Two general models for the analysis of the dynamics of confirmed cases of COVID-19 in Portugal and several other countries

Results June 14, 2020

By Francisco Castro Rego

1. Results for Portugal

Two simple models (see Annex) were applied to Portugal with a global analysis and specific analyses for the most affected regions based on daily data from the Direção Geral de Saúde (DGS).

The results for Portugal (global and for the three main regions affected, Norte, Centro, and Lisboa e Vale do Tejo) are shown graphically in Figure 1.

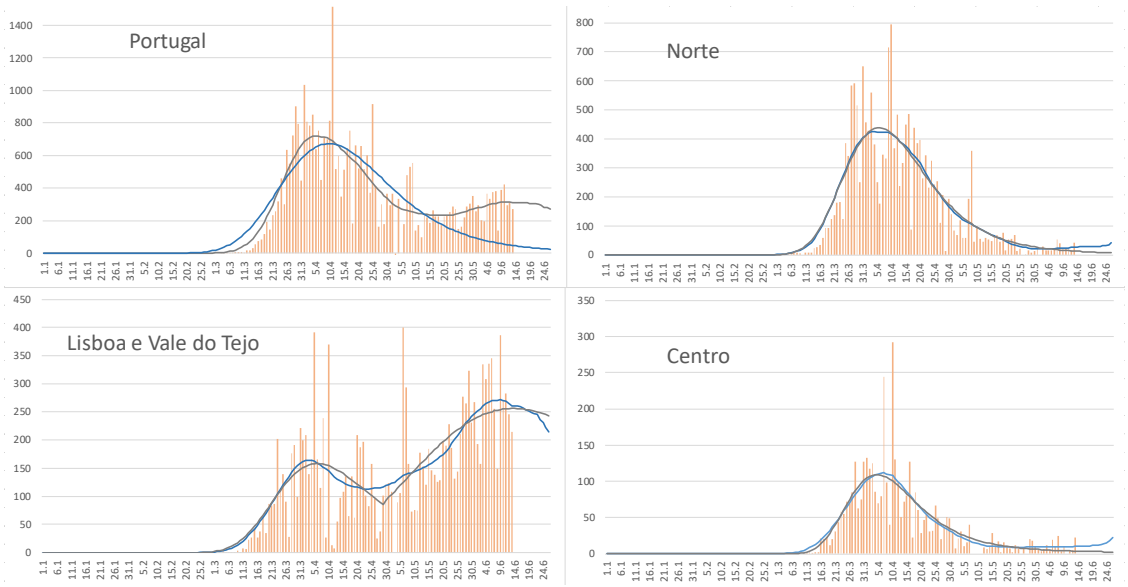

Figure 1. Global results for Portugal (upper left) indicate that after a typical curve of a single episode a new increase is apparent. Analyses for the three most affected regions show that in the North and Centre (right) the single episodes were practically finished, while in the region of Lisboa and Vale do Tejo (lower left) two peaks are apparent. The analysis of Lisboa and Vale do Tejo region was done by breaking the series in two periods, from January to Abril and from May to June.

The results for the equations are shown in Table 1.

2. Results for various countries

Analyses for various countries were done with data of daily new cases provided in: https://www.ecdc.europa.eu/en/publications-data/download-todays-data-geographic-distribution-covid-19-cases-worldwide.

Results for China and South Korea show that the episodes are practically controlled, even if new episodes might always occur. For Iran the numbers are now increasing after a first decrease. The second model is not able to capture these two episodes. The values for Turkey show a decrease. The numbers are still increasing in Pakistan and India. The two models show distinctive projections for Ukraine and Russia (Figure 2).

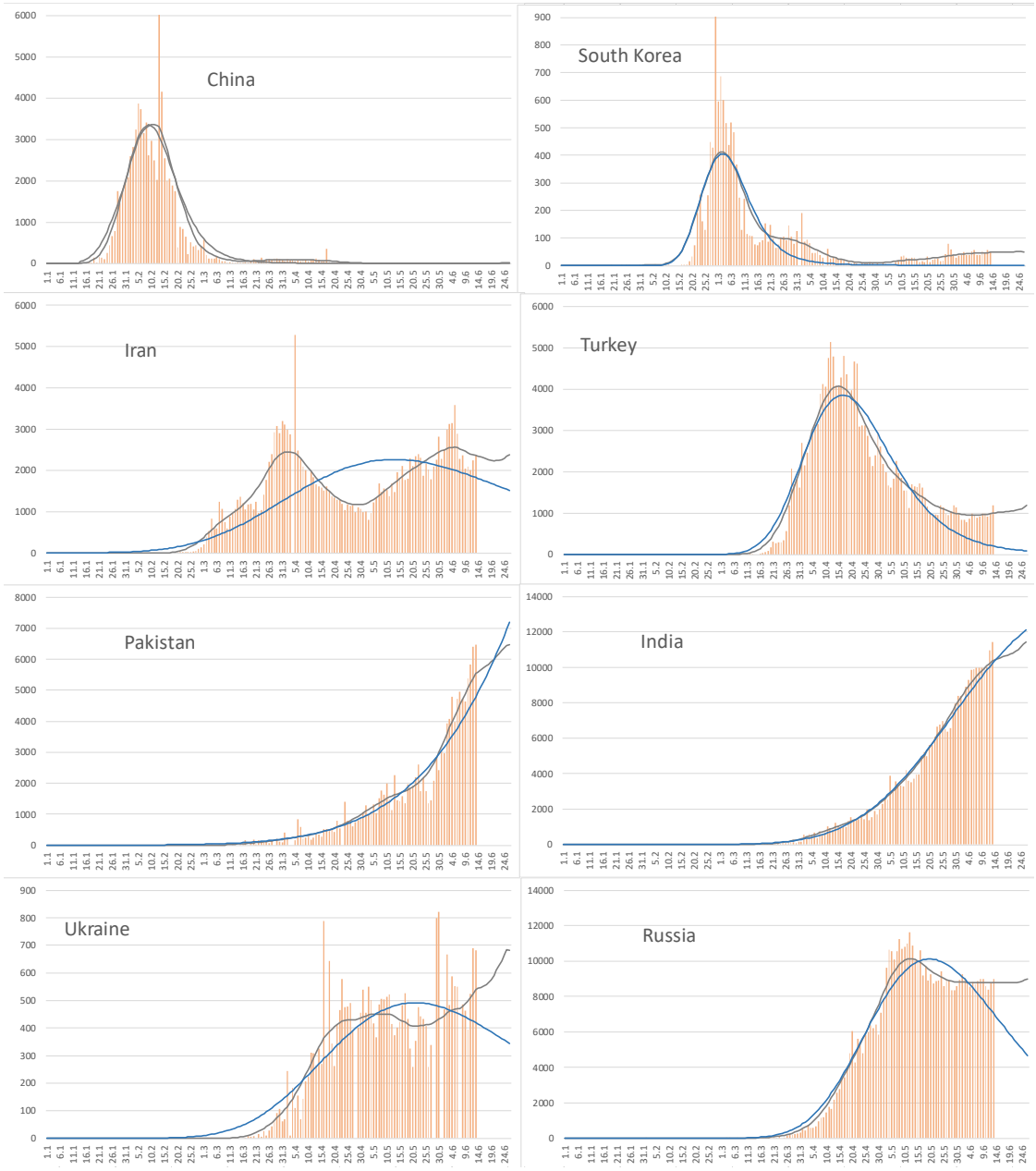

Figure 2. Observed and estimated cases in China, South Korea, Iran, Turkey, Pakistan, India, Ukraine and Russia.

The same analysis was done in other continents with more recent episodes, from North to South America and Australia. The numbers are already decreasing but not very rapidly in the USA and Canada, they are still increasing rapidly in Mexico, and show a tendency to slow down in Peru, Brasil, and Chile. In Argentina there is a strong increase. In Australia the episode already occurred for a long time and the numbers are very small (Figure 3).

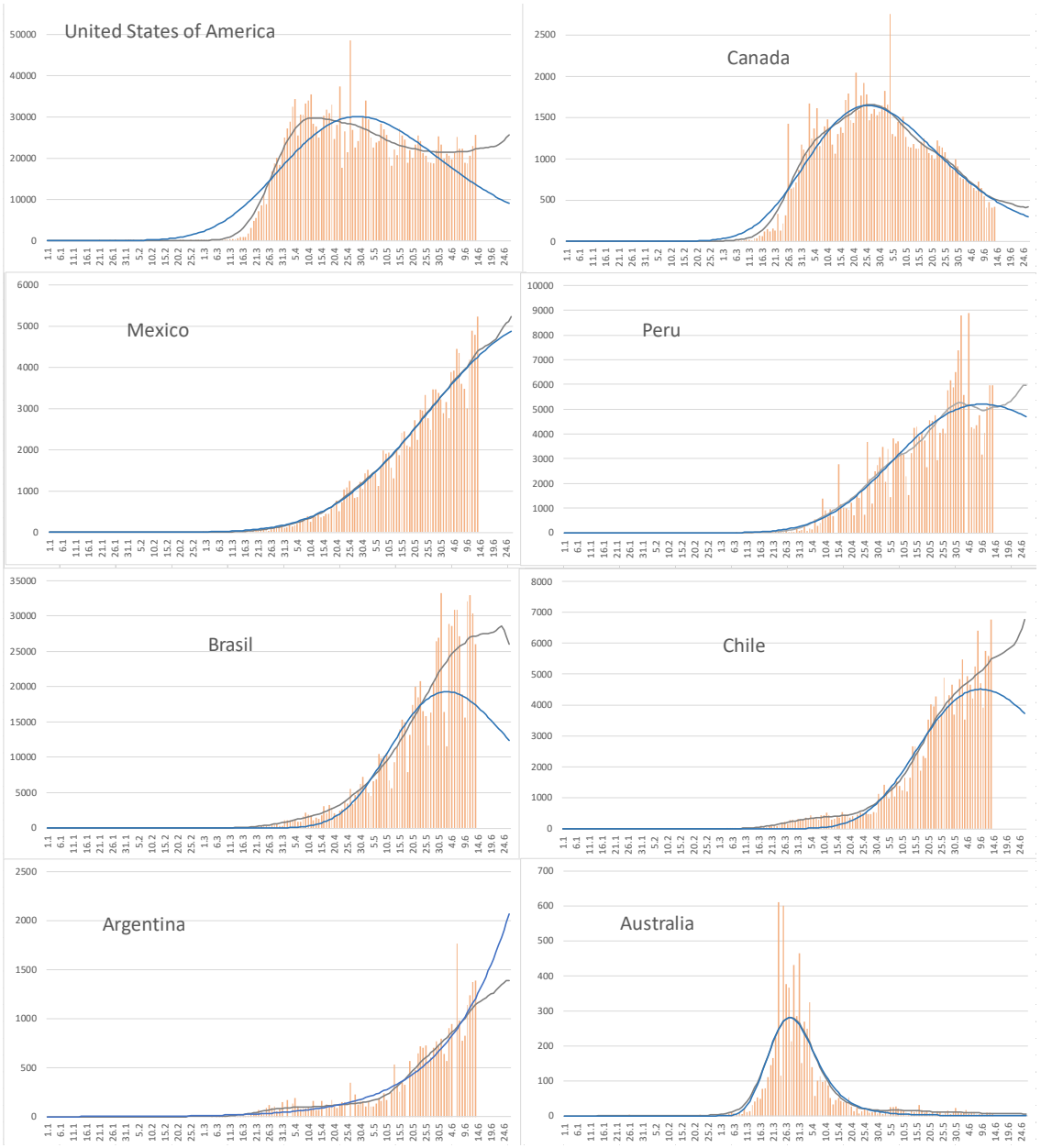

Figure 3. Observed and estimated cases in some countries from North to South America and Australia.

In Western Europe, the number of cases decreased significantly in most countries at various rates, with the exception for Sweden (Figure 4).

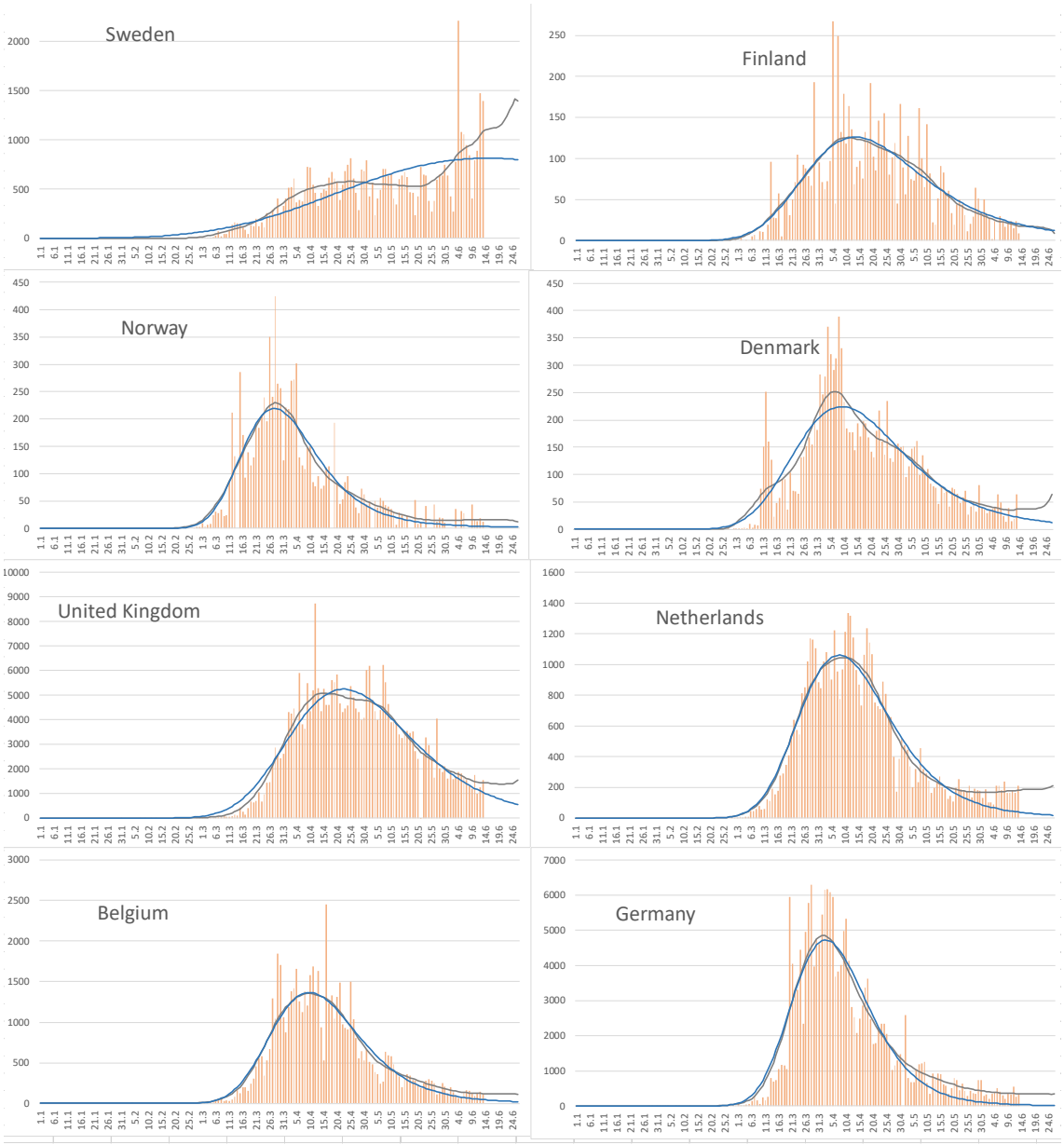

Figure 4. Observed and estimated cases in North and Central Europe.

Finally, the analysis of the situations in Southern Europe including Switzerland. The number of cases already decreased significantly in all cases but less clearly in Portugal where the two models diverge (Figure 5).

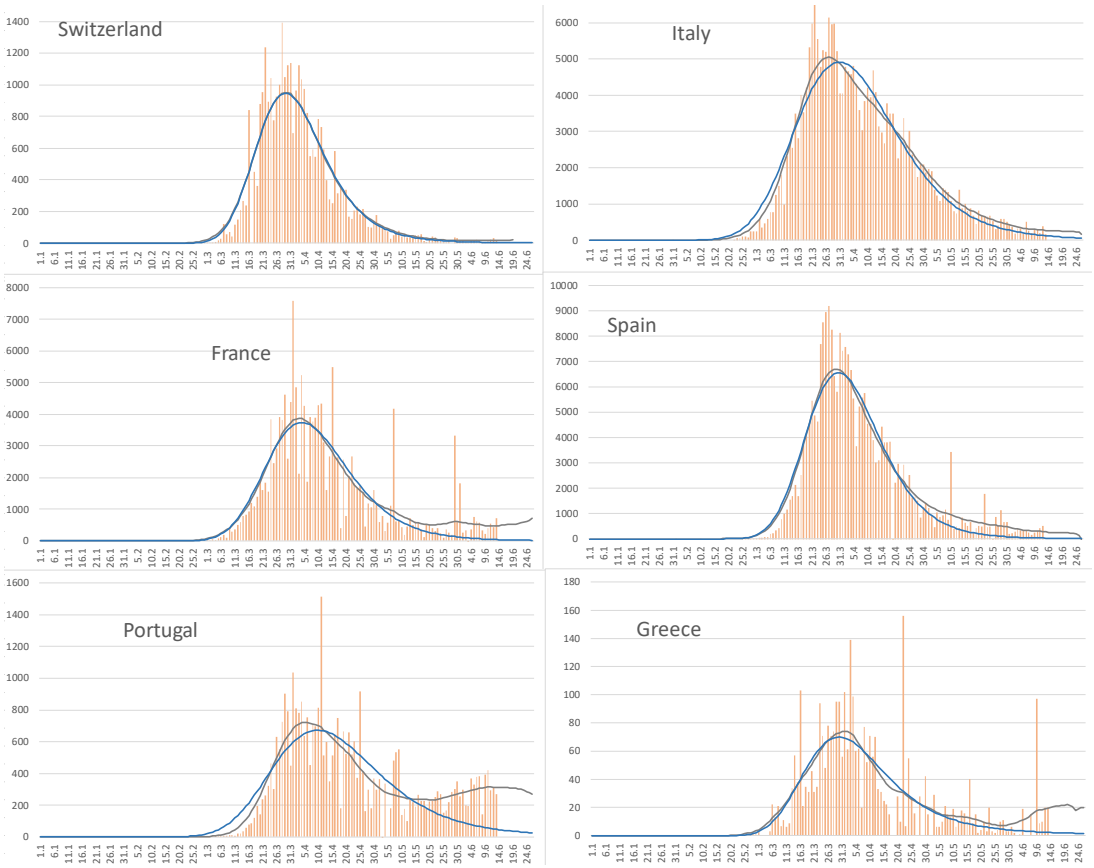

Figure 5. Observed and estimated symptomatic cases and number of infections in Southern Europe.

It is clear that the simple model 2 fits extremely well data from some countries or regions with a single episode. A single equation does not fit well situations with multiple episodes as in Iran or in Portugal (global values). Also, large countries as the USA, Russia or Brazil have lower fits probably due to the fact that they are a combination of various distinct episodes from the various regions within. The case for Portugal is a good indication that the analysis by regions or by periods may provide important indications of the evolution of the episodes.

Annex: The two models

1. The first model is simply a reciprocal averaging system. The number of infections is estimated from the number of new cases by the moving average of the cases of the following 14 days. Then, the number of estimated cases, including the projection, is estimated from the moving average of estimated infections of the previous 14 days. This is a special smoothing procedure. The model is sensitive to changes in the trends and it is more adjusted when there are multiple episodes, as in Iran, or in general when the conditions are greatly changing through time;

2. The second model adjusts a global equation to the whole episode from the estimated number of infections (N) calculated as in model 1 from the moving average of the number of cases of following 14 days.

   The equation used was of the form:

   $$N = (a)^{(t-i)\,(b\,)^{t-i}}$$

   The coefficients are interpreted as:

   - a is the initial infection rate;
   - t is time (in days from January 1st 2020)
   - i is the day of the start of the infections (from January 1st 2020);
   - b is a reaction rate (b where 1 represents no reaction).

   The values of the coefficients a, b, and i, together with the coefficient of determination R^2 are presented for various countries in the table below. After adjusting the estimated number of infections, the number of cases is obtained from the moving average of the estimated number of infections of the previous 14 days.

Table 1. Coefficients of the equation for model 2 for Portugal (with regions) and for various countries.

País	a	b	i	R^2
Portugal (global)	1,485	0,980	44,2	0,854
Norte	1,595	0,972	61,3	0,997
Centro	1,610	0,963	68,8	0,984
Lisboa e Vale do Tejo				
(January to April)	1,431	0,974	58,6	0,987
(May and June)	1,192	0,988	79,4	0,927
Argentina	1,058	0,999	0,0	0,945
Australia	2,429	0,951	60,3	0,989
Belgium	1,633	0,978	49,8	0,992
Brazil	1,478	0,986	73,8	0,942
Canada	1,363	0,986	38,7	0,988
Chile	1,386	0,987	78,5	0,990
China	2,681	0,960	8,2	0,972
Denmark	1,404	0,980	44,2	0,954
Finland	1,348	0,980	47,0	0,992
France	1,783	0,977	46,1	0,970
Germany	1,848	0,976	45,8	0,983
Greece	1,534	0,969	51,3	0,977
India	1,200	0,993	38,3	0,999
Iran	1,197	0,992	0,0	0,637
Italy	1,600	0,981	30,7	0,982
Mexico	1,180	0,993	36,1	0,999
Netherlands	1,593	0,978	46,9	0,986
Norway	1,671	0,970	48,2	0,982
Pakistan	1,093	0,997	0,0	0,994
Peru	1,264	0,991	47,2	0,986
Russia	1,393	0,988	52,4	0,988
South Korea	2,506	0,952	35,2	0,946
Spain	1,954	0,974	45,0	0,986
Sweden	1,134	0,994	0,0	0,963
Switzerland	1,632	0,969	50,1	0,864
Turkey	1,659	0,979	52,5	0,961
Ukraine	1,208	0,990	36,1	0,946
United Kingdom	1,447	0,985	38,4	0,984
United States of America	1,339	0,990	10,6	0,924