Open-Economy Growth Model for China (1980–2025)

Variables

Endogenous

Symbol	Definition	Units
Y_t	Real GDP	bn USD
K_t	Physical capital stock	bn USD
L_t	Labor force	million
A_t	Total factor productivity (TFP)	index
X_t	Exports	bn USD
M_t	Imports	bn USD
NX_t	Net exports	bn USD
C_t	Consumption	bn USD
I_t	Investment	bn USD
$openness_t$	(Exports + Imports) / GDP	fraction
e_t	Nominal exchange rate	CNY per USD

Exogenous

Symbol	Definition	Units
$\tilde{e}_t$	Counterfactual floating nominal exchange rate	CNY per USD
fdi_ratio_t	FDI inflows / GDP	fraction
Y_t^*	Foreign income	index (1980 = 1000)
H_t	Human capital index	index (2015 = Penn World Table value)

Parameters

Symbol	Definition	Units	Value
α	Capital share in production	unitless	0.30
δ	Depreciation rate	per year	0.10
g	Baseline TFP growth rate	per year	0.005
n	Labor-force growth rate	per year	0.00717
θ	Openness contribution to TFP growth	unitless	0.1453
ϕ	FDI contribution to TFP growth	unitless	0.10
K_0	Initial level of physical capital (1980)	bn USD	2050.10
X_0	Initial level of exports (1980)	bn USD	18.10
M_0	Initial level of imports (1980)	bn USD	14.50
L_0	Initial labor force (1980)	millions	428.30
A_0	Initial level of TFP (1980)	index	0.203
$\varepsilon_x,\ \varepsilon_m$	Exchange-rate elasticities (exports/imports)	unitless	1.5, 1.2
$\mu_x,\ \mu_m$	Income elasticities (exports/imports)	unitless	1.0, 1.0

Note: The initial TFP, A_0, is backed out from 1980 data via

$$A_0 \;=\; \frac{Y_{1980}}{K_0^{\alpha}\,(L_0\,H_0)^{1-\alpha}} \;=\; \frac{191.15}{2050.10^{0.30}\,(428.30\times 1.58)^{0.70}} \;\approx\; 0.203.$$

Paths of exogenous variables

Year	$\tilde{e}_t$	fdi_ratio_t	Y_t^*	H_t
1980	0.78	0.00	1000.00	1.58
1985	1.53	0.00	1159.27	1.77
1990	2.48	0.02	1343.92	1.80
1995	4.34	0.02	1557.97	2.02
2000	5.23	0.02	1806.11	2.24
2005	4.75	0.02	2093.78	2.43
2010	5.61	0.02	2427.26	2.61
2015	7.27	0.02	2813.86	2.60
2020	7.00	0.02	3262.04	6.71
2025	6.41	0.02	3781.60	6.49

Values for 2025 are latest available: - $\tilde{e}_t$ uses 2024 value - H_t uses 2022 value

Control Variables (Student/Player-Determined)

Symbol	Definition	Units
x_t	Exchange rate policy	1.2, 1.0 or 0.8
s_t	Saving rate	fraction (0.0 to 1.0)

- **Exchange-rate policy**

$$e_t = x_t\,\tilde{e}_t = \begin{cases} 1.2\,\tilde{e}_t, & \text{undervalued} \\ 1.0\,\tilde{e}_t, & \text{market value} \\ 0.8\,\tilde{e}_t, & \text{overvalued} \end{cases}$$

- **Saving-rate policy**

$$s \in [0.0, 1.0]$$

Model Equations

- **Production:**

$$Y_t = A_t\,K_t^{\alpha}\,(L_t\,H_t)^{1-\alpha}$$

- **Capital accumulation:**

$$K_{t+1} = (1-\delta)\,K_t + I_t$$
$$K_0 \text{ given}$$

- **Labor force:**

$$L_{t+1} = (1+n)L_t$$

- **TFP:**

$$A_{t+1} = A_t(1 + g + \theta\,openness_t + \phi\,fdi\_ratio_t)$$

- **Exports:**

$$X_t = X_0 \left(\frac{e_t}{e_{1980}} \right)^{\varepsilon_x} \left(\frac{Y_t^*}{Y_{1980}^*} \right)^{\mu_x}$$

- **Imports:**

$$M_t = M_0 \left(\frac{e_t}{e_{1980}} \right)^{-\varepsilon_m} \left(\frac{Y_t}{Y_{1980}} \right)^{\mu_m}$$

- **Net exports:**

$$NX_t = X_t - M_t$$

- **Consumption:**

$$C_t = (1 - s)\, Y_t$$

- **Investment:**

$$I_t = s\, Y_t + NX_t$$

- **Openness ratio:**

$$openness_t \;=\; \frac{X_t + M_t}{Y_t}$$

- **Nominal exchange rate:**

$$e_t = x_t\, \tilde{e}_t$$

Computation Steps for Each Round

1. Read values of x_t, s_t entered by player.
2. Read values of exogenous variables $\tilde{e}_t$, fdi_ratio_t, Y_t^*, H_t from table 'Paths of exogenous variables'.
3. Read values for K_t, L_t, A_t:

- For first round (1980), K_0, L_0, A_0 given by parameter values
- For second and later rounds (1985, 1990, …), K_t, L_t, A_t determined in the previous round

4. Compute output/production:

$$Y_t = A_t K_t^{\alpha} (L_t\, H_t)^{1-\alpha}$$

5. Compute nominal exchange rate:

$$e_t = x_t \tilde{e}_t$$

6. Compute exports:

$$X_t = X_0 \left(\frac{e_t}{e_0} \right)^{\varepsilon_x} \left(\frac{Y_t^*}{Y_0^*} \right)^{\mu_x}.$$

7. Compute imports:

$$M_t = M_0 \left(\frac{e_t}{e_0} \right)^{-\varepsilon_m} \left(\frac{Y_t}{Y_0} \right)^{\mu_m}.$$

8. Compute net exports:

$$NX_t = X_t - M_t$$

9. Compute openness ratio:
$$openness_t = \frac{X_t + M_t}{Y_t}$$

10. Compute consumption:
$$C_t = (1 - s)Y_t$$

11. Compute investment:
$$I_t = sY_t + NX_t$$

12. Compute next period's labor force:
$$L\_t + 1 = (1 + n)L_t$$

13. Compute next period's capital:
$$K\_t + 1 = (1 - \delta)K_t + I_t$$

14. Compute next period's TFP:
$$A_{t+1} = A_t(1 + g + \theta\, openness_t + \phi\, fdi\_ratio_t)$$

Round-by-Round Calendar

Rounds $t = 0, 1, ...$ correspond to 1980, 1985, ..., (five year intervals).

China Economic Data (1980–2024)

Table 6: Economic Indicators

Year	Exports (bn USD)	Imports (bn USD)	GDP (bn USD)	Capital Stock (2017 USD bn)	Labor Force (million)	Human Capital Index	TFP (2017 = 1)	Consumption (bn USD)	Investment (bn USD)	FX Rate (CNY/USD)	Counterfactual Floating Nominal Rate (CNY/USD)
1980	19.41	21.84	191.15	2050.10	428.30	1.58	0.832	123.65	66.15	1.50	0.78
1985	25.80	38.30	309.49	3062.30	496.80	1.77	0.878	201.39	120.90	2.94	1.53
1990	49.13	38.46	360.85	4507.30	550.80	1.80	0.805	229.68	123.26	4.78	2.48
1995	131.86	119.90	734.55	7287.10	629.00	2.02	0.869	433.84	285.28	8.35	4.34
2000	253.09	224.31	1211.35	12185.20	679.50	2.24	0.810	770.06	406.69	8.28	5.23
2005	773.34	648.71	2285.97	21265.50	748.70	2.43	0.895	1243.21	922.30	8.19	4.75
2010	1654.82	1432.42	6086.00	39311.20	783.00	2.61	1.031	2977.44	2833.95	6.77	5.61
2015	2362.10	2003.26	11061.00	68791.70	797.00	2.60	1.019	5972.23	4782.44	6.23	7.27
2020	2729.88	2374.74	14723.00	100000.00	787.10	6.71	0.936	8071.33	6370.00	6.90	7.00
2021	3554.11	3093.28	17734.10	102500.00	786.00	6.52	0.951	9420.00	6840.00	6.45	7.21
2022	3717.89	3140.04	17882.00	105000.00	783.00	6.49	0.961	10000.00	7520.00	6.73	7.15
2023	3513.24	3127.20	18273.00	107500.00	780.00	n/a	0.971	10500.00	7270.00	7.07	6.57
2024	3580.00	2590.00	19530.00	110000.00	778.00	n/a	0.979	11250.00	7500.00	7.00	6.41

Data Sources and Computations

- **GDP:** World Bank, World Development Indicators (1980-2023), IMF WEO projections (2024).
- **Capital Stock:** Penn World Table 10.01 (1980-2019), estimates post-2020 based on historical trends and investment data.
- **Labor Force:** World Bank / International Labour Organization (ILO) data.
- **Exports and Imports:** World Bank (1980-2023), World Development Indicators, Trading Economics (2024).
  - World Bank: Exports and Imports
  - Trading Economics: Exports and Imports
- **Human Capital Index:**
  - 1980-2019 from Penn World Table 10.01 Human Capital Index.
  - 2019-2022 from China Human Capital Index from the Center for Human Capital and Labor Market Research at Central University of Finance and Economics (CUFE), CPI-adjusted for entire country (2020-2022). Values normalized to match the Penn World Table number for 2015, then use growth rate of CUFE series from 2015 onward to create the human capital index series used. The annual value is the average of the two semi-annual values.
- **TFP (Total Factor Productivity):** Penn World Table 10.01 TFP Index (1980-2019), values post-2019 assumed based on:
  - Start from the last reliable official figure (2019 TFP from PWT).
  - Apply a negative adjustment for the year 2020, reflecting economic disruptions from COVID-19. This negative adjustment was presumably informed by GDP and productivity impacts documented by institutions like the IMF, World Bank, or OECD during the pandemic.
  - From 2021 onward, positive adjustments (gradual increases in TFP) were made, assuming partial recovery in productivity growth, possibly guided by international forecasts (e.g., IMF World Economic Outlook).
- **Consumption:** World Bank World Development Indicators (Final Consumption Expenditure), adjusted to match GDP accurately.
- **Investment:** World Bank World Development Indicators (Gross Capital Formation).
- **Nominal Exchange Rate (CNY/USD):** Historical official exchange rates (IMF International Financial Statistics, World Bank, historical accounts).
- **Real Exchange Rate:** Bank for International Settlements (2025), Effective exchange rates, BIS WS_EER 1.0 data set (accessed on 29 April 2025).
- **Counterfactual Floating Nominal Exchange Rate:** Models a hypothetical nominal exchange rate that would have been the market exchange rate if China had a floating exchange rate regime, computed as follows:
  - **Annual real exchange rate is average of monthly observations**

$$\bar{R}_t = \frac{1}{12} \sum_{m=1}^{12} R_{t,m}, \quad R_{t,m} \text{ from BIS series described above}$$

  - **Normalize**

$$\tilde{e}_{2020} = 7.00$$

– **Counterfactual**

$$\tilde{e}_t = 7.00 \times \frac{\bar{R}_t}{100}$$

– **Backfill** for (t<1994), let (t_1=1995):

$$\tilde{e}_t = e_t^{\text{nom}} \times \frac{\tilde{e}_{t_1}}{e_{t_1}^{\text{nom}}}$$

where e_t^{nom} is the observed realized nominal exchange rate.

Economics-Themed Team Names for Classroom Game

Theme: Inflation, Risk Premia, Interest Rates

1. **The Inflators**
2. **Premia Donnas**
3. **The Real Yields**
4. **2% and Furious**
5. **Risky Business Majors**
6. **The Nominal Nonsense**
7. **Fed Up and Rising**
8. **Duration Nation**
9. **Curve Flatteners**
10. **The Discounted Crew**
11. **QE Cuties**
12. **Revenge of the Basis Points**
13. **Taylor Rule Breakers**
14. **Zero Lower Bounders**
15. **The Term Structure Squad**
16. **Stagflation Sensations**
17. **Break-Even Bandits**
18. **Hawks, Doves & Shenanigans**
19. **Forward Guidance Counselors**
20. **Tipsy with TIPS**

Theme: China, Secular Stagnation, Tariffs, Trade

21. **Great Wall of Tariffs**
22. **Export or Die Trying**
23. **The Red Supply Chain**
24. **Stagnation Nation**
25. **Made in China, Priced Abroad**
26. **The Long March to Demand**
27. **Wokeflation Warriors**
28. **The Trade Deficitists**
29. **Ghost City Tycoons**
30. **Xi's Invisible Hand**
31. **Belt, Road, and Beyond**
32. **The Tariffic Trio**
33. **Low Rates, High Stakes**
34. **Stimulus & Soybeans**

35. **The Renminbi Riddlers**
36. **Unbalanced but Ambitious**
37. **The Great Decouplers**
38. **Import Export Emporium**
39. **The Demographic Timebombers**
40. **Losing My Supply Chain**

Theme: Macro Mayhem

41. **The PBOC Pivoteers**
42. **Tariff and Error**
43. **Yield Curve of the Yangtze**
44. **Stagnation with Chinese Characteristics**
45. **Exporting Inflation Since '08**
46. **The Premia Warriors**
47. **Quantitative Easing with Chinese Spice**
48. **The Great Wall of Real Rates**
49. **Red Capital, Negative Rates**
50. **Ghost Malls & Forward Guidance**
51. **Secularly Doomed But Hedged**
52. **Crouching Premia, Hidden Demand**
53. **Renminbi Raiders**
54. **The Belt and Road Rate Hike**
55. **Risk-On in the Middle Kingdom**
56. **The Low Interest Club of Shanghai**
57. **Stimulus & Stagnation Bros. Ltd.**
58. **Too Much Saving, Not Enough Fun**
59. **From Trade Surplus to Liquidity Trap**
60. **Flat Curves & Floating Yuan**

Theme: Economist Puns

61. **The Keynes to Success**
62. **Adam's Wealth of Smithies**
63. **Friedman's Free Marketeers**
64. **The Marx Brothers**
65. **Hayek's Road Crew**
66. **Pigou's Taxers**
67. **The Malthusian Optimists**
68. **Ricardo's Comparative Advantagers**
69. **Veblen's Conspicuous Consumers**
70. **The Galbraith Giants**
71. **Nash's Equilibrium Seekers**
72. **Schumpeter's Creative Destroyers**
73. **The Samuelson Solvers**
74. **Arrow's Impossibility Team**
75. **Solow's Growth Models**
76. **The Stiglitz Stigmas**
77. **Coase Theorem Provers**
78. **Krugman's Trade Warriors**
79. **Sen's Capability Approach**

80. **The Behavioral Thalers**
81. **The Keynesian Knights**
82. **Smith's Invisible Hands**
83. **Friedman's Freedom Fighters**
84. **Marx's Manifesto Makers**
85. **Hayek's Heroes**
86. **Pigou's Tax Tigers**
87. **Malthus Population Panthers**
88. **Ricardo's Raiders**
89. **Veblen's Vanguards**
90. **Galbraith's Gladiators**
91. **Nash's Navigators**
92. **Schumpeter's Storm**
93. **Samuelson's Scholars**
94. **Arrow's Archers**
95. **Solow's Stars**
96. **Stiglitz Strikers**
97. **Coase's Commandos**
98. **Krugman's Crusaders**
99. **Sen's Sentinels**
100. **Thaler's Titans**