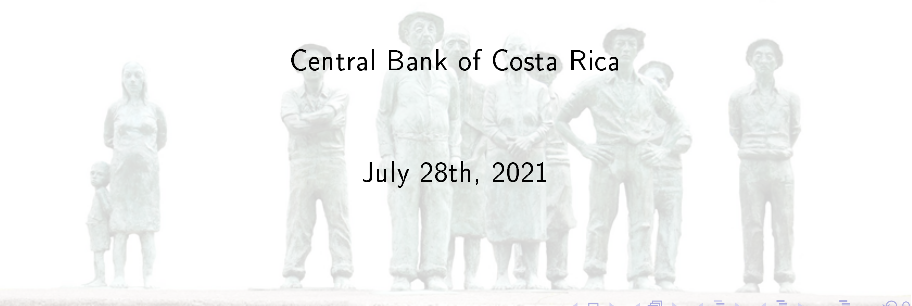
Impact of COVID-19 Restrictions in Costa Rica: a Local Approach

José Pablo Barquero
Esteban Méndez-Chacón
Carlos Segura-Rodriguez

Central Bank of Costa Rica

July 28th, 2021



Introduction

- Governments have implemented social distant measures due to COVID-19:
  - Hope is to decrease COVID-19 spread and the number of deaths.
  - Indirect negative effect in economic activity and employment.
- In Costa Rica, such measures have been tailored by municipality.
- We aim to use these differences to measure the effect of restrictions on economic activity, and the number of cases and deaths.

Introduction

Main result: the restrictions reduce the weekly growth rate of COVID-19 cases and deaths. However, the restrictions also negatively impact commercial activity.

- Municipalities that are under more restrictive measures:
  - Have a reduction in case growth rate of 6 %, and deaths of 12 %.
  - Have a reduction in commercial electricity consumption of 2 %.
  - Have no significant impact on total, residential or industrial electricity consumption.
- We explored the different components of the sanitary restrictions that can explain the findings:
  - Both the plate restrictions as well as the hours that driving is permitted have a significant impact.
  - Still work in progress.

Overview

Institutional Setting

- Costa Rica is administratively divided into 82 municipalities.
- For each municipality, the government periodically analyses data from infections, hospitalizations, and the number of positive tests. This is an input to decide which municipalities are placed on an orange alert.

Sanitary Alerts by Municipality during July 2020

Data

We collected data on alerts by municipality, and the specific policies that were put in place:

- Whether a municipality is in an orange alert.
- Percentage of license plates that can circulate.
- The hours of the day that vehicles cannot circulate.
- Source: National Emergency Commission (CNE).
- Daily data: From March 15th, 2020 to June 30th, 2021.

We are still working on collecting business closure policies data.

Data

To obtain a measure of the benefits related to the sanitary restrictions, we consider:

- The number of new COVID-19 cases and deaths, per municipality.
- Source: Ministry of Health.
- Daily data: From March 15th, 2020 to July 7th, 2021.

Data

To obtain an assessment of the economic cost of the restrictions, we consider as outcome variables:

- Electricity consumption, as a proxy for economic activity.
- Source: National Center for Energy Control (CENCE).
- The data is at a monthly level (From January 2017 to April 2021).
- The data differentiate between different uses:
    - Residential.
    - Commercial.
    - Industrial.

Data

Table. Relation between economic activity and electricity consumption between July 2019 and April 2021.

	log(VAT)
log(Electricity)	1.38
	(0.09)***
Time effects	Yes
N	1,628
Adjusted R^2	0.77

Notes: Robust standard error, adjusted for clustering by municipality, is in parentheses.
*** $p < 0{,}01$

The relationship is similar to findings in previous studies (e.g., Chen et al., 2020; Beyer et al, 2021).

Estimation Framework - Benefits related to the restrictions

- As outcome variables, we follow Chernozhukov et al. (2020), and consider the weekly growth rate of confirmed cases and deaths.
- For the confirmed cases:

$$\Delta log(\Delta C_{it}) = log(\Delta C_{it}) - log(\Delta C_{i,t-7})$$

  - Where C_{it} is the cumulative number of confirmed cases in municipality i on day t.
  - Δ denotes the differencing operator over 7 days from t to $t-7$. Therefore $\Delta C_{it} = C_{it} - C_{i,t-7}$

- Similarly, for deaths:

$$\Delta log(\Delta D_{it}) = log(\Delta D_{it}) - log(\Delta D_{i,t-7})$$

Estimation Framework - Benefits Related to the Restrictions

- To deal with zeros in our data, we use the inverse hyperbolic sine transformation $(\ln(y + (y^2 + 1)^{\frac{1}{2}}))$.
- In our baseline estimation, we restrict attention to alerts between June 3rd, 2020, and May 18th, 2021.

Estimation Framework - Benefits Related to the Restrictions

$$\Delta log(\Delta C_{it}) = \alpha + \gamma Orange_{i,t-14} + \mathbf{X}_{i,t-14}\beta + \beta_d + \beta_m + \beta_i + \beta_m\beta_i + \varepsilon_{it}$$

- $\Delta log(\Delta C_{it})$ is the weekly growth rate of confirmed cases for municipality i.
- $Orange_{i,t-14}$ is a dummy variable equal to 1 if municipality i was under an orange alert 14 days before. We choose a lag of 14 days because it is the period when nearly all cases develop symptoms after exposure (McAloon et al., 2020).
- $\mathbf{X}_{i,t-14}$ is a vector with characteristics for municipality i.
- β_d, β_m, and β_i corresponds to day of the week, month, and municipality fixed effects, respectively.
- γ **captures the effect of the restrictions to control COVID-19 spread on case growth.**

Estimation Framework - Benefits Related to the Restrictions

$$\Delta log(\Delta D_{it}) = \alpha + \gamma Orange_{i,t-21} + \mathbf{X}_{i,t-21}\beta + \beta_d + \beta_m + \beta_i + \beta_m\beta_i + \varepsilon_{it}$$

- $\Delta log(\Delta D_{it})$ is the weekly growth rate of deaths for municipality i.
- $Orange_{i,t-21}$ is a dummy variable equal to 1 if municipality i was under an orange alert 21 days before. We choose a lag of 21 days because it corresponds to the period that studies have found between exposure to death (Chernozhukov et al., 2020).
- $\mathbf{X}_{i,t-21}$ is a vector with characteristics for municipality i.
- β_d, β_m, and β_i corresponds to day of the week, month, and municipality fixed effects, respectively.
- **γ captures the effect of the restrictions to control COVID-19 spread on death growth.**

Estimation Framework - Costs Related to the Restrictions

$$\Delta log(y_{im}) = \alpha + \gamma Orange_{i,m} + \mathbf{X}_{i,m}\beta + \beta_m + \beta_t + \beta_m\beta_t + \varepsilon_{it}$$

- $\Delta log(y_{im})$ is the monthly growth rate of the economic outcome for the municipality i.
- $Orange_{i,m}$ is a variable that ranges from 0 to 1, and indicates the fraction of days during month m that municipality i was under an orange alert.
- $\mathbf{X}_{i,m}$ is a vector with characteristics for municipality i.
- β_m and β_t corresponds to month and municipality fixed effects, respectively.
- **γ captures the effect of the restrictions to control COVID-19 spread on economic outcomes.**

Results - Benefits Related to the Restrictions

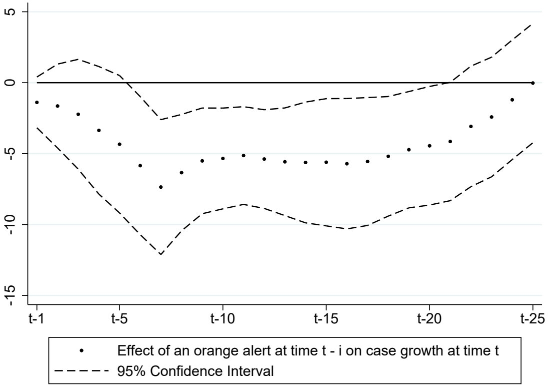
Table. The effect of an orange alert on case and death growth (N= 28,700 and 82 Clusters)

	Weekly growth rate of			
	Confirmed cases		Deaths	
	(1)	(2)	(3)	(4)
lag(Orange alert, 14)	**-0.082**	**-0.056**		
	(0.023)***	(0.021)***		
lag(Orange alert, 21)			**-0.111**	**-0.117**
			(0.037)***	(0.037)***
Past cases/deaths at municipality and national level	No	Yes	No	Yes
Day fixed effect	No	Yes	No	Yes
Adjusted R^2	0.121	0.173	0.030	0.032

Notes: Fixed effects specification. Robust standard errors, adjusted for clustering by municipality, are in parentheses. All regressions include municipality-by-month fixed effects and month fixed effects.
* $p < 0{,}10$, ** $p < 0{,}05$, *** $p < 0{,}01$

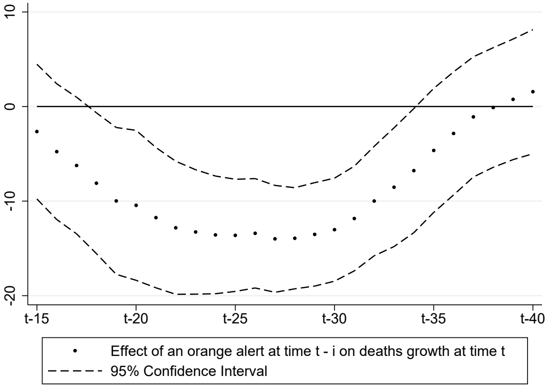
Robustness: Alternative Timing

- For confirmed cases, the result is robust to alternative timing, as long as we consider an alert imposed from 6 to 20 days before.
- The pattern is in line with the COVID-19 incubation period: nearly all cases develop symptoms within 14 days of exposure, with a median period of approximately 5-6 days (McAloon et al., 2020).

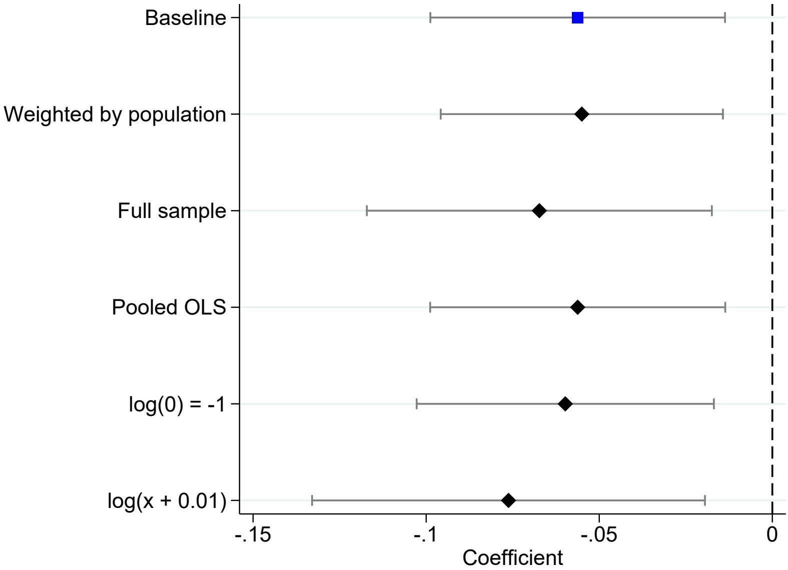


Robustness: Alternative Timing

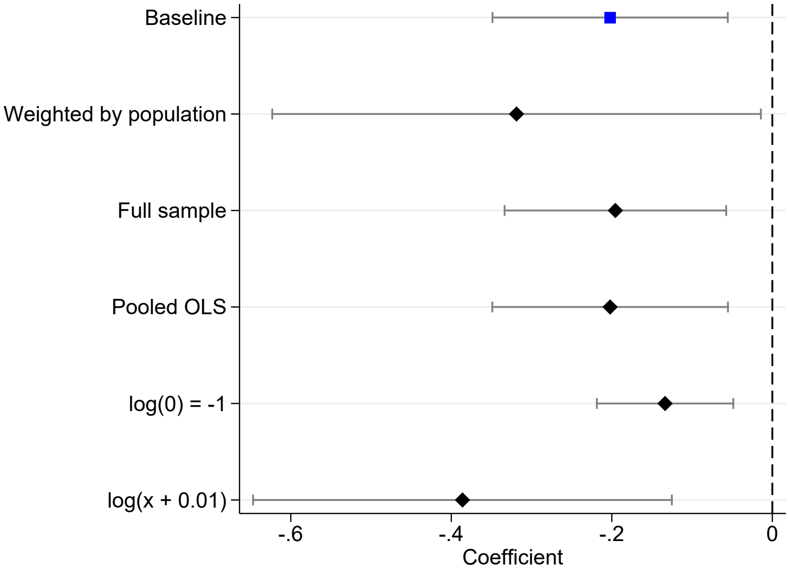
- For deaths, the result is robust to consider an alert imposed from 18 to 34 days before.
- The pattern is consistent with estimates of median time from illness onset to death: 18,5 days (Zhou et al., 2020)



Robustness for Weekly Case Growth



Robustness for Weekly Death Growth



Mechanism - Benefits Related to the Restrictions

Table. The effect of policies on case and death growth (N= 36,900 and 82 Clusters)

	Weekly growth rate of			
	Confirmed cases		Deaths	
	(1)	(2)	(3)	(4)
100 % of license plates can circulate	vs.	vs.	vs.	vs.
80 % of license plates	**-0.092**	**-0.093**	**-0.178**	**-0.145**
	(0.013)***	(0.018)***	(0.054)***	(0.082)*
50 % of license plates	**-0.088**	**-0.098**	**-0.159**	**-0.068**
	(0.014)***	(0.013)***	(0.049)***	(0.041)
20 % of license plates	**-0.038**	**-0.066**	**0.185**	**0.232**
	(0.044)	(0.046)	(0.243)	(0.232)
Fraction of day that vehicles cannot circulate	**-0.513**	**-0.482**	**-0.472**	**-0.485**
	(0.155)***	(0.192)**	(0.402)	(0.413)
Past cases deaths/ at municipality and national level	No	Yes	No	Yes
Day fixed effect	No	Yes	No	Yes
Adjusted R^2	0.103	0.125	0.030	0.033

Notes: Fixed effects specification. Robust standard errors, adjusted for clustering by municipality, are in parentheses. All regressions include municipality-by-month fixed effects and month fixed effects.
* $p < 0{,}10$, ** $p < 0{,}05$, *** $p < 0{,}01$

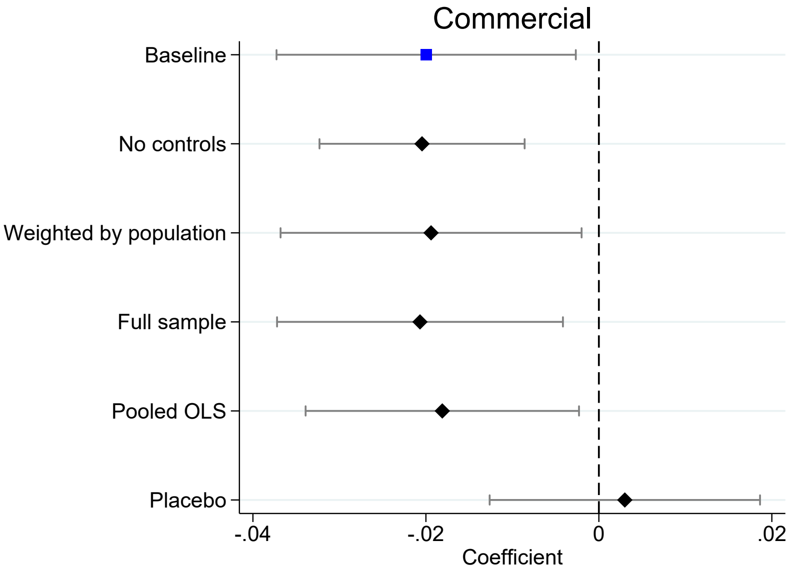
Results - Costs Related to the Restrictions

Table. The effect of an orange alert on electricity consumption growth (N= 822 and 82 Clusters)

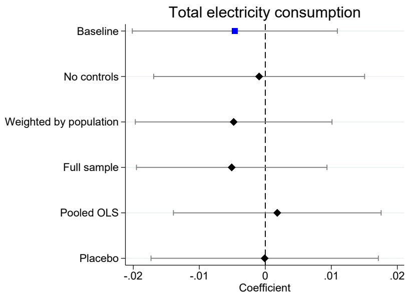
	Monthly growth rate of			
	Total	Residential	Commercial	Industrial
	(1)	(2)	(3)	(4)
Orange alert	**-0.005**	**-0.007**	**-0.020**	**-0.062**
	(0.008)	(0.006)	(0.009)**	(0.035)*
Past cases/deaths at municipality and national level	No	Yes	No	Yes
Adjusted R^2	0.474	0.714	0.538	0.314

Notes: Fixed effects specification. Robust standard errors, adjusted for clustering by municipality, are in parentheses. All regressions include municipality-by-month fixed effects and month fixed effects.
* $p < 0{,}10$, ** $p < 0{,}05$, *** $p < 0{,}01$

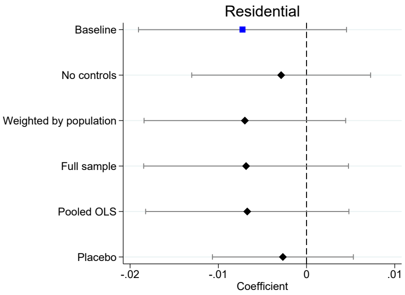
Robustness


Commercial
Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo
-.04
-.02
0
.02
Coefficient

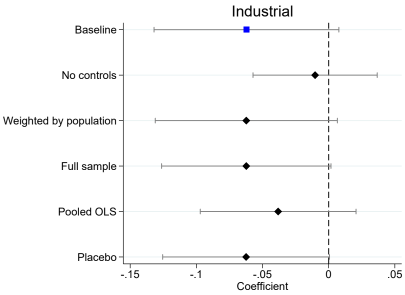
Robustness



Total electricity consumption
Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo
-.02
-.01
0
.01
.02
Coefficient



Residential
Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo
-.02
-.01
0
.01
Coefficient



Industrial
Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo
-.15
-.1
-.05
0
.05
Coefficient

Mechanism - Costs Related to the Restrictions

Table. The effect of policies on electricity consumption (N= 863 and 82 Clusters)

	Monthly growth rate of			
	Total	Residential	Commercial	Industrial
	(1)	(2)	(3)	(4)
100 % of license plates can circulate	vs.	vs.	vs.	vs.
80 % of license plates	**-0.084**	**0.104**	**-0.464**	**0.108**
	(0.062)	(0.034)***	(0.052)***	(0.174)
50 % of license plates	**0.107**	**0.097**	**-0.399**	**0.244**
	(0.167)	(0.049)**	(0.070)***	(0.291)
20 % of license plates	**-0.233**	**0.076**	**-0.574**	**0.176**
	(0.120)*	(0.062)	(0.096)***	(0.359)
Fraction of day that vehicles cannot circulate	**0.190**	**0.027**	**0.018**	**0.216**
	(0.124)	(0.069)	(0.117)	(0.359)
Past cases/deaths at municipality and national level	Yes	Yes	Yes	Yes
Adjusted R^2	0.432	0.545	0.611	0.657

Notes: Fixed effects specification. Robust standard errors, adjusted for clustering by municipality, are in parentheses. All regressions include municipality-by-month fixed effects and month fixed effects.
* $p < 0{,}10$, ** $p < 0{,}05$, *** $p < 0{,}01$

Preliminary Conclusions

- Our results suggest that the sanitary restrictions have decreased the spread of COVID-19 by 6 %. Similarly, the restrictions have reduced the growth rate of deaths by 12 %.
- However, these benefits come at a cost. The commercial electricity consumption in the municipalities subject to the restrictions decreased by 2 %.

Next Steps

- We are still collecting data on other types of restrictions not considered in the previous analysis. The most relevant is probably business closure policies.

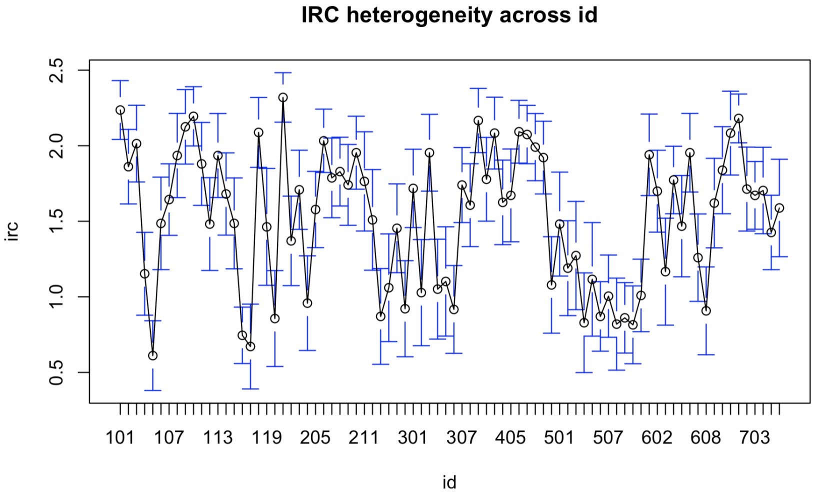
Thank you!

Municipal Index Risk, IRC

- The IRC summarizes the risk level in a municipality using data from infections, hospitalizations and amount of positive tests then it is used by authorities to define the alert level.
- If a formula based in observed past maximums values for each variable and weighted averages returns a value greater than 2 the alert level should be orange (high).
- Reconstructing the index we noticed that around 30 percent of the declared alerts do not coincide with the index calculations.
- Therefor we show graphs and calculate different sets of estimations for each sub set: consistent index and alert, and inconsistent index and alert.

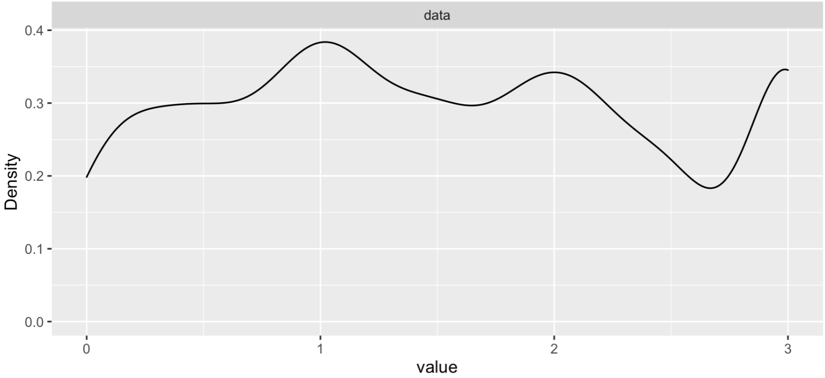
IRC, heterogeneity across municipalities

- For consistent index and alert.



IRC Levels

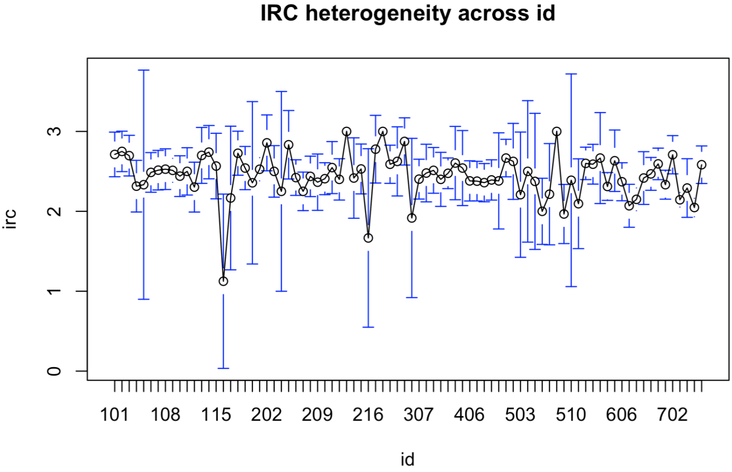
- Frequency data for IRC level calculations for consistent data.



- Values around 1 and around 3 are more frequent.

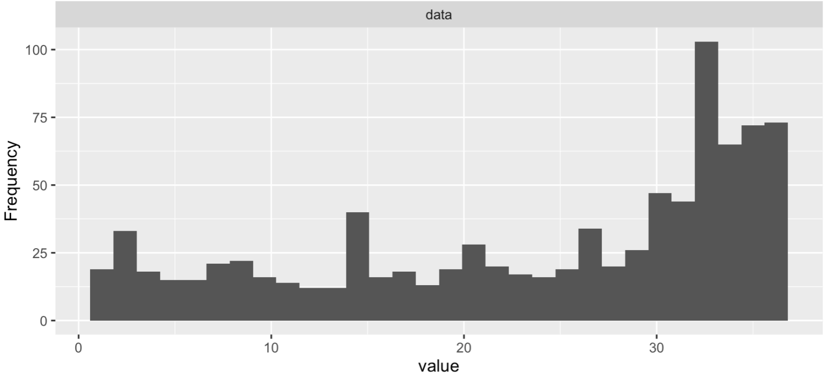
IRC, heterogeneity across municipalities

- For inconsistent index and alert.



Periods for inconsistent data

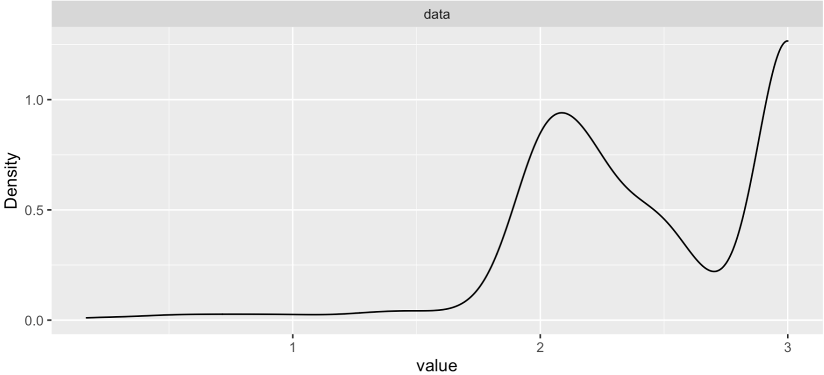
- Histogram for periods with inconsistencies.



- More recent periods are more probable to have inconsistencies.

IRC Levels for inconsistent data

- Frequency data for IRC level calculations for inconsistent data.



- Higher values around 2 and around 3 are more frequent.

Estimations for IRC determinants

- The models try to estimate which of the factor is more important to determine the IRC level.

Municipality Risk Indez IRC	Consistent IRC data	
Estimation method	*Fixed Effects**	*Random Effects**
Attack Rate (TA)	4.490	4.763
Hospitalization Rate (TH)	0.018	0.019
Positive Tests Rate (IP)	0.851	0.838
ID effects	All significant	
p(F/Chi)	2.20E-16	2.20E-16

*/ all coefficients are significant at 90%

Hausman Test

Chi	180.19
p(Chi)	2.2E-16
Decision	*Fixed effects model*

- The attack rate, which summarizes the risk to get sick from COVID-19 is the most important determinant of the risk level calculated.