Effect of control responses applied in countries of the European Union and Latin America on COVID-19 cases

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Abstract

Due to the COVID-19 pandemic, various countries have found it necessary to implement sanitary control measures. Currently, the impact of policy responses is unknown, and whether it varies according to the continent and between countries of the same continent. We implement a mixed linear model whose outcome corresponds to the logarithm of the rate of new cases, with different health measures as predictors. We applied this model to the countries of the European Union and Latin America. In the first one, all responses have a diminishing effect on cases. In the second one, only some responses indicate a decrease in cases.

1 Introduction

Since the beginning of 2020, the world has been affected by the COVID-19 pandemic. During this period, governments have had to implement control and policy responses to slow the spread of the virus, avoid a collapse of the health system, and avoid increasing deaths from COVID-19. Among the best-known measures is quarantine. Various investigations have been carried out to evaluate its effectiveness (Hou et al., 2020; Tang et al., 2020) and there have been extensive debates about whether this measure manages to reduce the number of cases. The discussion has raised whether its effectiveness varies depending on which country applies the policy response. In addition to quarantines, governments have implemented a set of control measures, including border closures, school closings, public transport restrictions, closing workspaces, meeting regulations, and cancellation of mass events.

Although it is suspect that the different policy responses implemented achieve an effect in reducing infections, it is not known the magnitude of the impact that these generate in the reduction of cases, nor how much time must elapse for them to take effect. In addition, it is unknown which of all the measures implemented is the one that manages to generate the most significant decrease in cases and if there is any difference in effectiveness between countries.

2 Goal

The objective of this study was to measure the impact of policy responses implemented in the European Union and Latin America and compare the effectiveness of the measures between both continents.

3 Methodology

The design corresponded to a mixed linear model longitudinal analysis (Fahrmeir et al., 2013) where the outcome is the logarithm of the rate of new cases between two consecutive weeks $r_t = \ln\left(\frac{n_t}{n_{t-1}}\right)$. When it takes positive values means that the new cases are increasing. When it takes negative values, it means that the new cases are decreasing. We obtained the data from the COVID-19 Data Hub (Guidotti and Ardia, 2020) repository, where it is updated with different frequencies by country. We corrected, grouping by calendar week. Thus, we established comparable time observations. Policy responses are reported in four levels of intensity. We transformed it to binary variables whose equivalence indicates whether the policy response exists. This analysis makes it possible to evaluate the variation in the effectiveness of a sanitary measure in different countries. The incorporation criteria for policy responses was variability over time, that is if the variable varied during the observation time. We also incorporated lags in policy responses to check the delay of the impact on it. Policy responses collected are: school closures, information on social media, meeting restrictions, cancellation of events, internal movement restrictions, border closures, restrictions on public transport, quarantine, and closure of spaces of work. We defined as the beggining of the observation time the sixth week from the first positive case of COVID-19 in the countries of the European Union and the fourth week for the countries of Latin America. This is because r_t tends to present great variability due to the low number of cases in the previous period. After the indicated weeks, the logarithm of the rate of new cases tends to show more stable behavior. For more details of the data, see Ortiz et al. (2021).

A mixed model was adjusted separately for the countries of the continental European Union (excluding Ireland), and another was adjusted for the countries of Latin America. The model for the European Union is given by:

$$\begin{aligned}
r_{it} &= \beta_0 + \beta_1 \text{ cancel events}_{it} + \beta_2 \text{ gath. rest.}_{it} + \beta_3 \text{ school closing}_{it} + \beta_4 \text{ int. rest.}_{it} + \beta_5 \text{ ext. rest.}_{it} \\
&\quad + \beta_6 \text{ stay home}_{it} + \beta_7 \text{ workplace closing}_{it} + \gamma_{0i} + \varepsilon_{it}, \\
\gamma_{0i} &\sim \mathrm{N}\left(0, \tau_0^2\right), \\
\varepsilon_{it} &\sim \mathrm{MA}(1),
\end{aligned}$$

where i denotes the country and t the week, γ_{0i} corresponds to the random intercept and ε_{it} has a temporal correlation structure of mobile media MA(1), es decir $\varepsilon_{it} = \theta\varepsilon_{i(t-1)} + z_t$, where $z_t \sim N(0, \sigma^2)$. The model for Latin America is given by:

$$\begin{aligned}
r_{it} =& \beta_0 + \beta_1 \text{ cancel events}_{it} + \beta_2 \text{ school closing}_{it} + \beta_3 \text{ int. rest.}_{it} + \beta_4 \text{ ext. rest.}_{it} + \beta_5 \text{ stay home}_{it} \\
&+ \beta_6 \text{ workplace closing}_{it} + \gamma_{0i} + \gamma_{2i} \text{ school closing}_{it} + \varepsilon_{it}, \\
\gamma_{0i} \sim& \mathrm{N}\left(0, \tau_0^2\right), \\
\gamma_{2i} \sim& \mathrm{N}\left(0, \tau_2^2\right), \\
\varepsilon_{it} \sim& \mathrm{MA}(1),
\end{aligned}$$

where γ_{2i} corresponds to the random slope for the school closure sanitary measure.

4 Results

The adjustment of the model for the countries of the European Union indicates that all the health measures implemented help to reduce the number of new cases (Table 1). The negative sign in the estimators indicates a decrease in new cases. On the other hand, the variability between the different countries is only given by a random intercept, which indicates that each country presents a different starting condition, but that the effect of sanitary measures in reducing new cases is the same for all the countries of the European Union. Figure 1 indicates the initial condition of each of the countries. It is observed that among the countries with a more unfavorable condition are Slovenia, Cyprus, Germany, Italy, and Spain. By contrast, Lithuania and Luxembourg start on a favorable basis.

Table 1: Estimators of policy responses for countries in European Union.

Variable	Coef.	Standard error	z	P>z	95% IC	
cancel events lag3	-.1161043	.0339834	-3.42	0.001	-.1827105	-.0494982
gatherings restrictions lag1	-.0797237	.045705	-1.74	0.081	-.1693039	.0098565
school closing lag2	-.1235829	.0294432	-4.20	0.000	-.1812905	-.0658753
internal movement restrictions lag3	-.0606834	.0352165	-1.72	0.085	-.1297066	.0083398
international movement restrictions lag2	-.2267163	.0736471	-3.08	0.002	-.3710619	-.0823706
transport closing lag3	-.2819966	.0805741	-3.50	0.000	-.439919	-.1240742
stay home restrictions lag2	-.0918296	.0329591	-2.79	0.005	-.1564283	-.027231
workplace closing lag4	-.1140052	.0333621	-3.42	0.001	-.1793937	-.0486167
constant	.6417848	.0787332	8.15	0.000	.4874705	.7960992
τ_0^2	.0060339	.003076			.0022216	.0163879
θ_1	.2160528	.0257744			.1649992	.2659518
ε	.1528746	.0061243			.1413302	.1653619

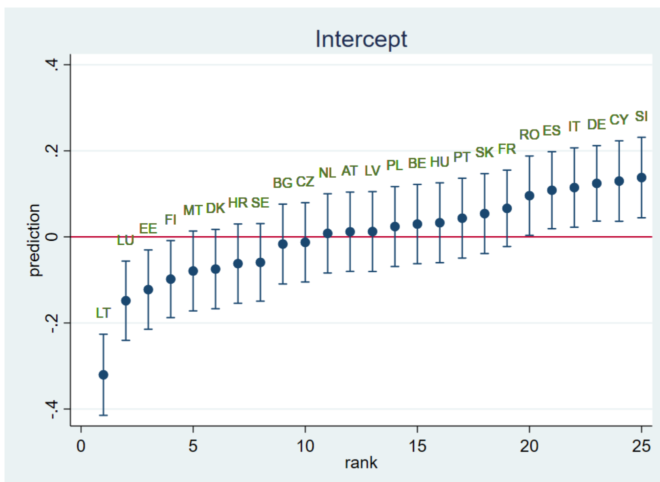
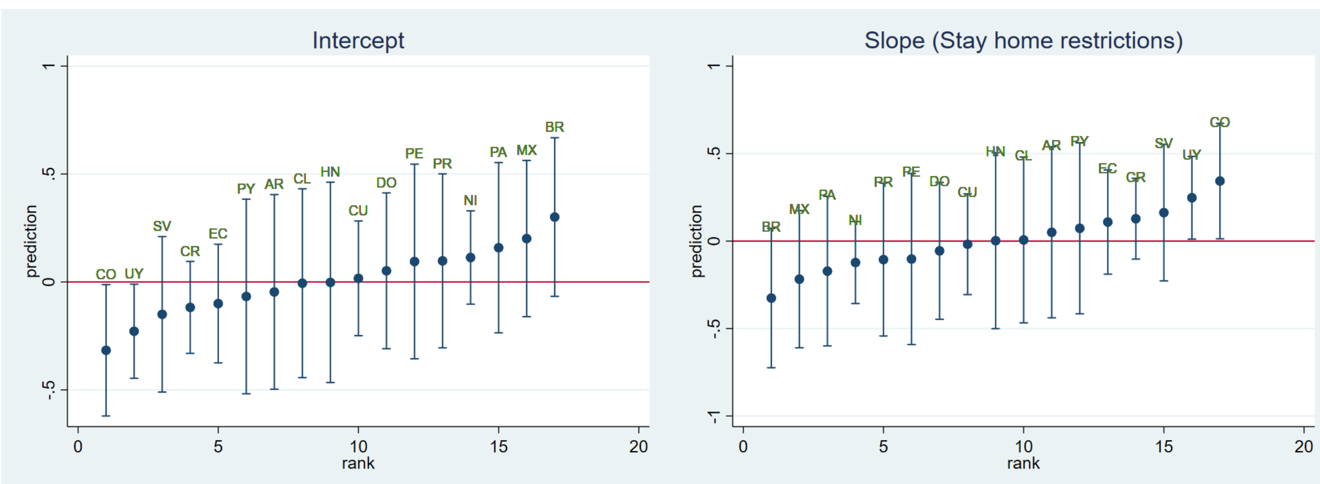


Figure 1: Random intercept graph for countries in European Union.

In the Latin American model, the analysis was carried out with a smaller number of sanitary measures because the excluded measures presented little or no variability throughout the observation time. Almost all sanitary measures have an effect of reducing r_t, except for the case of internal movement restrictions and border closures (Table 2). The positive sign in the provisions of some sanitary measures may be mainly since compliance with the measures in Latin America may differ from adopting the restriction to their effective compliance by the population. Figure 2 shows that Brazil, Mexico, and Paraguay are in the most unfavorable conditions concerning the number of new cases. Chile is within the average of Latin America. Colombia and Uruguay have the most favorable conditions. In the case of Latin America, We implemented a random slope for quarantine, which shows differences in the effectiveness of its application for the different countries of the region. Brazil, Mexico, and Paraguay are among the countries that most impact the application of quarantines to reduce cases.

Table 2: Estimators of policy responses for countries in Latin America.

Variable	Coef.	Standard error	z	P>z	95% IC	
cancel events lag4	-.0402643	.0543764	-0.74	0.459	-.1468402	.0663115
school closing lag4	-.2451908	.0778414	-3.15	0.002	-.3977571	-.0926245
internal movement restrictions lag1	.0594991	.0309257	1.92	0.054	-.0011141	.1201123
international movement restrictions lag4	.0835673	.0301904	2.77	0.006	.0243953	.1427393
transport closing lag2	-.0506744	.0281552	-1.80	0.072	-.1058576	.0045088
stay home restriction lag3	-.039004	.0321033	-1.21	0.224	-.1019253	.0239173
workplace closing lag3	-.035624	.0457551	-0.78	0.436	-.1253023	.0540543
constant	.3132123	.0745984	4.20	0.000	.1670022	.4594224
τ_2^2	.0396446	.0255634			.0112026	.1402978
τ_0^2	.0374259	.024906			.0101559	.1379195
θ_1	-.0482589	.0327421			-.1121458	.0160253
ε	.1399128	.0064784			.1277745	.1532041



(a) Random intercepts

(b) Random slope for quarintine

Figure 2: Ranfom effects in Latin America.

If the effects of the measures between the European continent and Latin America are compared, it is observed that the magnitude of the coefficients concerning the policy responses implemented in Europe achieve a greater decrease in new cases, in contrast to Latin America, where the magnitude is less, or even the application of some sanitary measures results in an increase in new cases.

To view interactive graphics, see Result 2 available at `https://www.epicovid.cl`. The data used in this study are available at `https://github.com/COVID0248/Resultado2`.

5 Preliminary conclusions

The implementation of policy responses to reduce infections, analyzed through the number of new cases, has an expected effect, based on the adjustment of the applied models. In the case of Europe, the measures implemented reflect a decrease in new cases of COVID-19. In Latin America, the vast majority of health measures also show a reduction effect in the number of new cases. In the case of quarantines in Latin America, these have a more significant impact in reducing new cases in countries in less unfavorable conditions. It mainly occurs because quarantine is not applied effectively in these countries. The main implications that compromise the results obtained, specifically in Latin America, correspond to the lack of homogeneity and suspicion of poor compliance with the sanitary measures implemented by the authority.

Regarding the behavior as a continent as a whole, we observed that the European continent achieves a more significant decrease in the number of new cases than Latin America for the same measures implemented.

References

Fahrmeir, L., Kneib, T., Lang, S., and Marx, B. (2013). Mixed models. In *Regression*, pages 349–412. Springer.

Guidotti, E. and Ardia, D. (2020). Covid-19 data hub. *Journal of Open Source Software*, 5(51):2376.

Hou, C., Chen, J., Zhou, Y., Hua, L., Yuan, J., He, S., Guo, Y., Zhang, S., Jia, Q., Zhao, C., et al. (2020). The effectiveness of quarantine of wuhan city against the corona virus disease 2019 (covid-19): A well-mixed seir model analysis. *Journal of medical virology*, 92(7):841–848.

Ortiz, O., Garrido, D., Arriagada, G., Gutiérrez, L., Cerda, J., Pavani, J., Jofré, L., Varas, I., and Gutiérrez, I. (2021). Base de datos epidemiologica y sociodemográfica COVID-19 en Chile y el mundo. `https://epicovid.cl/`.

Tang, B., Xia, F., Tang, S., Bragazzi, N. L., Li, Q., Sun, X., Liang, J., Xiao, Y., and Wu, J. (2020). The effectiveness of quarantine and isolation determine the trend of the covid-19 epidemics in the final phase of the current outbreak in china. *International Journal of Infectious Diseases*, 95:288–293.