Water quality and socio-economic simulations of the Yangtze River Basin

Group: STE
Group Members:
Zhi Li (4765729)
Xinxin Sui (4691326)
Chang Gao (4725735)

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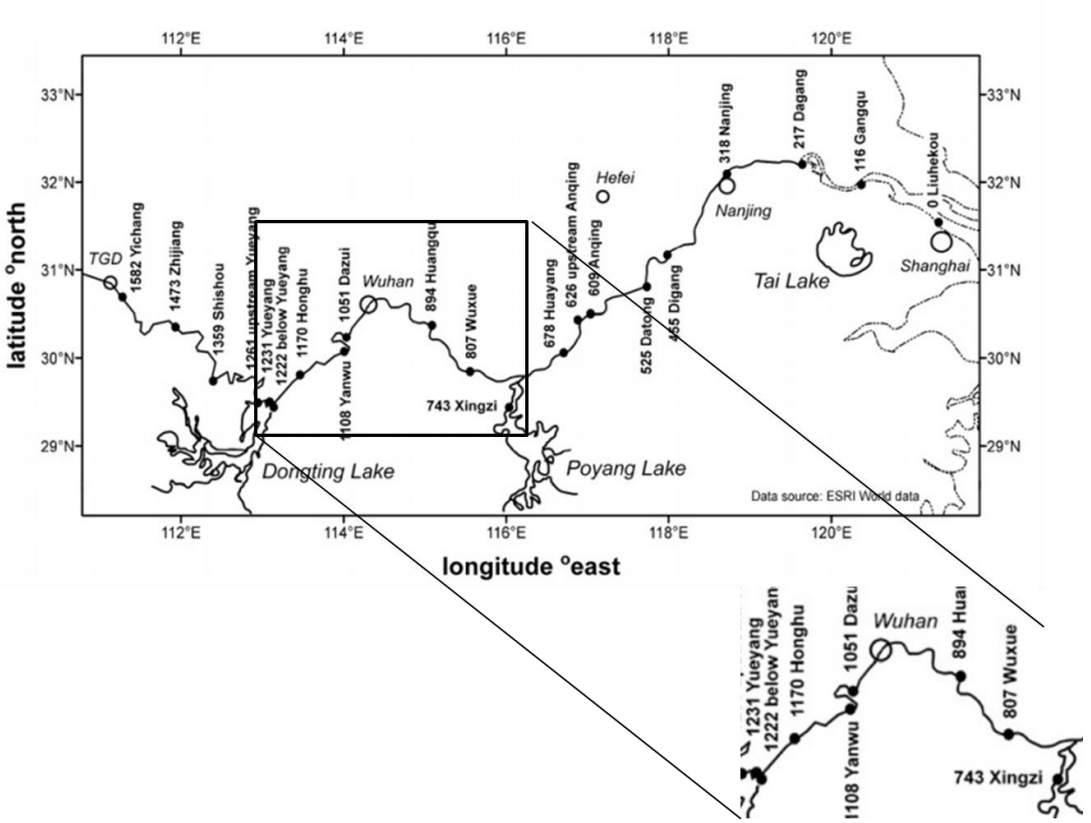
Brief Introduction

Areas Under Simulation



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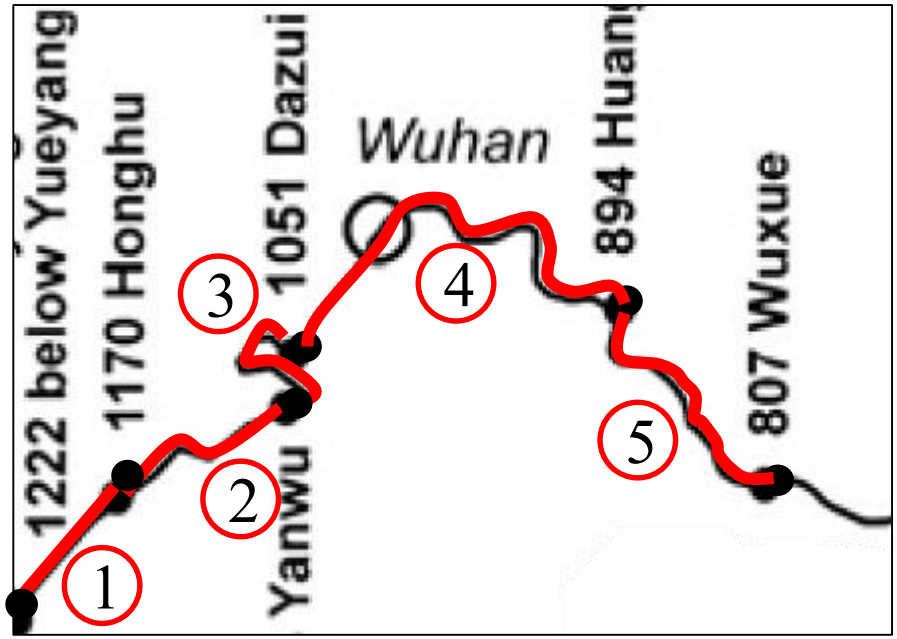
Brief Introduction

Areas Under Simulation



	Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 5
Length(km)	52	62	57	157	87
W of COD (kg/s)	4.632	4.849	4.537	5.362	5.221
W of Nitrogen(kg/s)	0.786	0.863	0.842	1.112	0.965

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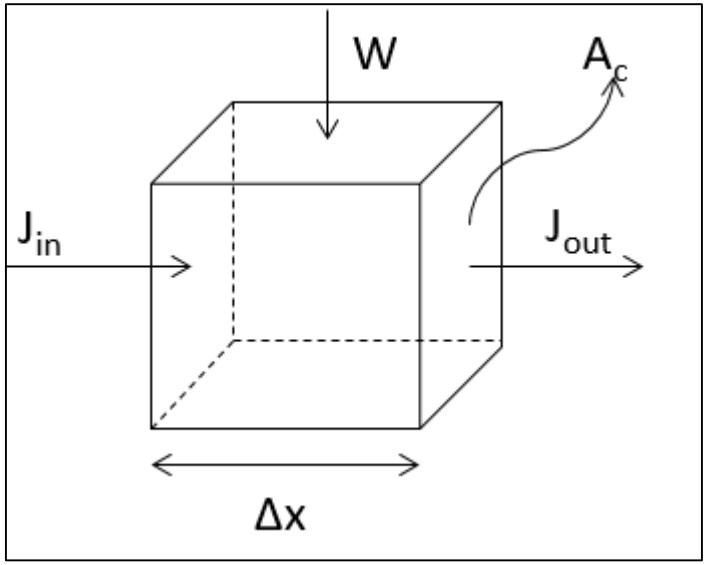
Environmental Perspective

Model Description



Mass Balance of Water:

$$\frac{d\rho\Delta V}{dt} = J_{in}^{\rho}A_c - J_{out}^{\rho}A_c + W$$

Mass Balance of Pollutant:

$$\frac{dc\Delta V}{dt} = J_{in}^{c}A_c - J_{out}^{c}A_c + W - kVc$$

At steady state !

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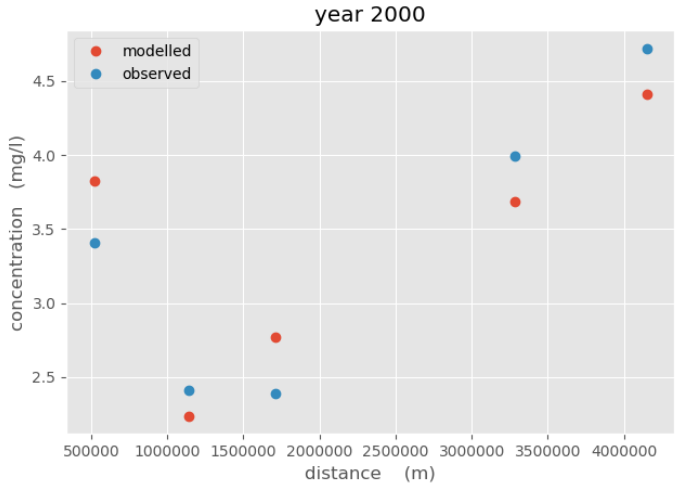
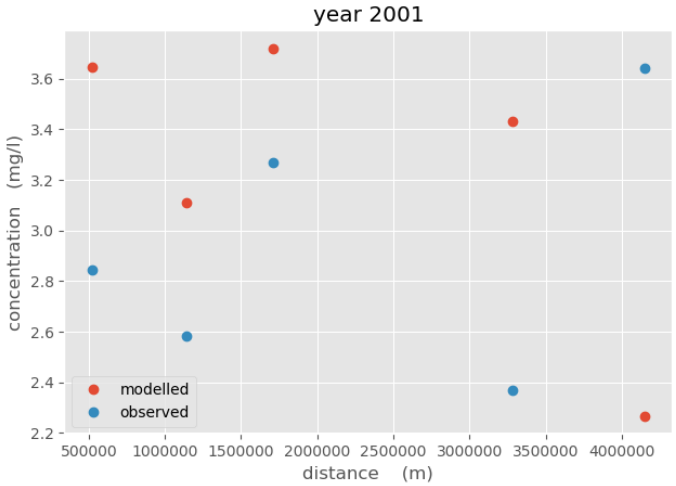
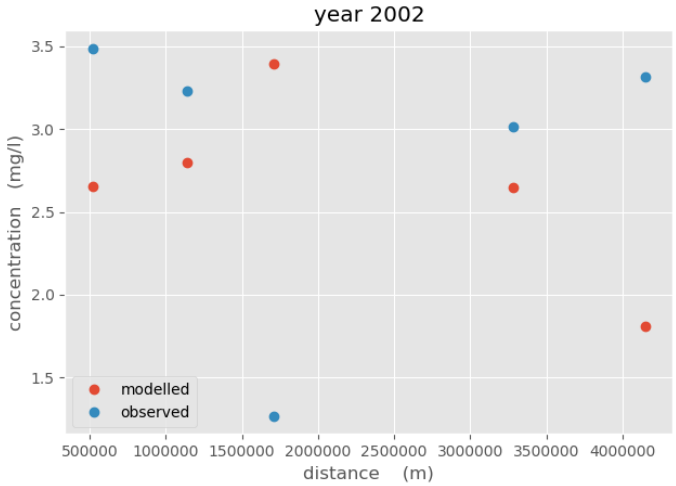
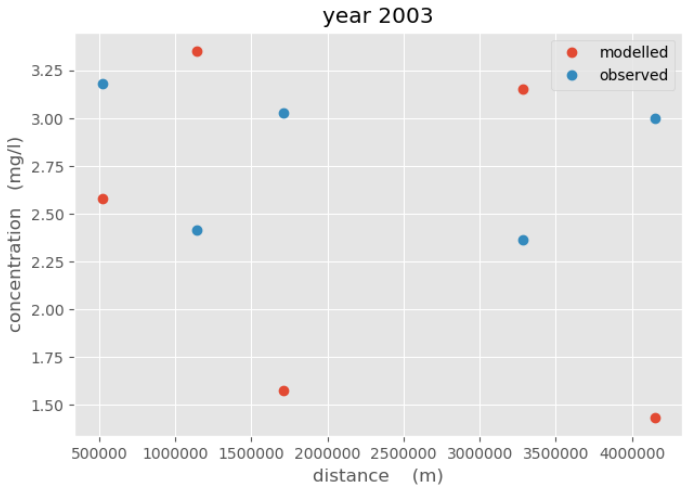
Completely Mixed System (2000 - 2004)

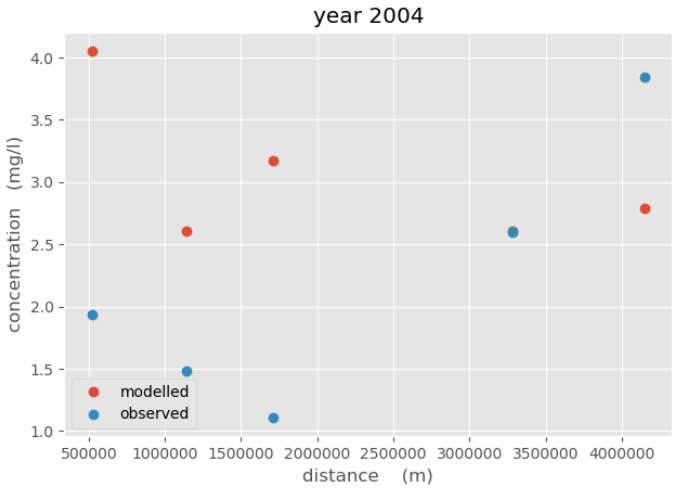
Model Results of COD











$$k = 0.0291 \text{ /d}$$

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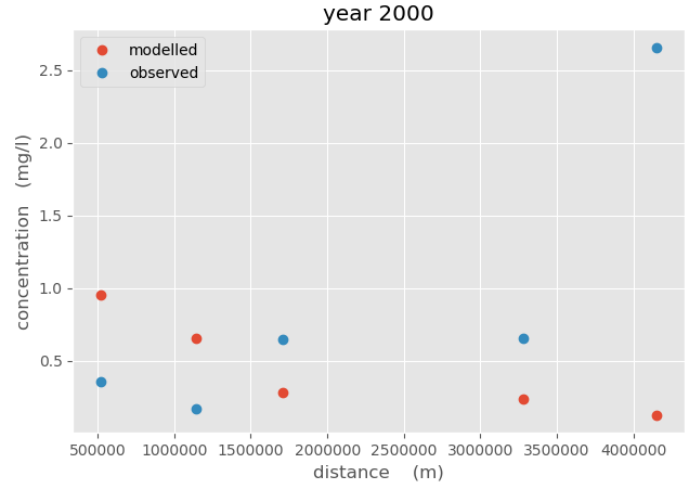
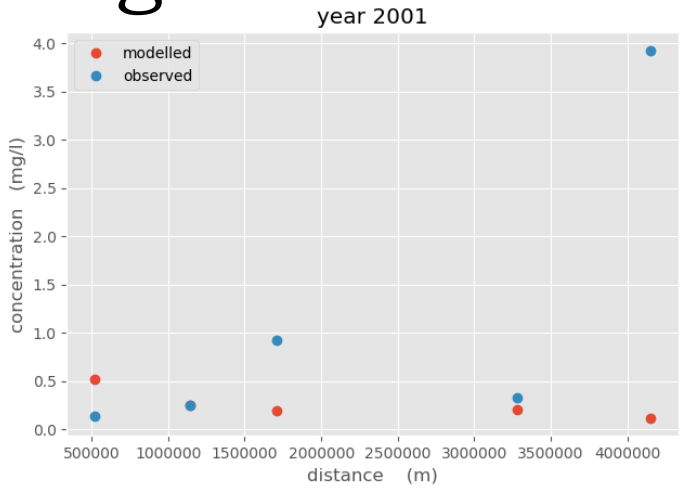
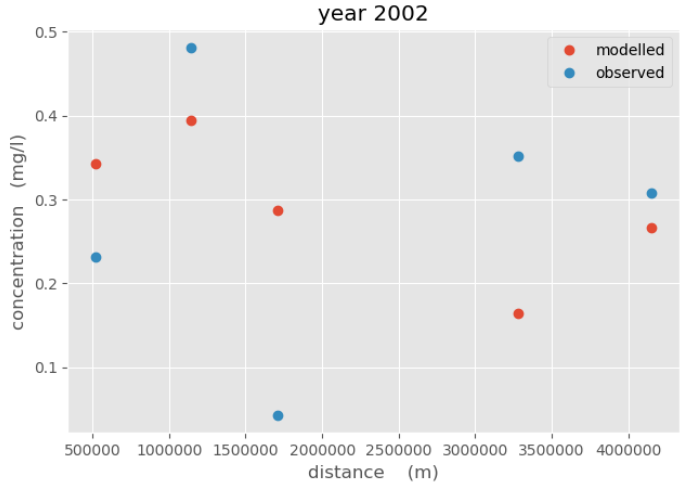
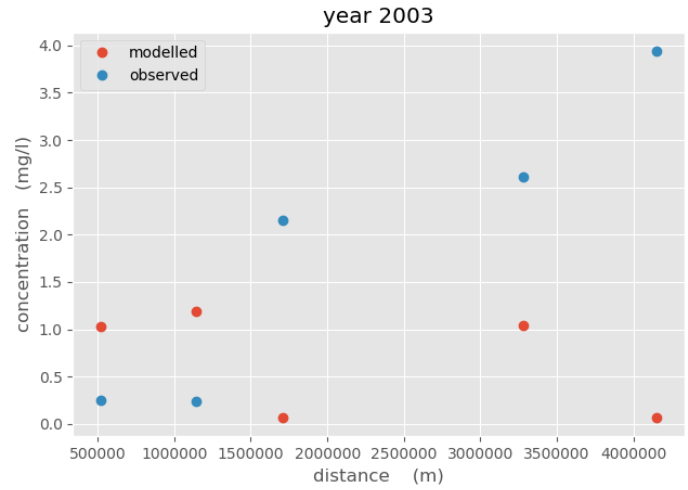
Completely Mixed System (2000 - 2004)

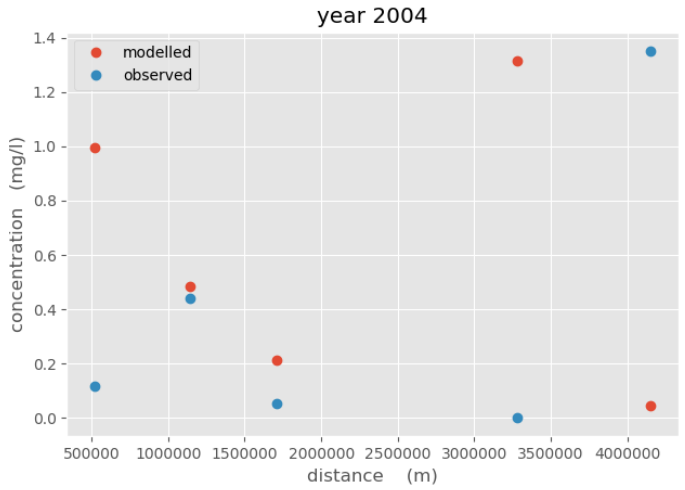
Results of Nitrogen











$k = 0.283$ /d

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Completely Mixed System (2000 - 2004)

Results Analysis

Possible Reasons:

- Data scarcity?
- First order decay?
- Simplified model?
- Integrated decay factor?

Completely Mixed System (2000 - 2004)

System Diagnosis

System Susceptibility:

$$\Rightarrow c = \frac{W}{Q + kV + vA_s} = \frac{W}{a}$$

a: assimilation factor

System Recovery Time:

$$V\frac{dc}{dt} = W(t) - Qc - kVc - vA_s c$$

System Susceptibility Analysis

System Diagnosis

Table. Assimilation factor of COD

Year	Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 5
2000	34.3147	34.311	34.313	34.3136	34.3133
2001	34.3148	34.3112	34.3132	34.3136	34.3132
2002	34.3147	34.311	34.313	34.3137	34.3134
2003	34.3148	34.311	34.3131	34.3135	34.3132
2004	34.3148	34.311	34.313	34.3136	34.3135
Mean	34.31476	34.31104	34.31306	34.3136	34.31332
std	5.48E-05	8.94E-05	8.94E-05	7.07E-05	0.00013

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System Susceptibility Analysis

System Diagnosis

Table. Assimilation factor of Nitrogen

Year	Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 5
2000	197404	122002	152898	165097	160037
2001	201335	124532	156260	166811	157076
2002	197818	121798	153359	167412	160801
2003	199871	121517	155021	163996	157164
2004	199715	121315	153052	165335	162902
Mean	199228.6	122232.8	154118	165730.2	159596
std	1442.576944	1173.317	1311.824	1229.728	2228.953

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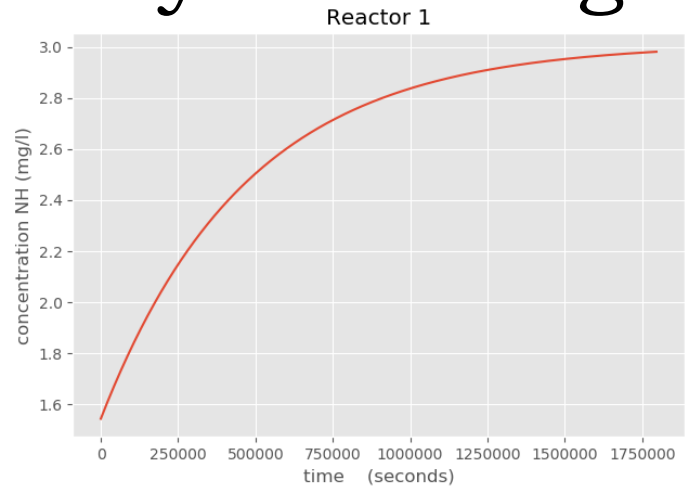
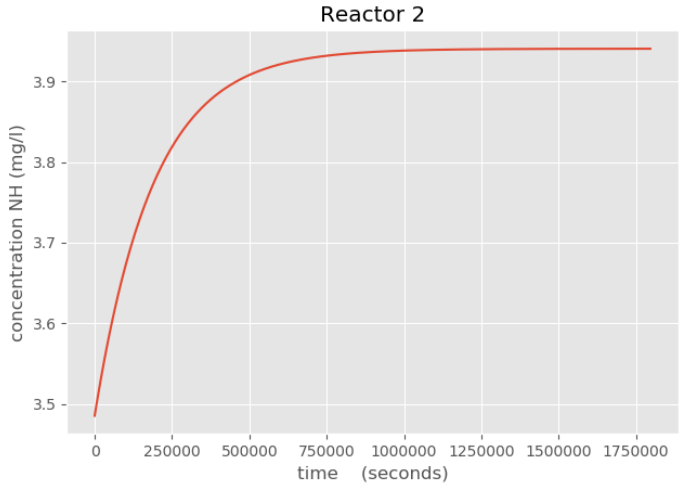
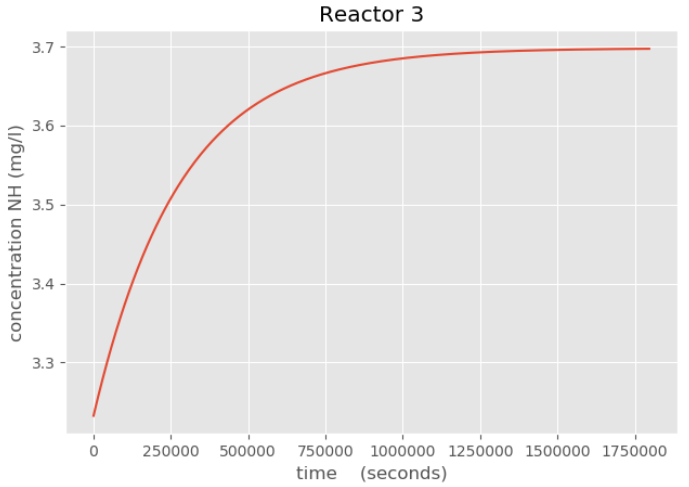
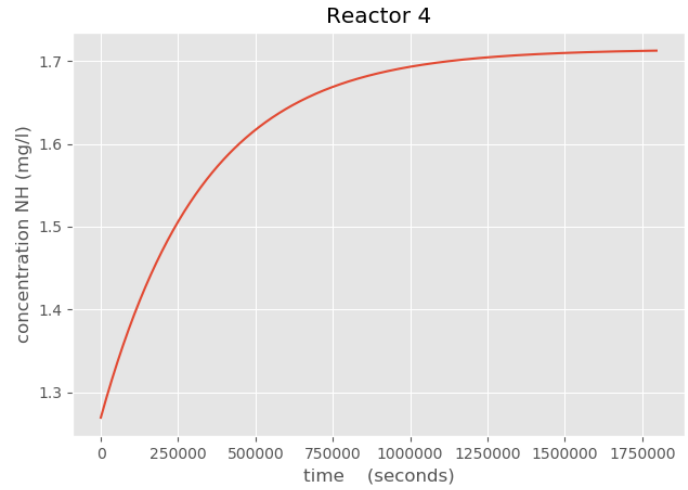
System Recovery Time of COD (2002)

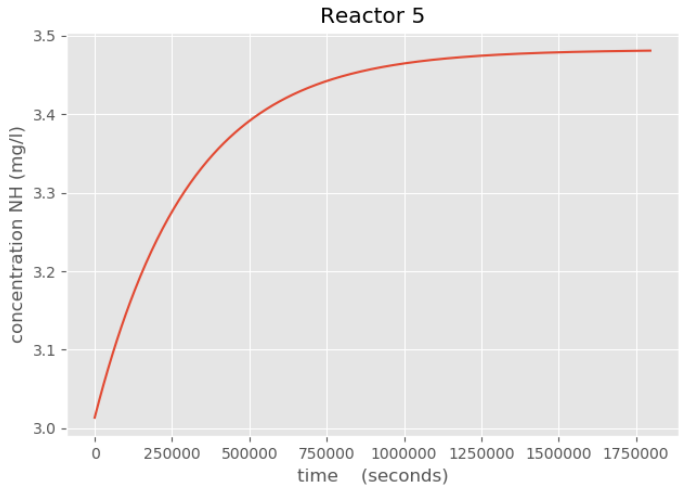
System Diagnosis











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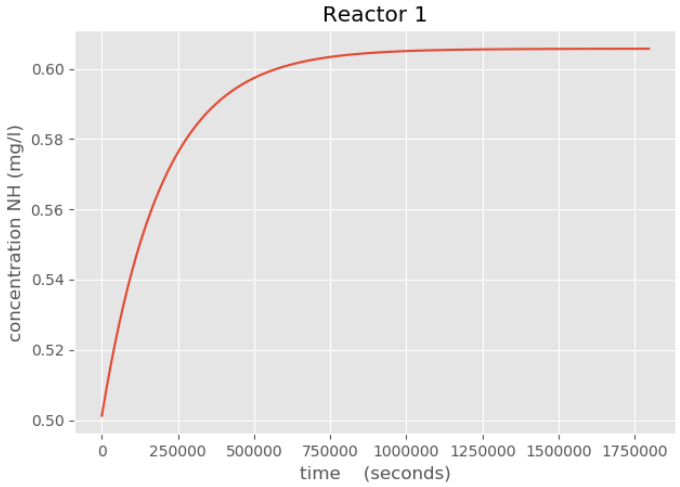
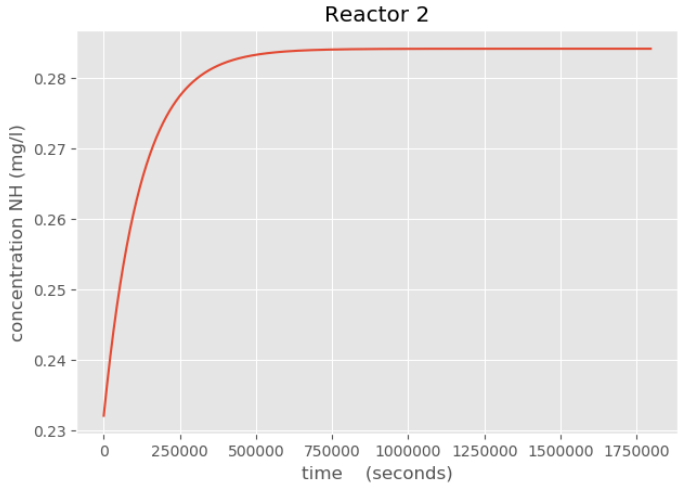
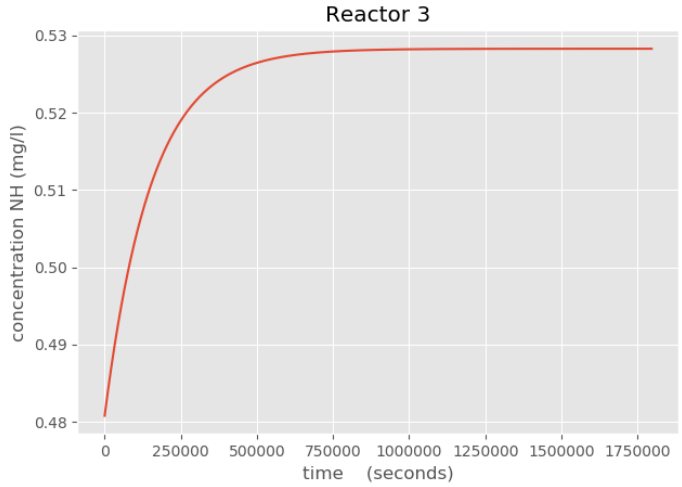
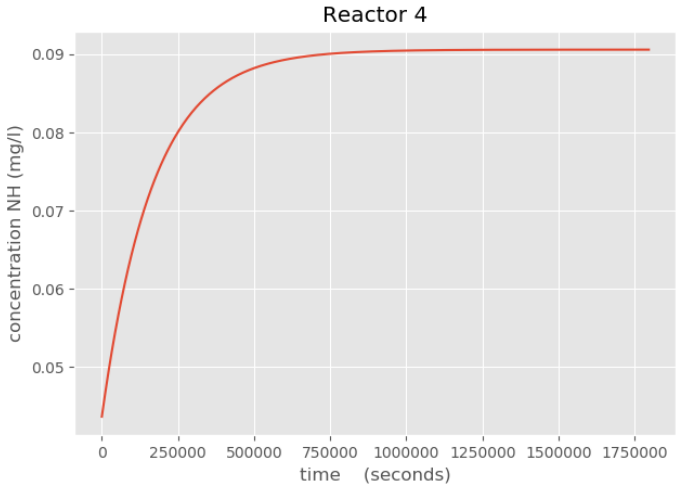
System Recovery Time of Nitrogen (2002)

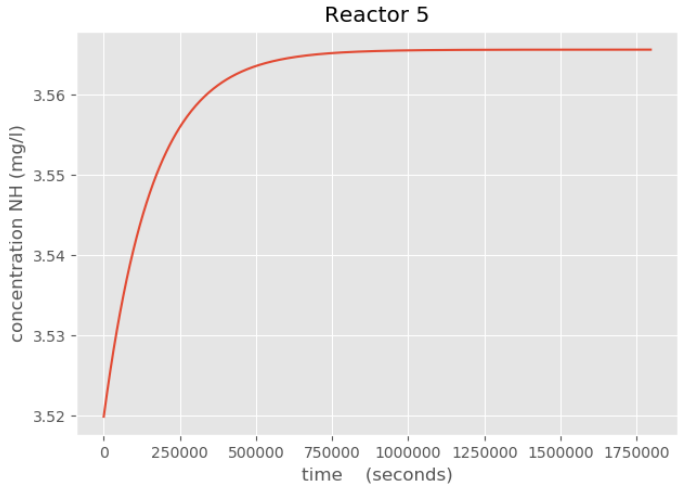
System Diagnosis











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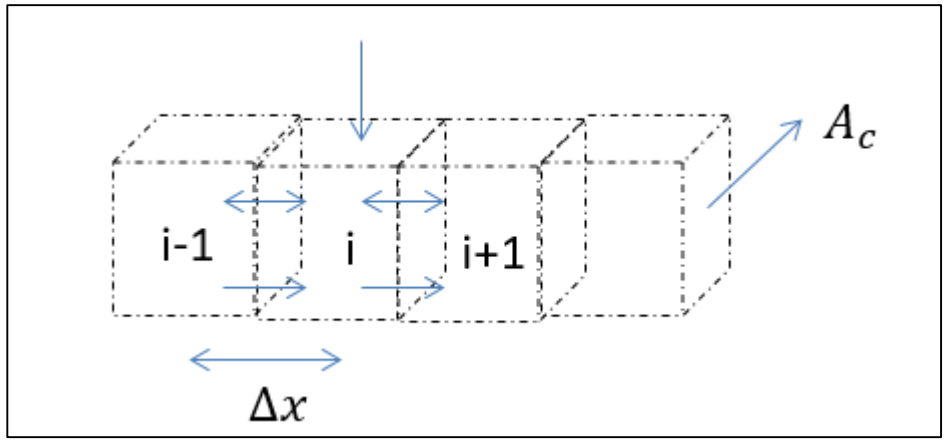
Incompletely Mixed System

Prediction — Control Volume Approach



Matrix form:

$$\begin{pmatrix} a_{11} & a_{12} & 0 & .. & 0 & 0 \\ a_{21} & a_{22} & a_{23} & .. & 0 & 0 \\ .. & .. & .. & .. & .. & ... \\ 0 & 0 & .. & .. & a_{n,n-1} & a_{nn} \end{pmatrix} \begin{pmatrix} c_1 \\ c_2 \\ .. \\ c_n \end{pmatrix} = \begin{pmatrix} W_1 \\ W_2 \\ .. \\ W_n \end{pmatrix}$$

$$\frac{\partial c}{\partial t} = D\frac{\partial^2 c(x)}{\partial^2 x} - U\frac{\partial c}{\partial x} - kc + W$$

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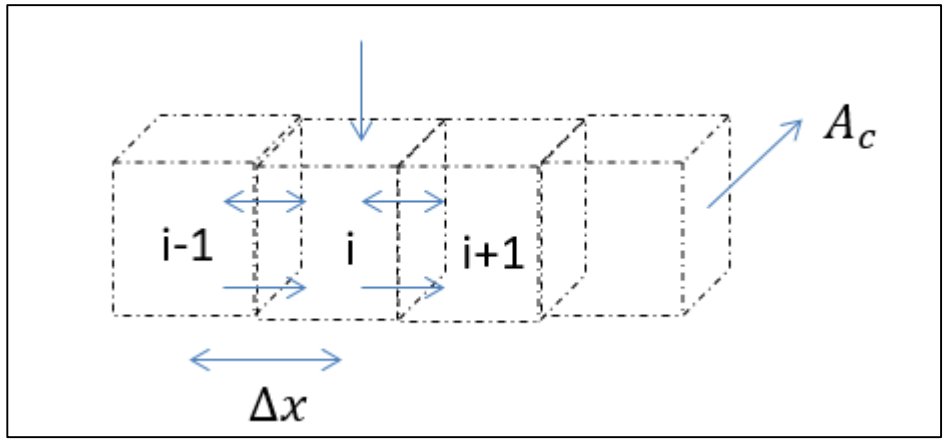
Incompletely Mixed System

Prediction — Control Volume Approach



$$\frac{\partial c}{\partial t} = D\frac{\partial^2 c(x)}{\partial^2 x} - U\frac{\partial c}{\partial x} - kc + W$$

Model Configuration:

Segment	Length (km)	$\Delta x(m)$	boxes	k_COD(/d)	k_NH(/d)	Dispersion m^2/s
1	52	100	520	0.0291	0.283	0.1
2	62	100	620			
3	57	100	570			
4	157	100	1570			
5	87	100	870			

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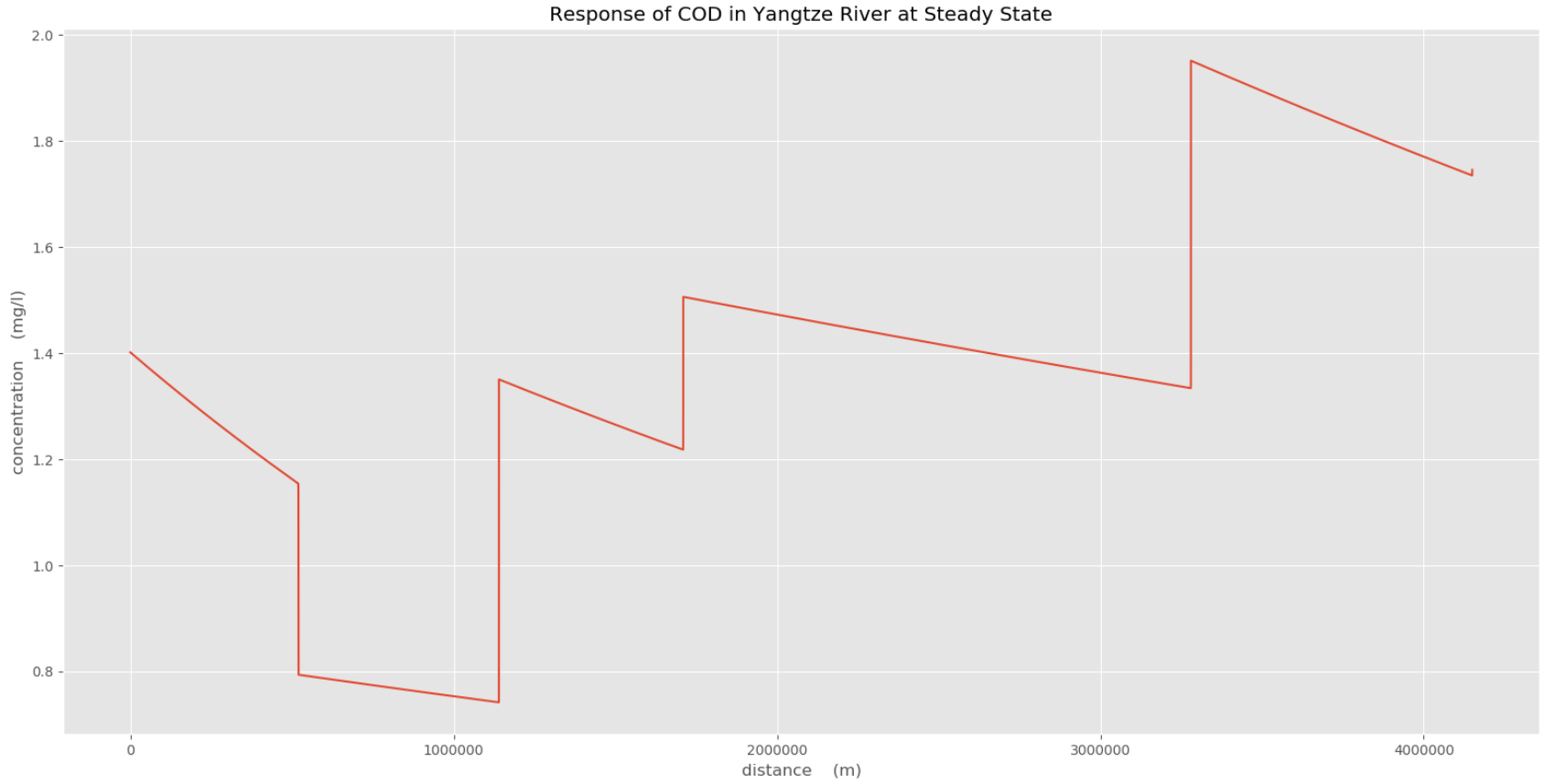
Incompletely Mixed System

Prediction of COD in 2005



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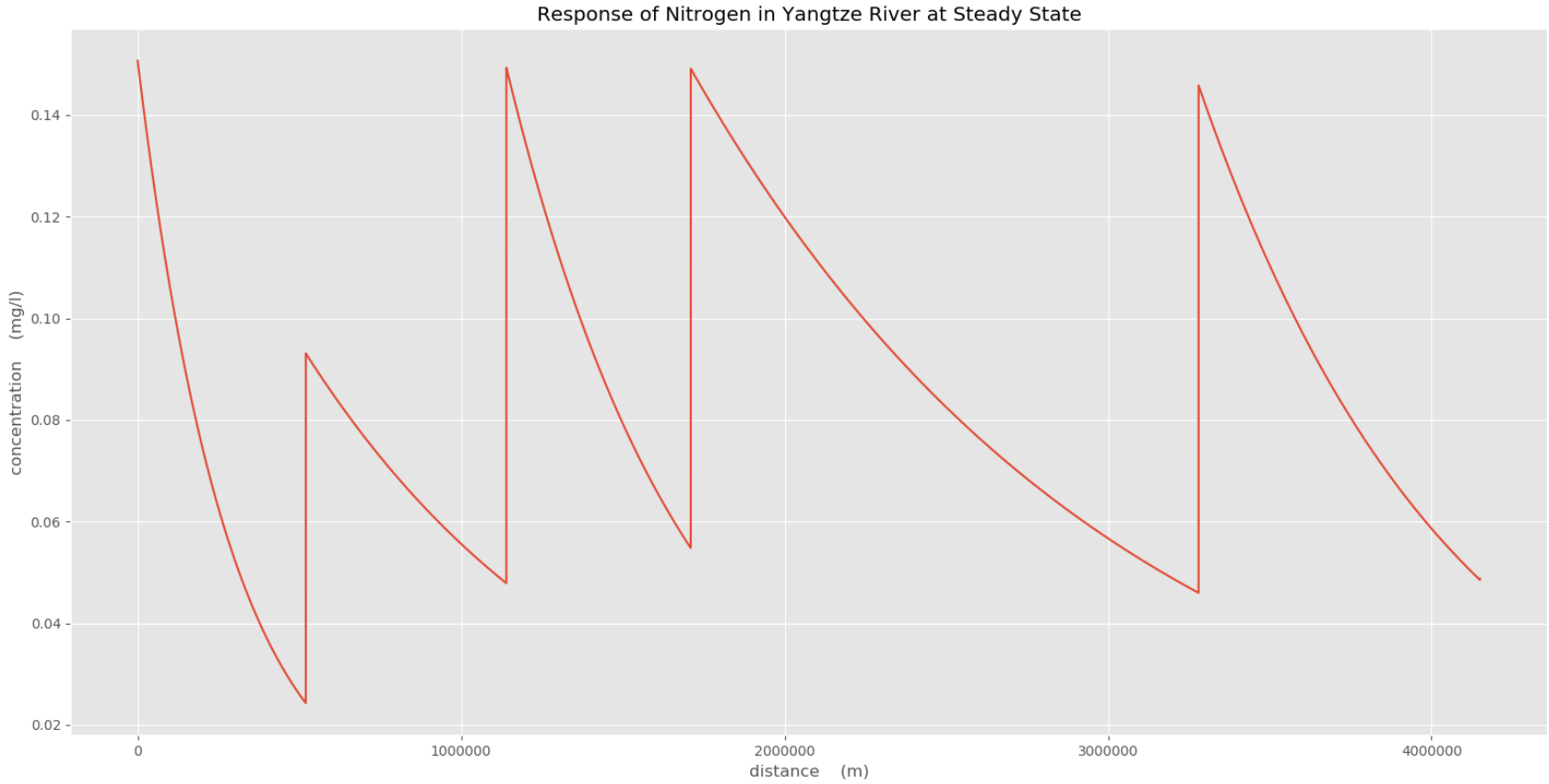
Incompletely Mixed System

Prediction of Nitrogen in 2005



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  - Environmental Prediction
  - Social-Environmental Issue Over Generations
    - a) Model Configuration and Results

Social-Economy modelling

Model Description

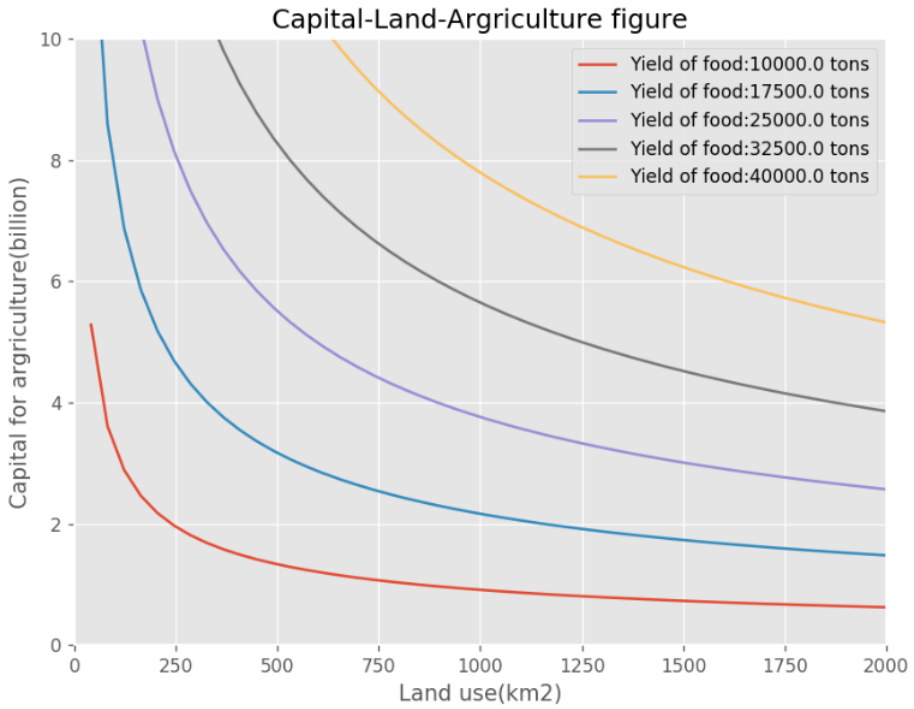
$$X = A1 \times Lx^{\alpha} \times Cx^{(1-\alpha)}$$

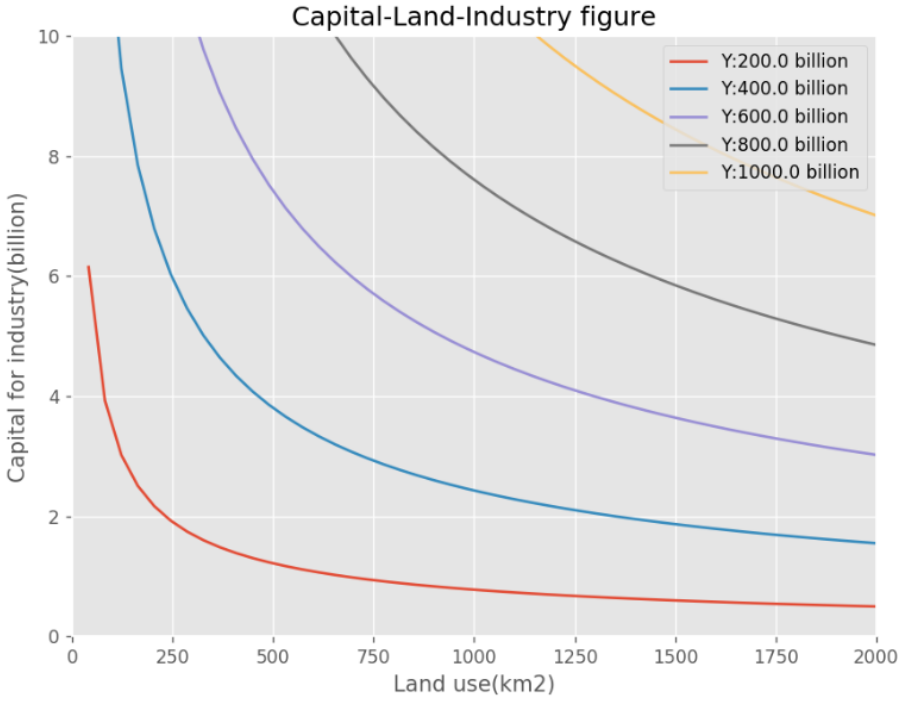
$$Y = A2 \times Ly^{\alpha} \times Cy^{(1-\alpha)}$$

Two Products:
X - Cotton Production (tons)
Y - Industry Output Value (billions)
Two Resources:
L - Land use (km^2)
C – Capital (billions)

Social-Economy modelling

Model Configuration of 2000





$$X = 915.85 \times Lx^{0.355} \times Cx^{0.645}$$

$$Y = 15.45 \times Ly^{0.393} \times Cy^{0.607}$$

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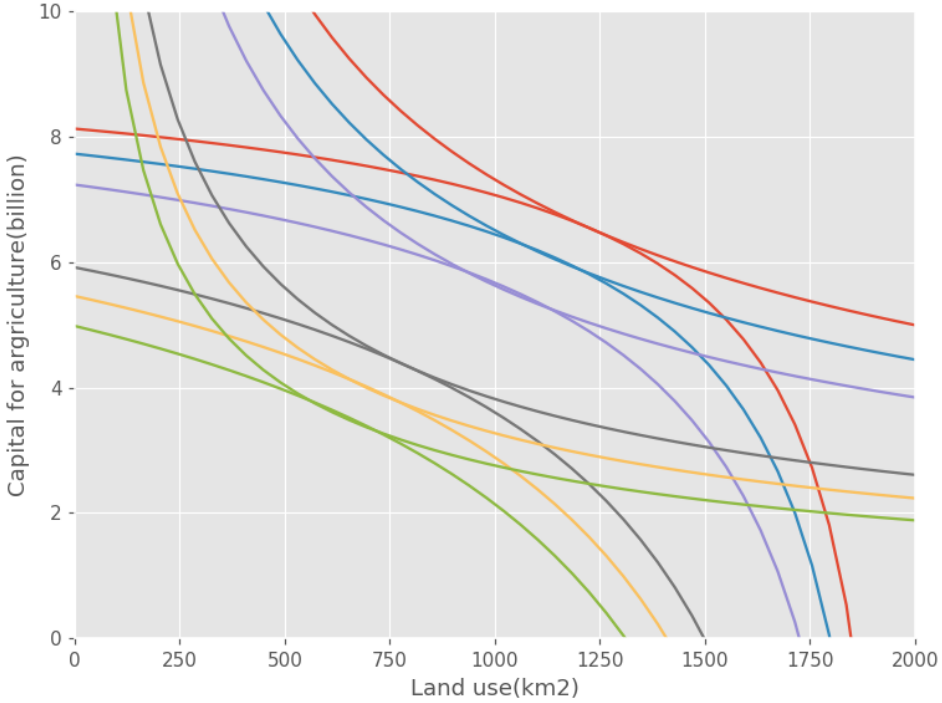
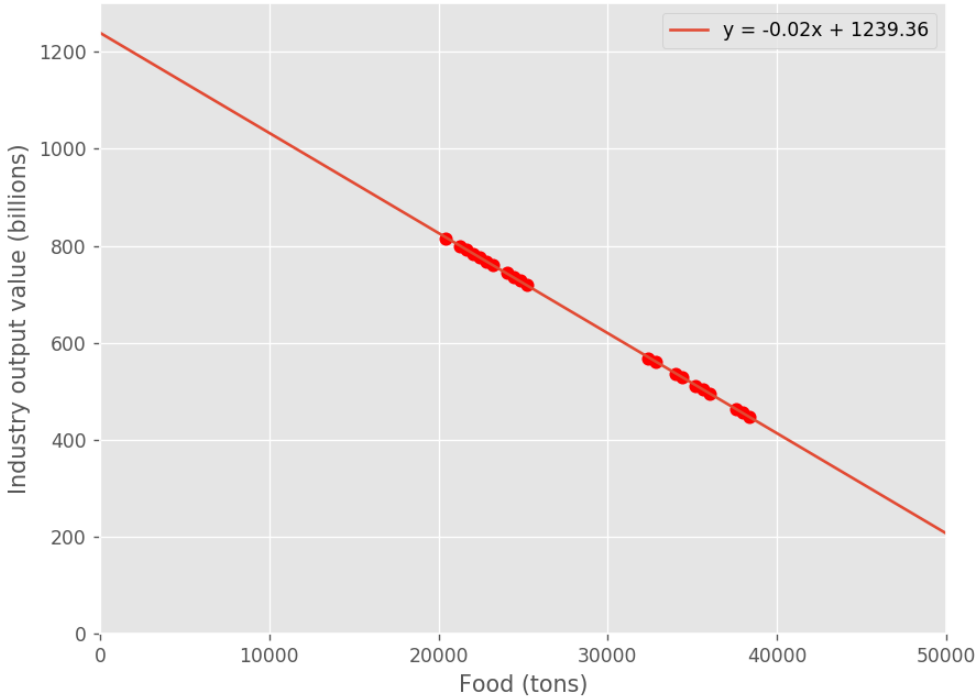
Social-Economy modelling

Model Configuration of 2000





$\bar{L} = 2000\ km2$

$\bar{C} = 10\ billion$

Production Possibility Frontier:

$Y = -0.02 * X + 1239.36$

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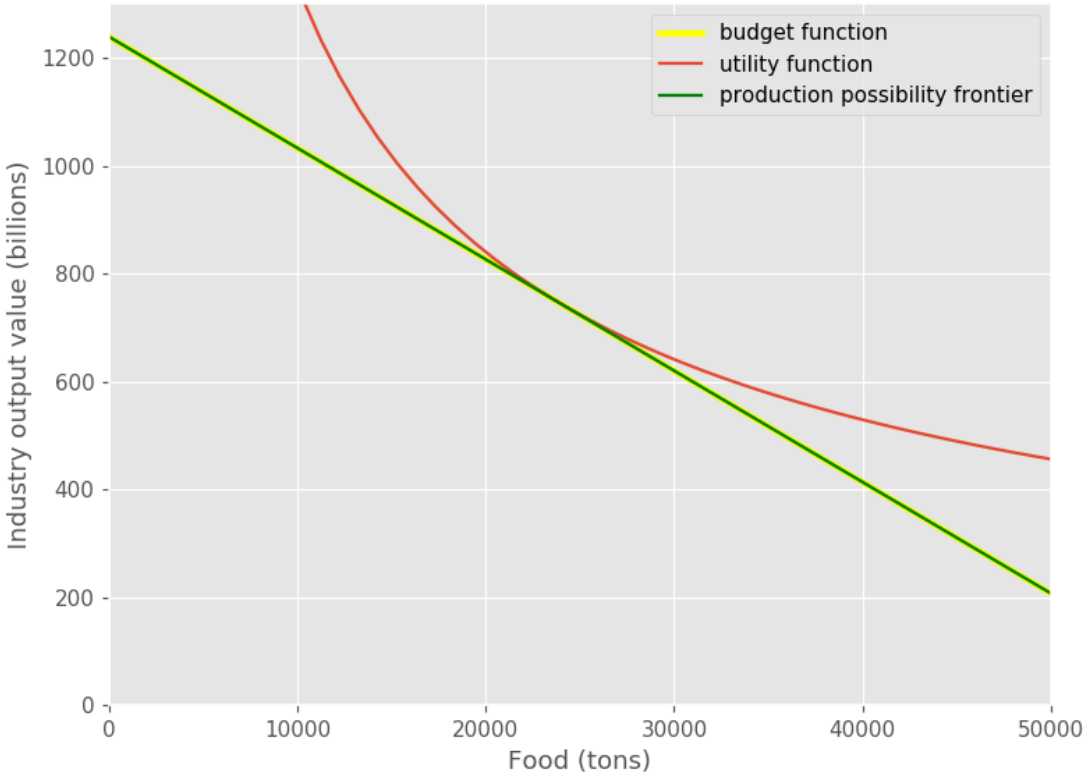
Social-Economy modelling

Model Configuration of 2000



$$U = ln(C1) + \eta \ln(C2)$$
$$M = P1 * C1 + P2 * C2$$
$$Y = -0.02 * X + 1239.36$$
$$\eta = 1.5$$

C1-consumption of cotton
C2-consumption of industry
P1-Price of cotton
P2-Price of industry

Through the Largrange deriviation:
$U(2000) = 20.004$

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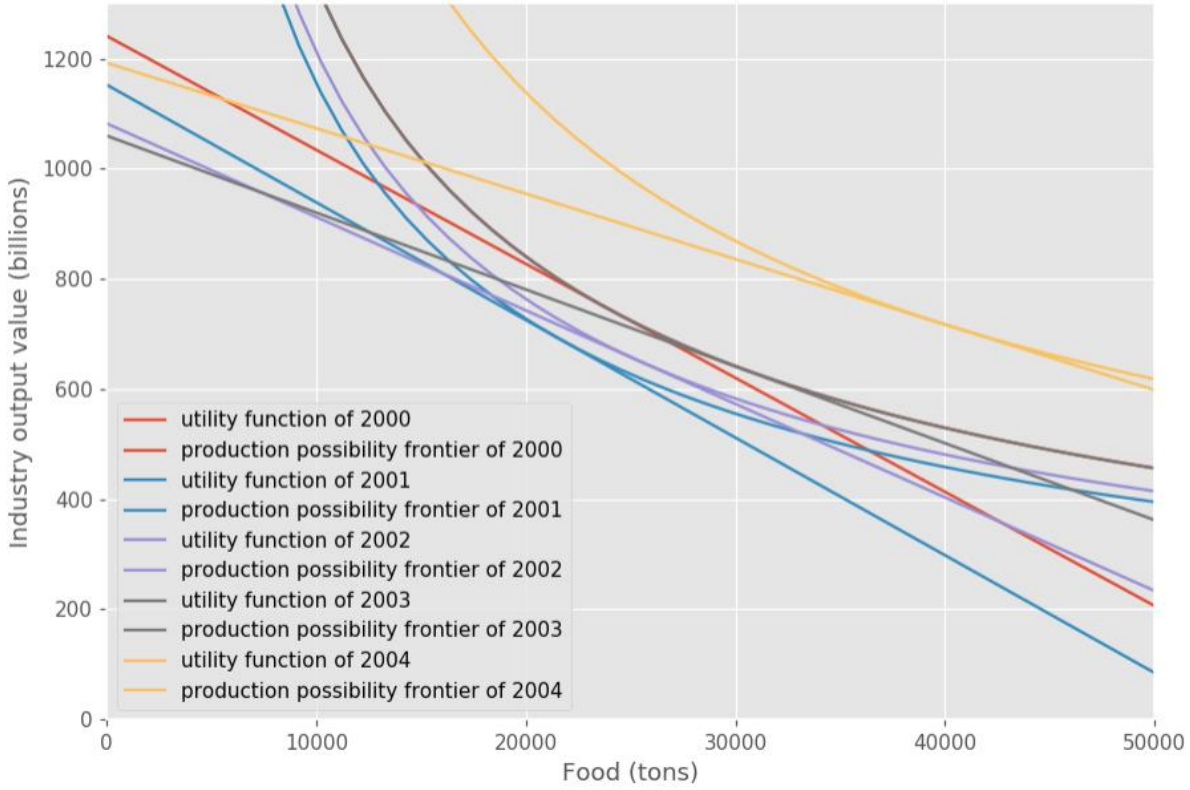
Social-Economy modelling

Model Result from 2000 to 2004



Year	Utility Value
2000	20.004
2001	20.09
2002	20.16
2003	20.32
2004	20.458

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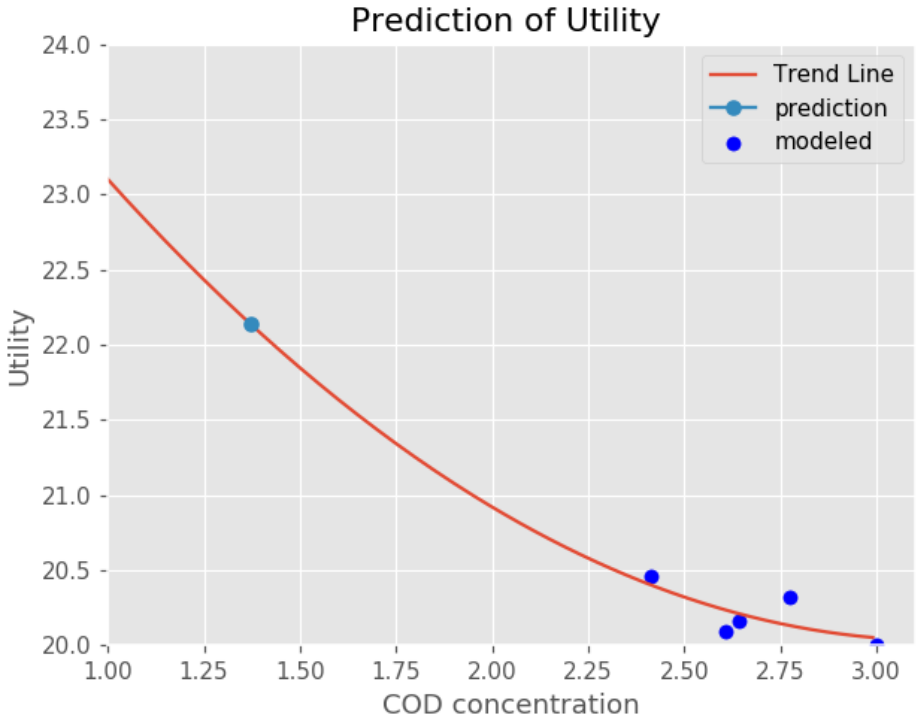
Environmental Prediction

Connection between COD and utility value



Year	Utility Value	COD (mg/L)
2000	20.004	3.0013
2001	20.09	2.6073
2002	20.16	2.6434
2003	20.32	2.7744
2004	20.458	2.4149

COD decreases by 19.54%; Utility Value increases by 2.27% from 2000 to 2004.

According to the COD prediction value, the utility value will increase by 7.80%.

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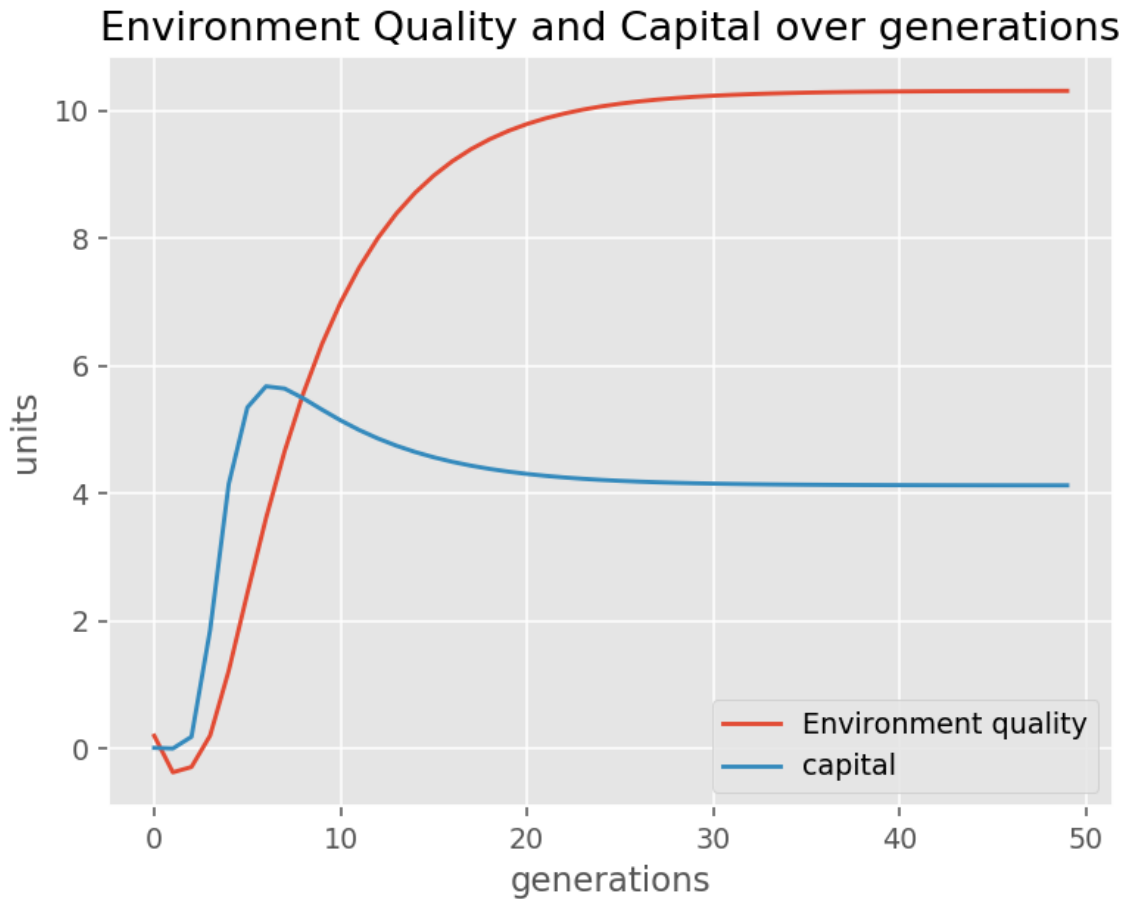
Social-environmental issue over generations

Parameter set	Parameter description	Value
η	Preference for environment quality	0.5
ϕ	Degree of habit formation for quality	0.9
b	Environment self rate of degradation	0.2
γ	Environmental maintenance efficiency	0.5
τ	Tax rate to conserve environment per unit consumption	0.1
δ	Capital share of output	0.025
β	Degradation of environment cause by 1 unit of consumption	0.1
α	Capital share of output	0.393
A	Total factor of productivity	15.45

$$Y = A \times Ly^{\alpha} \times Cy^{(1-\alpha)}$$

Social-environmental issue over generations



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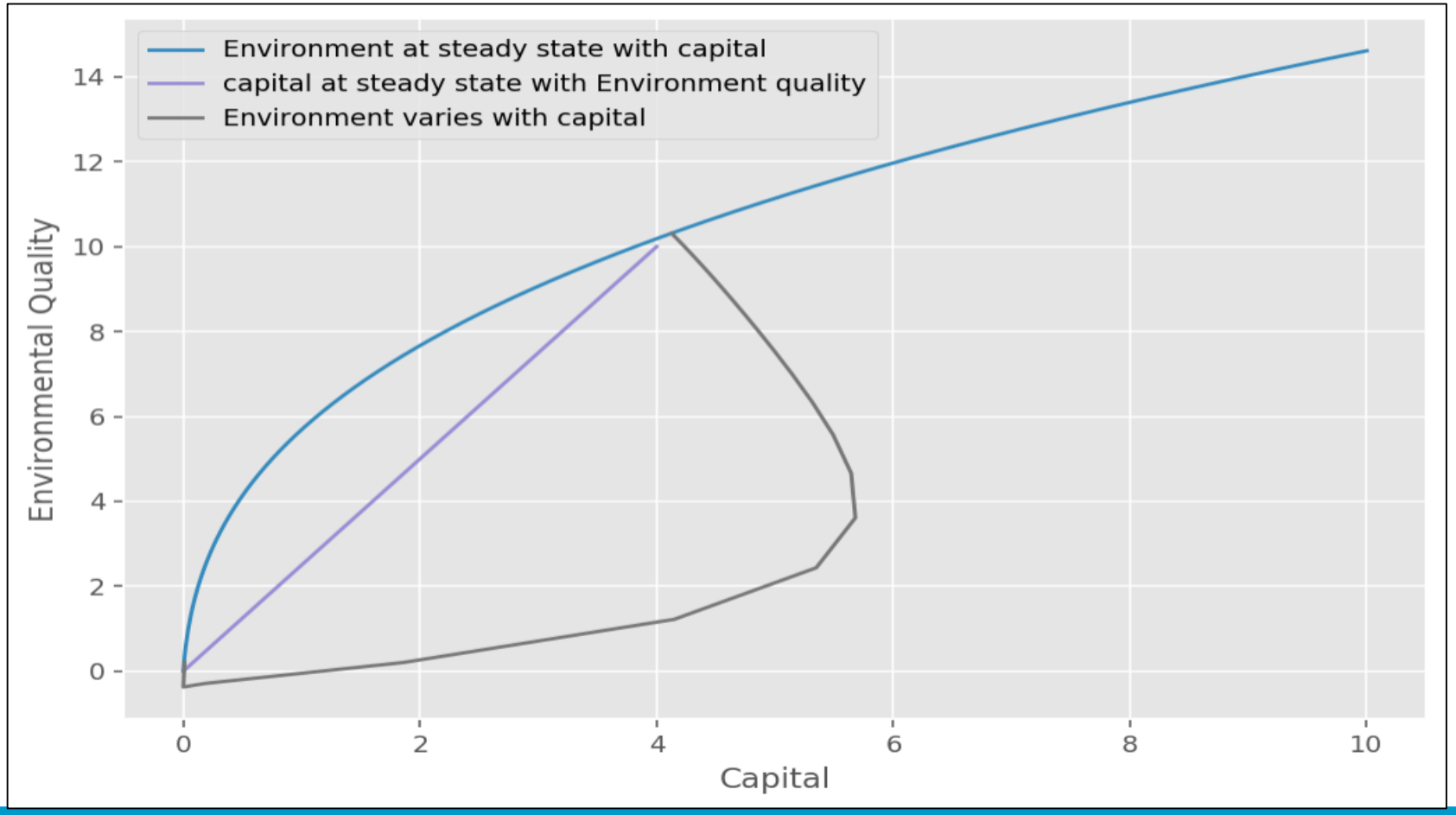
Social-environmental issue over generations

Environment and Capital evolve until Equilibrium Point



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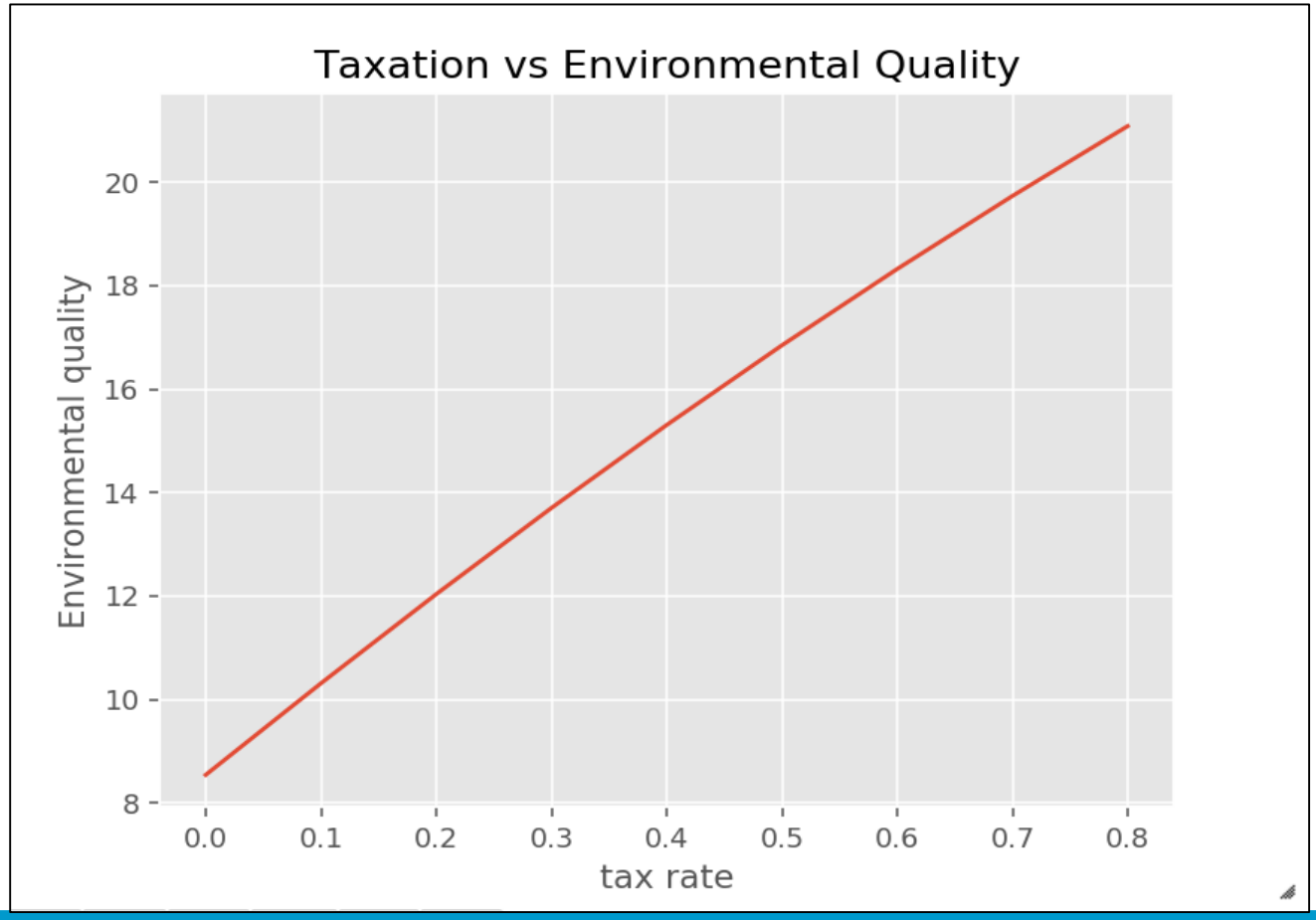
Social-environmental issue over generations

How taxation affect the environment



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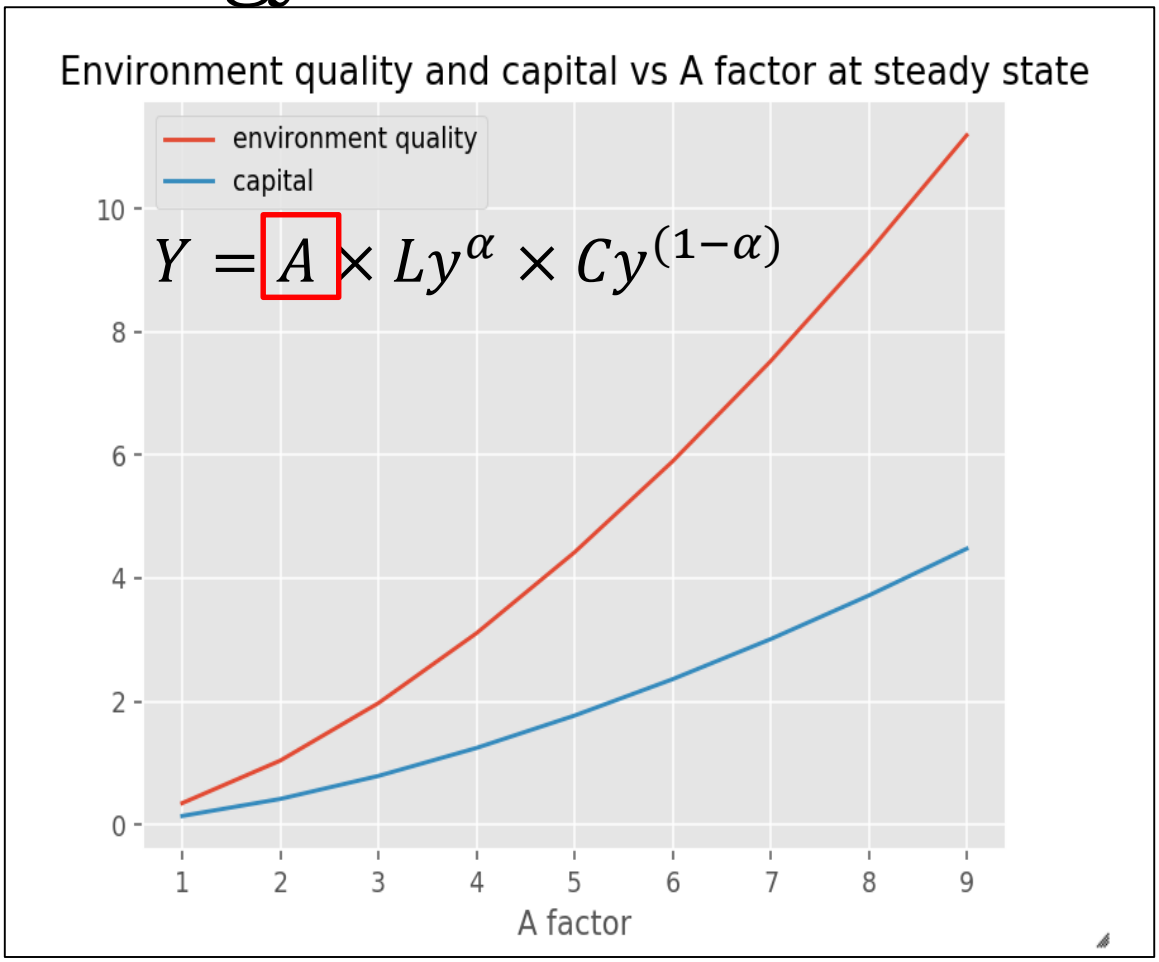
Social-environmental issue over generations

How technology affects the environment



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Conclusions

- Our environmental models are oversimplified to represent the real situation.
- Social development and Environment quality are closely associated and complicated under different combinations of parameter sets.
- The parameterization of the dynamic model can direct us to a certain level understanding the evolutions of environment and society