1 Variable Definitions and Parameters

Variable	Description	Unit / Scale
Core Productive Capacity		
X_{real}	Actual productive capacity, derived from primary energy, animal power, and human labor (KWPE).	million kWh
X_{norm}	Normalized productive capacity, relative to baseline $X_{\text{real},0}$.	Dimensionless
KWPE	Kilowatt Productivity Equivalent: human labor converted to energy-equivalent productivity.	million kWh
PrimaryEnergy (PE)	Total primary energy supply.	million kWh
AnimalPower (AP)	Animal-based mechanical power supply.	million kWh
Population	Total population.	persons
ArableLand	Total arable land.	hectares
Technology and Innovation		
X_{bonus}	Technology dividend factor, capturing the impact of STEM, education, TFP, and patent growth.	0–5
STEM	Share of STEM workforce or education index.	Dimensionless
EduRate	Education enrollment or attainment rate.	Dimensionless
TFP	Total factor productivity index.	Dimensionless
PatDen	Patent density per capita.	patents / 1000 people
Societal Tension Metrics		
Z_{raw}	Raw social tension before scaling.	Dimensionless
Z_{scaled}	Scaled social tension (normalized).	Dimensionless
Z_{eff}	Effective societal contradiction index.	Dimensionless
Zc	Societal complexity contradiction index, composite of Gini, poverty, violence, etc.	0–5
Gini	Gini coefficient of inequality.	0–1
MurderRate	Homicide rate.	per 100k pop.
PovertyRate	Poverty incidence rate.	0–1
MCapGDP	Market capitalization relative to GDP.	Ratio
Trust	Social trust index (survey-based).	0–1
$S_{popdens}$	Population density friction factor.	0–2.5
Resilience and Stability		
Ω	Structural resilience index (including shocks).	-5 to 5

Variable	Description	Unit / Scale
Ω_{shock}	Exogenous shock to resilience (e.g., disasters).	Dimensionless
Oc	Composite baseline resilience (savings, unemployment, debt, LPI).	Dimensionless
SavingsRate	Gross savings as % of GDP.	0–1
Unemployment	Unemployment rate.	0–1
DebtRate	Government debt ratio.	0–1
LPI	Logistics Performance Index (normalized).	0–10
Demography and Pressure		
PopPressure	Population pressure on land and productivity.	Dimensionless
$KWPE_{pc}$	Per capita kilowatt productivity equivalent.	kWh / capita
UrbanRate	Urbanization rate.	0–1
Contradiction Dynamics		
Y_{base}	Baseline social tension.	Dimensionless
Y	Actual societal contradiction level.	Dimensionless
Y_{limit}	Societal carrying capacity (max sustainable contradiction).	Dimensionless
MilitaryRatio	Military expenditure as share of GDP.	0–1
k_Y	Scaling factor for Y growth.	Dimensionless
k_{Limit}	Scaling factor for carrying capacity.	Dimensionless
$ZImpactK$	Weight of social tension (Z) in Y dynamics.	Dimensionless
$YLimitDecayBeta$	Decay acceleration factor during negative productivity growth.	Dimensionless
Crisis and Collapse		
S	Crisis accumulation pool.	Dimensionless
$SDecayRate$	Crisis pool decay rate when $Y \leq Y_{limit}$.	0–1
I_{reset}	Collapse trigger indicator (binary).	0/1

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