Modeling the Spread of COVID-19 in Lebanon: A Bayesian Perspective

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Abbreviated abstract: We present a Bayesian statistical model which can be employed to understand the contagion dynamics of COVID-19. The model is a Poisson auto-regression of the daily new observed cases, and considers both short-term and long-term dependence in the infections counts. The model can reveal whether contagion has a trend and estimate when the peak of contagion is reached, so that preventive measures can be applied and/or relaxed. Model results are exemplified from some observed series.

Related publications:

– Kharroubi, SA. Modeling the spread of COVID-19 in Lebanon: A Bayesian perspective. Frontiers in Applied Mathematics and Statistics 2020; 6, 40
– Agosto, A.; Giudici, P. A Poisson Autoregressive Model to Understand COVID-19 Contagion Dynamics. Risks

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Approach

- As COVID-19 pandemic progresses, countries around the world are implementing a range of responses to suppress the spread of this disease

- Structured mathematical/statistical techniques can be powerful tools in the fight against COVID-19
    - These allow the COVID-19 spread to be modelled
    - The resulting models can be used to predict and explain COVID-19 infections

- Infectious diseases grow exponentially and are usually driven by the basic reproduction number R

- R is the ratio between the new cases arising in consecutive days
    - A short-term dependence

- Incubation time is variable among individuals and data occurrence and measurement is not uniform across different countries
    - A long-term dependence

- We model newly infected counts as a function of both a short-term and a long-term component

Techniques and Methods

- The number of new cases Y_t reported at time (day) t is assumed to follow a Poisson distribution i.e.

$$Y_t \sim Poisson\ (\lambda_t),$$

with a log-linear autoregressive intensity specification, as follows:

$$\log(\lambda_t) = \alpha + \beta \log(1 + y_{t-1}) + \gamma \log(\lambda_{t-1}),$$

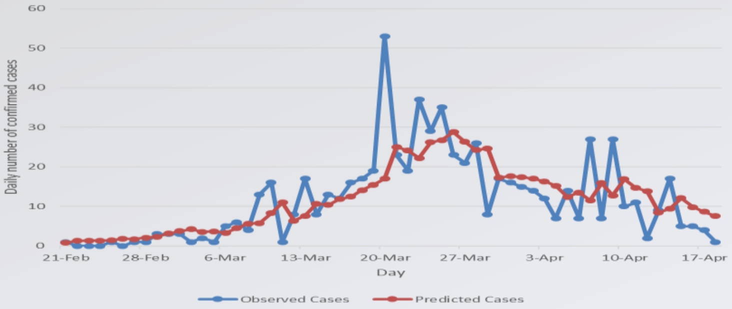
where $y \in \mathbb{N}$ and $\alpha, \beta, \gamma \in \mathbb{R}$ [1].

- Model was implemented from a Bayesian perspective using MCMC simulation methods

- The model can be applied to any country, region, and in different time periods. We exemplify its usage on some available data from the daily World Health Organization reports, from which we have extracted the "Total confirmed new cases“

- Model was presented in terms of its coefficients with its associated 95% credible intervals, as well as its predictive performance using plots of predicted to actual values, calculations of the mean predictions, RMSE and DIC.

Results and Conclusions



Parameter	A Poisson autoregressive model	China
α	0.169 (0.038, 0.301)	0.402
β	0.608 (0.514, 0.693)	0.815
γ	0.332 (0.241, 0.429)	0.131
RMSE	7.68	NA
DIC	444.7	NA

- Bayesian model is more flexible in characterizing inputs to regression models and more comprehensive in characterizing the uncertainty in the model outputs
- It can also be applied to any country, region, and in different time periods

What's next?

- To model and predict the number of COVID-19 infections, drawing out the effects of its spatial diffusion i.e. the use of spatio-temporal models!
- Predictions about where and when the disease will occur may be of great usefulness for public [illegible]cision-makers

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