replace the linear time trend with time fixed effect (FE), namely a full-set of weekly dummies. Finally, in Column (5), we present our preferred specification which also controls for province FE in order to account for provinces time-invariant characteristics, both observable and unobservable. Robust standard errors are clustered on the running variable. ** $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

In Table 4, we investigate heterogeneous effects and explore whether, and to what extent, the estimated impact of the NEBC policy differed by population size.[11] Interestingly, the RD estimates report that the effects of the NEBC policy did not have a significant effect in rural areas and only had a strong and significant effect in urban areas. Specifically, a two-week closure of the non-essential business in municipalities with a population size greater than 5,000 reduced the number of new COVID-19 cases by roughly 100, while the same number for municipalities in rural areas (population size less than 5,000) is not statistically different from zero. Similarly, with respect to COVID-deaths, a two-week closure of the non-essential business in municipalities with a population size greater than 5,000 reduced new COVID-19 deaths by roughly 1.5, while the same number for municipalities in rural areas (population size less than 5,000) is not statistically different from zero.

[11] Results are robust when choosing different definition of rural and urban areas.

Table 4: RD Estimates of the NEBC Policy - Heterogeneity Analysis

	Rural Areas		Urban Areas	
	(1) **COVID-19 Cases**	(2) **COVID-19 Deaths**	(3) **COVID-19 Cases**	(4) **COVID-19 Deaths**
NEBC Policy [0,1]	-2.818	-0.064	-99.939**	-1.389*
	(1.739)	(0.062)	(46.761)	(0.789)
$Z_{i,t}$	✓	✓	✓	✓
$P_{i,t} \cdot Z_{i,t}$	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Province FE	✓	✓	✓	✓
Observations	6615	6615	3201	3201

Note: The Table presents RD estimates of the NEBC policy on new COVID-19 cases and deaths, respectively. Key regressor: NEBC Policy [0,1]. This is a dummy for whether a municipality as a 14-day infection rate (per 10000 inhabitants) greater than 1000. In Columns (1) and (2) we report RD estimates for the sample of municipalities with size less than 5000 (i.e. Rural areas), whereas in Columns (3) and (4) we report RD estimates for municipalities with size that exceeds 5000. Robust standard errors are clustered on the running variable. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

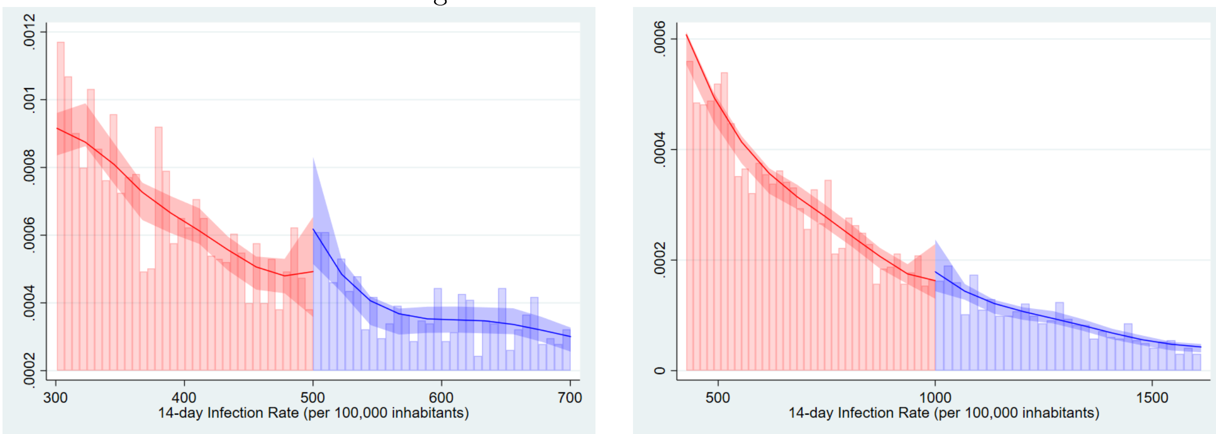
5.2 Validity and Sensitivity Checks

The main threat to identification in our context is the possibility of manipulation of the running variable McCrary (2008). In our context, this would entail that municipality finely manipulate their 14-day infection rate in order to narrowly avoid closure of the non-essential business. Theoretically, this is plausible because the NEBC threshold is publicly known, and municipality could potentially find a way in order to manipulate the 14-day infection rate. However, in practice, this is very unlikely since the 14-day infection rate was computed directly from the Andalusia authority using direct data from the hospitals. Ultimately, whether manipulation is likely to substantially bias our estimates is an empirical question. We explore the magnitude, if any, of the manipulation employing the testing procedures proposed in (Cattaneo et al., 2018), which the local polynomial density estimators. Figure 3 exhibits the results of this test and reveals no evidence of a discontinuity at the cut-off (discontinuity size: 0.347; p-value: 0.728).

Additionally, in order to dispel any potential concerns about municipalities sorting around the running variable, we implement the "donut hole" approach suggested by Barreca et al. (2016). The main idea behind this approach is that municipalities closest to the cut-off are those most likely to have engaged in manipulation. Consequently, excluding such municipalities from the analysis would eliminate any potential concern. In Table 5 we report RD estimates of the NEBC policy on new COVID-19 cases and deaths, excluding municipalities with a 14-day infection rate 5, 10, and 20 points around the cut-off. As the results reported in Table 5 show, our results remain robust to such validation tests.

Lastly, we conduct a falsification test to show that the estimated effects do not exist when, in fact, they should not. Results, reported graphically in Figure 4, confirm that when using an alternative cut-off value of the 14-day infection rate, namely 200, estimated effects are not significantly different from zero.

Figure 3: Manipulation Test



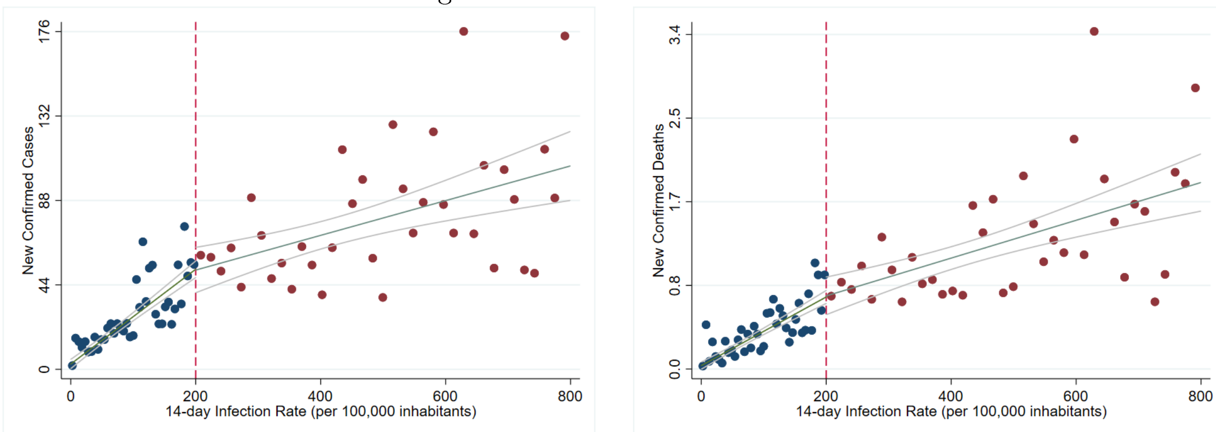
Note: The Figure shows evidence of no manipulation of the forcing variable (discontinuity:0.347; p-value:0.728). The testing procedures uses the local polynomial density estimators as proposed in Cattaneo, Jansson and Ma (2020a). Similarly, the graphical procedure, with valid confidence bands, uses the results in Cattaneo, Jansson and Ma (2020b)

Table 5: RD Estimates of the NEBC Policy - "Donut" Approach

	COVID-19 Cases			COVID-19 Deaths		
	(1) **Donut 5**	(2) **Donut 10**	(3) **Donut 20**	(4) **Donut 5**	(5) **Donut 10**	(6) **Donut 20**
NEBC Policy [0,1]	-64.331***	-69.748***	-71.853***	-0.785***	-0.869***	-0.894***
	(17.153)	(17.134)	(16.449)	(0.300)	(0.302)	(0.295)
$Z_{i,t}$	✓	✓	✓	✓	✓	✓
$P_{i,t} \cdot Z_{i,t}$	✓	✓	✓	✓	✓	✓
Date FE	✓	✓	✓	✓	✓	✓
Province FE	✓	✓	✓	✓	✓	✓
Observations	9803	9784	9757	9803	9784	9757

Note: The Table reports RD estimates of the NEBC Policy on new COVID-19 cases and deaths, respectively. Key regressor: NEBC Policy [0,1]. This is a dummy for whether a municipality as a 14-day infection rate (per 10000 inhabitants) greater than 1000. Robust standard errors are clustered on the running variable. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 4: Falsification Test



Note: The figure shows local polynomial estimates when using a different cut-off (200) in the running variable.

6 Discussion

In this study, we analysed the impact of the NEBC policy implemented in Andalusia, Spain from January 17, 2021, at the municipal level, using a regression discontinuity approach. Our findings indicate that the policy effectively reduced the number of new COVID-19 cases and deaths. A two-week closure of non-essential businesses, on average, led to 63 fewer COVID-19 cases and 0.8 fewer deaths per municipality. To put these figures into perspective, we multiplied the estimate coefficients by the number of municipalities affected by the policy, and the results suggest that the NEBC policy saved approximately 700 lives in Andalusia between January and May 2021, demonstrating its significant impact.

Although the diversity in characteristics, data, variables, and methodology used prevents us from making a proper comparison of our results with those of other studies in the literature, our findings are consistent with previous estimations on the impact of business shutdown policies. Bongaerts et al. (2021) reported that the first non-essential business shutdown in Italy saved 9,500 Italian lives in one month in 2,000 municipalities. Similarly, Ciminelli & Garcia-Mandicó (2022) found that the same policy prevented 78,000 deaths in 5,000 municipalities across the 10 northern Italian regions, thanks to the shutdown of non-essential businesses.

The effectiveness of this policy would likely come from minimising the exposure of people to the SARS-CoV-2. The closure of the non-essential businesses would be avoiding the physic contact both with people and things, thereby reducing the risk of COVID-19 infection and, consequently, of death. Likewise, this intervention reduces the risk of intrahousehold transmission. This hypothesis was contrasted by Song et al. (2021) in their analysis of the non-essential business closure order applied in Pennsylvania on March 19, 2020. They observed that the policy implementation reduced the likelihood of being positive for COVID-19 in workers who laboured in businesses designated as non-essential compared with those workers in essential jobs. In the case of the NEBC policy implemented in Andalusia, the main non-essential businesses affected by the intervention were those related to the hostelry (hotels, hostels, inn, beds and breakfasts, camps), catering (bars, restaurants, nightclubs), and sports (gyms, sport facilities) sectors where a high risk of superspreading events tend to be expected given the high level of close physic contact in crowded and/or poorly ventilated places (Delgado-Sánchez et al., 2022).

One of the main findings of this study is that the effectiveness of the NEBC policy seems to be related to the population size of the municipality. In this sense, we find that the intervention did not prevent the COVID-19 infections and deaths in those municipalities having a population size below 5,000 inhabitants (rural areas). On the contrary, in those municipalities with more than 5,000 inhabitants (urban areas), the effect of the policy was highly positive and significant by avoiding, on average, 100 and 1.3 COVID-19 infections and deaths, respectively, two weeks after the intervention. The features of these scarcely populated municipalities could explain why the NEBC policy was not effective. Recent studies have shown that the southern half of the Spanish territory features to present a low density of settlements and a high degree of population concentration in some areas compared to the rest of Spain and European countries (Gutiérrez et al., 2023). This means that rural municipalities tend to be far from each other, as well as from the main urban agglomerations. Furthermore, they usually present a low population density, which seems to be correlated to a lower COVID-19 infections and deaths rate at municipal level in Spain (Amate-Fortes & Guarnido-Rueda, 2023). Likewise, their non-essential activity is mainly based on the agricultural and farmer sectors and limited to a few businesses providing services to a small number of people. This situation implies that the risk of COVID-19 infections and deaths by means of the contact through non-essential businesses in these areas is already low. Given the negative consequences that the business closure could have for the economy of families and companies (loss of incomes, a higher risk of permanent closure of the companies, and a higher likelihood of unemployment) and its lack of effectiveness, these results suggest that the implementation of the NEBC policy could be avoided in those municipalities whose population is below 5,000 inhabitants.

Our results suggest that non-essential business closures can effectively reduce COVID-19 infections and deaths, but their effectiveness may vary depending on the population size of the municipality where the policy is implemented. This information can help policymakers make targeted and informed decisions about the implementation of NPIs, taking into account the unique socioeconomic features of the region or country in question.

This study is not without limitations. First, due to the lack of municipal-level information, we are not able to include more municipal characteristics in our vector of control variables, such as unemployment rate, GDP per capita, or the economic structure of each municipality. Having more data about municipalities could have provided us with a more accurate estimation of the results, as well as a wider discussion. Second, as explained in Section 4, our analysis is based weekly data. However, it is possible that the status of municipalities regarding mandated non-essential business closure may have changed within the week. Unfortunately, this kind of change cannot be observed in our data. As a result, there are some instances where we identified certain municipalities as a control group, but in reality, they may have been assigned to the policy group. Nonetheless, we have taken steps to minimize the potential impact of this limitation by conducting sensitivity analyses and robustness checks to assess the validity of our findings. These methods help to provide a more accurate picture of the causal effects of the policy, despite the potential for misclassification or unobserved changes in the data. Third, our study is internal validity is reliable and accurate, but caution should be exercised when generalizing the findings due to two important limitations. Firstly, the data we used for our study only represents a single region of Spain, which means that it may not be representative of other regions or areas with different characteristics. Secondly, our estimates of the effects of the NEBC policy can only be interpreted within the specific context of municipalities with a 14-day infection rate of around 1,000. This means that our findings may not be generalizable to areas with different epidemiological situations, and it is unclear what impact the NEBC policy would have in those areas. As a result, our study´s findings should be considered in the context of these limitations and should not be applied broadly without further research or analysis. Finally, it is worth noting that the data on COVID-19 cases and deaths may be underestimated due to the reliance on PCR or rapid antigen tests for diagnosis. As these tests may produce false negatives or individuals may not get tested, some cases may go undetected, and the impact of NPIs policies may be greater than what is reflected in the reported data. However, the degree of underestimation may vary depending on factors such as testing capacity, strategies, and the prevalence of the virus in the population, highlighting the need for caution in interpreting the results.

7 Conclusion

This study is one of the few studies to quantify reliably the role played by the non-essential business closure policies to reduce the number of new COVID-19 cases and deaths. We specifically assessed the policy implemented at the municipal level in Andalusia, Spain, during the third wave of the pandemic starting on January 17, 2021. The design of this policy allowed us to isolate the influence of other interventions on our variables of interest, thereby obtaining causal estimates by means of a regression discontinuity approach.

Our study findings suggest that the NEBC policies has been effective in reducing the number of COVID-19 cases and deaths. The intervention in our case study prevented approximately 700 deaths between January and May. Our analysis highlights that the effectiveness of the Andalusian NEBC policy varied depending on the population size of the municipality where it was implemented. Specifically, we found no significant effects of the policy in municipalities with a population size below 5,000 inhabitants, likely due to the lower risk of infection that non-essential activities have in these areas. Overall, these results support the use of NEBC policies as a mechanism to curb the spread of SARS-CoV-2 and other new variants or pathogens in the absence of more effective vaccines or medicines. However, it is important to apply such policies in a targeted and controlled manner that takes into account the socioeconomic features of the region or country in which the intervention is implemented.

Unfortunately, the lack of available municipal-level data prevented us from conducting additional analysis. Therefore, future research should aim to further investigate the role of NEBC policies and other non-pharmaceutical interventions in reducing COVID-19 infections and deaths, as well as their impact on public health and the economy. For example, it would be useful to empirically compare the effectiveness of the NEBC policy in municipalities where non-essential businesses have a marginal importance or a low risk of infection with those where they have a greater impact. Such research could provide valuable insights into the optimal use and implementation of NPIs in different contexts.

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A Appendix

A.1 Additional Tables and Figures

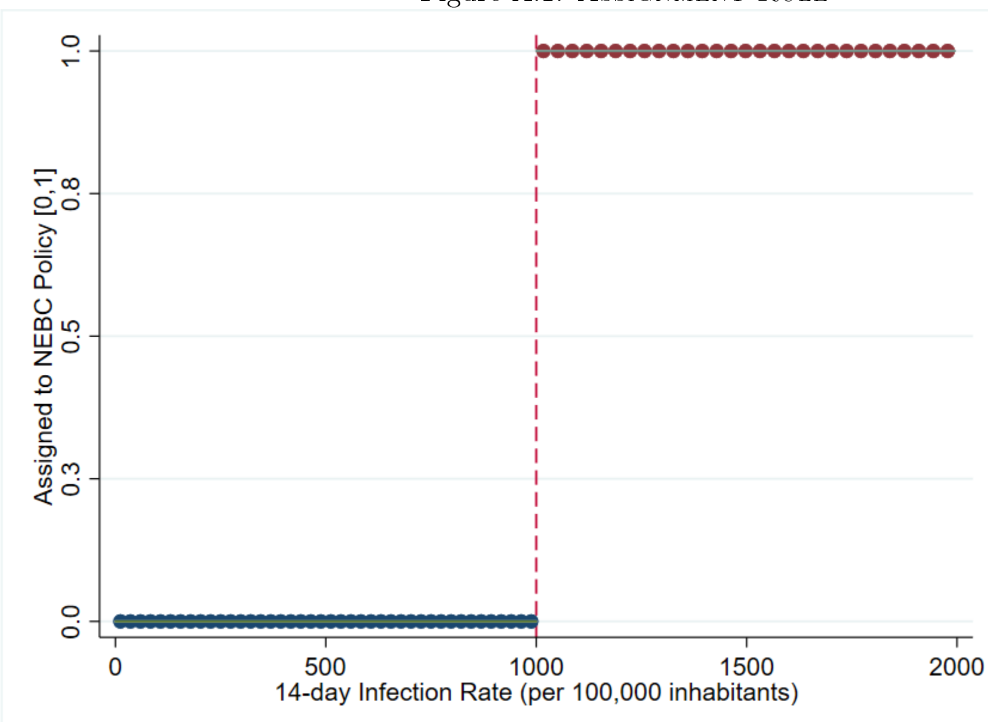
Table A.1: List of essential businesses which are allowed to open in municipalities with a 14-day infection rate by COVID-19 per 100,000 inhabitants above 1,000 cases

ID	**Business**
1	Commercial retail establishments for food, beverages, products and basic necessities
2	Health centres, services and establishments
3	Social and socio-sanitary services
4	Pharmacy
5	Parapharmacy
6	Veterinary centres or clinics
7	Supply markets
8	Optics and orthopaedic products
9	Hygienic products
10	Professional and financial services
11	Press, bookstore and stationery
12	Florist
13	Sale of fuel
14	Mechanical workshop
15	Repair services and construction material
16	Hardware stores
17	Vehicle technical inspection stations
18	Tobacconists
19	Technological and telecommunications equipment
20	Food for pets
21	Home delivery services
22	Dry cleaners
23	Laundries
24	Hairdressers
25	Household employees
26	Street markets

Table A.2: Municipalities by province and population size in Andalusia, 2021

Province	Number of Municipalities	Population $< 5,000$		Population $\geq 5,000$	
		n	%	n	%
Almería	103	82	79.6	21	20.4
Cádiz	45	13	28.9	32	71.1
Córdoba	77	52	67.5	25	32.5
Granada	174	133	76.4	41	23.6
Huelva	80	60	75.0	20	25.0
Jaén	97	69	71.1	28	28.9
Málaga	103	75	72.8	28	27.2
Sevilla	106	43	40.6	63	59.4
Andalusia	785	527	67.1	258	32.9

Figure A.1: Assignment Rule



Note: The Figure shows the non-essential business closure (NEBC) policy assignment rule.

Table A.3: Summary Statistics - Full Sample

	(1) Mean	S.D.	Min	Max
Total COVID-19 Cases	484.21	1873.65	0	41511
Total COVID-19 Deaths	8.54	34.71	0	744
14-day Infection Rate (per 100,000 people)	359.25	569.53	0	10976
Population	10726.58	39496.84	51	691395
N^o of Municipalities	115.85	37.58	51	179
Observations	21877			

Note: The Tables shows the summary statistics of the main variables of interest for the full-sample.

Table A.4: Summary Statistics - By Province

	(1) **Almería**	(2) **Cádiz**	(3) **Córdoba**	(4) **Granada**	(5) **Huelva**	(6) **Jaén**	(7) **Málaga**	(8) **Sevilla**
Total COVID-19 Cases	349.84	1106.20	454.81	341.31	253.32	348.24	631.62	732.42
	(1309.875)	(2083.026)	(1777.195)	(1483.654)	(692.438)	(823.459)	(2617.597)	(2869.499)
Total COVID-19 Deaths	4.87	19.53	8.67	7.01	3.01	7.40	10.68	12.28
	(16.070)	(42.289)	(30.557)	(32.463)	(8.162)	(19.348)	(44.866)	(53.726)
14-day Infection Rate (per 100,000 people)	323.33	425.84	342.07	395.38	373.65	394.51	309.03	326.83
	(643.548)	(469.317)	(596.573)	(605.506)	(589.796)	(545.819)	(566.397)	(422.923)
Population	7017.28	27605.36	10074.45	5270.59	6919.50	6519.53	16255.33	17604.09
	(23330.580)	(42276.258)	(36747.291)	(18588.277)	(17369.673)	(13666.570)	(60095.018)	(66281.681)
N^o of Municipalities	107.00	51.00	83.00	179.00	78.00	102.00	110.00	117.00
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2884	1260	2184	4872	2072	2716	2781	3108

Note: The Tables shows the summary statistics of the main variables of interest, by province

Table A.5: RD Estimates of the NEBC Policy - Different Polynomials Order of the Running Variable

	(1)	(2)	(3)	(4)
Panel A: COVID-19 Cases				
NEBC Policy [0,1]	-63.038***	-56.418***	-55.462***	-58.267***
	(17.009)	(18.514)	(18.761)	(17.992)
Panel B: COVID-19 Deaths				
NEBC Policy [0,1]	-0.774***	-0.691**	-0.689**	-0.708**
	(0.297)	(0.308)	(0.320)	(0.309)
$Z_{i,t}$	✓			
$Z_{i,t}^2$		✓		
$Z_{i,t}^3$			✓	
$Z_{i,t}^4$				✓
$P_{i,t} \cdot Z_{i,t}$	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Province FE	✓	✓	✓	✓
Observations	9816	9816	9816	9816

Note: In Panel A and B we present RD estimates of the NEBC policy on new COVID-19 cases and deaths, respectively. Key regressor: NEBC Policy [0,1]. This is a dummy for whether a municipality as a 14-day infection rate (per 10000 inhabitants) greater than 1000. The Table presents the consistency of our results with different polynomial orders of the running variable, ranging from a polynomial of order 1 (Column (1), or baseline estimates) to a polynomial of order 4 (Column (4)). Robust standard errors are clustered on the running variable. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.2 The Spanish Region of Andalusia

Andalusia is one of the seventeen regions composing Spain. It is located in the most south part of the Iberic Peninsula. According to the last population statistics published by the National Statistics Institute in July 2022 (NSI, 2022), it had a population size of around 8.5 million of people (4.2 million of men, and 4.3 million of women), so it is the most populated Spanish region. Likewise, it is one of the regions with the lowest GDP per capita (19,522 euros to current prices in 2019) only before Extremadura and Melilla (NSI, 2022). The territory of Andalusia is administratively divided into eight provinces. In turn, each province is composed of several municipalities. In total, there are 785 municipalities in the whole territory. They are usually sparsely populated municipalities. Around 70 percent of them has a population lower than 5,000 inhabitants (around 30 percent lower than 1,000 inhabitants and 40 percent between 1,000 and 5,000 inhabitants) (see Table A.1). Only 12 municipalities have a population higher than 100,000 inhabitants.

In Spain, three government levels can be mainly distinguished: state or central government, regional government (autonomous communities), and local government (provinces and municipalities). Although the state-wide government is the responsible for the development of the basic legislation applying in the whole Spain in most of main areas, there exists a high administrative decentralisation mainly in the regional level. In this way, Andalusia has its own government, which is responsible for the management of issues like, among others, healthcare, agriculture, environmental protection, territorial planning, or rails and roads inside their territory. These competences are financed by means of taxes and levelling subsidies devolved by the central government, as well as of their own fiscal revenues from the fiscal decentralisation.