Behavioral epidemiology **September 2, 2020**

Note 1: Readme file - Codes

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PURPOSE OF THE NOTE:
This readme files documents the procedures and features of the MATLAB codes realted to the project *Behavioural Epidemiology*. There are 4 files that is the key focus of this note:

- *Initialization Codes*
  - **BE_DataSetup.m**: Loads the dataset and initializes the fixed parameters
- *Estimation Codes*
  - **BE_EstimationCode.m**: The main file that invokes the estimation exercise
  - **Objective_Avec.m**: The objective function that describes the agent's problem for the estimation exercise
- *Simulation Codes*
  - **BE_SimulationCode.m**: This is the main file that invokes the simulation exercise
  - **Objective_Solve.m**: The objective function that solves the full problem for the simulation exercise

1.1 General Organization

1.2 Structure of Codes

Algorithm 1 Estimate $\beta, \gamma, \phi_+, \frac{\phi_-}{\phi_+}, rl2, c$

Require: `Datafile` $\rightarrow$ *`data_upd3xlsx.xlsx`*
Data: Poisitve cases (POSN), Negative cases (NEGN), Deaths (DN), Hospitalization (H)
Fixed Parameters: $t_i, t_h, e_0, \delta_p, \delta_a, \lambda_{min}, ifr, rl1, \beta_{share}, mi, mh$
Vaccine Arrival: $p \rightarrow$ `Negative Binomial`$(\mu = 540, \sigma^2 = 180)$
Misc. Fixed Parameters: $pop, T, Tmax, p, q$

Require: `Smoothening data`:
Smooth POSN, NEGN, DN, H $\rightarrow$ use *5-period moving average*
Extrapolate Tests: $X_t = max\{\omega_0 + \omega_1(POSNr + NEGNr)^2, 1e6\}$
Ensure: Save Parameters $\rightarrow$ *Initial_Parameters.mat*

Require: Parameter set $\rightarrow$ *Initial_Parameters.mat*
Bounds: for $\beta, \gamma, \phi_+, \frac{\phi_-}{\phi_+}, rl2, c$
SOLVE AGENT'S PROBLEM
Optimization Routine: $\rightarrow$ *Particle Swarm*: 100 particles
while Iterations $\leq$ 50 *or* Tolerance $\leq$ $1e-12$ **do**
Generate *random swarm (size 100)* of Parameters
Evaluate Objective function $\rightarrow$
Initialize variable: $S_1^1 = 1 - e0; I_1^1 = e0$

$$\text{Calculate } \lambda_t = \begin{cases} 1 & \text{for } T \in \{1, 2, \dots, 54\} \\ \sqrt{1 - \frac{1-\lambda_{min}}{(\frac{70}{55}-1)^{rl1}}(\frac{t}{55} - 1)^{rl1}} & \text{for } T \in \{55, \dots, 70\} \\ L_{min} & \text{for } T \in \{71, \dots, 100\} \\ \sqrt{L_{min}^2(rl2^{t-101}) + 1(1 - rl2^{t-101})} & \text{for } T \in \{101, \dots, T\} \end{cases}$$

Solve *State Variables* forward (with initial conditions)
Solve *Adjoint Variables* backward (with terminal conditions)
while Iterations $\leq$ 30 *or* Tolerance $\leq$ $1e-4$ **do**
Given *parameters*: solve for Control Variable $\alpha_t^k \rightarrow$ updating weights $b = 0.9$
Express α_t^k as $\kappa \rightarrow 0$.
end while
Generate moments: (1) $M_t^1 = [POSN_t - XP0_t]$; (2) $M_t^2 = [DN_t - D0_t]$; (3) $M_t^3 = [HST_t - H_t]$ where $XP0$: No of positive tests, DN: No. of deaths, HST: No of hospitalized
Calculate Mean Squared Errors: $\sum_{i=1}^{3} \omega_i \{\sum_{t=1}^{T} (M_t^i)^2\}$ where ω_i are weights: $\omega_1 = (\frac{pop*1e6}{max(POSN)})^2$, $\omega_2 = (\frac{pop*1e6}{max(DN)})^2$, $\omega_3 = (\frac{pop*1e6}{max(HST)})^2$
if Mean Squared Error $\leq$ $1e-12$ **then**
Break
end if
end while
Ensure: Output: $\rightarrow XP0, D, XN0, SR, SA, \lambda$
Ensure: Plot: (1) $XP0$ *vs.* $POSN$; (2) D *vs.* DN; (3) $\frac{SR}{SA} =$ *vs.* λ where $\frac{SR_t}{SA_t} = \sum_{k=1}^{t} \alpha_t^k \frac{S_t^k}{SA_t}$
Ensure: Save Parameters $\rightarrow$ *EstimationParameters.mat*

Algorithm 2 Simulate Optimal $\eta_t^k, \chi_t, \lambda_t, \alpha_t^k$

Require: Parameter set $\rightarrow$ *EstimationParameters.mat*

```
Initialize χ_1 = 0, η_t^1 = 0, λ_1 = Lmin, α_1^1 = 0.5
Set δ_A = [0.9899, 0.9949, 0.9989, 0.9994] and b = [0.99, 0.995, 0.999, 0.9999]
for each b and δ_A do
    SOLVE FULL PROBLEM
    while Iterations ≤ 10000 or Tolerance ≤ 1 do
    end while
end for
```