Substitution of Energy and Capital an Its Uncertainty for China

Zhaoning ZHENG

Research Center of Contemporary Management

Global Climate Change Institute

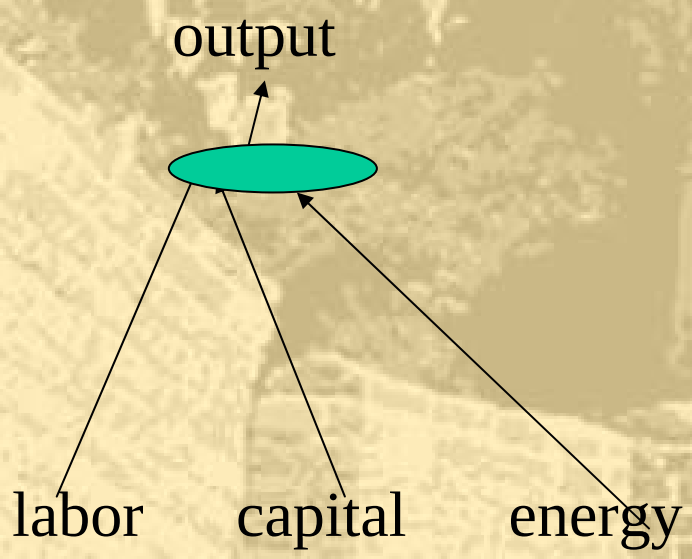
School of Public policy and management

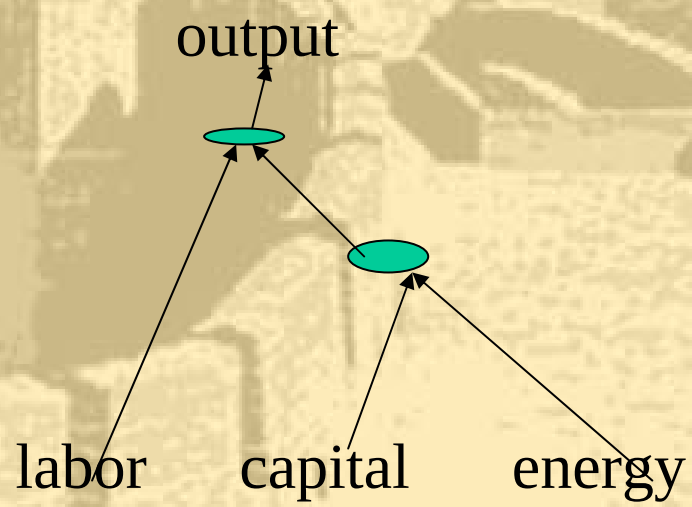
Tsinghua university, Beijing 100084, China

Background

$$Y_1 = (1+\rho_1)^t A_1 (L^{\alpha_1} K^{\beta_1} E^{\gamma_1})$$

$$Y_5 = (1+\rho_5)^t A_5 \left[a_5 \left(b_5 K^{-\phi_5} + (1-b_5) E^{-\phi_5} \right)^{\frac{\mu_5 \theta_5}{\phi_5}} + (1-a_5) L^{-\theta_5} \right]^{-\frac{h_5}{\theta_5}}$$

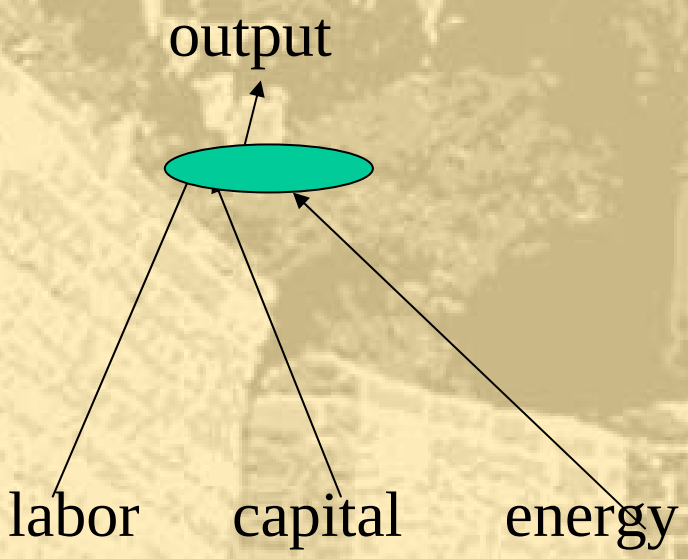


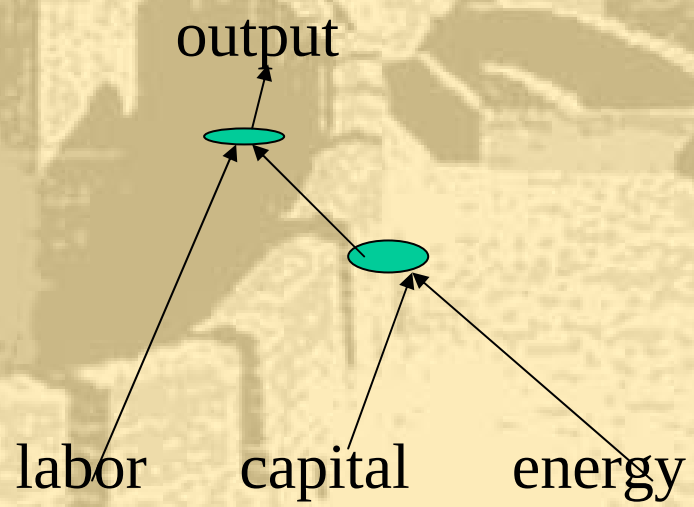


Background

$$Y_1 = A_1(L^{\alpha_1} K^{\beta_1} E^{\gamma_1})$$

$$Y_5 = A_5\left[a_5\left(b_5 K^{-\phi_5} + (1-b_5)E^{-\phi_5}\right)^{\frac{\mu_5\theta_5}{\phi_5}} + (1-a_5)L^{-\theta_5}\right]^{-\frac{h_5}{\theta_5}}$$

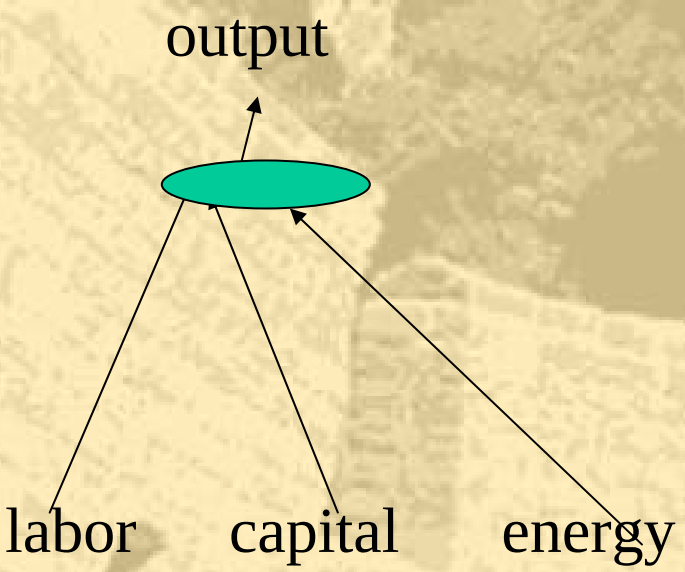




Version 1 and 2

$$Y_3 = (1+\rho_3)^t A_3 [a_3 L^{-\theta_3} + b_3 K^{-\theta_3} + (1-a_3-b_3) E^{-\theta_3}]^{-\frac{h_3}{\theta_3}}$$

$$Y_4 = A_4 [a_4 L^{-\theta_4} + b_4 K^{\theta_4} + (1-a_4-b_4) E^{\theta_4}]^{-\frac{h_4}{\theta_4}}$$



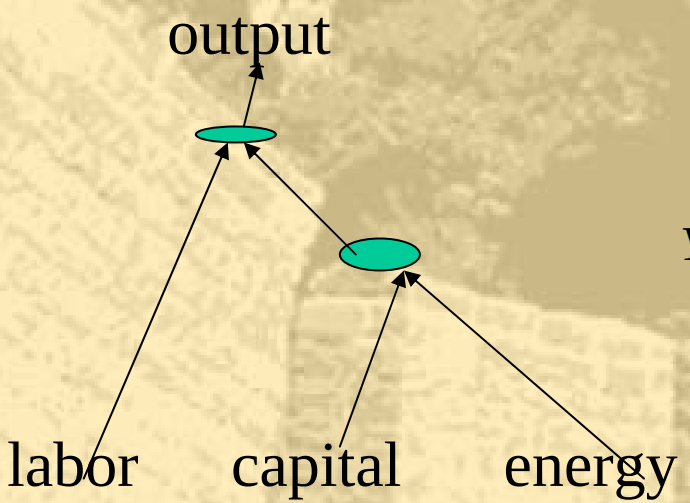
$$Y_1 = (1+\rho_1)^t A_1 (L^{\alpha_1} K^{\beta_1} E^{\gamma_1})$$

$$Y_2 = A_2 (L^{\alpha_2} K^{\beta_2} E^{\gamma_2})$$

Version 3 , 6 and 9

$$Y_5 = (1+\rho_5)^t A_5 \left[a_5 \left(b_5 K^{-\phi_5} + (1-b_5) E^{-\phi_5} \right)^{\frac{\mu_5 \theta_5}{\phi_5}} + (1-a_5) L^{-\theta_5} \right]^{-\frac{h_5}{\theta_5}}$$

$$Y_{11} = (1+\rho_{11})^t A_{11} \left[a_{11} \left(K^{\beta_{11}} E^{\gamma_{11}} \right)^{-\theta_{11}} + (1-a_{11}) L^{-\theta_{11}} \right]^{\frac{h_{11}}{\theta_{11}}}$$



$$Y_{17} = (1+\rho_{17})^t A_{17} \left[L^{\alpha_{17}} [b_{17} K^{-\theta_{17}} + (1-b_{17}) E^{-\theta_{17}}]^{-\frac{h_{17}}{\theta_{17}}} \beta_{17} \right]$$

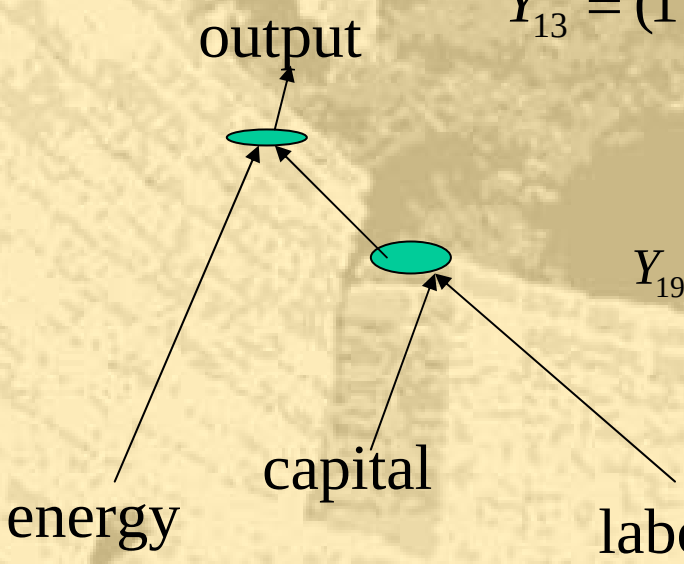
GREEN, HERMES, MS-MRT

DEMETER, EPPA

Version 4 , 7 and 10

$$Y_7 = (1+\rho_7)\ {}^{t}A_7\left[a_7\left(b_7K^{-\phi_7} + (1-b_6)L^{-\phi_7}\right)^{\frac{\mu_7\theta_7}{\phi_7}} + (1-a_7)E^{-\theta_7}\right]^{-\frac{h_7}{\theta_7}}$$

$$Y_{13} = (1+\rho_{13})\ {}^{t}A_{13}\left[b_{13}\left(L^{\alpha_{13}}K^{\beta_{13}}\right)^{-\theta_{13}} + (1-b_{13})E^{-\theta_{13}}\right]^{-\frac{h_{13}}{\theta_{13}}}$$



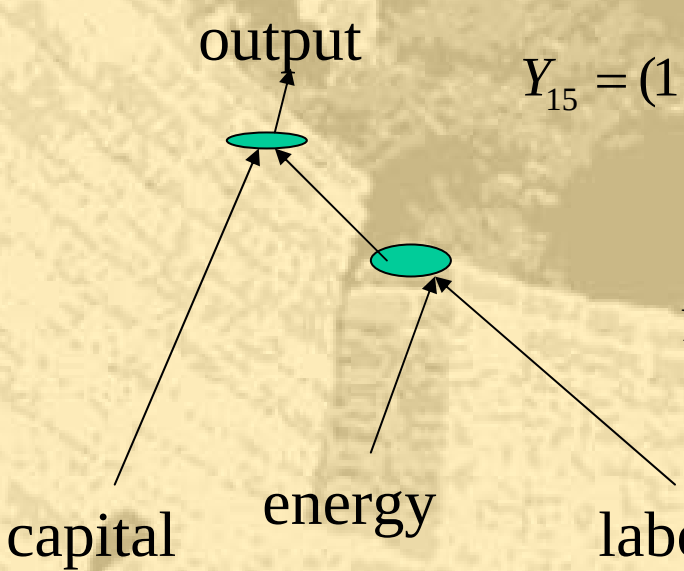
$$Y_{19} = (1+\rho_{19})\ {}^{t}A_{19}\left[E^{\gamma_{19}}[b_{19}K^{-\theta_{19}} + (1-b_{19})L^{-\theta_{19}}]^{-\frac{h_{19}}{\theta_{19}}\beta_{19}}\right]$$

GLOBAL2100,

MARKAL-MACRO

Version 5 ,8 and 11

$$Y_9 = (1+\rho_9)^{t} A_9 \left[a_9 \left(b_9 E^{-\phi_9} + (1-b_9) L^{-\phi_9} \right)^{\frac{\mu_9 \theta_9}{\phi_9}} + (1-a_9) K^{-\theta_9} \right]^{-\frac{h_9}{\theta_9}}$$



$$Y_{15} = (1+\rho_{15})^{t} A_{15} \left[b_{15} \left(L^{\alpha_{15}} E^{\gamma_{15}} \right)^{-\theta_{15}} + (1-b_{15}) K^{-\theta_{15}} \right]^{-\frac{h_{15}}{\theta_{15}}}$$

$$Y_{21} = (1+\rho_{21})^{t} A_{21} \left[K^{\beta_{21}} [b_{21} L^{-\theta_{21}} + (1-b_{21}) E^{-\theta_{21}}]^{-\frac{h_{21}}{\theta_{21}} \alpha_{21}} \right]$$

What I found

- neutral technology progress rate lies between 0.03 and 0.05 for all production functions
- For C-D function, labor input can be omitted in the models without TP, and is equal to 0 in the model with TP. For CES production function, the distribution parameter of labor input, is also very small and can be omitted in the models without TP, and is equal to 0 in the models with TP
- no production function whose entire estimated parameters passed t-ratio test
- According to regression results, the labor input can be excluded from functions

Why labor no impact

- Surplus labor : apparent or potential

1. the high rate of employment in China is to great extent for the sake of keeping social stability trading off economic efficiency
2. potential rate of unemployment in China is about 18%, based on some research
3. more than 200 million surplus rural labor cannot be transferred out to other industries

Point of view

- More often, to china, population is a kind of burden, not resource, regarding to poor education and training on technology skills—whose fault?
- Energy supply and investment supply are constrained

literatures

- T.-Y. Zhou, “ The trend and way out for China’s employment, re-employment and labor transfer,” Research on Finance and Economic Issues, vol. 11, pp.3-12, Nov.,1999.
- X.-L. Wu, Y.-J. Jing, “Causes and countermeasures for much excess labor supply in China,” Population J., vol. 10, pp.36-38, Apr.2000.

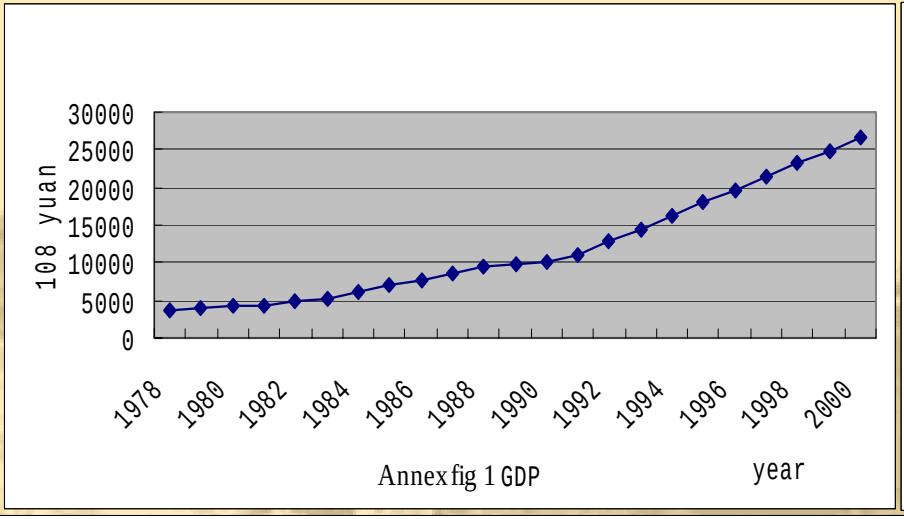
AK model characteristic for China's economical growth

- Y. Su, X.-X. Xu, "Specification of China's economic growth model:1952-1998, Economic Research J., no.11 , pp.3-11, Nov. 2002

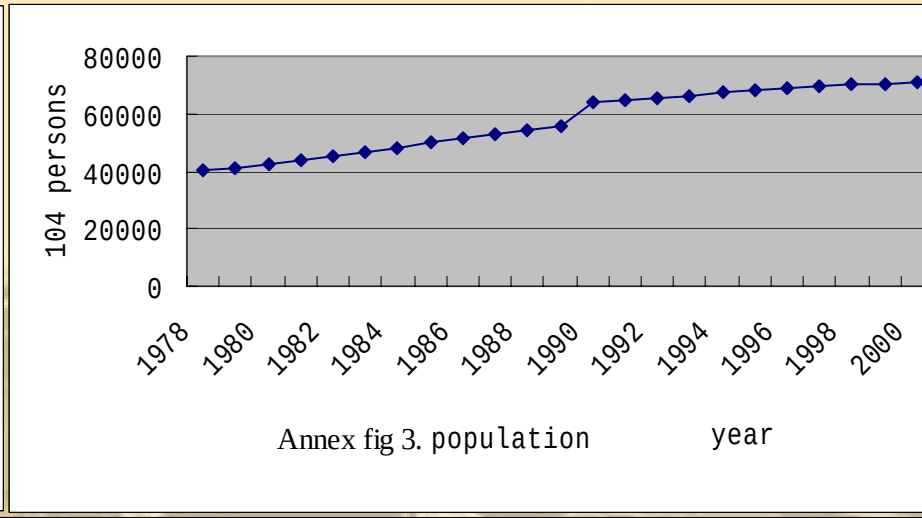
$$Y = 0.314839834K^{0.993571058}$$

(5.559) (60.951)

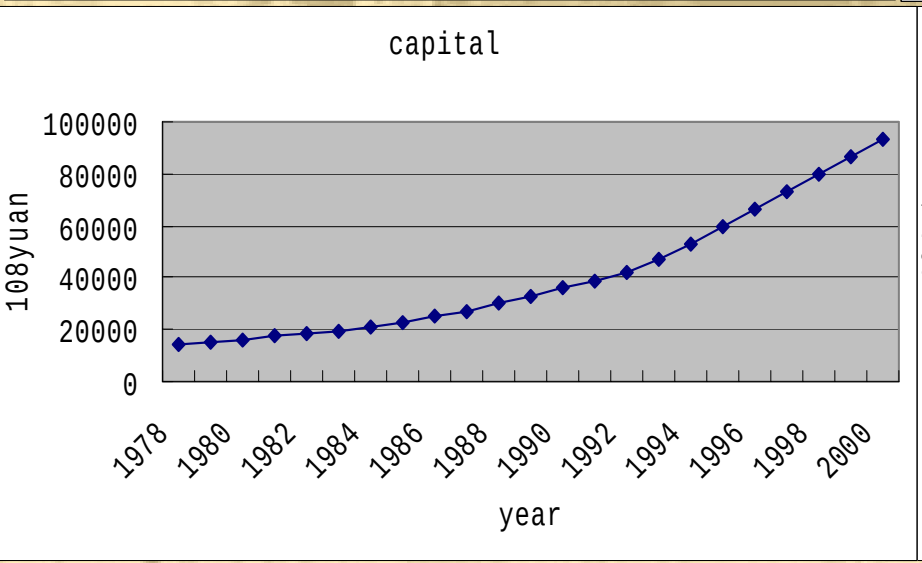
- capital / GDP =about 3.3

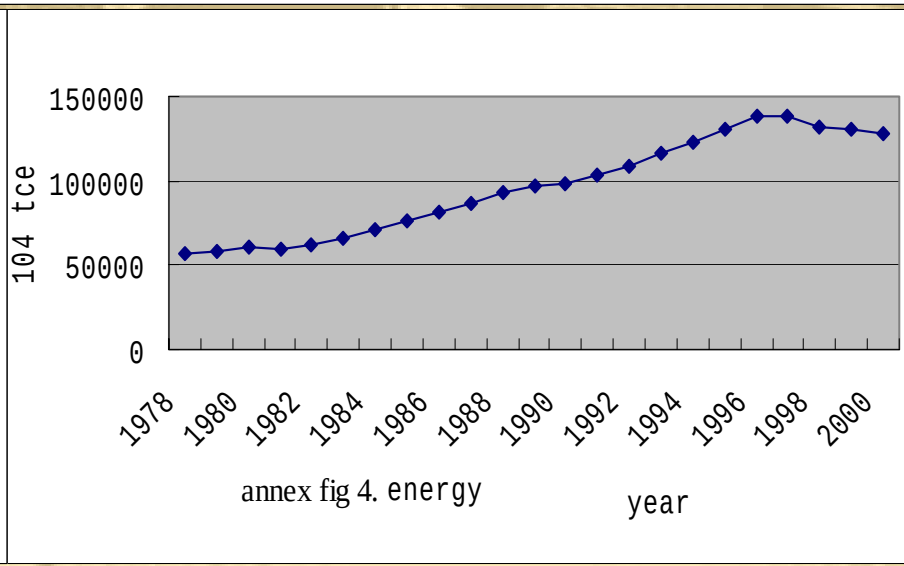


Annex fig 1 GDP

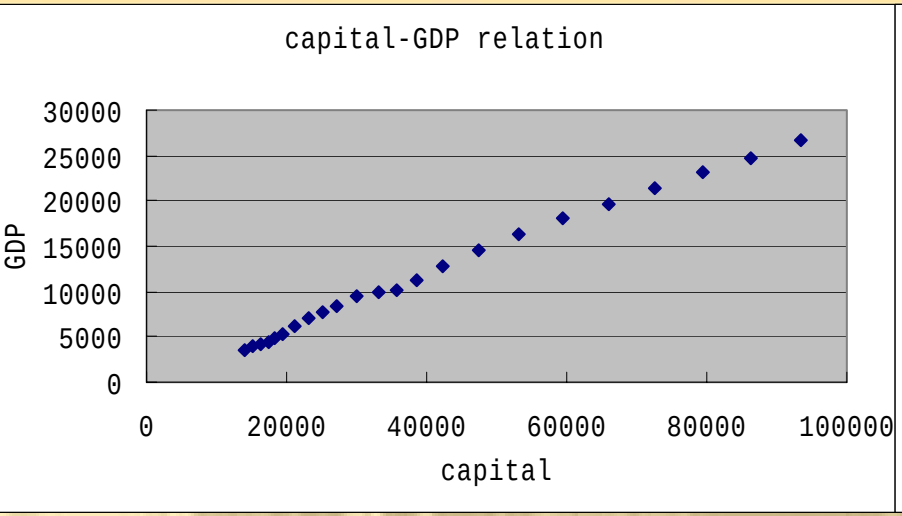


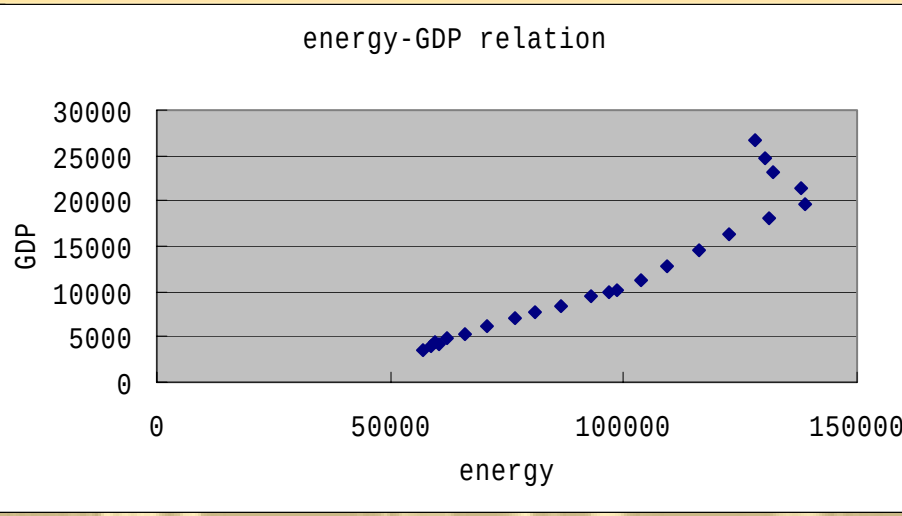
Annex fig 3. population

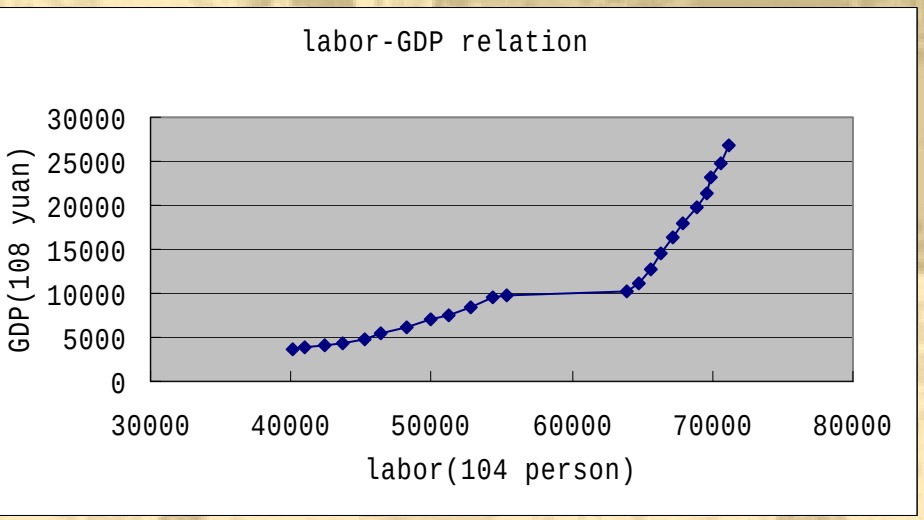


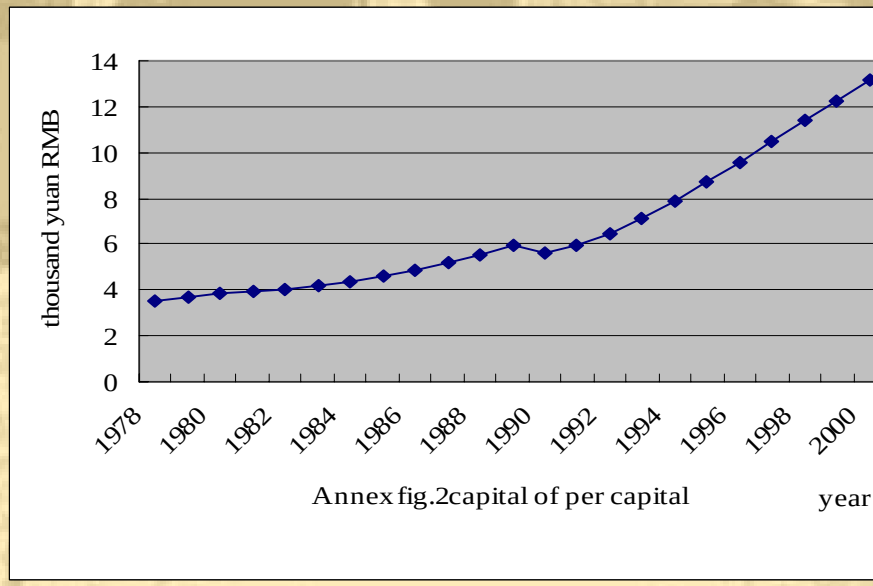


annex fig 4. energy



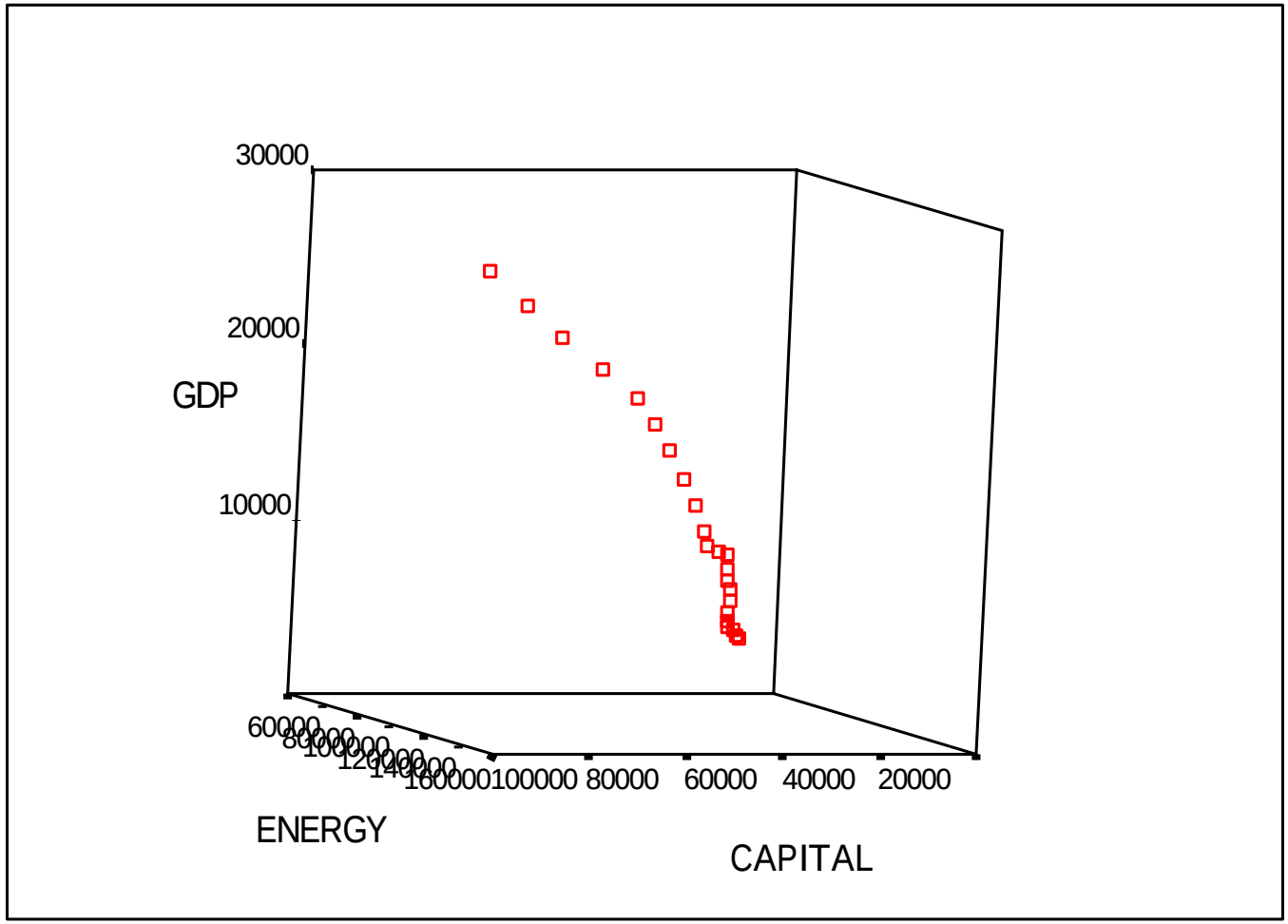






Annex fig.2capital of per capital

GDP-capital-energy relation



Recommended version 1:

CES

$$Y_{1r} = (1+\rho)^t A[aK^{-\theta} + (1-a)E^{-\theta}]^{-\frac{h}{\theta}}$$

$$Y_{2r} = A[aK^{-\theta} + (1-a)E^{-\theta}]^{-\frac{h}{\theta}}$$

Recommended version 1:

C-D

$$Y_{3r} = (1+\rho)^t AK^{\beta}E^{\gamma}$$

$$Y_{4r} = AK^{\beta}E^{\gamma}$$

$$Y_{1r} = (1+\rho)^t A[aK^{-\theta} + (1-a)E^{-\theta}]^{-\frac{h}{\theta}}$$

Parameters name	Parameter value	Standard error	t-ratio
ρ	0.0408	0.00395	10.33
A	1		
a	0.7011	0.05569	12.59
θ	-1		
h	0.8064	0.00879	91.72

$$Y_{2r} = A[aK^{-\theta} + (1-a)E^{-\theta}]^{-\frac{h}{\theta}}$$

Parameters name	Parameter value	Standard error	t-ratio
A	0.0118	0.00656	1.79
a	0.7995	0.032019	24.97
θ	-1		
h	1.2703	0.04687	27.10

$$Y_{3r} = (1+\rho)^t AK^{\beta}E^{\gamma}$$

Parameters name	Parameter value	Standard error	t-ratio
ρ	0.0344	0.00407	8.46
A	1		
β	0.5196	0.05932	8.76
γ	0.2975	0.05025	5.92

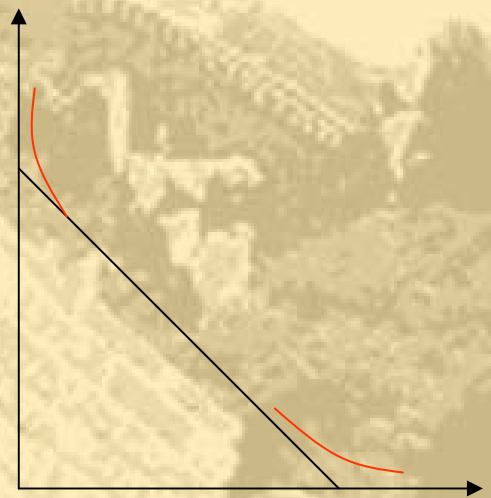
$$Y_{4r} = AK^{\beta}E^{\gamma}$$

Parameters name	Parameter value	Standard error	t-ratio
A	0.0326	0.01613	2.02
β	0.8766	0.02686	32.64
γ	0.3041	0.06360	4.78

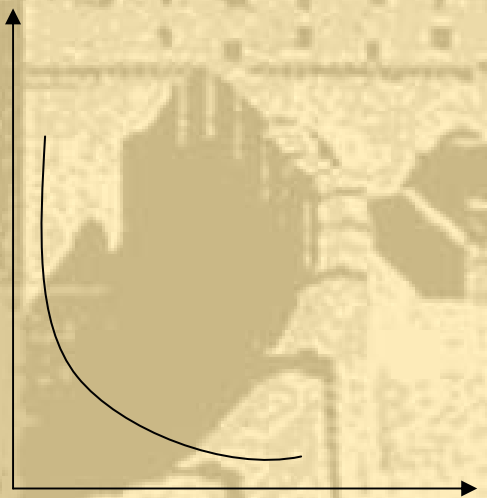
Substitution elasticity and Returns to scale

Model	Substitution elasticity	Returns to scale
Model 1	∞(K/E)	<1
Model 2	∞(K/E)	>1
Model 3	1 (K/E)	<1
Model 4	1(K/E)	>1

CES



C-D



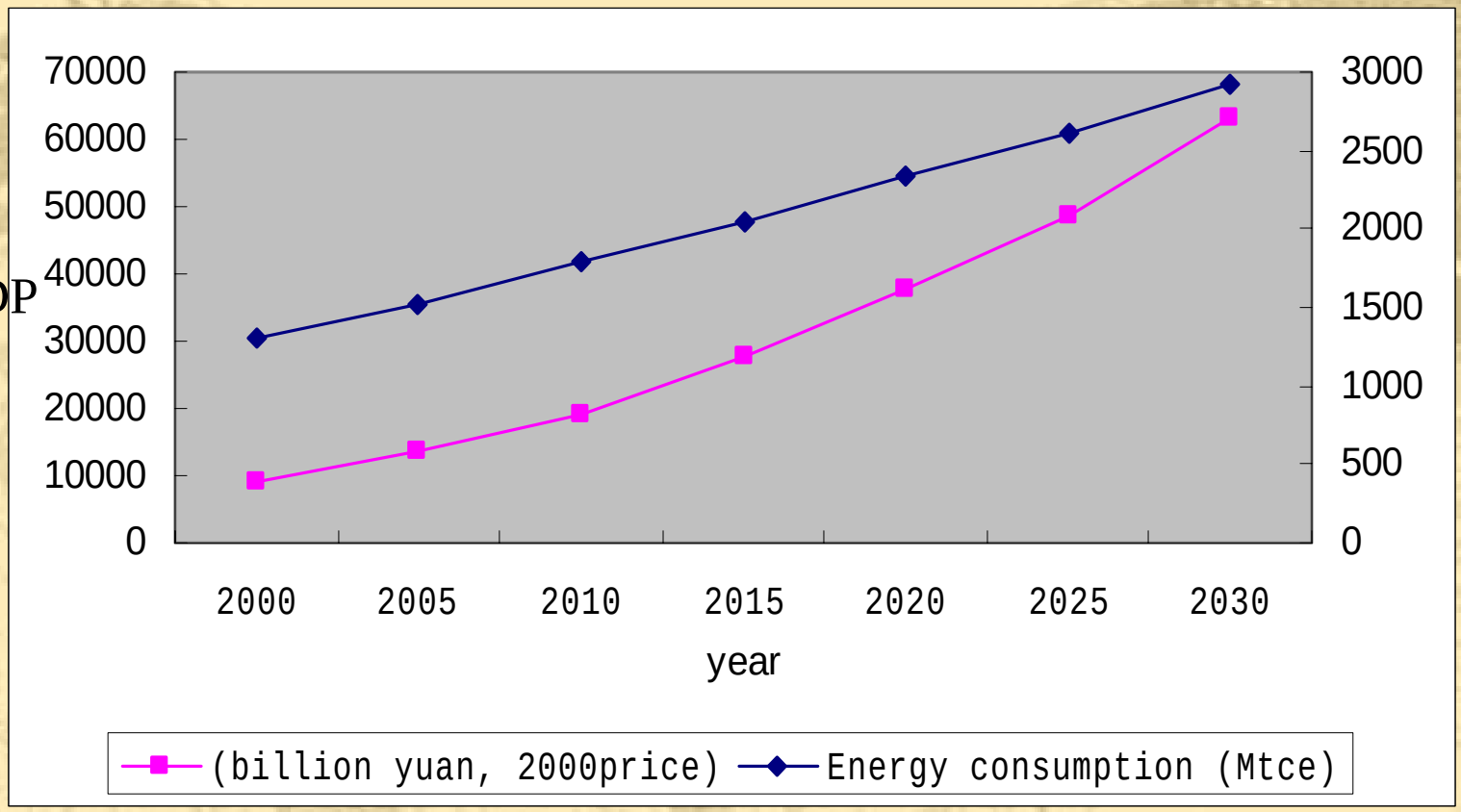
Summary

- Only capital and energy are used as inputs.
- Great uncertainty exists regarding the substitution elasticity between energy and capital
- Technology progress has great influence on the parameters of production functions
- output elasticity of capital input is much higher than that of energy input

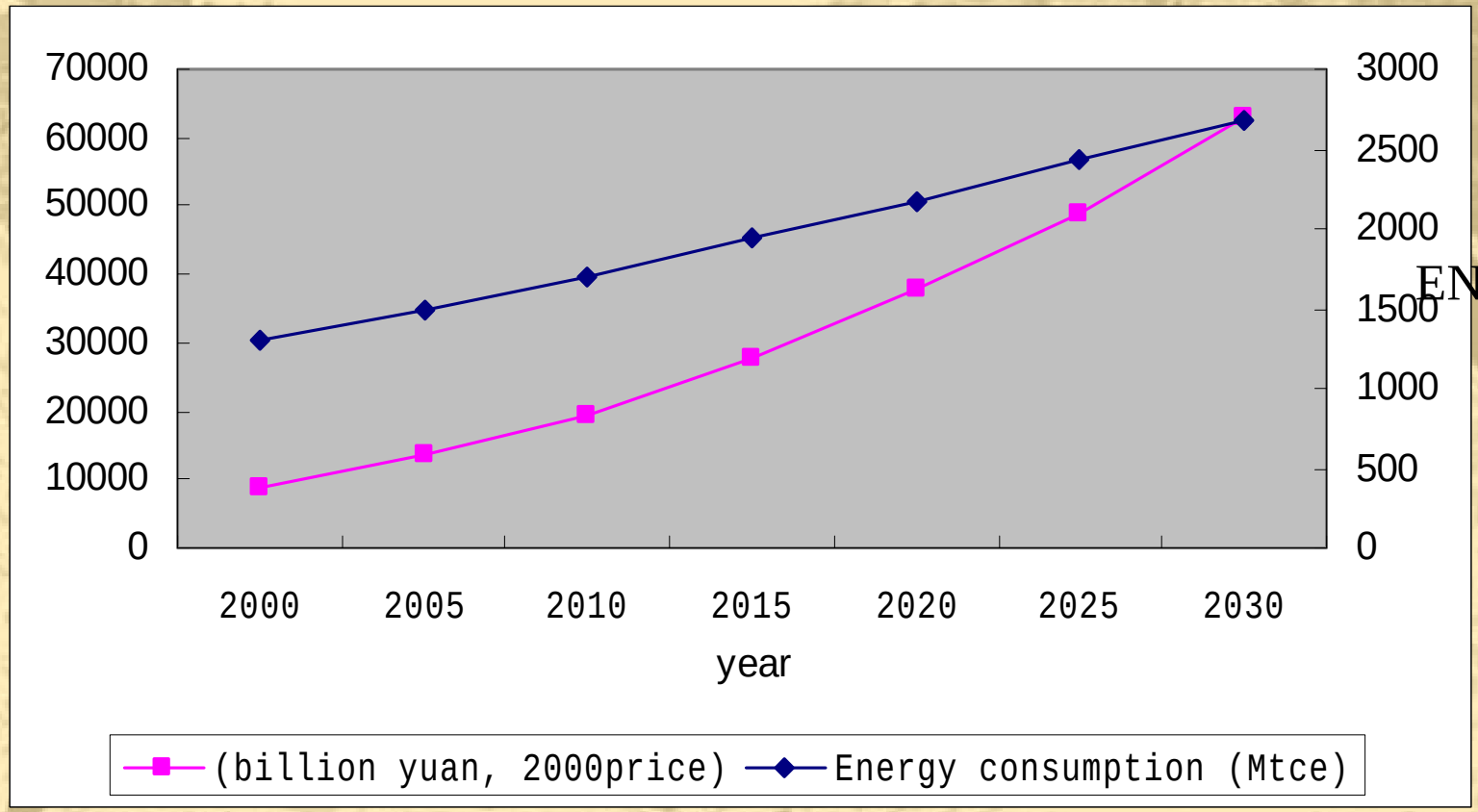
Discussion

- Surplus labor issue .
- Sectoral production functions may be more appropriate than national production function for China
- control energy consumption growth while keeping high economic growth rate,
- R&D and technology promotion.

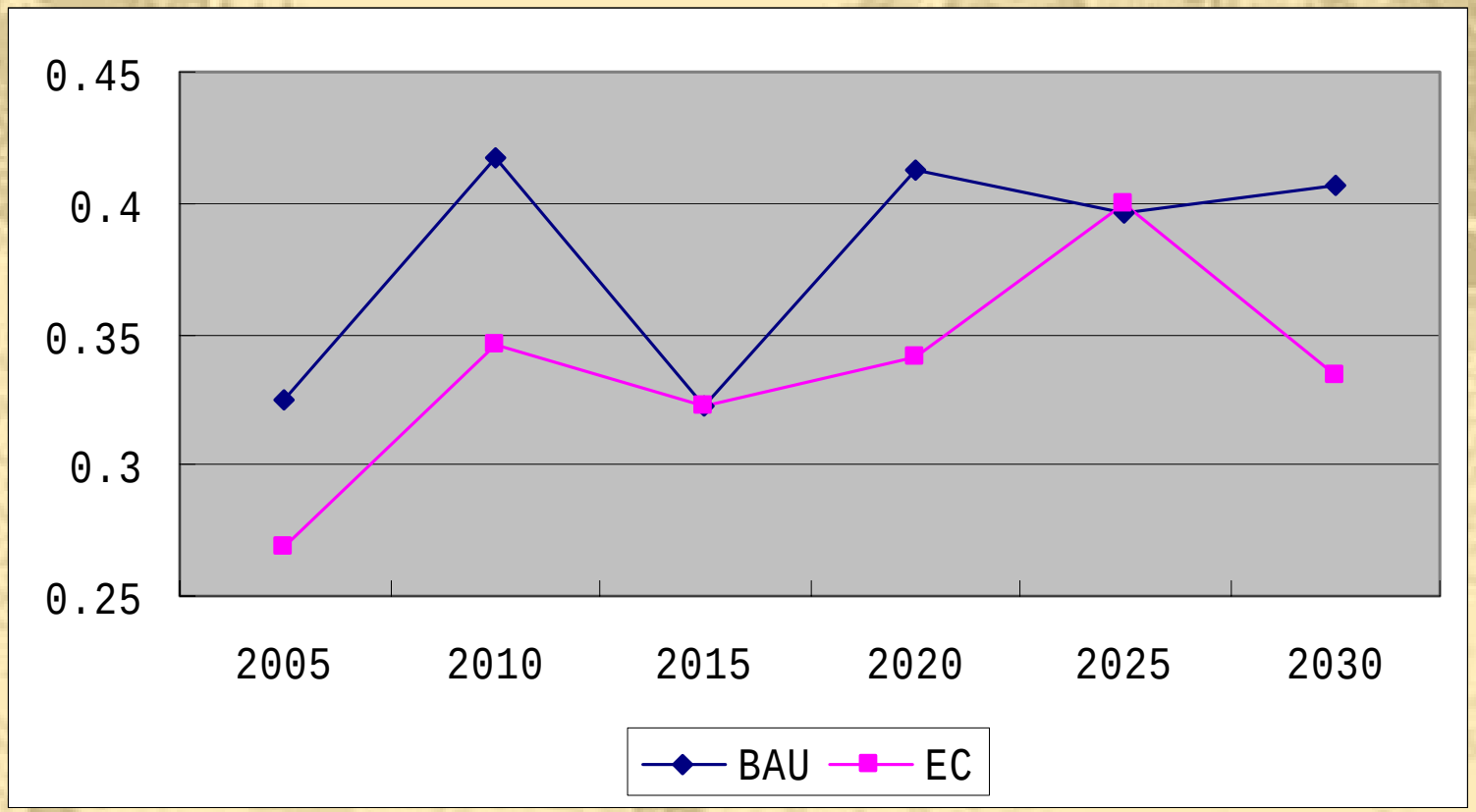
Scenario Set –Business as Usual



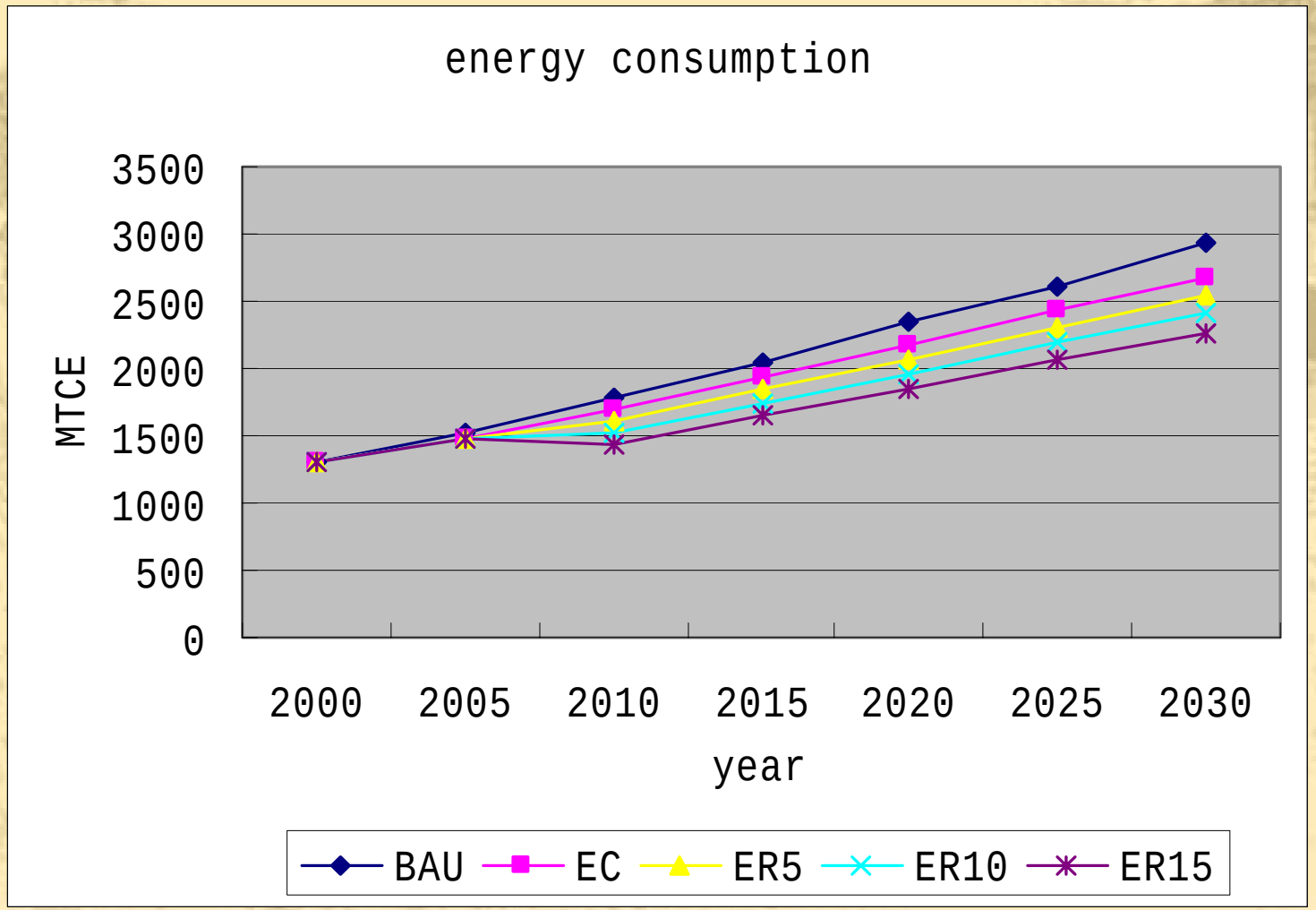
Scenario Set –energy conservation



Scenario Set –energy elasticity

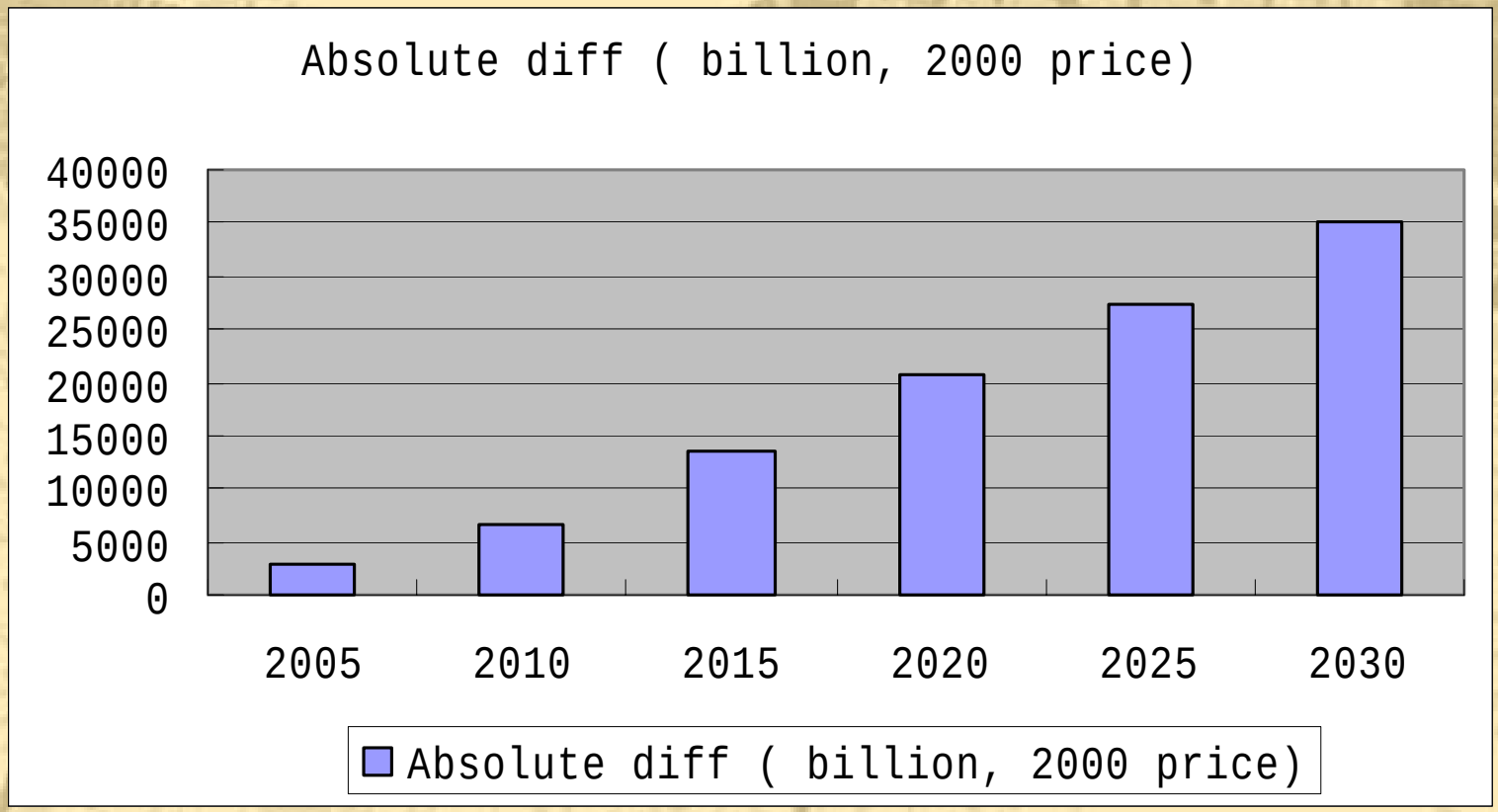


Energy consumption for different scenarios



Uncertainty of capital stock demand Between C-D and CES under BAU

-----With technological progress



Uncertainty of capital stock demand Between C-D and CES under BAU

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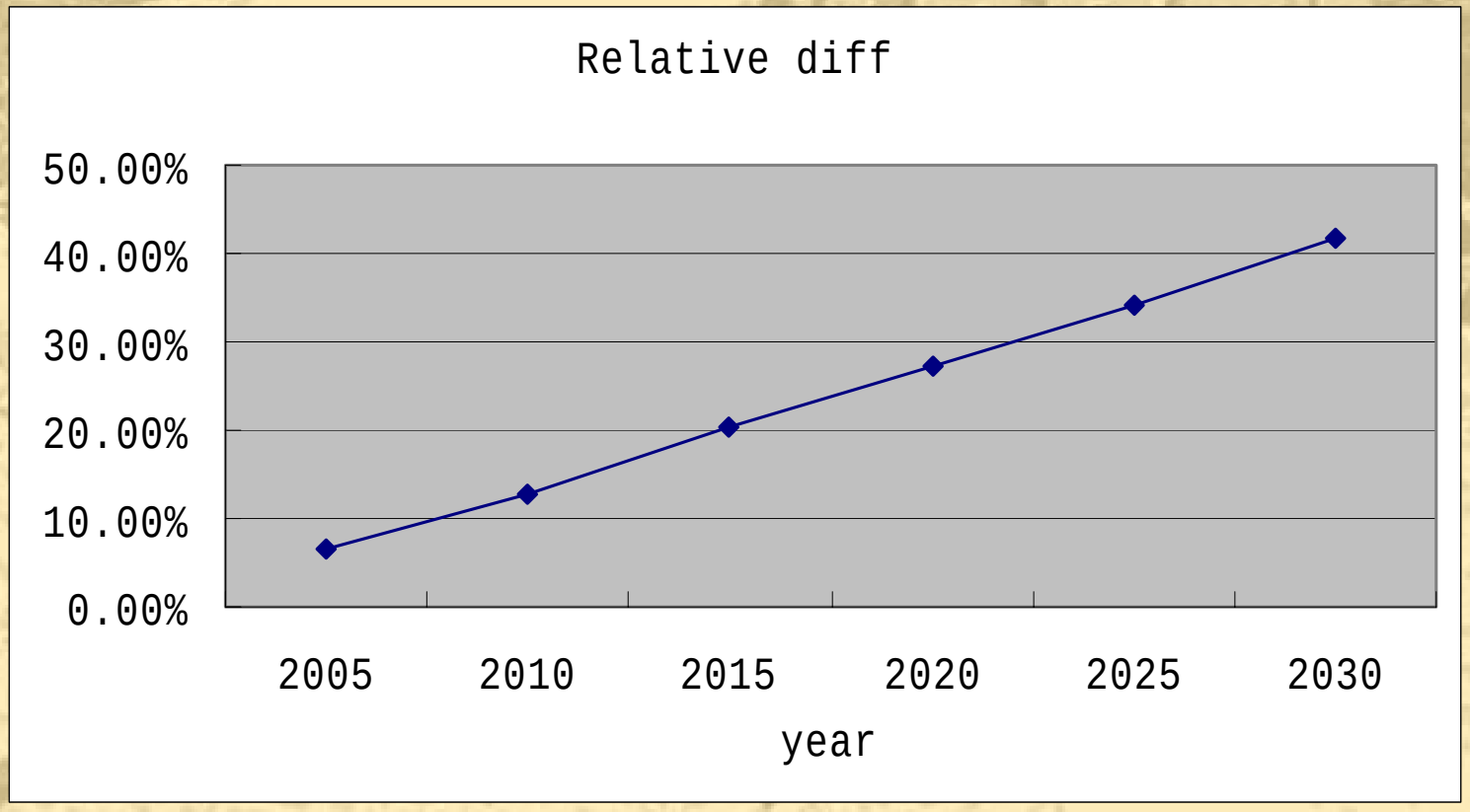
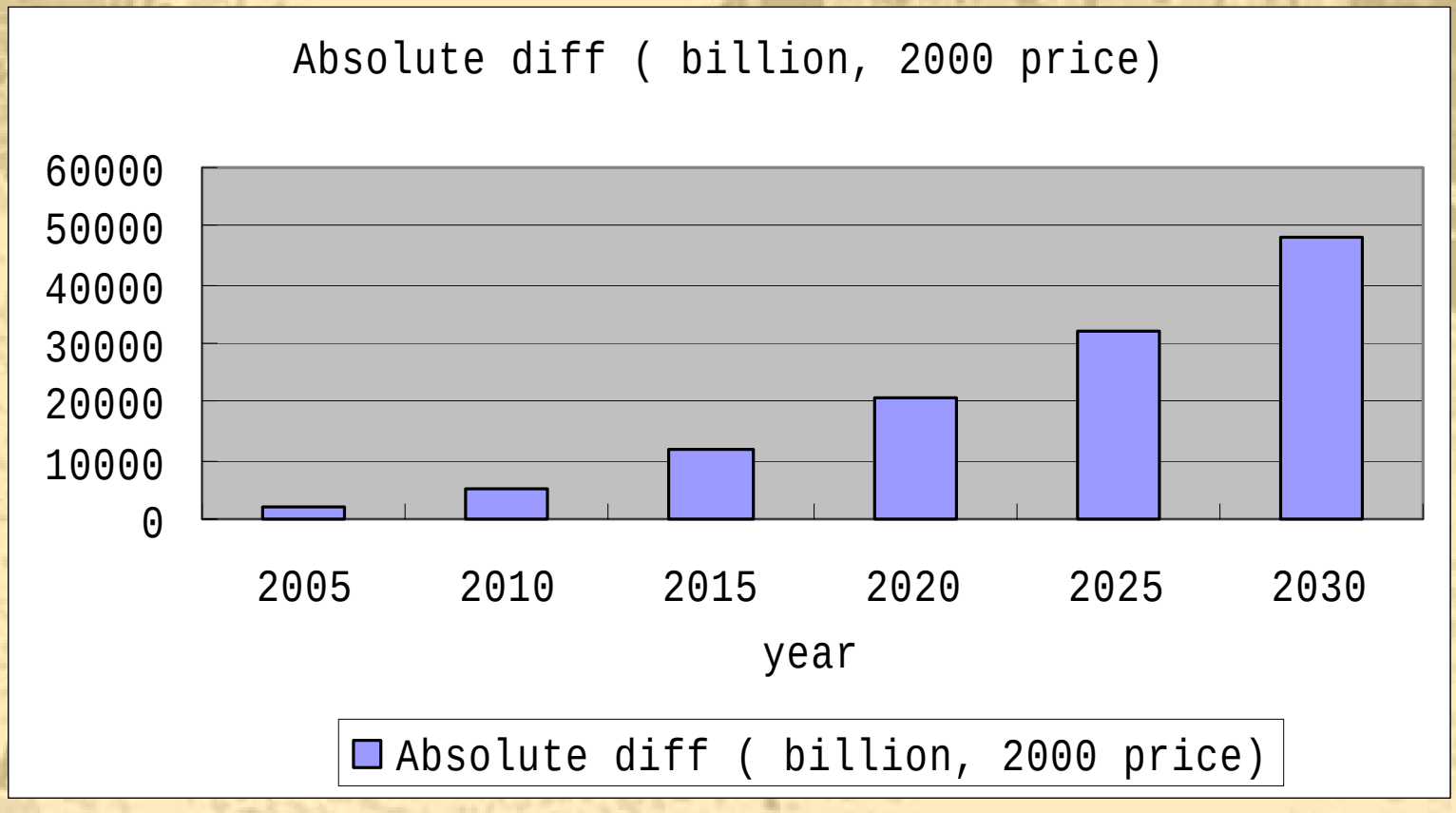
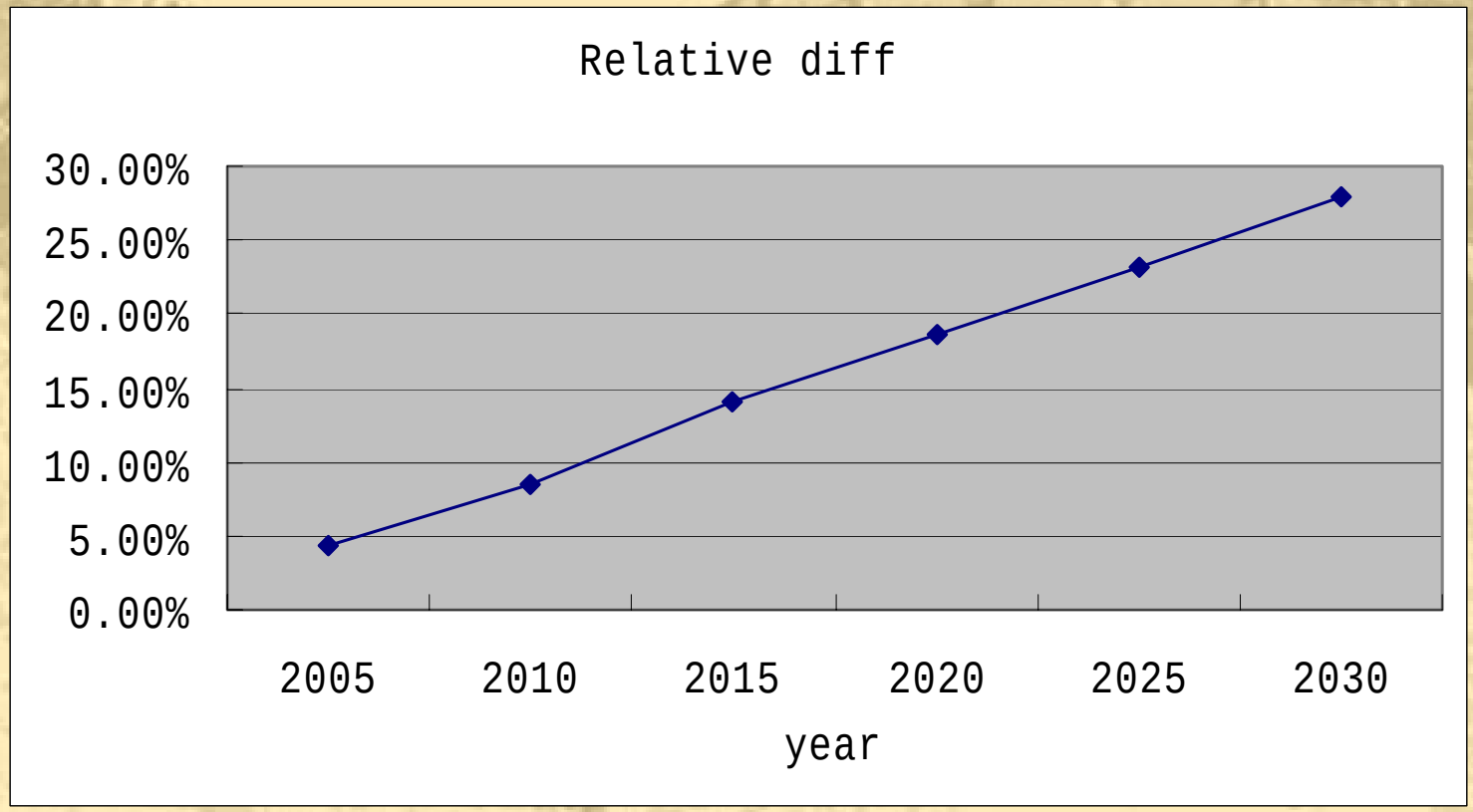


Uncertainty of capital stock demand Between C-D and CES under BAU -------Without technological progress



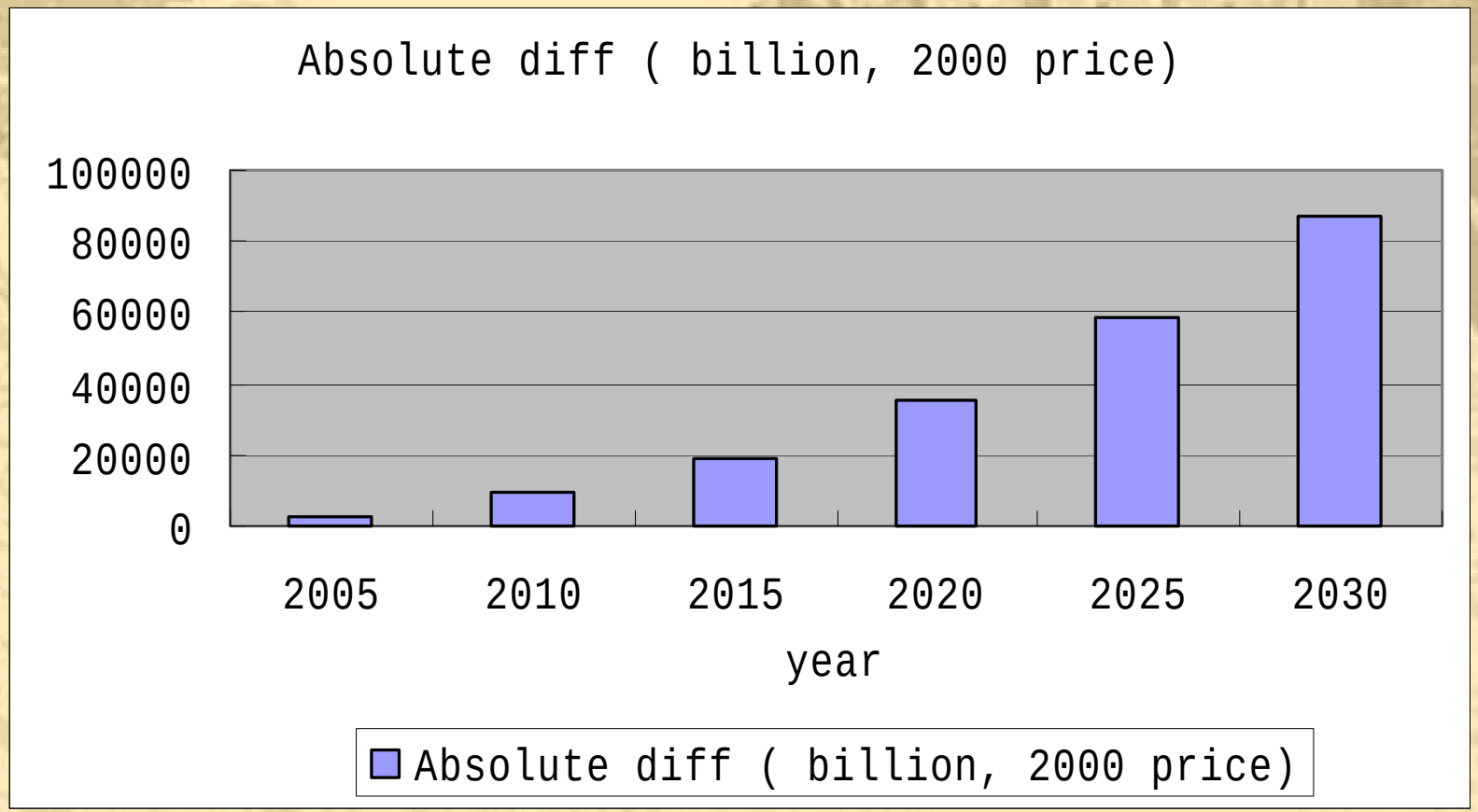
Uncertainty of capital stock demand Between C-D and CES under BAU

-------Without technological progress



The difference of capital stock with- and without-technological progress under BAU scenario

-------CES production function



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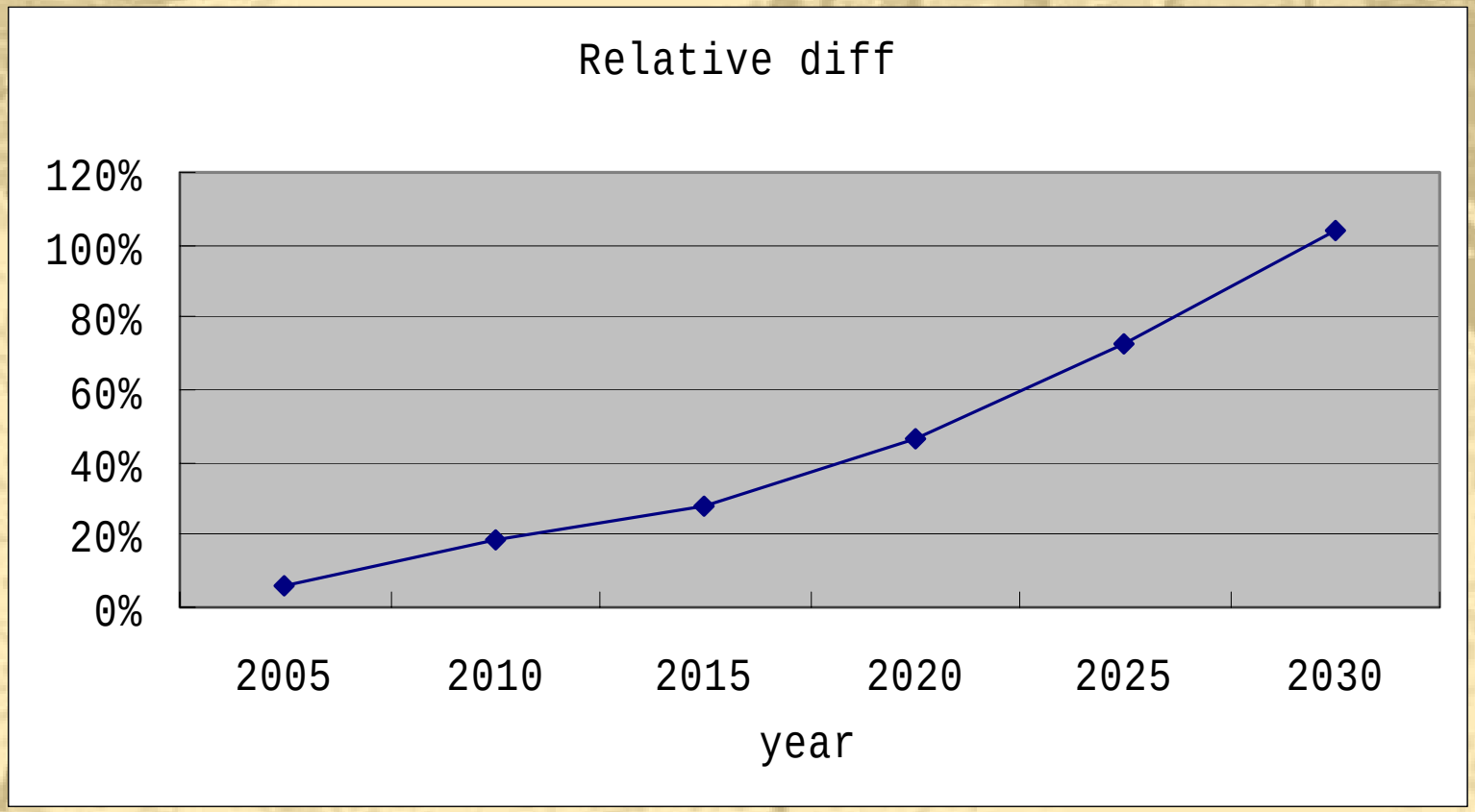
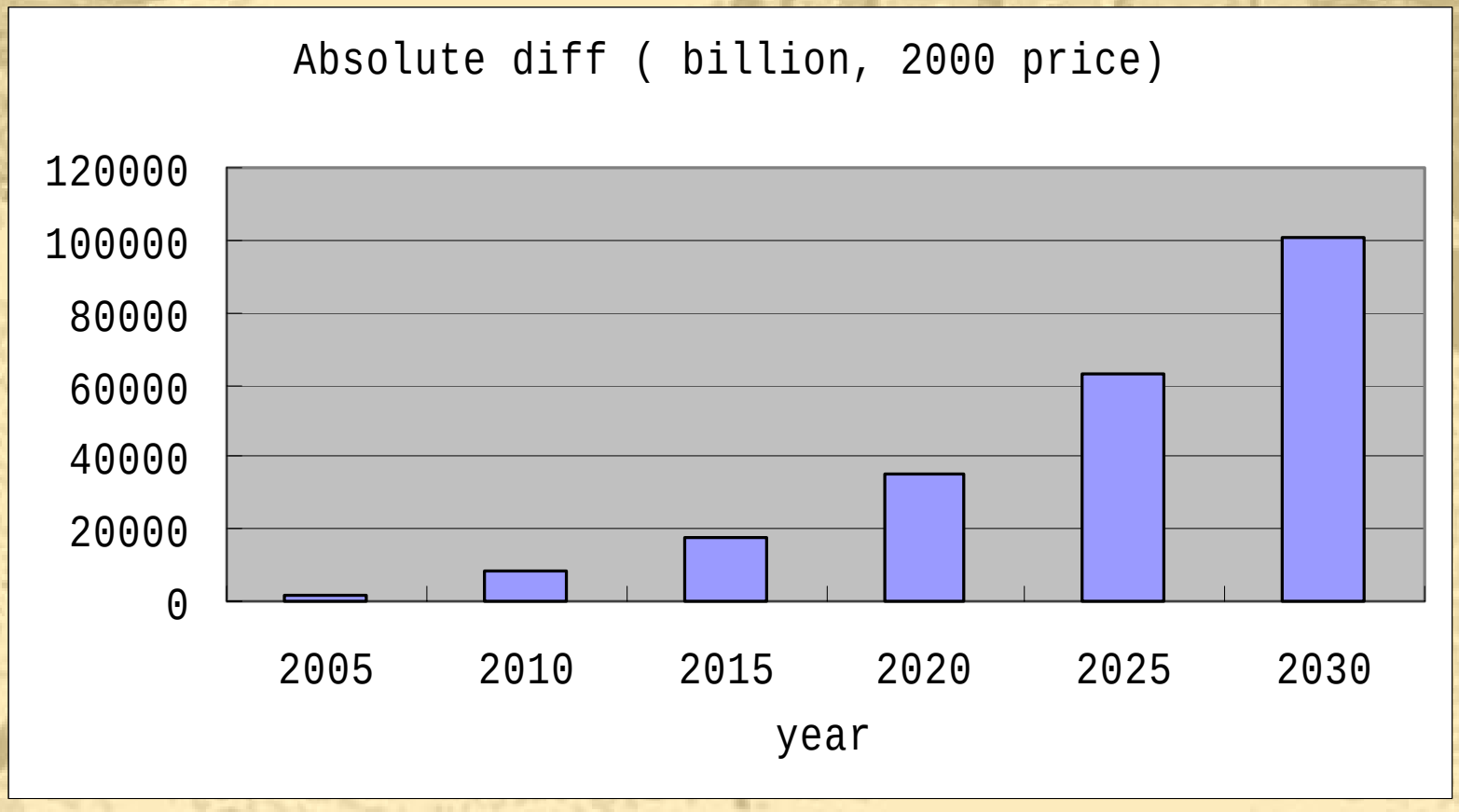


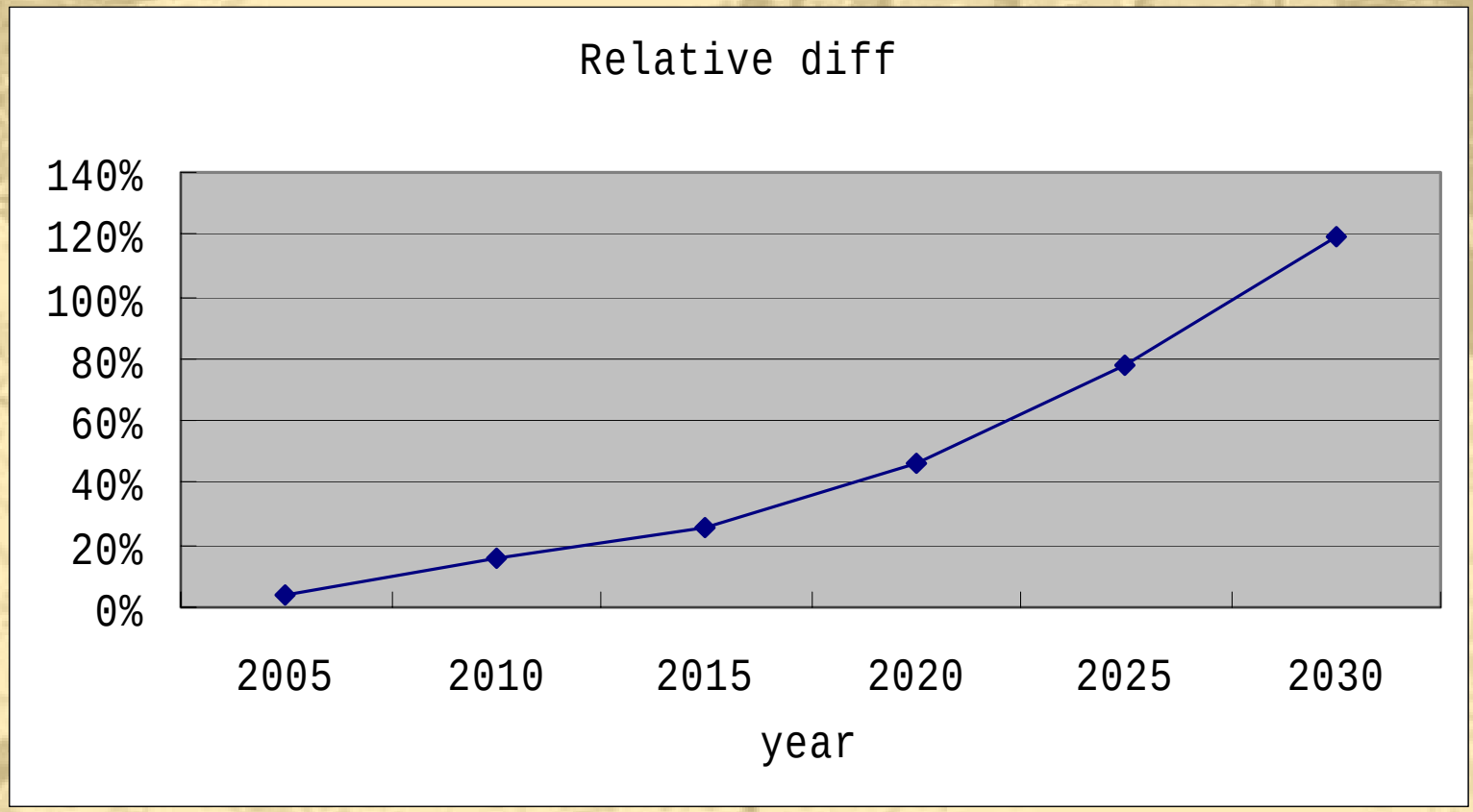
The difference of capital stock with- and without-technological progress under BAU scenario

-------C-D production function



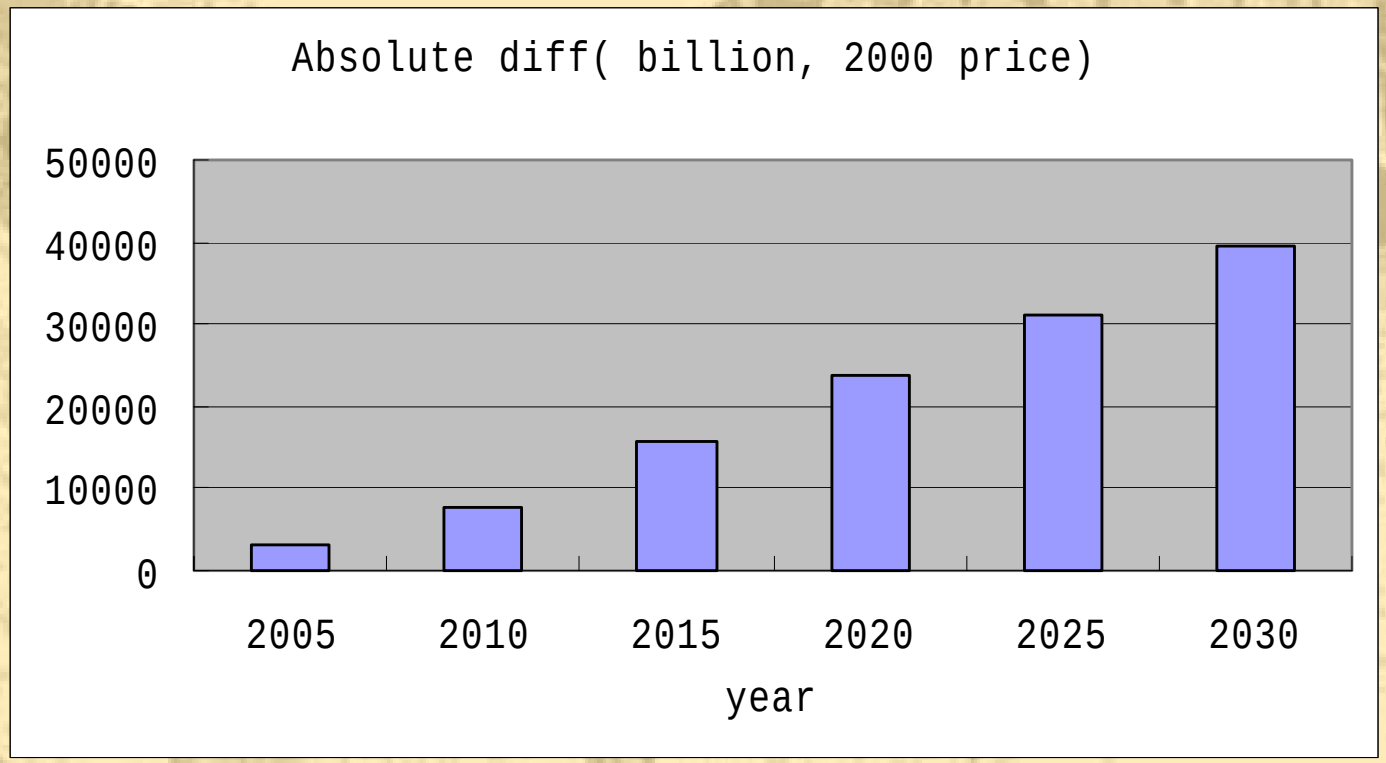
The difference of capital stock with- and without-technological progress under BAU scenario

-------C-D production function



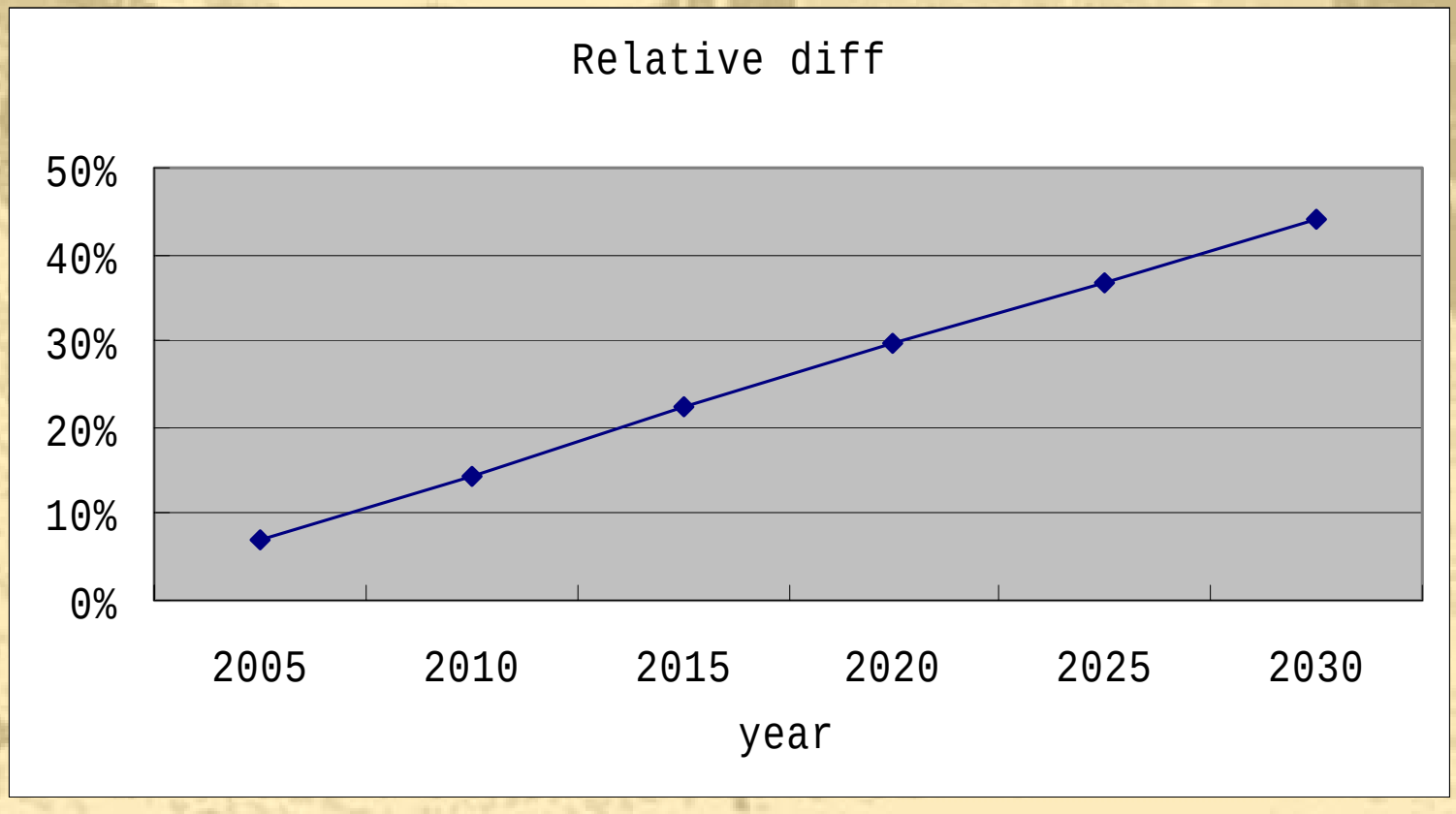
Uncertainty of capital stock demand Between C-D and CES under EC

-----With technological progress

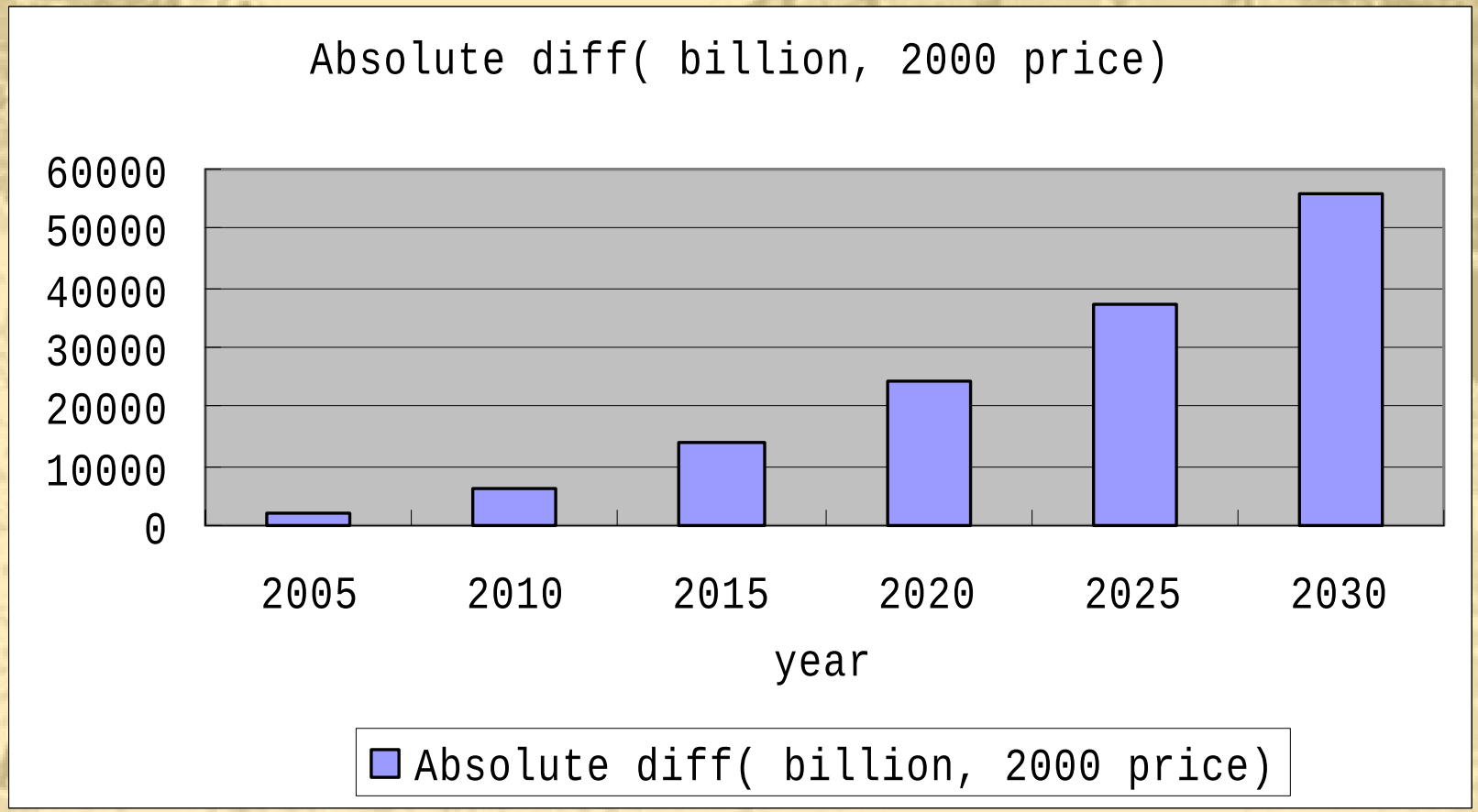


Uncertainty of capital stock demand Between C-D and CES under EC

-------With technological progress

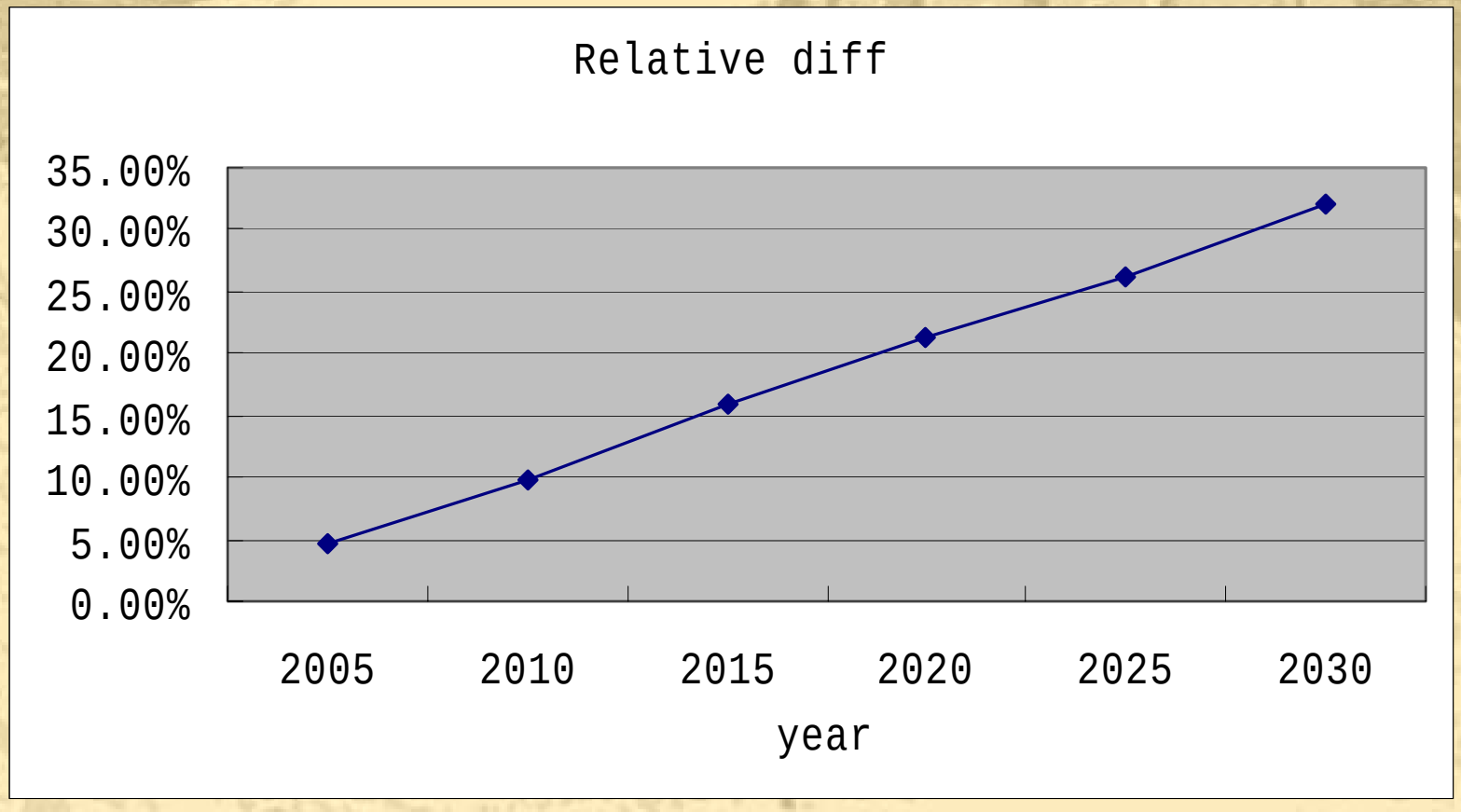


Uncertainty of capital stock demand Between C-D and CES under EC -------Without technological progress



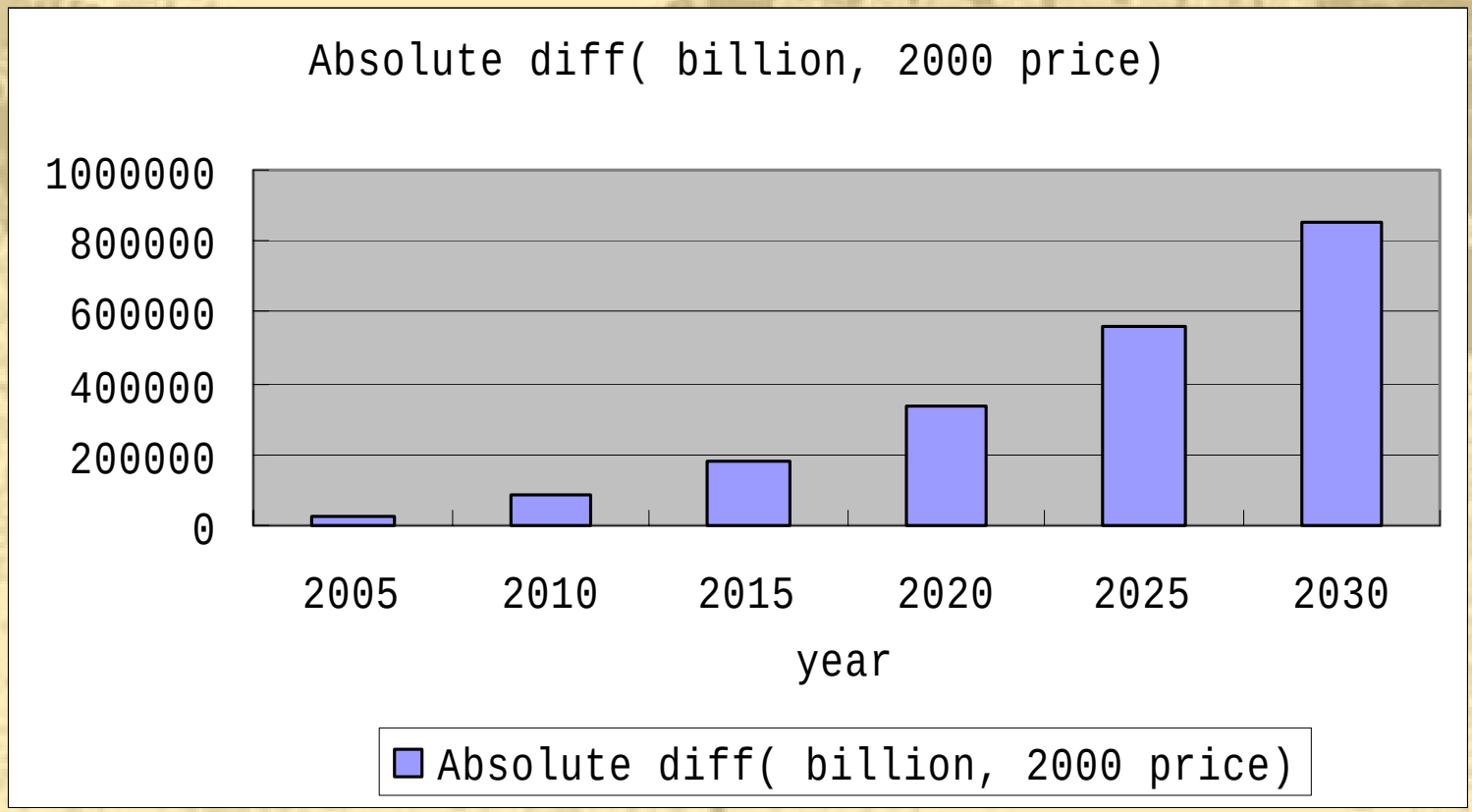
Uncertainty of capital stock demand Between C-D and CES under EC

-------Without technological progress



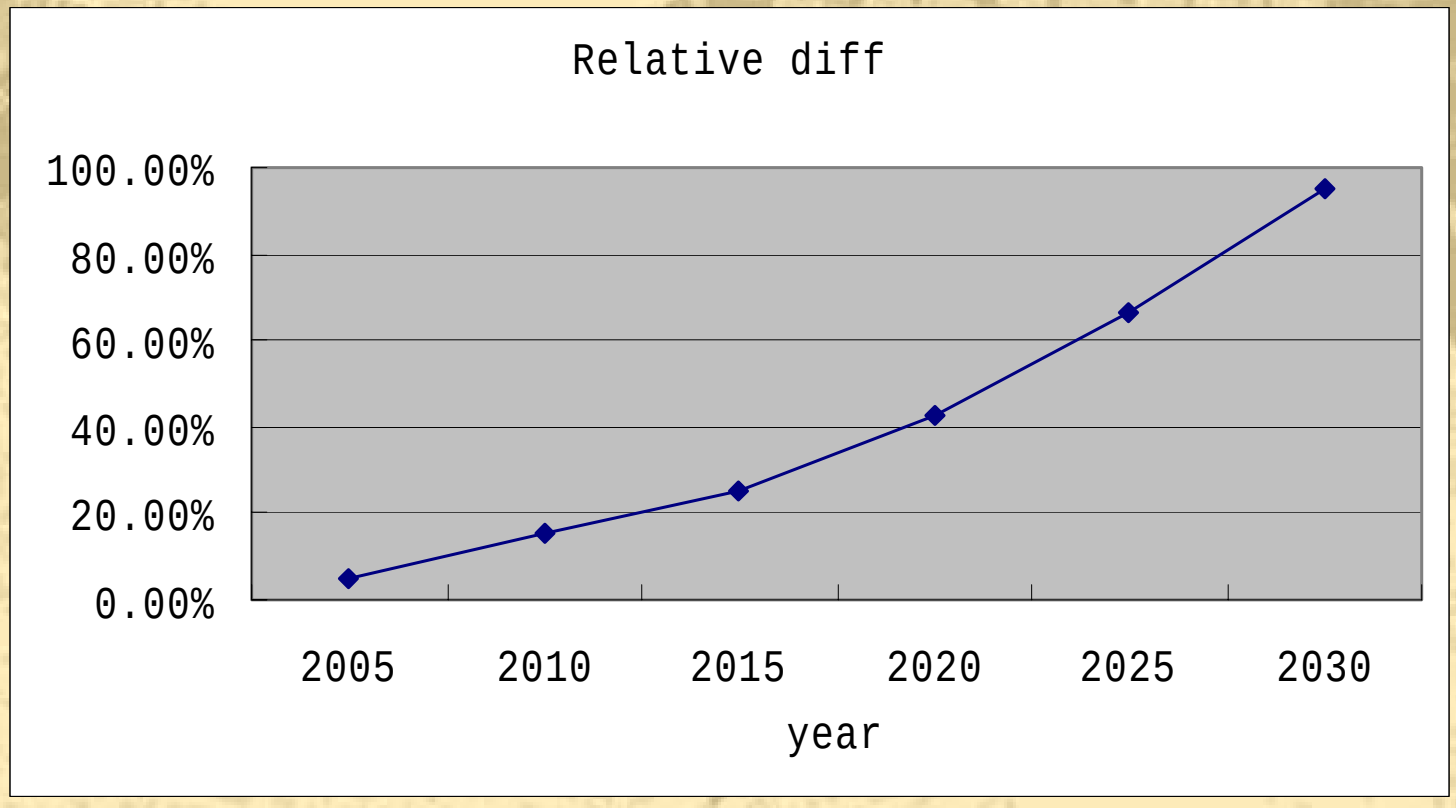
The difference of capital stock with- and without-technological progress under EC scenario

-------CES production function



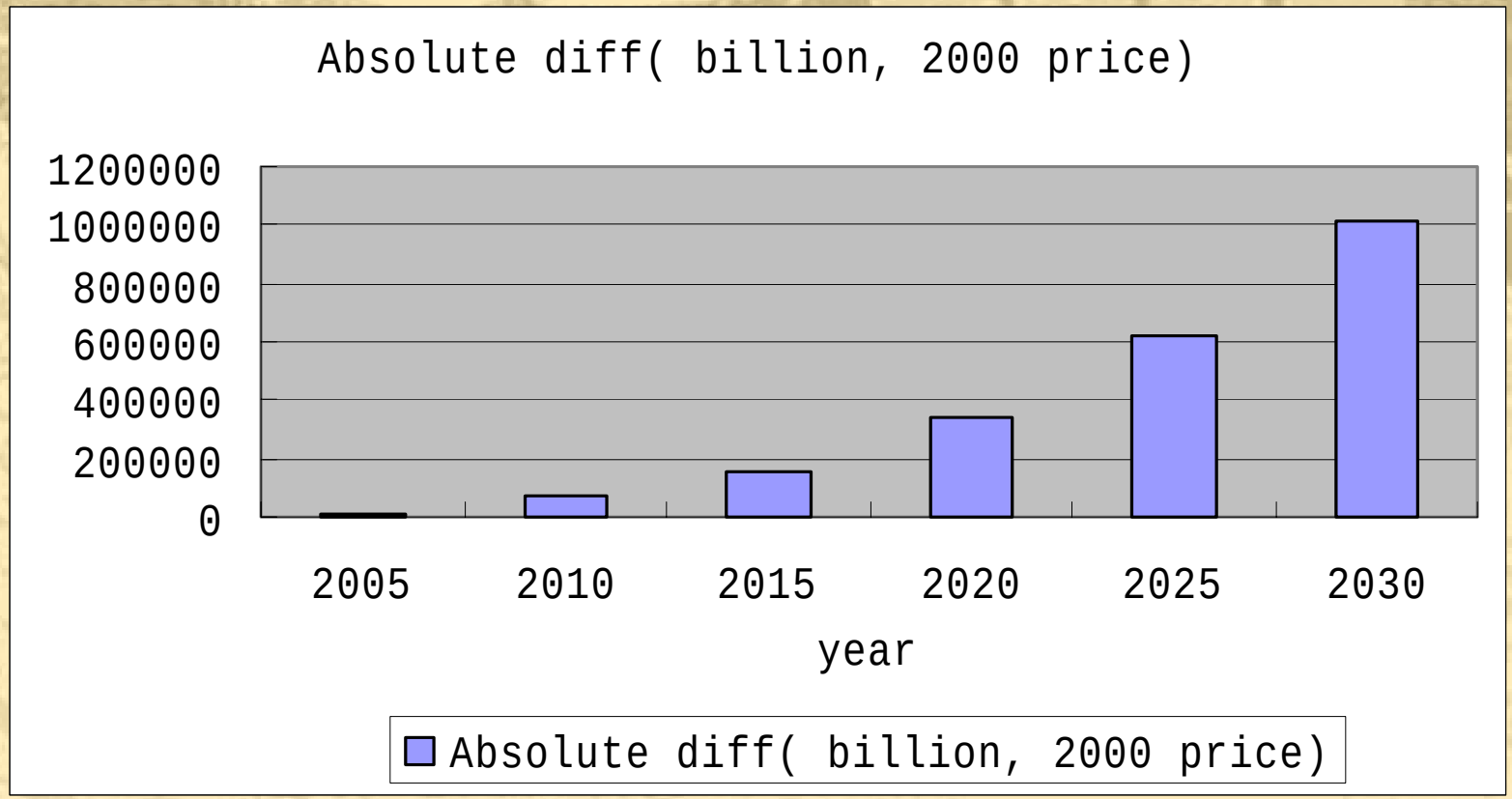
The difference of capital stock with- and without-technological progress under EC scenario

-------CES production function



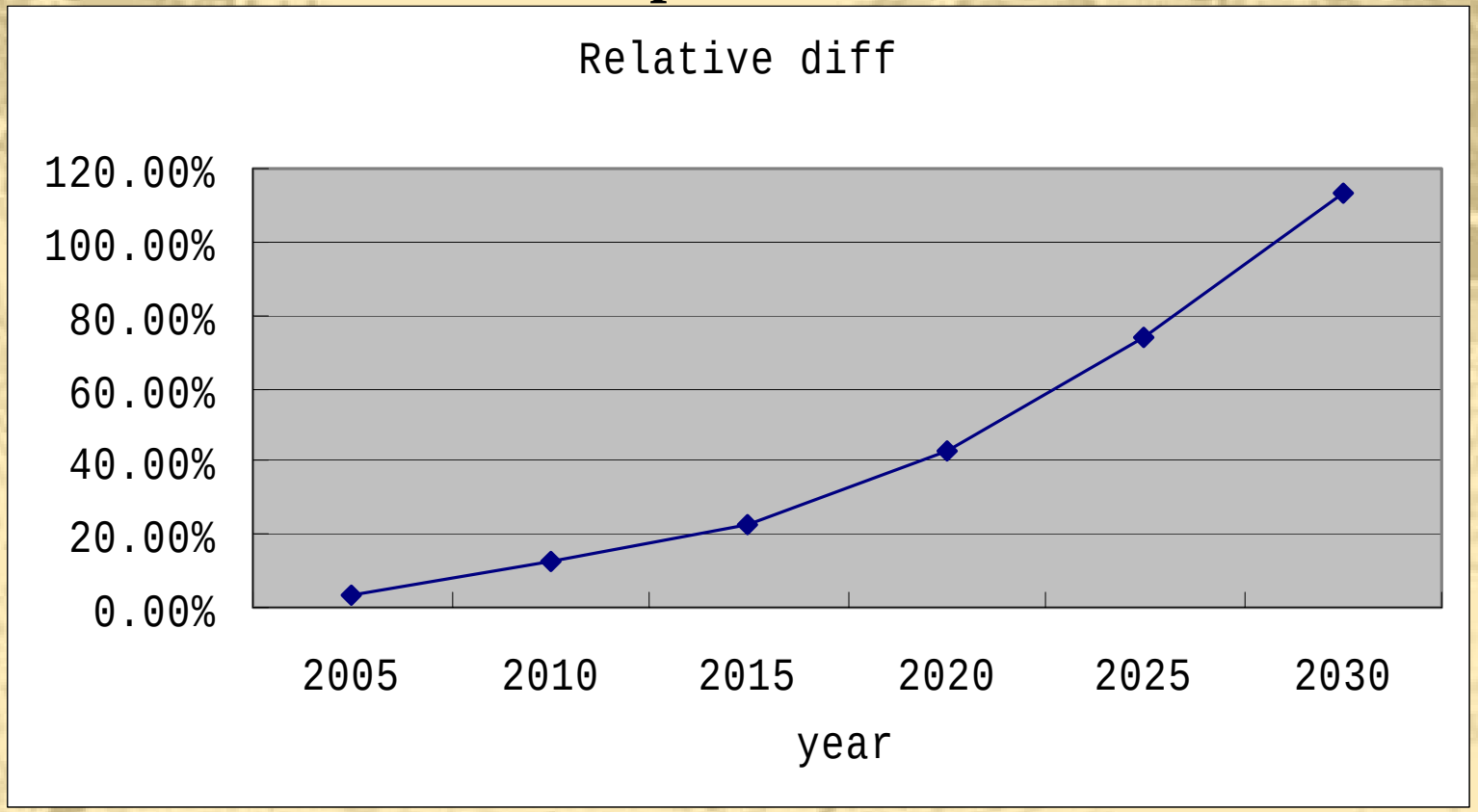
The difference of capital stock with- and without-technological progress under EC scenario

-------C-D production function



The difference of capital stock with- and without-technological progress under EC scenario

-------C-D production function



The incremental capital of CES functions under different scenarios to BAU

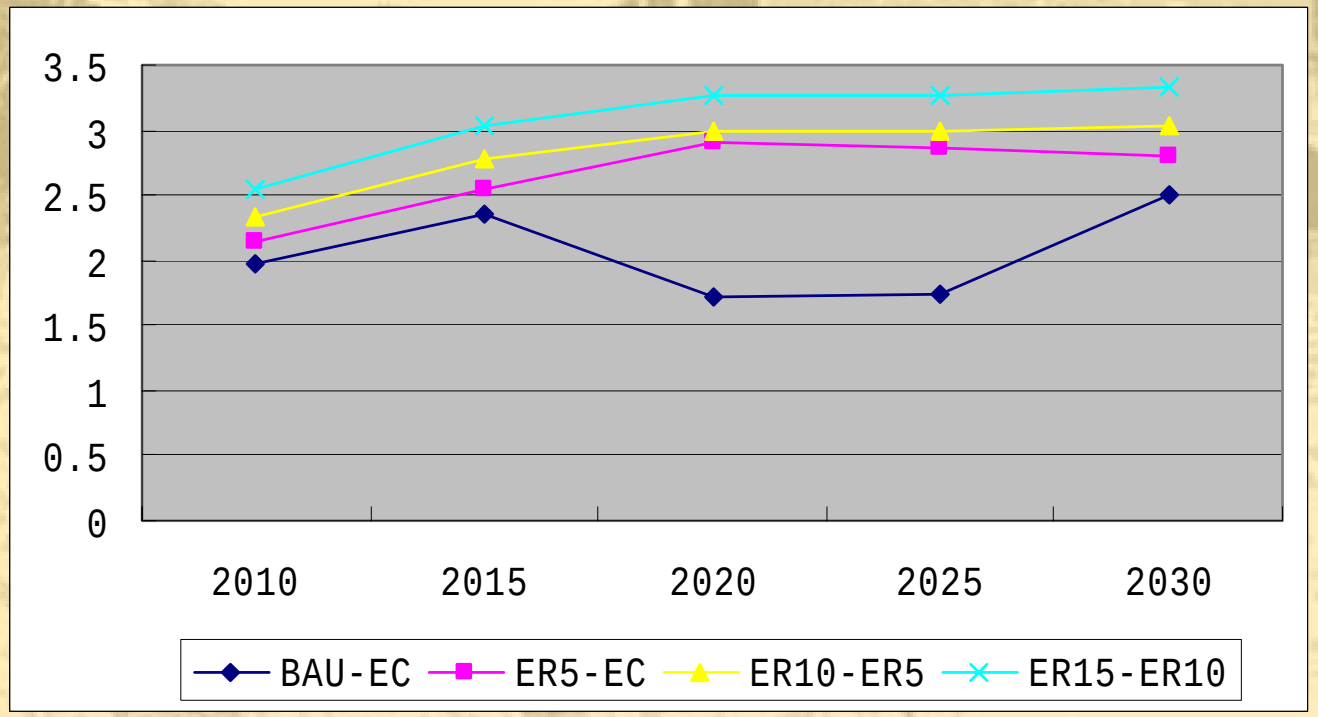
With TP :8380yuan/tce

Without TP:14240 yuan/tce

The incremental capital of C-D functions under different scenarios to BAU

-------With technological progress

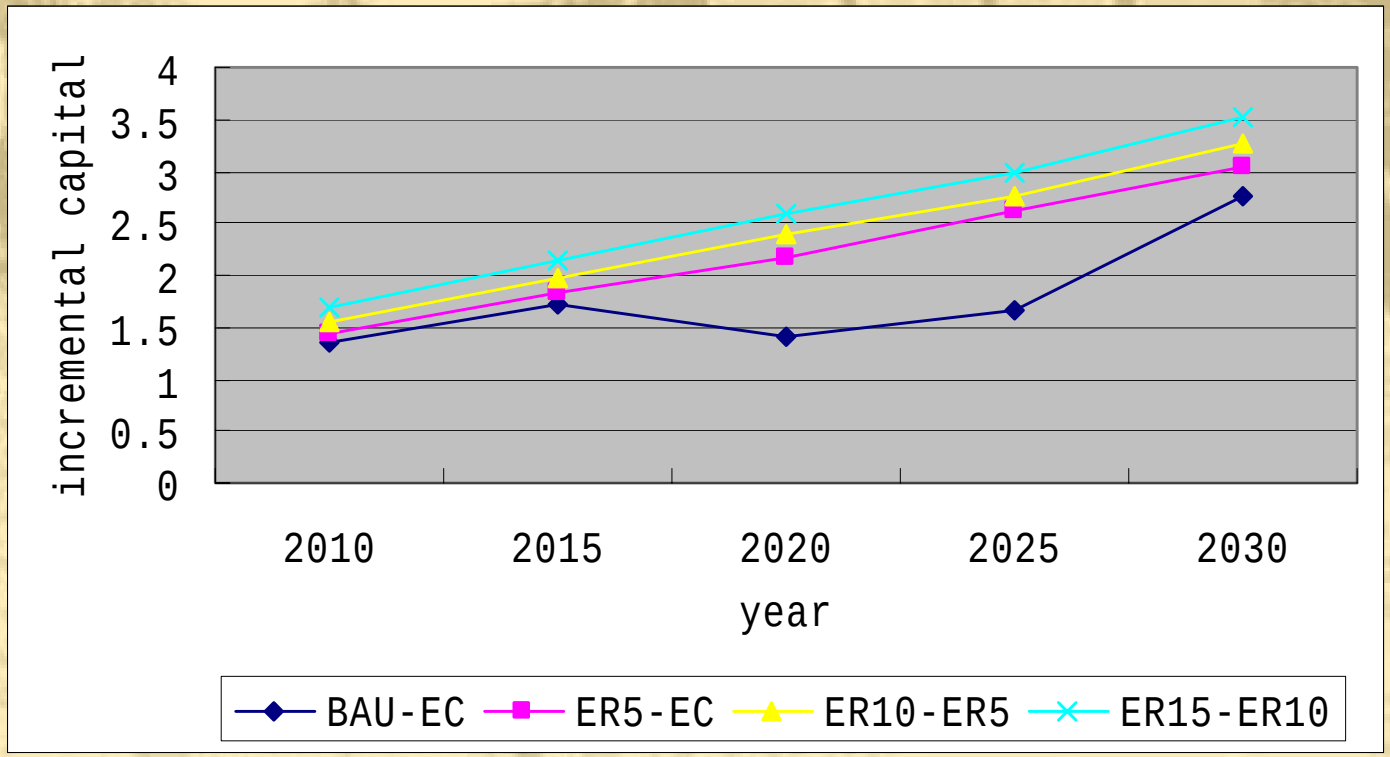
(10^4 yuan/tce)



The incremental capital of C-D functions under different scenarios to BAU

-------Without technological progress

(10^4 yuan/tce)

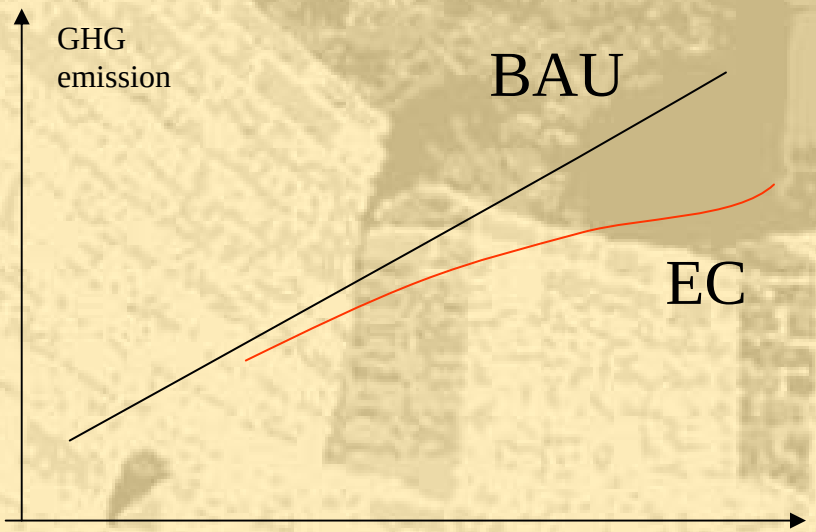


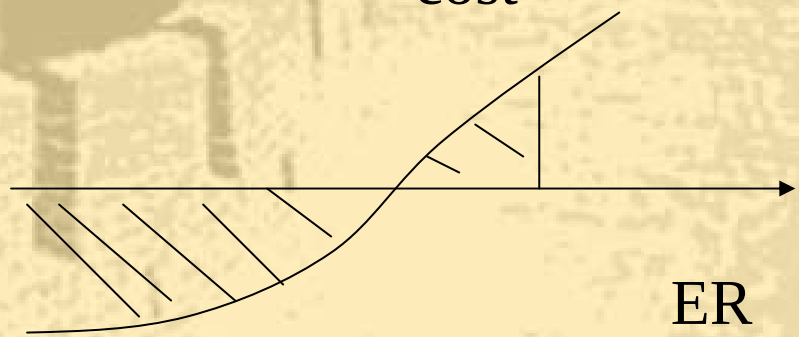
Conclusion

- **the strong energy supply constraint, the uncertainty of energy-capital substitution asks the huge and uncertain investment to improve energy efficiency and develop new energy to ensure the future sustainable development of China**
- **strong constraint of energy availability determines the active energy saving and energy substitution policies must be implemented in China**

Conclusion

- **energy conservation and energy substitution had already asked China increase huge investment to save and substitute energy. So , if real GHG emission=BAU emission for China?**





Conclusion

- **High substitution elasticity of energy and capital shows the promising prospect that China have huge potential to participate the global GHGs emission reduction cooperation mechanism such as CDM of Kyoto protocol**

- **Depreciation year of capital: 20year**

CO2 Abatement cost: 10 US$ /t co2e----41US$/t co2e

Thank you