The Covid-19 pandemic in Greece

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1 Introduction

The world has entered into unprecedented and turbulent times due to the Covid-19 pandemic. Severe restricting measures have been implemented in many places worldwide; economic and social activities are shrinking and they are expected to keep doing so in the near future. However, what is of great interest at the moment, is to grasp an idea about how the pandemic unfolds around the globe and when it should be expected to "end". For this purpose, this note uses data collected from the Johns Hopkins (Center for System Science and Engineering) Github repository in order to analyse the Covid-19 trends in Greece. These data are daily updated on the reports provided by various users, therefore the results provided by this note will be regularly modified as new information arrives.[1]

This note follows closely the work released from Peracchi (2020) regarding the Covid-19 pandemic in Italy, and which is available online on the Covid-19 forum of the Einaudi Institute for Economics and Finance. Therefore, this note does not make any attempts to structurally model the situation, but rather aims in describing some basic aspects of the pandemic in Greece and provide some predicted end dates based on simple empirical model specifications that control for time trends and day fixed effects.

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[1] Updates of this note can be found on this link.

2 Data

The Johns Hopkins University (JHU) Github repository hosts data from daily reports on Covid-19 collected worldwide. With only few exceptions, e.g. the United States, China, Canada, and Australia, these data are reported at the country level and no regional breakdown is possible. A more local data source could be the National Public Health Organization (EODY) in Greece, which publishes daily reports on the Covid-19 situation in the country. However, those reports are not available online for each single day singe the beginning of the outbreak. Another data source could be the European Centre for Disease Prevention and Control (ECDC), however, those data do not report the number of recovered cases. Therefore, I solely rely on JHU aggregate data for Greece and focus on the following daily time series: total number of confirmed cases, total number of deaths, total number of recovered and total number of active cases. The total number of active cases (or currently positive) is not originally reported in the repository data but it is calculated as the difference between the total number of confirmed cases minus the sum of deaths and recovered cases. Finally, the daily variation of the above series, i.e. the "new" cases is also considered. It should be noticed that the number of active (or positive) cases is likely to be downwards biased as it refers to tested cases only, and this bias might vary across places and over time.

The data are available from 22 January 2020 onwards, and they are updated once a day around 23:59 (UTC). The next Section displays some descriptive graphs and Section 4 discusses the predictions and forecasts.

3 Descriptive analysis

Figure 1 displays how the total number of cases has been evolving since the first case in 26 February 2020. Two series are displayed. The dots represent the daily number of new cases from day 1, i.e. when the first patient was observed (26 February) until the most recent date for which data are available. This is often referred to as the epidemiological curve, or epi chart (Baldwin and di Mauro, 2020). However, as it conveys a rather noisy picture which is not very informative about the size of the medical shock imposed by the pandemic, a trajectory curve is plotted (solid line) as well. In this case, the log of the cumulative number of confirmed cases is plotted and its slope is indicative on whether a country is on an acceleration or a deceleration phase. Figure 1 also plots the dates at which some serious containment public policies were implemented as those are expected to slow down the spread of the disease given that they are practiced quickly.

At the moment, numbers seem to be quite low for Greece, as the number of total daily cases is increasing but in a low pace. Figure 2 plots the number of new daily cases along with their 3-day moving average (black thick line) in order to highlight the trend of the daily series. Figures 3 presents the respective graph for the daily number of reported deaths. The number of deaths has been quite low so far and peaked at the beginning of April (Figure 3). A similar picture emerges for the daily number of recovered cases (not plotted here). Hence, the evolution of the daily active cases, (total cases minus deaths plus recovered), is following closely the pattern observed for the daily number of confirmed cases in Figure 1. Peaks in the daily number of deaths seem to be occurring every 7 days and they follow the peaks in the daily number of new cases with a lag of about 4-7 days.

4 Forecasts

The purpose of this note is not to provide a structural modelling of the pandemic in Greece, but to use a simple model that will allow for in-sample predictions and out-of-sample forecasts, starting from the date the data have been lastly updated, for the daily number of total and active cases. As seen in the descriptive graphs, there are days in which the count of new total and active cases is equal to zero. Taking the logs of a transformed dependent variable has been shown to lead to biased estimates (Santos Silva and Tenreyro, 2006). Therefore, I estimate the following polynomial time trend model using negative binomial regressions:

$$y_t = b_0 + b_1 t + b_2 t^2 \cdots + b_k t^k \tag{1}$$

where y_t is the (non-negative) number of new daily cases, $b_0, b_1, ..., b_k$, are parameters to be estimated, u_t is a random disturbance term with zero mean and finite variance, and t is a time trend with $t = 0$ on February 26, 2020. Forecasting using variants of the above model critically depends on the (strong) assumption that the Covid-19 pandemic in Greece unfolds with a time-invariant process. Using the model above, I use all the data published up to the current date T, to obtain the estimates $\hat{b}_{0|T}, ..., \hat{b}_{k|T}$ that will allow me to predict y_t for the period $t = 0, ..., T$, as well as to forecast at any future date $t = T+1, T+2, ...$ as follows:

$$\hat{y}_{t|T} = exp(\hat{b}_{0|T} + \hat{b}_{1|T} t + \hat{b}_{2|T} t^2 + \cdots + \hat{b}_{k|T} t^k) \tag{2}$$

The inverse exponential transformation ensures that any predictions under this forecast rule will be non-negative. After experimenting with several specifications of the time function, I specify daily cases to be a function of a quadratic time trend. The choice of quadratic specifications is also justified by the fact that they minimise the Schwarz Information Criterion (BIC), as compared to cubic or quartic models. The negative binomial regression estimates are also benchmarked against Gamma, Ordinary Least Squares (OLS) and Least Absolute Deviations (LAD) ones, using the logarithmic version of the daily count of cases in the last two cases, i.e. OLS and LAD regressions. Therefore, using count and OLS regressions, $\hat{y}_{t|T}$ is interpreted as an estimate of the mean of the probability distribution of new positives. Using LAD, which is less sensitive to outliers, $\hat{y}_{t|T}$ is interpreted as an estimate of the median of the probability distribution of new positive cases.

All of the in-sample predictions and out-of-sample forecasts are based on the information being available up to the current date T, i.e. April 21, 2020. As new data are being released, new parameter sets $\hat{b}_{0|T+1}, \hat{b}_{1|T+1}, ..., \hat{b}_{k|T+1}$ will be being estimated, hence producing a new set of forecasts for the number of new daily cases $\hat{y}_{T+2|T+1}, ...$ etc. Using the simple forecasting rule in (2), the date at which the pandemic will end can be predicted, i.e. the date at which $\hat{y}_{t0|T} \approx 0$, i.e. when the daily number of cases is rounded to zero. The forecasting rule in (2), is also extended to include an interrupted time trend after the enforcement of some public containment measures announced by the government and implemented at the national level, i.e. schools closure (11 March 2020), non-essential shops closure (18 March 2020) and all-day lockdown (23 March 2020) in order to account for changes in how the series trend before and after.[2] For robustness, I experiment by allowing the model to control for day-of-the-week fixed effects in order to allow for a possible differentiation of the distribution of cases over weekdays.

Figure 4 displays the actual, predicted and forecasted values based on a quadratic model allowing for a time trend break on March 18, 2020. The vertical lines are set at the current date (April 21, 2020) and the predicted "end" date of the pandemic in Greece. The red area represents a 90% confidence interval based on negative binomial estimates of the model. According to this model specification, the earliest forecasted "end" date is April 26, 2020. Figure 5 reports the respective results after running Gamma, OLS and LAD estimates of the model. The Gamma estimates are nearly identical to the negative binomial ones and set the estimated end of the pandemic on 26 April. The OLS and the LAD results suggest that the "end" day will be 28 April and 29 April, respectively. However, new predicted dates will be produced as more observations are being added to the data.

Next, the estimation results are based on model specifications that control for day-of-week fixed

[2]More specifically, piecewise quadratic polynomial regressions are fitted allowing for breaks in the dates mitigation policies were implemented and their possible combinations.

effects. Figure 6 presents the predicted 90% negative binomial confidence interval after incorporating day-of-week fixed effects into the model. In this case, the predicted "end" date of the pandemic is April 28. Figure 7 repeats the same exercise using the other estimation methods. Based on these, the predicted "end" dates are April 28 (Gamma estimates), April 30 (OLS estimates), and April 29 (LAD estimates).

Finally, Table 1 displays a set of predicted end dates using alternative empirical model specifications and estimators, specifying the date where no new cases will be observed at the end of April.

References

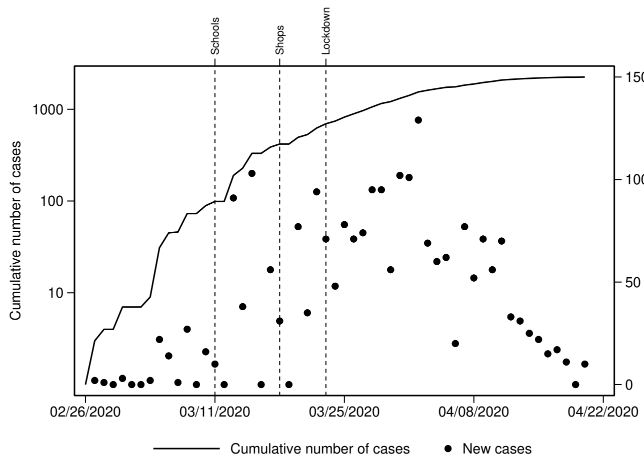
1. Peracchi F. (2020), The Covid-19 pandemic in Italy, Daily note, Einaudi Institute for Economics and Finance.

2. Santos Silva J.M.C. & Tenreyro S. (2006), The log of gravity, Review of Economics and Statistics, 88(4): 641-658.

3. Baldwin R. & di Mauro B.W. (2020), Mitigating the COVID Economic Crisis: Act fast and do whatever it takes, CEPR Press, ISBN: 978-1-912179-29-9.

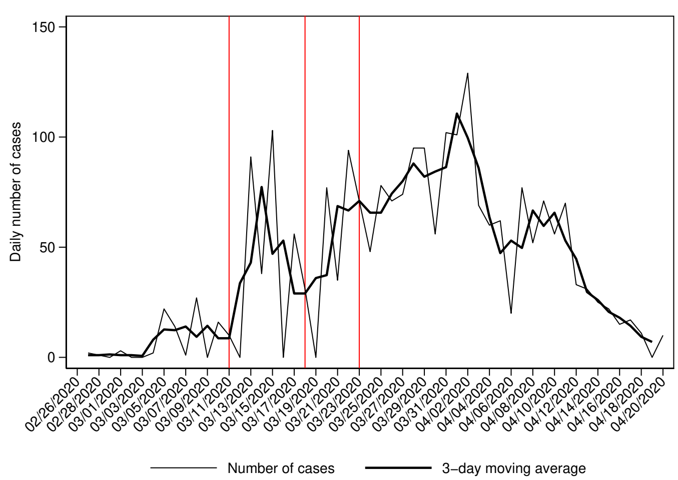
Figures & Tables

Figure 1: Epidemiological and trajectory curves for Greece (February 26, 2020 – April 21, 2020).



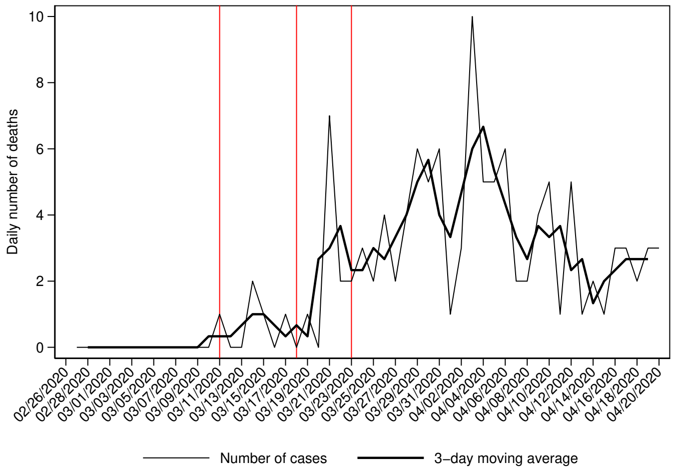
Source: Johns Hopkins University; author's calculations. Notes: 26 February 2020 is when the first patient was observed in the country. Dashed vertical lines stand on dates where containment public policies where implemented, i.e. schools closure (11 March), non-essential shops closure (18 March), and general lock down (24 March).

Figure 2: Number of total daily cases in Greece (February 26, 2020 – April 21, 2020).



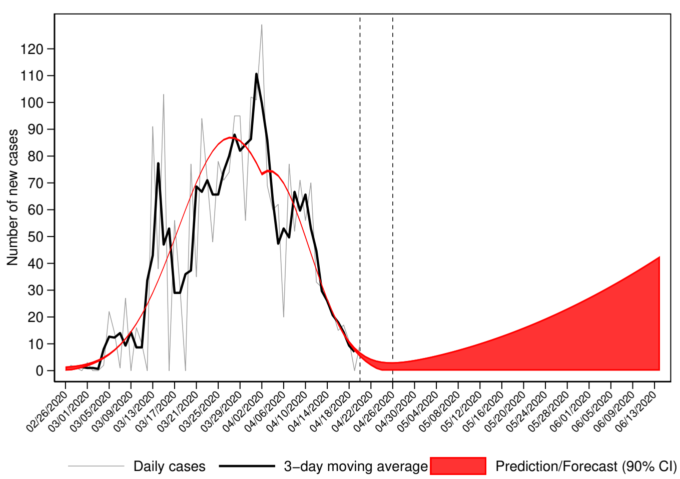
Source: Johns Hopkins University; author's calculations. Notes: 26 February 2020 is when the first patient was observed in the country. Red vertical lines stand on dates where containment public policies where implemented, i.e. schools closure (11 March), non-essential shops closure (18 March), and general lock down (24 March).

Figure 3: Number of total daily deaths in Greece (February 26, 2020 – April 21, 2020).



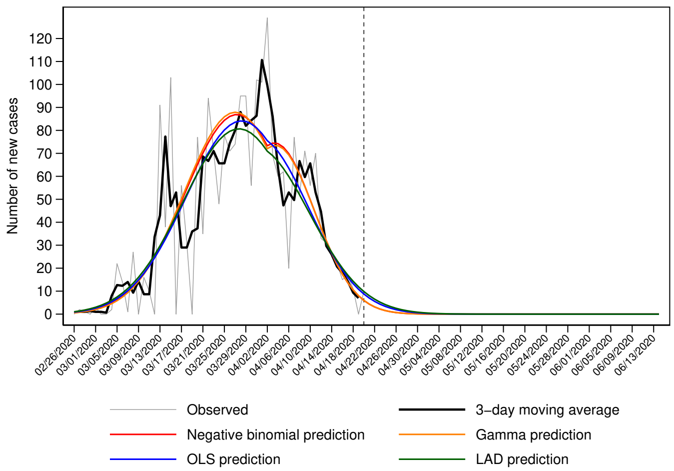
Source: Johns Hopkins University; author's calculations. Notes: 26 February 2020 is when the first patient was observed in the country. Red vertical lines stand on dates where containment public policies where implemented, i.e. schools closure (11 March), non-essential shops closure (18 March), and general lock down (24 March).

Figure 4: Observed, predicted and forecasted daily number of total new cases: Negative binomial estimates.



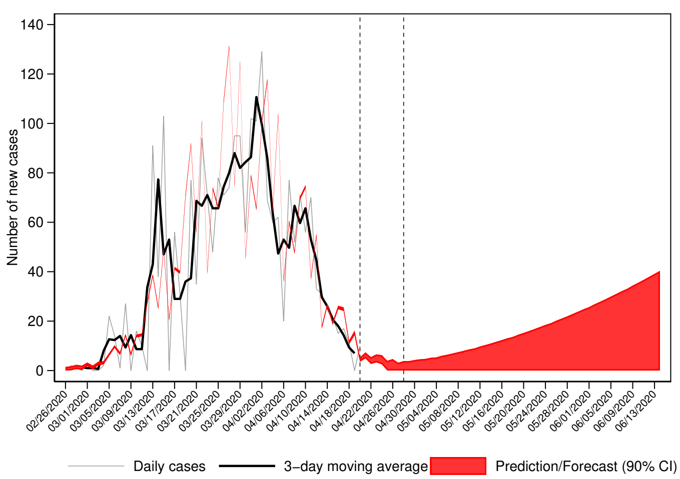
Source: Johns Hopkins University; author's calculations. Notes: 26 February 2020 is when the first patient was observed in the country. Grey line is the actual number of total daily cases. Black line is a 3-day moving average. Red area is a 90% confidence interval based on negative binomial estimates. Vertical dotted lines are specified at the current date (April 21, 2020), and at the predicted "end" date.

Figure 5: Observed, predicted and forecasted daily number of total new cases: Negative binomial, Gamma, OLS and LAD estimates.



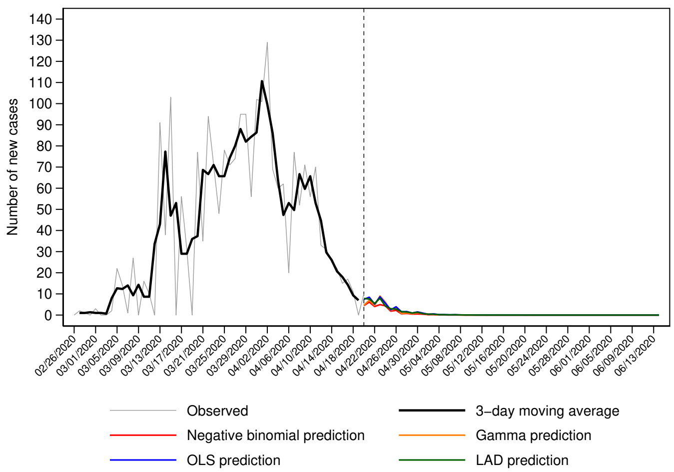
Source: Johns Hopkins University; author's calculations. Notes: 26 February 2020 is when the first patient was observed in the country. Grey line is the actual number of total daily cases. Black line is a 3-day moving average. Vertical dotted line is specified at the current date (April 21, 2020).

Figure 6: Observed, predicted and forecasted daily number of total new cases: Negative binomial estimates controlling for day-of-week fixed effects.



Source: Johns Hopkins University; author's calculations. Notes: 26 February 2020 is when the first patient was observed in the country. Grey line is the actual number of total daily cases. Black line is a 3-day moving average. Vertical dotted line is specified at the current date (April 21, 2020).

Figure 7: Observed, predicted and forecasted daily number of total new cases: Negative binomial, Gamma, OLS and LAD estimates controlling for day-of-week fixed effects.



Source: Johns Hopkins University; author's calculations. Notes: 26 February 2020 is when the first patient was observed in the country. Grey line is the actual number of total daily cases. Black line is a 3-day moving average. Vertical dotted line is specified at the current date (April 21, 2020).

Table 1: Set of predicted "end" dates for new active cases.

	Estimation method:			
Model specification:	Negative binomial	Gamma	OLS	LAD
Quadratic trend	28 April	28 April	29 April	30 April
Quadratic trend + day FE	28 April	28 April	28 April	28 April
Piecewise quadratic trend (18 Mar)	26 April	26 April	28 April	29 April
Piecewise quadratic trend (18 Mar) + FE	28 April	28 April	30 April	29 April
Piecewise quadratic trend (23 Mar)	25 April	25 April	26 April	01 May
Piecewise quadratic trend (23 Mar) + FE	26 April	28 April	28 April	30 April

Source: Johns Hopkins University; author's calculations. FE stands for day-of-the-week fixed effects, i.e. Monday, Tuesday, ..., Sunday.