SOME FUCKING TITLE

SDIV, FPA, DGS, GASV

ABSTRACT. BACKGROUND. CONTRIBUTION. IMPLICATIONS-

1. INTRODUCTION

2. MODEL FORMULATION

Uncontrolled dynamics. We split the the constant population N in a base SEIR structure with segregation infected classes according with manifestation of symptoms. We also propouse the extra state CIs to fit data from Mexico city in the exponential grow phase. The dynamics reads

$$
\begin{aligned}
L' &= -\epsilon\lambda L - \delta_L L - \mu L, \\
S' &= \mu N^\star + \delta_L - (\lambda + \mu) S, \\
E' &= \lambda(\epsilon L + S) - (\kappa + \mu) E, \\
I_S' &= p\kappa E - (\gamma_S + \delta_H + \mu_{I_S} + \mu) I_S, \\
I_A' &= (1-p)\kappa E - \gamma_A I_A - \mu I_A, \\
H' &= \delta_H I_S - (\gamma_H + \mu_H) H - \delta_H H - \mu H, \\
R' &= \gamma_S I_S + \gamma_A I_A + \gamma_H H - \mu R, \\
D' &= \mu_{I_S} I_S + \mu_H H, \\
\frac{d}{dt} CI_S &= p\kappa E, \\
\lambda &:= \frac{\beta_A I_A + \beta_S I_S}{N^\star}, \\
N^\star(t) &= L + S + E + I_S + I_A + H + R.
\end{aligned} \tag{1}
$$

See table[*] for notation and values.

Hypothesis. We consider that susceptible individuals become infected when they are in contact with asymptomatic individuals and individuals with symptoms, we will propose that a proportion of asymptomatic individuals have a way to get relief and not die. A proportion of individuals infected with symptoms may die from the disease or may be relieved.

We callibrate parameters of our base dynamics in (1) via Multichain Montecarlo (MCMC). To this end, we assume that the comulative incidence of new infected symptomatic cases CI_S follows a Poisson distribution with mean $\lambda_t = IC_s(t)$. Further, following [] we postulate priors for p and κ

$$
\begin{aligned}
Y_t &\sim Poisson(\lambda_t), \\
\lambda_t &= \int_0^t p\delta_e E, \\
p &\sim \text{Uniform}(0.3, 0.8), \\
\kappa &\sim \text{Gamma}(10, 50).
\end{aligned} \tag{2}
$$

Ussing the reproductive number definition of VanDenDrishe, we obtain

$$R_0 := \frac{N^*(\beta_S p\kappa + \beta_A \kappa(1-p))}{(\mu-\kappa)(\gamma_S + \mu_{I_s} + S_A + \mu)N^*\mu}$$

Figure [...] displays data of coumulative confirmed cases of COVID-19 of Mexico city, and the fitt of our model in eqs. (1) and (2).
Controlled Model. We model vaccination, treatment and lockdown as a optimal control problem.

3. SEIR version

Here we propose a SEIR structure which considers hospitalized compartment H. To overcome stability issues we also consider vital dynamics.

$$\min_{u\in\mathcal{U}} = \int_0^T \left(a_{I_S} I_S + a_H H + a_D D + \frac{a_L}{2}u_L^2 + \frac{a_V}{2}u_V^2 + \frac{a_H}{2}u_H^2 + \frac{a_M}{2}u_M^2 \right) dt$$

s. t.

$$\begin{aligned}
L' &= -\epsilon\lambda L - u_L(t)L - \mu L\\
S' &= \mu N^\star + u_L(t)L + (1-\widehat{q})\gamma_V V - \lambda S - u_V(t)S - \mu S\\
E' &= \lambda(\epsilon L + S) - \kappa E - \mu E\\
I_S' &= p\kappa E - (\gamma_S + \mu_{I_S} + \delta_H)I_S - u_M(t)I_S + (1-q)\gamma_M M(t) - \mu I_S\\
I_A' &= (1-p)\kappa E - \gamma_A I_A - \mu I_A\\
M' &= u_M(t)I_S - \gamma_M M - \mu M\\
H' &= \delta_H I_S - (\gamma_H + \mu_H)H - \mu H\\
R' &= \gamma_S I_S + \gamma_A I_A + \gamma_H H + q\gamma_M M + \widehat{q}\gamma_V V - \mu R\\
D' &= \mu_{I_S} I_S + \mu_H H\\
V' &= \delta_S - \gamma_V V - \mu V\\
\lambda &:= \frac{\beta_A I_A + \beta_S I_S}{N^\star}\\
N^\star(t) &= L + S + E + I_S + I_A + M + H + R + V
\end{aligned} \tag{3}$$

Bayesian estimation.

4. Parameters

5. Optimal control problem

6. Numerical Results

Bayesian.

7. Appendix

Consider the following cost functional that we want to minimize

$$\int_0^T C(t, X(t), u(t))dt \tag{4}$$

subject to the dynamics

$$\dot{X}(t) = f(t, X(t), u(t)), \qquad 0 \le t \le T, \tag{5}$$

and the initial state $X(0) = x_0$. Let $t_0 < t_1 < \ldots < t_n$, with $t_0 = 0$ and $t_n = T$, be a partition of the interval $[0,T]$. We consider *piecewise constant controls* $\tilde{u}$ of the form

$$\tilde{u}(t) = a_j \qquad t_j \le t < t_{j+1} \tag{6}$$

Parameter	Median	Reference
β_S	$8.690\,483 \times 10^{-1}$	$*$
β_A	$7.738\,431 \times 10^{-1}$	$*$
κ	$2.143\,749 \times 10^{-1}$	$*$
p	$4.387\,130 \times 10^{-1}$	$*$
δ_H	$4.603\,172 \times 10^{-1}$	$*$
μ	0.000039139	$**$
μ_{I_S}	$5.691\,990 \times 10^{-2}$	$*$
μ_H	$3.280\,390 \times 10^{-2}$	$*$
γ_S	$1.197\,828 \times 10^{-1}$	$*$
γ_A	$5.113\,880 \times 10^{-1}$	$*$
γ_H	$4.880\,279 \times 10^{-1}$	$*$
N	8 918 653	$**$
S_0	$N - (E_0 + I_{S_0} + I_{A_0})$	
E_0	1388	$*$
I_{S_0}	22	$***$
I_{A_0}	1595	$*$
H_0	0	$**$
R_0	0	$**$
D_0	0	$**$

for $j = 0, \ldots, n-1$.

Assumption 1.

Assumption 2.

By Assumption 1, the system

$$\dot{X}(t) = f(t, X(t), a_0), \quad X(0) = x_0, \qquad 0 \le t \le t_1,$$

has a unique solution $\tilde{X}_0(t; x_0, a_0)$ which is continuous in (x_0, a_0). Next, put $x_1 := \tilde{X}_0(t_1; x_0, a_0)$ and consider the system

$$\dot{X}(t) = f(t, X(t), a_1), \quad X(t_1) = x_1, \qquad t_1 \le t \le t_2,$$

which, again by Assumption 1, has a unique solution $\tilde{X}_1(t; x_1, a_1)$ continuous in (x_1, a_1). By following this procedure, we end up having a recursive solution

$$\tilde{X}_{n-1}(t; x_{n-1}, a_{n-1}), \quad x_{n-1} := \tilde{X}_{n-2}(t_{n-1}; x_{n-2}, a_{n-1}), \qquad t_{n-1} \le t \le T.$$

Thus, for a control $\tilde{u}$ of the form (6) and the corresponding solution path $\tilde{X}$, we have

$$\int_0^T C(t, \tilde{X}(t), \tilde{u}(t))dt = \sum_{j=0}^{n-1} \int_{t_j}^{t_{j+1}} C(t, \tilde{X}_j(t), a_j)dt.$$

Notice that each $\tilde{X}_j$ is a continuous function of $(a_0, \ldots, a_j)$ and x_0. Therefore, by Assumption 2, the mapping

$$(a_0, \ldots, a_{n-1}) \mapsto \sum_{j=0}^{n-1} \int_{t_j}^{t_{j+1}} C(t, \tilde{X}_j(t), a_j)dt$$

is continuous.

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