The contagion rate of the COVID-19 in Catalonia

Regional Quantitative Analysis Research Group (AQR–UB)

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BACKGROUND

The spread of the epidemic of the COVID-19 in Catalonia has experienced a differentiated evolution in both time and space – initial days of the epidemic with few cases, localised at different focuses of the territory. A popular measure that synthesizes the rate of spread is the contagion rate or R0 rate – also known as the effective reproduction number – which collects the number of secondary cases caused by primary cases. This measure could be used as an additional indicator when planning deconfinement. The information available for the whole of Catalonia is made available to the general public from the press releases made, on the one hand, by the Department of Health of the Government of Catalonia and, on the other hand, by the Ministry of Health. Although the data are coincident for a certain time period, the time series have undergone a methodological change that encourages the interest in making an analysis comparing both statistical sources.

OBJECTIVE

This research computes an approximation to the R0 rate of the COVID-19 epidemic using data from the Department of Health of the Government of Catalonia, on the one hand, and the Ministry of Health, on the other. The available data correspond to the cases that have tested positive in a diagnostic test (PCR or rapid test). At the time of writing, the information for the whole of Catalonia covers the period from February 25th to May 4th, 2020 – T = 70 daily observations. This time series coincides with that provided by the Ministry of Health until April 8th, 2020 – see statistics by autonomous community on the website datos.gob.es, “Evolución de enfermedad por coronavirus (COVID-19)” – but small discrepancies begin to appear in the period April 9th to April 16th, the date from which the series is no longer published bringing together all the positive cases. Thus, from April 17th, the Ministry of Health will distinguish between positive cases according to PCR, on the one hand, and according to rapid tests, on the other hand. The sum of the two categories would result in the number of positive cases, although the magnitudes obtained still do not coincide with those of the Department of Health, the first being slightly lower. Figure 1 shows the number of positive cases for Catalonia according to the two statistical sources.

The discrepancy in the number of cases is remarkable towards the end of the period, so it would be expected that a study on the transmission rate of the epidemic based on data from the Ministry of Health could offer different conclusions from those obtained with data from the Department of Health. In order to assess the sensitivity of the analysis with respect to the statistical source used, this research note will use both series of positive cases to approximate the R0 rate for Catalonia as a whole.

Figure 1. Cumulative number of positive cases for Catalonia as a whole

This note summarizes some of the results on the analysis of the geographical distribution of COVID-19 in Catalonia that is being carried out by researchers from the AQR Research Group of the UB (http://www.ub.edu/aqr/). Special emphasis is placed on considering geographic and territorial aspects, facts of special interest in the research for the group.

The detailed results that have been used in this note are available to the interested reader.

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The information given in the daily press release by the Department of Health also indicates the number of suspicious cases in Catalonia as a whole, although the time coverage is much lower – the series is only available from April 15th. The suspicious cases correspond to people who at some point have presented symptoms and a health professional has classified them as a possible case, but do not have a diagnostic test with a positive result. It is expected that the consideration of suspicious cases and the total number of cases (positive and suspicious) will provide different results than those obtained in this research, which is why the calculation for these categories has also been made using the information provided by the Department of Health.

**APPROACH TO MEASURE THE R₀ RATE IN CATALONIA**

The method used in this research note to approximate the rate R₀ – the approximation is denoted as ρ – is based on the expression:

\[
ρ_t = \frac{y_t + y_{t-1} + \cdots + y_{t-q}}{y_{t-k} + y_{t-k-1} + \cdots + y_{t-k-q}}
\]

where \(y_t\) denotes the new cases that have occurred on a given day (\(t\)) for the whole of Catalonia, \(t = k+q+1, ..., T\). As can be seen, the rate R₀ is approximated as the ratio between the sum of new cases in a time window of \(w = 1 + q\) days and the sum of new cases in a time window of \(w\) days lagged \(k\) periods. \(w = k = 7\) were set to perform the calculation. The popular interpretation of the R₀ rate is made in terms of the average of secondary cases caused by primary cases, so a value of the rate higher than one would indicate that the epidemic would be in an expansive phase (the cases detected today are higher than the cases that were detected \(k\) days ago). Therefore, what would be desirable is to have a R₀ below one.

**CONTAGION RATE R₀ OF COVID-19 FOR THE WHOLE OF CATALONIA**

Figure 2 shows the evolution of the R₀ of positive cases for the whole of Catalonia between March 9th (the first day from which the rate can be calculated) and May 4th, 2020. First, we found the existence of a first time subperiod of rapid spread of the epidemic, with a speed of spread that reaches its maximum of 16.5 on March 18th (Department of Health) and 28.1 on March 13th, 2020 (Ministry of Health). From this day on, the speed begins to decrease, taking values close to one – the horizontal line denoting the value 1.

Data from the Department of Health indicates that as of April 6th, the R₀ rate is below one – the overall minimum of 0.71 is reached on April 22nd – with the exceptions of April 20th and April 21st, as well as from April 29th (last period where an increasing evolution is observed). With those of the Ministry of Health, between April 6th and 18th the R₀ rate is estimated below one, to take values higher than one in the period April 19th to 25th, when it starts a decreasing trend – the overall minimum is reached on May 3rd.

Therefore, despite the decline in the R₀ rate in Catalonia as a whole, there are some values higher than one that reverse the process of deceleration in the spread of the epidemic that was observed in previous periods when using the data from the Department of Health. The view is more optimistic when using data from the Ministry of Health, as in the last days of the period values lower than one are observed.

In order to complement the analysis, we compute the R₀ rate for suspicious cases, although the time period available is shorter. The R₀ rate estimate for suspicious cases is 1.194 (April 29th), 1.197 (April 30th), 1.26 (May 1st), 1.17 (May 2nd), 1.08 (May 3rd), and 1.12 (May 4th), values that are slightly above one. The consideration of the total cases (positive and suspicious) implies an estimate of the rate R₀ clearly higher than one and that would be placed between the one obtained for the suspicious and for the positive cases. Specifically, the values of the R₀ rate for total cases is 1.23 (April 29th), 1.2 (April 30th), 1.29 (May 1st), 1.21 (May 2nd), 1.11 (May 3rd) and 1.14 (May 4th).
Finally, it should be mentioned that Català et al. (2020) obtain an approximation for the R0 rate in Catalonia of 0.9 using data until March 23rd, a value clearly lower than that obtained in this research note, which is 5 (data from the Government of Catalonia) and 4.84 (Ministry of Health). A possible explanation for the discrepancy must be attributed to the fact that Català et al. (2020) use $w=3$ and $k=5$ contemplating, therefore, a smaller window width and a shorter reference period. However, calculations made with these values of $w$ and $k$ with the data used in this note do not provide results close to 0.9 for March 23rd – which is 2.04.

There are other calculations of the R0 rate at the level of autonomous communities that are based on epidemiological models. The National Epidemiology Centre uses the data provided by the Ministry of Health to obtain estimates of the R0 rate – see detailed information at https://portalne.isciii.es/covid19/. In the case of Catalonia, the estimate for May 1st, 2020 would be around 0.69. With the methodology used in this note, the R0 rate for Catalonia calculated with data from the Ministry of Health would be 0.499 to May 1st, 2020.

The Institute of Environmental Assessment and Water Research (IDAEA-CSIC), the Department of Mathematics, Universitat Autònoma de Barcelona (UAB) and the Biostatistics Unit, Bellvitge Biomedical Research Institute (IDIBELL) publish a tool (app) called COVID-19 TRACKER (https://ubidi.shinyapps.io/covid19/) which allows to estimate the evolution of the R0 rate at the level of autonomous communities. For Catalonia, the estimate available as of May 4th, 2020 is 0.55 – the graph does not allow us to know the exact value for some dates. Days for which the exact value of the estimate obtained by this group of researchers can be obtained from the graph and that of this note (according to the source of statistical information) would be:

<table>
<thead>
<tr>
<th>Date</th>
<th>COVID-19 TRACKER</th>
<th>This research note</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 27, 2020</td>
<td>0.77</td>
<td>0.76</td>
</tr>
<tr>
<td>April 28, 2020</td>
<td>0.66</td>
<td>0.83</td>
</tr>
<tr>
<td>April 29, 2020</td>
<td>1.38</td>
<td>0.47</td>
</tr>
<tr>
<td>April 30, 2020</td>
<td>1.23</td>
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<tr>
<td>May 1, 2020</td>
<td>1.42</td>
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</tr>
<tr>
<td>May 2, 2020</td>
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</tr>
<tr>
<td>May 3, 2020</td>
<td>1.30</td>
<td>0.43</td>
</tr>
<tr>
<td>May 4, 2020</td>
<td>0.55</td>
<td>1.20</td>
</tr>
</tbody>
</table>

The discrepancy on the last day of the period is significant, with the estimate obtained with the data from the Department of Health being the largest.

**CONCLUSION**

The results summarized in this research note show the heterogeneity in the spread of the COVID-19 epidemic, a heterogeneity that has been assessed by computing the R0 rate for the whole of Catalonia. We have found that the official source used to have the information of positive cases of COVID-19 for the whole of Catalonia is of great relevance as the conclusions drawn at the end of the period analysed can be interpreted as contradictory by the different sources. On the one hand, the positive case data provided by the Department of Health lead to an estimate of a rate R0 slightly higher than one from April 29th – with a value of 1.2 for May 4th – while the one obtained with data from the Ministry of Health is less than one – with a value of 0.52 for May 4th. It should be noted that the conclusion reached by the positive cases with the series of the Department of Health is qualitatively similar to that emerging from considering the suspicious cases and the totals.

Finally, it should be noted that the calculation of the R0 rate is an element that needs to be updated on a daily basis in order to be able to capture trends in the evolution of the epidemic and thus be able to adapt or moderate measures to relax the mobility restrictions of the population in the territory.

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i There are different epidemiological models that are used to calculate the R0 rate based on different starting assumptions. In this research we have chosen to calculate the statistic to approximate the rate R0, a statistic that only needs to have the number of new cases in each period of time.