$$X_{\text{real}} = PE + AP + \frac{Population \times 130}{10^6} \tag{1}$$

$$X_{\text{norm}} = \frac{X_{\text{real}}}{X_{\text{base}}} \tag{2}$$

$$\begin{aligned} X_{\text{bonus},t} = {} & \theta \cdot STEM_t \cdot EduRate_t \cdot (1 + TFP_t) \\ & \cdot \left[1 + \frac{PatDen_t - PatDen_{t-1}}{PatDen_{t-1}}\right] \\ & \cdot \left[1 + \frac{X_{\text{real},t} - X_{\text{real},t-1}}{X_{\text{real},t-1}}\right]^P \end{aligned} \tag{3}$$

$$0 \;\le\; X_{\text{bonus},t} \;\le\; 5 \tag{4}$$

$$\begin{aligned} Z_{\text{raw},t} = \text{avg}\Big( & ZShock_t,\ -relax_t,\ \gamma_S \cdot Zc_t, \\ & -\gamma_X \cdot X_{\text{bonus,norm},t},\ Drift_t \Big) \end{aligned} \tag{5}$$

$$Z_{\text{scaled},t} = \frac{Z_{\text{raw},t}}{Z_{\text{max}}} \cdot Z_{\text{scale}} \tag{6}$$

$$Z_{\text{eff},t} = \begin{cases} \big((1 + Z_{\text{scaled},t})^2 - 1\big), & Z_{\text{scaled},t} \ge 0 \\ -\big((1 + |Z_{\text{scaled},t}|)^2 - 1\big), & Z_{\text{scaled},t} < 0 \end{cases} \tag{7}$$

$$\Omega_t = Oc_t + \Omega_{shock,t} \tag{8}$$

$$Oc_t = \text{avg}\Big( -SavingsRate_t,\ \ \sqrt{2} \cdot Unemployment_t,\ \ DebtRate_t,\ \ -\tfrac{LPI_t}{10} \Big) \tag{9}$$

$$-5 \;\le\; \Omega_t \;\le\; 5 \tag{10}$$

$$\begin{aligned} Zc_t = w_{Zc} \cdot \text{avg}\Big( & Gini_t,\ \sqrt{2} \cdot MurderRate_t,\ \sqrt{2} \cdot PovertyRate_t, \\ & \min(MCapGDP_t, 3),\ (1 - Trust_t),\ S_{popdens,t} \Big) \end{aligned} \tag{11}$$

$$Zc_t \;\le\; 5 \tag{12}$$

$$S_{popdens,t} = 1 - \frac{1}{UrbanRate_t \cdot \left( \frac{Population_t}{ArableLand_t} \right)} \tag{13}$$

$$0 \;\le\; S_{popdens,t} \;\le\; 2.5 \tag{14}$$

$$PopPressure_t = \frac{\frac{Population_t}{ArableLand_t}}{\frac{KWPE_{pc,t}}{LandCapLimitCoef}} \tag{15}$$

$$KWPE_{pc,t} = \frac{\left(PE_t + AP_t + \frac{Population_t \times 130}{10^6}\right)}{Population_t} \times 10^6 \tag{16}$$

$$Y_{base,t} = a_0 + a_1 \cdot X_{\text{norm},t} + b_1 \cdot Gini_t + \mu \cdot \ln(1 + X_{\text{real},t}) \tag{17}$$

$$Y_0 = \begin{cases} Y_{first}, & \text{if explicitly provided} \\ Y_{base,0}, & \text{otherwise} \end{cases} \tag{18}$$

$$\begin{aligned} Y_1 = Y_{base,1} + \Delta X_1 \cdot k_Y \cdot \big(1 + ZImpactK \cdot Z_{\text{eff},1}\big) \\ \cdot \big(1 + PopPressure_1\big) \end{aligned} \tag{19}$$

$$\begin{aligned} Y_t = Y_{t-1} + \Delta X_t \cdot k_Y \cdot \big(1 + ZImpactK \cdot Z_{\text{eff},t}\big) \\ \cdot \big(1 + PopPressure_t\big) \end{aligned} \tag{20}$$

$$Y_{limit,t} = \begin{cases} X_{\text{norm},t} \cdot (1 - MilitaryRatio_t) \cdot k_{Limit} \cdot (1 + |\Omega_t|), & \Omega_t \leq 1 \\ \dfrac{X_{\text{norm},t} \cdot (1 - MilitaryRatio_t) \cdot k_{Limit}}{1 + \Omega_t}, & \Omega_t > 1 \end{cases} \tag{21}$$

$$Y_{limit,t} \leftarrow \frac{Y_{limit,t}}{(1 + YLimitDecayBeta) \cdot (1 + |\Delta X_t|)} \quad \text{if } \Delta X_t < 0 \tag{22}$$

$$S_t = \begin{cases} S_{t-1} + (Y_t - Y_{limit,t}), & Y_t > Y_{limit,t} \\ S_{t-1} \cdot (1 - SDecayRate), & Y_t \leq Y_{limit,t} \end{cases} \tag{23}$$

$$I_{reset,t} = \begin{cases} 1, & S_t \geq Y_{limit,t} \\ 0, & S_t < Y_{limit,t} \end{cases} \tag{24}$$