Bayesian Evidence Synthesis for Covid-19 Modelling

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Why are we here?

A specific virus wanders freely over the globe.

- Inference and prediction for cases
- Inference and prediction for deaths
- Inference and prediction for epidemic stuff
- Synthesize different sources of data
- Save the world

One (wrong) model

$$cases_t \sim NB(\theta_c^{(t)}, \psi_1)$$

$$deaths_t \sim NB(\theta_d^{(t)}, \psi_2)$$

$$\theta_c^{(t)} = p_t \cdot C_t$$

$$\theta_d^{(t)} = \sum_{k=1}^{t-1} \pi_{t-k} \cdot ifr \cdot C_k$$

$$C_t = \lambda_t \cdot \frac{S_{t-1} I_{t-1}}{N}$$

$$\lambda_t = exp(\eta_t)$$

$$\eta_t = \beta_0 + \beta_1 m_t + \phi \eta_{t-1}$$

$$\psi_j \sim HalfCauchy(0, 10) \ , \ j = 1, 2$$

$$p_t \sim U(0, 1)$$

$$ifr = \begin{cases} ifr_1 \text{ for } t = 1, ..., l-1 \\ ifr_2 \text{ for } t = l, ..., N \end{cases}$$

$$ifr_1 \sim N(0.011, 10^{-8})$$

$$ifr_2 \sim N(0.009, 10^{-8})$$

$\pi_s = \int_{s-0.5}^{s+0.5} \pi(t)dt$, where $\pi(t)$ is $Gamma(5.1, 0.86) + Gamma(18.8, 0.45)$

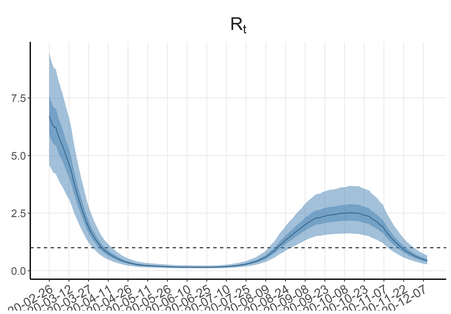
S_t : # susceptible people at time t

I_t : # infected people at time t

m_t : 1st PC of mobility

$\phi \sim U(-1, 1)$

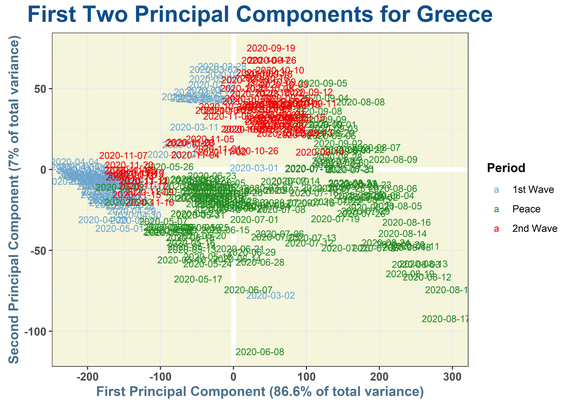
Reproduction number estimation



How to make it... less wrong

1. Work on the True cases, instead of the Observed cases, i.e. estimate I_t and S_t
2. Estimate the changepoint(s)

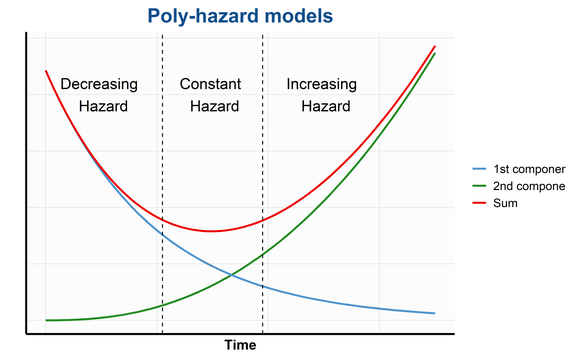
More data to consider



- Age group data from NPHO (for ifr)
- Data for intubations, tests, intensive care (for p_t, C_t)
- Mobility data (for λ_t)

Incomplete work

- Comparison of survival models
- Sampling (HMC) vs approximate methods (VB, INLA)
- Combination for both statistical and computational efficiency
- Data extraction



Acknowledgements

We'd like to thank Thomas Bayes the great for his beautiful theorem.