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Central Bank of Costa Rica

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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.
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.

We are still working on collecting business closure policies 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.

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.

<table>
<thead>
<tr>
<th></th>
<th>log(VAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(Electricity)</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>(0.09)***</td>
</tr>
<tr>
<td>Time effects</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>1,628</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.77</td>
</tr>
</tbody>
</table>

*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).
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 \( t \).

\( \Delta \) 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:

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

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

- \( \Delta \log(\Delta C_{it}) \) is the weekly growth rate of confirmed cases for municipality \( i \).

- \( \text{Orange}_{i,t-14} \) 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 (McAlloon et al., 2020).

- \( \mathbf{X}_{i,t-14} \) is a vector with characteristics for municipality \( i \).

- \( \beta_d, \beta_m, \) and \( \beta_i \) corresponds to day of the week, month, and municipality fixed effects, respectively.

- \( \gamma \) captures the effect of the restrictions to control COVID-19 spread on case growth.
Estimation Framework - Benefits Related to the Restrictions

\[ \Delta \log(\Delta D_{it}) = \alpha + \gamma Orange_{i,t-21} + X_{i,t-21} \beta + \beta_d + \beta_m + \beta_i + \beta_m \beta_i + \varepsilon_{it} \]

- \( \Delta \log(\Delta D_{it}) \) 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).

- \( X_{i,t-21} \) is a vector with characteristics for municipality \( i \).

- \( \beta_d, \beta_m, \) and \( \beta_i \) corresponds to day of the week, month, and municipality fixed effects, respectively.

- \( \gamma \) captures the effect of the restrictions to control COVID-19 spread on death growth.
Estimation Framework - Costs Related to the Restrictions

\[ \Delta \log(y_{im}) = \alpha + \gamma \text{Orange}_{i,m} + X_{i,m}\beta + \beta_m + \beta_t + \beta_m\beta_t + \epsilon_{it} \]

- \( \Delta \log(y_{im}) \) is the monthly growth rate of the economic outcome for the municipality \( i \).
- \( \text{Orange}_{i,m} \) 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.
- \( X_{i,m} \) is a vector with characteristics for municipality \( i \).
- \( \beta_m \) and \( \beta_t \) corresponds to month and municipality fixed effects, respectively.
- \( \gamma \) 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)

<table>
<thead>
<tr>
<th></th>
<th>Confirmed cases</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>lag(Orange alert, 14)</td>
<td>-0.082</td>
<td>-0.056</td>
</tr>
<tr>
<td></td>
<td>(0.023)***</td>
<td>(0.021)***</td>
</tr>
<tr>
<td>lag(Orange alert, 21)</td>
<td></td>
<td>-0.111</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.037)***</td>
</tr>
<tr>
<td>Past cases/deaths at</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>municipality and</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>national level</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Day fixed effect</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.121</td>
<td>0.173</td>
</tr>
<tr>
<td></td>
<td>0.030</td>
<td>0.032</td>
</tr>
</tbody>
</table>

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).

![Effect of an orange alert at time t - i on case growth at time t](image)

- Effect of an orange alert at time t - i on case growth at time t
- 95% Confidence Interval
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

Baseline
Weighted by population
Full sample
Pooled OLS
log(0) = -1
log(x + 0.01)

Coefficient

BCCR COVID-19 in Costa Rica
## Robustness for Weekly Death Growth

<table>
<thead>
<tr>
<th>Method</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-0.6</td>
</tr>
<tr>
<td>Weighted by population</td>
<td>-0.4</td>
</tr>
<tr>
<td>Full sample</td>
<td>-0.2</td>
</tr>
<tr>
<td>Pooled OLS</td>
<td>0</td>
</tr>
<tr>
<td>(\log(0) = -1)</td>
<td>-0.6</td>
</tr>
<tr>
<td>(\log(x + 0.01))</td>
<td>-0.2</td>
</tr>
</tbody>
</table>

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**BCCR COVID-19 in Costa Rica**
Table. The effect of policies on case and death growth (N= 36,900 and 82 Clusters)

<table>
<thead>
<tr>
<th>Percentage of License Plates</th>
<th>Confirmed cases (1)</th>
<th>Confirmed cases (2)</th>
<th>Deaths (3)</th>
<th>Deaths (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% of license plates can circulate vs. vs. vs. vs. 80% of license plates</td>
<td>-0.092 (0.013)*** vs. -0.093 (0.018)*** vs. -0.178 (0.054)*** vs. -0.145 (0.082)***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% of license plates</td>
<td>-0.088 (0.014)*** vs. -0.098 (0.013)*** vs. -0.159 (0.049)*** vs. -0.068 (0.041)***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20% of license plates</td>
<td>-0.038 (0.044) vs. -0.066 (0.046) vs. 0.185 (0.243) vs. 0.232 (0.232)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fraction of day that vehicles cannot circulate

<table>
<thead>
<tr>
<th>Past cases deaths/ at municipality and national level</th>
<th>No</th>
<th>Yes</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day fixed effect</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.103</td>
<td>0.125</td>
<td>0.030</td>
<td>0.033</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th></th>
<th>Total (1)</th>
<th>Residential (2)</th>
<th>Commercial (3)</th>
<th>Industrial (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange alert</td>
<td>-0.005</td>
<td>-0.007</td>
<td>-0.020</td>
<td>-0.062</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.006)</td>
<td>(0.009)**</td>
<td>(0.035)*</td>
</tr>
<tr>
<td>Past cases/deaths at</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>municipality and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>national level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.474</td>
<td>0.714</td>
<td>0.538</td>
<td>0.314</td>
</tr>
</tbody>
</table>

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

![Graph showing coefficient values for different scenarios: Baseline, No controls, Weighted by population, Full sample, Pooled OLS, Placebo. Coefficients range from approximately -0.04 to 0.02.]

- Coefficient for Baseline: -0.02
- Coefficient for No controls: -0.04
- Coefficient for Weighted by population: -0.02
- Coefficient for Full sample: -0.04
- Coefficient for Pooled OLS: 0
- Coefficient for Placebo: 0
Robustness

Total electricity consumption

Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo

Coefficient

Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo

Coefficient

Residential

Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo

Coefficient

Industrial

Baseline
No controls
Weighted by population
Full sample
Pooled OLS
Placebo

Coefficient
Mechanism - Costs Related to the Restrictions

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

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

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.
- Therefore 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.
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.

![IRC heterogeneity across id graph](image-url)
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.

<table>
<thead>
<tr>
<th>Municipality Risk Index IRC</th>
<th>Consistent IRC data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimation method</td>
<td>Fixed Effects*</td>
</tr>
<tr>
<td>Attack Rate (TA)</td>
<td>4.490</td>
</tr>
<tr>
<td>Hospitalization Rate (TH)</td>
<td>0.018</td>
</tr>
<tr>
<td>Positive Tests Rate (IP)</td>
<td>0.851</td>
</tr>
<tr>
<td>ID effects</td>
<td>All significant</td>
</tr>
<tr>
<td>p(F/Chi)</td>
<td>2.20E-16</td>
</tr>
</tbody>
</table>

*/ all coefficients are significant at 90%

**Hausman Test**

<table>
<thead>
<tr>
<th>Chi</th>
<th>180.19</th>
</tr>
</thead>
<tbody>
<tr>
<td>p(Chi)</td>
<td>2.2E-16</td>
</tr>
</tbody>
</table>

**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.