Social Distancing, Temperature, BCG and the Evolution of Covid-19: A Panel-Model Analysis

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Eduardo Lima Campos
EPGE, ENCE

Rubens Penha Cysne
EPGE

Alexandre Madureira
EPGE, LNCC

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Topics in Empirical Analysis and Economic Modeling Related to COVID-19

EPGE Escola Brasileira de Economia e Finanças

1. Overview

- Objective:

Investigate and measure the possible association between some variables and daily variation rate of cases of COVID-19.

- Sample:

Panel data for 165 countries from January, 22 to July, 31.

- Model

Empirical panel model, no theoretical foundation.

2. Some Recent Works

- Effects of Social Distancing

  Alfano & Ercolano (2020)

  Baumgartner et al (2020)

  Cano et al (2020)

  Maloney et al (2020)

- Effects of Climate Variables

  Fredericks (2020)

  Wang et al (2020)

  Shi et al (2020)

2. Some Recent Works

- Effects of BCG

  Hamiel et al (2020)

  Miller et al (2020)

  Sala et al (2020)

  Shet et al (2020)

3. Our Contributions

1 - A more precise statistical analysis of the possible assotiation between COVID-19 and climate variables, controlling “omitted variables” that might be confusion factors.

2 - The use of new control variables still not exploited by the literature. For example: the number of days since the first case.

3 - A indicator of social distancing, based on the percentage of people circulating on the streets in relation to a pre-pandemic period (3rd January - 6th February 2020).

Source: Google COVID-19 Community Mobility Reports.

4 - A wider way to measure the BCG effect, considering time to immunization. We do not take into account only if the country has BCG coverage or not. Instead, we try to estimate the percentage of people immunizated by the vaccine, considering:

- Immunization time
- Age structure
- Years as of the last vacination program
- Birth and mortality rates

4. Data

- Daily number of new COVID-19 cases

  Source: OMS - https://covid19.who.int/table

- Climate variables

  - Temperature

  - Precipitation

  - Humidity

  Source: NOAA (National Oceanic and Atmospheric Administration)

  https://www.ncdc.noaa.gov/cdo-web/datatools/selectlocation and

  https://www.ncei.noaa.gov/access/search/data-search/daily-summaries

- Relative percentage of people circulation

  (in relation to the pre-pandemic period)

  Source: Google - https://www.google.com/covid19/mobility/

- BCG Vaccine Immunization

  - Coverage percentage data

Source: OMS - https://www.who.int/data/gho/indicator-metadata-registry/imr-details/2442

  - Demographic data

Source: World Bank - https://data.worldbank.org/indicator/SP.DYN.CDRT.IN

- Proportion of elderly people

Source: World Bank - https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS

- Days since first case

Source: Our World in Data - https://ourworldindata.org/coronavirus-data-explorer?tab=map&zoomToSelection=true&country=~OWID_WRL&region=World&casesMetric=true&interval=daily&hideControls=true&smoothing=0&pickerMetric=location&pickerSort=asc

- Capacity of healthcare system (ICU hospital beds)

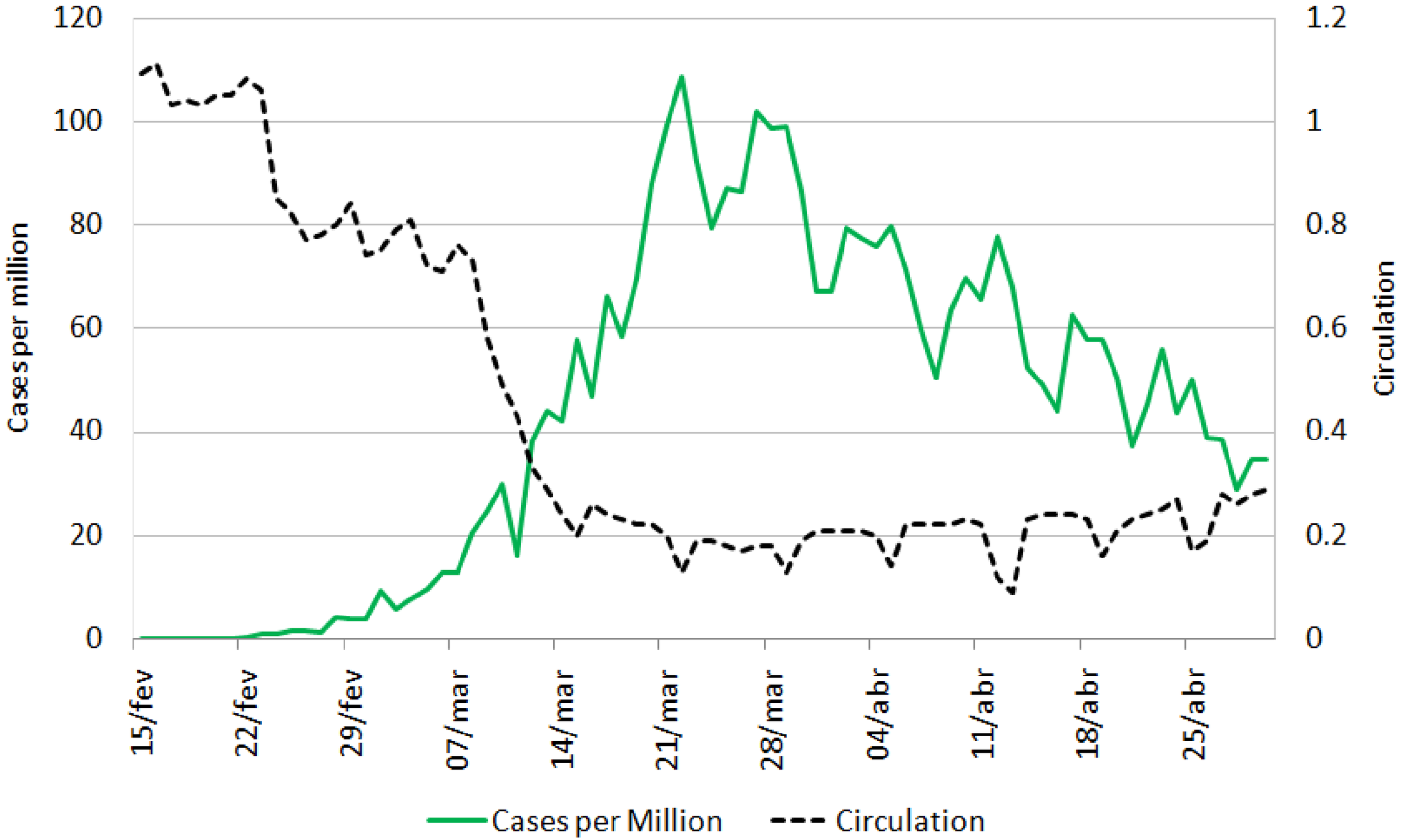
Source: World Bank - https://data.worldbank.org/indicator/SH.MED.BEDS.ZS

- Other variables (not significant)

5. Social Distancing Indicator

$$\mathrm{SD}_{it} = \begin{cases} 1, \text{if circulation(compared to pre} - \text{pandemic)} < 4 \\ 0, \text{if circulation(compared to pre} - \text{pandemic)} \geq 4 \end{cases}$$

COVID-19 (cases per million) x People Circulation (%) – Italy

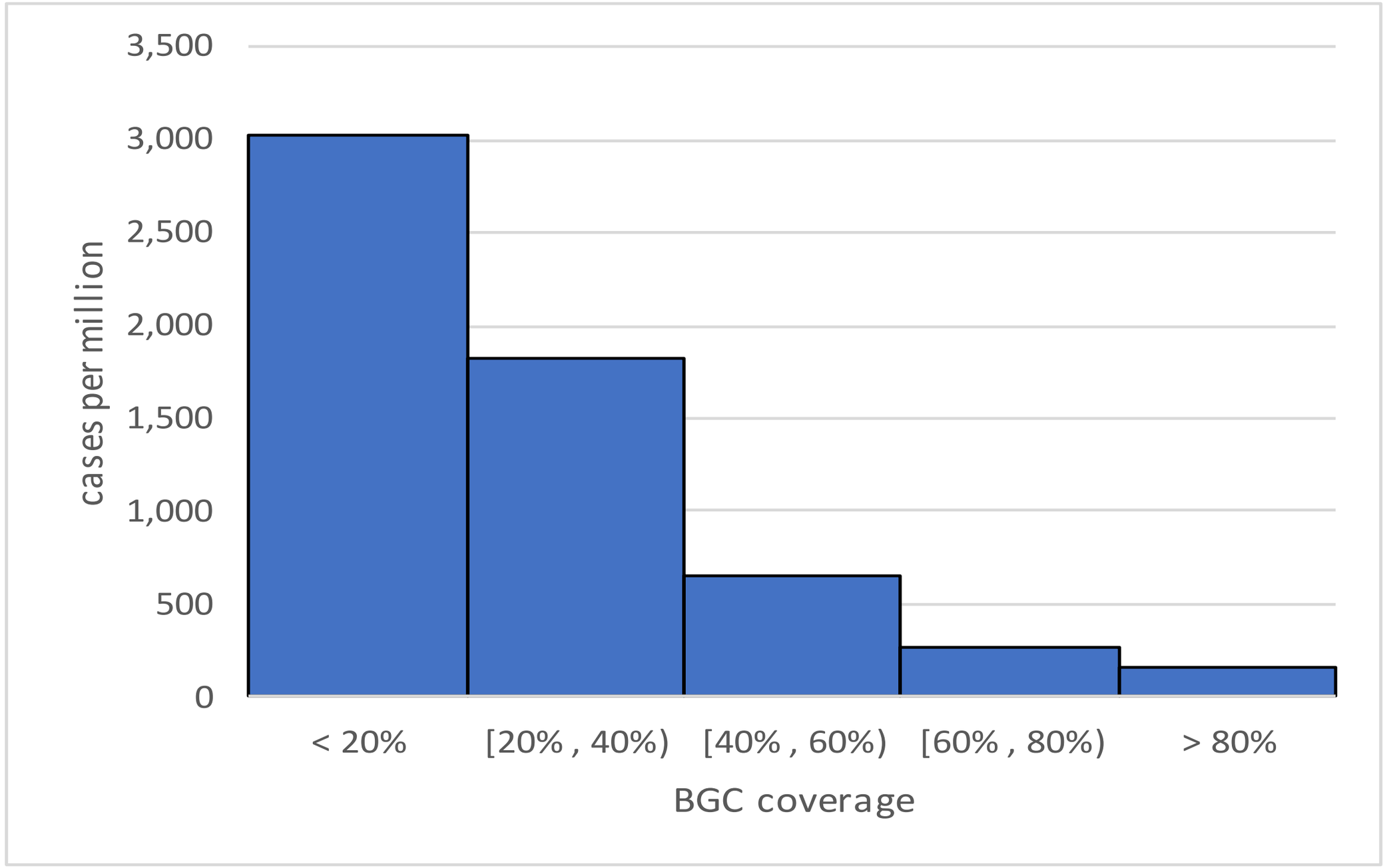


6. BCG Imunization Indicator

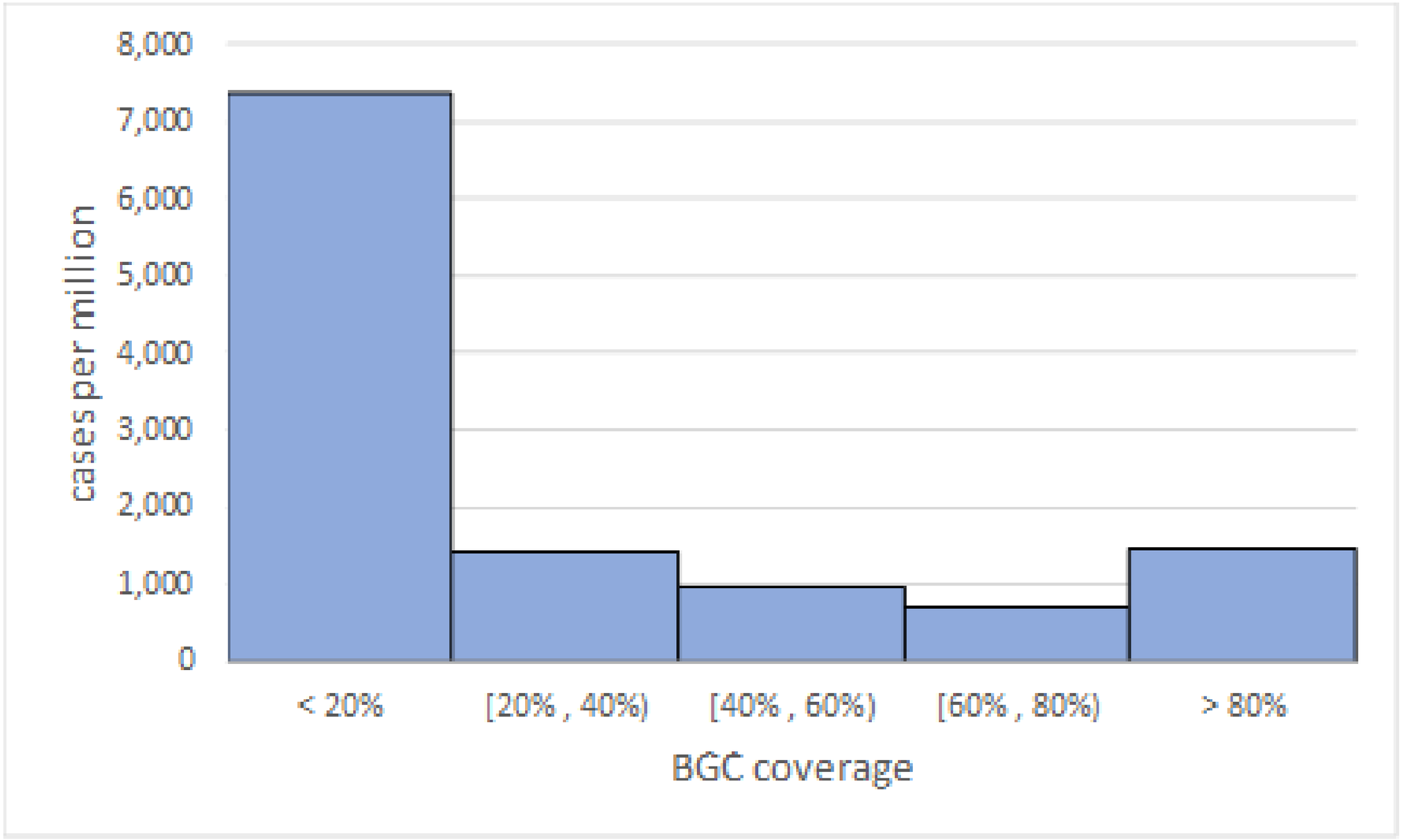
$$\text{BCG}_{\,i} = \begin{cases} \text{p, if the country has p\% of the population covered} \\ k, \text{if the country } \mathbf{had} \text{ BCG vacine coverage in the past} \\ 0, \text{if the country had never a BCG vacine coverage} \end{cases}$$

k = coverage percentage when the vacination program was interrupted, actualizated by demographic factors.

- **COVID-19 (cases per million) x BCG Coverage (%) - 30/04/2020**



- **COVID-19 (cases per million) x BCG Coverage (%) - 31/07/2020**



7. Model

$$\ln\left(\frac{C_{it}}{C_{i,t-1}}\right) = \gamma_i + \gamma_i \mathbf{t} + \phi_t + \theta' \mathbf{X} + \varepsilon_{it}$$

C_{it} : number of cases per million of COVID-19 (country i, day t)

γ_i: fixed effect between countries – intercept

$\gamma_i \mathbf{t}$: fixed effect between countries – trend

ϕ_t: fixed effect – over time

$\mathbf{X}$: independent variables (described in next section)

8. Significant Variables

$Temp_{it}$: average temperature in country i and on day t;

BCG_i: estimated proportion of immunization for BCG in country i;

FC_{it}: number of days since the first case of COVID-19 was registered in country i and on day t;

SD_{it}: binary variable that indicates whether or not there is strict social distancing $=$

$$\begin{cases} 1, \text{if } circutation < 40\% \text{ of that observed pre} - \text{pandemic} \\ 0, \text{if } circuation \geq 40\% \text{ of that observed pre} - \text{pandemic} \end{cases}$$

EP_i:proportion of elderly people (aged 65 or greater) in country i

HM_{it}: average humidity (10^3 hPA Kg/Kg)

HB_i: number of ICU beds per thousand people

9. Results

Label	Variable	Coeficient
Constant	C	0.01097
Temperature	$Temp_{it}$	- 0.000093
Social Distancing	SD_{it}	- 0.06024
DaysSinceFirst case	FC_{it}	0.00027
PercentageofElderly People	EP_i	0.03541
BCG Immunization	BCG_i	- 0.00196
Humidity	HM_{it}	- 0.00070
ICU Beds	HB_i	- 0.00102
Non-linear and interaction terms	$Temp_{it}^2$	0.00002
	$Temp_{it}\, SD_{it}$	0.00024
	$SD_{it}FC_{it}$	0.00008
	BCG_iEP_i	0.00207

10. Discussion

- lower temperatures might favor the epidemic evolution, especially in countries whose average temperature is very low, below 3°C. The magnitude of the impact, however, is quite small.

- The greater the elderly population, the greater the COVID-19 growth rate.

- The evolution of the disease seems to be a little more severe in drier climates.

- The capacity of the healthcare system attenuates the COVID-19 evolution.

- Data and model used make it impossible to deny the hypothesis that populations with a higher percentage of BCG immunization experience a milder evolution of COVID-19. The effect is attenuated as the population ages.

- What about the effect of social distancing?

11. Social Distancing Effects

Estimated Growth Rates without Social Distancing

	Scenarios (Possible Values for the Explanatory Variables)							
$Temp_{it}$	25	20	15	10	5	0	-5	-10
EP_i	0.02	0.06	0.1	0.14	0.18	0.22	0.26	0.3
BCG_i	1	0.8	0.7	0.6	0.5	0.4	0.2	0
FC_{it}	30	50	70	90	120	140	160	180
HM_{it}	8	7	6	5	4	3	2	1
HB_i	8	7	6	5	4	3	2	1
	Estimated Logarithmic Variation Rates (Cases Per million):							
	2.12%	2.90%	3.56%	4.35%	5.61%	6.63%	7.77%	7.63%

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HM_{it}	8	7	6	5	4	3	2	1
HB_i	8	7	6	5	4	3	2	1
	Estimated Logarithmic Variation Rates (Cases Per million):							
	-3.06%	-2.65%	-2.10%	-1.43%	-0.30%	0.61%	1.63%	2.80%

Effects of Social Distancing on Growth Rates of COVID-19

Days Since the First Case Temperature (°C)	30	50	70	90	120	140	160	180
-10	6.02	5.86	5.70	5.54	5.30	5.14	4.98	4.82
-5	5.90	5.74	5.58	5.42	5.18	5.02	4.86	4.70
0	5.78	5.62	5.46	5.30	5.06	4.90	4.74	4.58
5	5.66	5.50	5.34	5.18	4.94	4.78	4.62	4.46
10	5.54	5.38	5.22	5.06	4.82	4.66	4.50	4.34
15	5.42	5.26	5.10	4.94	4.70	4.54	4.38	4.22
20	5.30	5.14	4.98	4.82	4.58	4.42	4.26	4.10
25	5.18	5.02	4.86	4.70	4.46	4.30	4.14	3.98
30	5.06	4.90	4.74	4.58	4.34	4.18	4.02	3.86

12. Conclusion

- Potential association between a strict social distancing and a reduction in the evolution of cases of COVID-19 , in accordance with the current debate about the relevance of social distancing.

- Social distancing may be associated with a reduction of around 5 percentage points in the log-variation rate of cases per million.

- Social distancing is the most important variable in the work to explain COVID-19 evolution.

- This work does not allow to exclude the hypothesis that the evolution of cases may be positively related with low temperatures and a low BCG immunization.

- The results are only based on statistical techniques. There is no underlying epidemiological model to allow more specific conclusions.