SECM Model Variable Dictionary (Full Table)

Symbol / Name	Definition / Description	Units / Normalization	Real-World Proxy / Calculation	Main Data Source / Note
X_t	Aggregate productive capacity at time t	Index, normalized or PPP	Real GDP (excluding finance/real estate), industrial output	World Bank, OECD, Maddison, Seshat
Y_t	Social opportunity cost	Dimensionless, normalized	Gini, mobility cost, stratification indices	World Bank, OECD, LIS, national stats
Z_t	Destabilization index (systemic risk/shock)	Index, normalized	War/pandemic/ disaster/ financial crisis index	EM-DAT, UCDP, GDELT, IMF, WTO
$\Delta X_{\text{bonus}}(t)$	Raw innovation bonus	Index, %ΔX per year	Patent bursts, breakthrough events, sectoral R&D surge	USPTO, Seshat, Nature Index
$\Delta X^{\text{eff}}_{\text{bonus}}(t)$	Education-absorbed effective innovation bonus	Index, $\%\Delta X$ per year	$\Delta X_{\text{bonus}} \times$ education/STEM/PISA filter	WIPO, OECD, UNESCO, PISA
$\Phi_{\text{edu}}(t)$	Education innovation absorption filter	[0,1], dimensionless	Sigmoid(PISA_math − PISA_threshold) × STEM filter	OECD, UNESCO
PopDens_t	Population density at time t	Persons/km^2	N_t/HabitableArea$_t$	WorldPop, HYDE 3.2
D_{opt}	Productivity-optimal density	Persons/km^2	Calibrated regional optimum (default $\approx$ 150/km^2)	Empirical regression
λ_d	Productivity density bonus coefficient	Dimensionless	Patent-GDP density regression	World Bank, USPTO/EPO
$\lambda_r(t)$	Density penalty coefficient	Dimensionless, dynamic	See main formula: commute/infrastructure	OSM, Google Mobility, WorldPop
η_t	Productivity friction sensitivity	Dimensionless	High-risk investment, M2/GDP, regression	IMF, central banks

$\Delta X_{\text{diff}}(t)$	International knowledge/tech diffusion increment	$\%\Delta X$ per year	See formula (distance, trade, patent diff)	OECD, patent, education datasets
$\Delta X_{\text{trade}}(t)$	Trade/integration/resource gain increment	$\%\Delta X$ per year	Net trade gain, FDI, value chain upgrades	UN Comtrade, UNCTAD
$\Delta X_Z(t)$	Direct external shock impact on productivity	$\%\Delta X$ per year	Disaster, war, aid, regime effect	SIPRI, EM-DAT, disaster databases
PISA_math	National PISA math score (standardized, mean ≈ 500)	Score	OECD PISA	OECD
PISA_threshold	PISA math proficiency baseline (passing threshold)	Score	OECD passing cutoff	OECD
N_t	Population at time t	Persons, normalized	Census or UN estimate	UN, national census
$N_{t,\text{STEM}}$	STEM researcher count	Persons	OECD, UNESCO STEM stats	OECD, UNESCO
N_{crit}	Critical STEM scale for innovation absorption	Persons	Empirical inflection value	OECD calibration
TER_t	Tertiary education enrollment rate at t	[0,1]	% of population enrolled in tertiary education	UNESCO, World Bank
TER_ref	Reference tertiary enrollment rate (benchmark)	[0,1]	OECD reference	Model calibration
N_t^{edu}	Tertiary-educated population at time t	Persons	$N_t \times \text{TER}_t \times (1 - \beta_y \cdot Y_t)$	UNESCO, national stats
β_y	Y impact on education attainment	Dimensionless	Opportunity cost effect on education	Model calibration
HabitableArea_t	Habitable land area at t	km^2	Excludes deserts, glaciers, etc.	HYDE 3.2, NASA SEDAC
Area_ref	Reference area for land buffer	km^2	Typically 1,000,000 km^2	Calibration
σ	Base innovation friction relief	Dimensionless	Empirical estimate	Historical panel, regression
σ^{new}	Education/trust-filtered friction relief	Dimensionless	See new formula	Model output
η_e	Education-innovation synergy coefficient	Dimensionless	Mobility/innovation regression	Model calibration

α	Scaling elasticity (innovation, Z effect)	Dimensionless	Tech diffusion literature	Literature, empirical fit
γ	Innovation relief scaling	Dimensionless	Empirical fit	Model fit
$\kappa_d(t)$	Density-friction amplifier	Dimensionless	$d(\text{Gini})/d\ln(\text{PopDens})$ trust adjustment	Model output, Gini stats
D_t	Normalized population density	Dimensionless	PopDens_t / 100	Derived variable
ρ_t	Baseline friction growth rate	Dimensionless	Gini growth, mobility decline	Gini, mobility stats
ρ_t^{new}	Upgraded density/education modulated friction rate	Dimensionless	See formula	Model output
$\varepsilon_0^{\text{buff}}$	Land buffer term	Dimensionless	$-\beta_a \cdot (\text{HabitableArea}_t/\text{Area}_{\text{ref}})$	Model output
β_a	Land buffer elasticity	Dimensionless	Civil war frequency–area regression	Empirical fit, Seshat
U_t	Tech/structural unemployment rate	[0,1]	Innovation/sectoral displacement share	OECD, WB, labor stats
Ψ_t	Psycho-social integration/trust index	[0,1]	Survey trust, social capital	WVS, Gallup, Seshat
β_t	Trust shock sensitivity parameter	Dimensionless	$\beta_0 \cdot (1 - \text{ClearanceRate}_t)^\gamma$; unrest/protest rates	FBI, Eurostat, V-Dem, GDELT
η_t	Trust recovery elasticity	Dimensionless	$\Delta\text{Trust}_t \sim \Delta X_t/X_t$ regression	WVS, Gallup, IMF
$\omega_{1,t}$	Innovation-aligned trust weight	[0,1]	$(P_{\text{break},t}/P_{\text{total},t}) \cdot (A_{\text{break},t}/A_{\text{total},t})$	Nature Index, Clarivate, USPTO/EPO
Trust_t	Institutional trust	[0,1]	Survey, regime longevity, legal compliance	WVS, Gallup
SocialCapital_t	Civic/interpersonal trust	[0,1]	Association density, volunteerism, contract rate	WVS, legal/association records
$\Gamma(\Psi_t)$	Trust scaling function	[0,1]	Fitted monotonic map of Ψ_t	Model output
$Z_{\text{ext}}(t)$	Raw exogenous shock signal	Index, normalized	Event-specific formulas	SIPRI, UNDRR, WHO, Comtrade, SWIFT

ν_t	Low trust penalty coefficient	Dimensionless	Regression on trust collapse impact	V-Dem, GDELT, WVS/Gallup
ϕ_{dens}	Density shock coefficient	Dimensionless	Elasticity of urban unrest to density	OECD, WDI, urban unrest data
ϕ_{edu}	Education filter penalty coefficient	Dimensionless	Education-shock elasticity fit	UNESCO, OECD, PISA
$f(\text{TER}_t, \text{STEM}_t, \text{PISA}_{\text{math}})$	Education shock filter function	[0,1]	See formula	Model output
TFP	Total factor productivity	% per annum, normalized	Penn World Table	TFP growth rate, efficiency
High-Tech Exports	High-tech exports as share of total exports	[0,1] or %	National trade data	UNCTAD, OECD
Inst_t	Institutional resilience index	[0,1]	Governance effectiveness, rule of law	World Bank, WGI
Hist_t	Historical inertia	Years or normalized	Years since last rupture/regime change	Seshat, Penn AWED
K	Demographic scaling parameter	Persons	Calibration	Model parameter
TLI_t	Technology Level Index (patents, R&D/GDP, TFP index)	[0,1]	Patents per capita, R&D/GDP, TFP index	OECD, WIPO, USPTO/EPO
S_t	Cumulative stress memory	Dimensionless model output	$\sum_{\tau=t_0}^{t} \max(0, Y_\tau - Y\text{-}Limit_\tau)$	Model internal variable
$\beta_0, \gamma, \kappa, \xi, \theta_0, \delta_c$	Core/secondary model coefficients	Dimensionless	Fitted per model calibration	Model fit
$\text{SEI}(t)$	Socialization Efficiency of Innovation Dividend	[0,1]	Weighted sum: $S_{\text{civil}}, S_{\text{mil}\to\text{civil}}, S_{\text{bubble}}^{-1}, S_{\text{equity}}$	OECD, patent data, startup indices
T_t	Trade Stress Index	[0,1] or ratio	Seaborne Tonnage / Total Trade Volume	World Bank, UNCTAD, ship registers
$Y_{\text{eff},t}$	Effective Social Opportunity Cost	Dimensionless	$Y_{\text{base}} + c_1 \cdot Q_{\text{gap},t} + c_2 \cdot \max(0, 1 - \text{Adeq}_t)$	National stats, OECD
$Q_{\text{gap},t}$	Quality-of-life Gap	Income or normalized	Median wage – living cost	OECD, World Bank

$Adeq_t$	Resource Adequacy	[0,1]	Population share with essential access	Poverty/coverage data
CriticalShock	Bifurcation/rupture threshold	Dimensionless	Scenario parameter	Sensitivity/robustness scenario