**Supplementary Material 1**

Probability statement:

$$\left(N^{1,1,1},N^{1,1,0},N^{1,0,1},N^{1,0,0},N^{0,1,1},N^{0,1,0},N^{0,0,1},N^{0,0,0}\right) \~ Multinomial\left(N^{t};\left(θ^{1,1,1},θ^{1,1,0},θ^{1,0,1},θ^{1,0,0},…\right)\right)$$

$$θ\_{y}^{1,1,1}=φ\_{o,y}ρ\_{o,y}φ\_{u,y}ρ\_{u,y}φ\_{t,y}ρ\_{t,y}$$

$$θ\_{y}^{1,1,0}=φ\_{o,y}ρ\_{o,y}φ\_{t,y}ρ\_{t,y}\left(1-φ\_{u,y}\right)+φ\_{o,y}ρ\_{o,y}φ\_{t,y}ρ\_{t,y}φ\_{u,y}\left(1-ρ\_{u,y}\right)$$

$$θ\_{y}^{1,0,1}=φ\_{o,y}ρ\_{o,y}\left(1-φ\_{t,y}\right)φ\_{u,y}ρ\_{u,y}+φ\_{o,y}ρ\_{o,y}φ\_{t,y}\left(1-ρ\_{t,y}\right)φ\_{u,y}ρ\_{u,y}$$

$$θ\_{y}^{1,0,0}=φ\_{o,y}ρ\_{o,y}\left(1-φ\_{u,y}\right)\left(1- φ\_{t,y}\right)+φ\_{o,y}ρ\_{o,y}φ\_{u,y}\left(1-ρ\_{u,y}\right)\left(1- φ\_{t,y}\right)+φ\_{o,y}ρ\_{o,y}\left(1-φ\_{u,y}\right)φ\_{t,y}\left(1- ρ\_{t,y}\right)+φ\_{o,y}ρ\_{o,y}φ\_{u,y}\left(1-ρ\_{u,y}\right)φ\_{t,y}\left(1- ρ\_{t,y}\right)$$

$$θ^{0,1,1}=φ\_{o,y}\left(1-ρ\_{o,y}\right)φ\_{t,y}ρ\_{t,y}φ\_{u,y}ρ\_{u,y}$$

$$θ^{0,0,1}=φ\_{o,y}\left(1-ρ\_{o,y}\right)\left(1-φ\_{t,y}\right)φ\_{u,y}ρ\_{u,y}+φ\_{o,y}\left(1-ρ\_{o,y}\right)φ\_{t,y}\left(1-ρ\_{t,y}\right)φ\_{u,y}ρ\_{u,y}$$

$$θ^{0,1,0}=φ\_{o,y}\left(1-ρ\_{o,y}\right)φ\_{t,y}ρ\_{t,y}\left(1-φ\_{u,y}\right)+φ\_{o,y}\left(1-ρ\_{o,y}\right)φ\_{t,y}ρ\_{t,y}φ\_{u,y}\left(1-ρ\_{u,y}\right)$$

$$θ^{0,0,0}=(1-φ\_{o,y})+φ\_{o,y}\left(1-ρ\_{o,y}\right)\left(1- φ\_{t,y}\right)\left(1- φ\_{u,y}\right)+φ\_{o,y}\left(1-ρ\_{o,y}\right)φ\_{t,y}\left(1- ρ\_{t,y}\right)\left(1- φ\_{u,y}\right)+φ\_{o,y}\left(1-ρ\_{o,y}\right)φ\_{t,y}\left(1- ρ\_{t,y}\right)φ\_{u,y}\left(1- ρ\_{u,y}\right)$$

Hyper-priors for transition probabilities:

$$φ\_{o,y} \~ Beta\left(α\_{o}, β\_{o}\right)$$

$$φ\_{t,y} \~ Beta\left(α\_{t}, β\_{t}\right)$$

$$φ\_{u,y} \~ Beta\left(α\_{u},β\_{u}\right)$$

Priors:

$$α\_{o} \~ uniform\left(2, 5\right)$$

$$β\_{o} \~ uniform\left(2, 5\right)$$

$$α\_{t} \~ uniform\left(1.5, 2.5\right)$$

$$β\_{t} \~ uniform\left(6, 9\right)$$

$$α\_{u} \~ uniform\left(2, 5\right)$$

$$β\_{u} \~ uniform\left(2, 5\right)$$

$$ρ\_{o,y} \~ uniform\left(0, 1\right)$$

$$ρ\_{t,2016}= 0$$

$$ρ\_{t,y} \~ uniform\left(0.9, 1\right)$$

$$ρ\_{u,2017} \~ uniform(0.6, 0.9)$$

$$ρ\_{u,y} \~ uniform\left(0.9, 1\right)$$