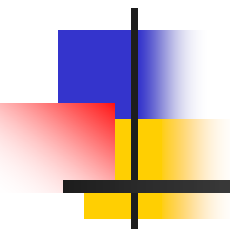


Clean Development Mechanism, Technological Diffusion Effect and Economic Growth



Kwo-Dong Wey & Jye-Chen Chen*

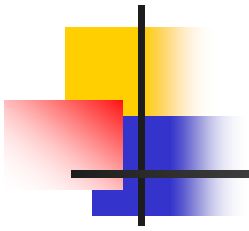
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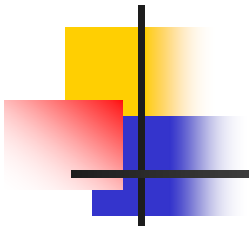
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The purpose of Study

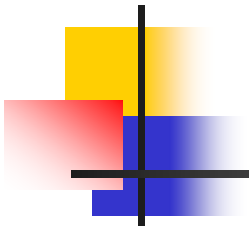
- To establish a model of exploring the mechanism of C.D.M..
- To explore the diffusion effects of C.D.M..
- To explore the relationships between diffusion effects and economic growth in C.D.M..
- To explore the impacts of C.D.M. for the investing country and host country.



Literature Review (I)

Economic Growth and Pollution Control.

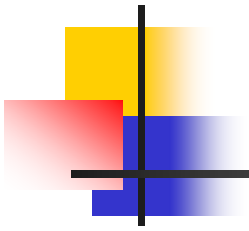
- Keeler & Zeckhauser (1971):Golden Age Equilibrium must be better than Murkey Age Equilibrium.
- Brock (1977):The economic growth would converge to a static equilibrium.
- Tahvonen & Kuuluvainen (1991):The pollution abatement would affect the economic growth and social welfare.
- Huang & Chen (1991):The pollution control and economic growth could be fulfilled in the developed countries in the same period.



Literature Review (II)

Pollution Control And Technological Diffusion Effects

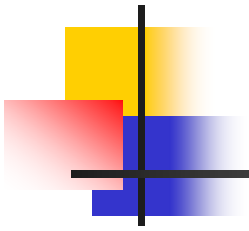
- Milliamn & Prince (1989):The technological diffusion effects would reduce the profit difference between the innovative country and the followers.
- Goulder & Mathai (2000):The technological diffusion effects of new abatement technology would decrease the profit of the country.
- Baudry (2000):The optimal emission level would decrease with new abatement technology.



Literature Review (III)

Technological Diffusion Effects and Economic Growth

- Barro & Sala-I-Martin (1995, 1997): The economic growth rate of developing country would converge to the same level as developed country. Thus, the economic growth rate of developing country would be higher than that of the developed country in the short run.

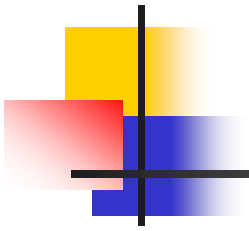


Introduction

- Similar to Barro & Sala-I-Martin (1997) and Goulder & Mathai's (2000) methodology, this study employs the optimal control theory.
- Under the clean development mechanism , here is to discuss the impacts of technological diffusion effects on economic growth of the investing country (Annex I Countries) and the host country (non-Annex I countries), respectively.

Emission Quota and Economic Growth

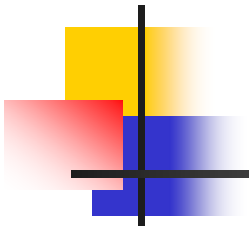
The Model of Investing Country


$$\max_{\{C_1, S_1, N_1\}} U_1 = \int_0^{\infty} \frac{\left(\frac{C_1}{S_1^\beta} \right)^{1-\sigma} - 1}{1-\sigma} \cdot e^{-\rho t} dt \quad (3.1)$$

$$s.t. \quad \dot{N}_1 = \frac{1}{\eta_l} \left\{ A_1 \cdot E_1^{\frac{1}{1-\alpha}} \cdot \left[\int_0^{N_1} X_{1j}^\alpha dj \right] - C_1 - N_1 \cdot X_1 \right\} \quad (3.2)$$

$$\dot{S}_1 = E_1 - bS \quad (3.3)$$

$$E_1 = \bar{E}_1 \quad (3.4)$$



Emission Quota and Economic Growth

The Model of Host Country

$$\max_{\{C_2, S_2, K_2\}} U_2 = \int_0^{\infty} \frac{\left(\frac{C_2}{S_2^\beta} \right)^{1-\sigma} - 1}{1-\sigma} \cdot e^{-\rho t} dt \quad (3.7)$$

$$s.t. \quad \dot{K}_2 = A_2 K_2 - C_2 - \delta K_2 - G_2 \quad (3.8)$$

$$\dot{S}_2 = E_2 - b S_2 \quad (3.9)$$

$$E_2 = K_2^{1+\alpha} G_2^{-\alpha} \quad (3.10)$$

Emission Quota and Economic Growth

Derivation of The Model

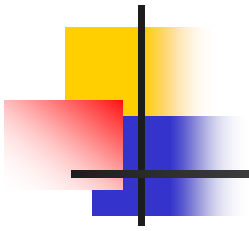
- Investing Country

- The Change Rate of Intermediate Input Price

$$-\frac{\dot{\mu}_1}{\mu_1} = \frac{1}{\eta_1} \cdot \left(\frac{1-\alpha}{\alpha} \right) \cdot \alpha^{\frac{1}{1-\alpha}} \cdot A_1^{\frac{1}{1-\alpha}} \cdot \bar{E}_1^{\frac{1}{(\alpha-1)^2}} \quad (3.13)$$

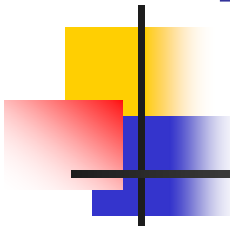
- The Economic Growth Rate

$$\frac{\dot{C}_1}{C_1} = \frac{1}{\sigma} \left[\frac{1}{\eta_1} \cdot \left(\frac{1-\alpha}{\alpha} \right) \cdot \alpha^{\frac{1}{1-\alpha}} \cdot A_1^{\frac{1}{1-\alpha}} \cdot \bar{E}_1^{\frac{1}{(\alpha-1)^2}} - \rho \right] = \frac{1}{\sigma} (r_1 - \rho) \quad (3.14)$$



Discussion (I)

- The rate of return for the investment of intermediate goods would be decreased when the change rate of its shadow price was increasing.
- The economic growth rate has the same direction as substitutive elasticity of intertemporal consumption, technological parameter and CO_2 emission quota.
- The economic growth rate would be risen by increasing the variety of intermediate goods.
- The economic growth rate of investing country would be decreased without the limit of CO_2 emission quota.



Emission Quota and Economic Growth

Derivation of The Model

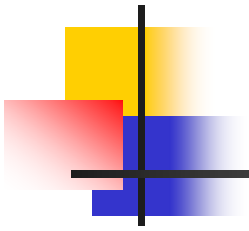
- Host Country

- The Change Rate of Capital's Price

$$-\frac{\dot{\mu}_2}{\mu_2} = (A_2 - \rho) - \left(\frac{1 + \alpha}{\alpha} \right) \cdot G_2 \cdot K_2^{-1} \quad (3.15)$$

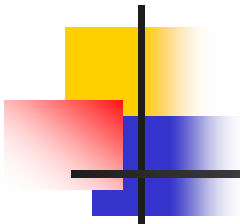
- The Economic Growth Rate.

$$\frac{\dot{C}_2}{C_2} = \frac{1}{\sigma - \beta(\sigma - 1)} \left[A_2 - \delta - \rho - \left(\frac{1 + \alpha}{\alpha} \right) \cdot m \cdot A_2 \right] \quad (3.16)$$



Discussion (II)

- The larger proportion of CO₂ abatement cost to capital investment is, the higher shadow price of capital is.
- The economic growth rate has opposite direction to capital depreciation rate, time preference and the proportion of CO₂ abatement cost to output.
- The economic growth rate would be increased when the proportion of CO₂ abatement cost to output is decreased.
- The economic growth of host country would be higher without the limit of CO₂ emission quota.



Clean Development Mechanism, Technological Diffusion Effect, and Economic Growth Rate

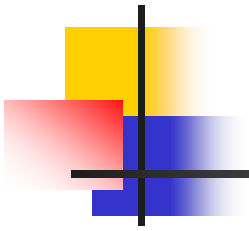
■ The Model of Investing Country

$$\max_{\{C_1, S_1, N_1\}} U_1 = \int_0^{\infty} \frac{\left(\frac{C_1}{S_1^\beta} \right)^{1-\sigma} - 1}{1-\sigma} \cdot e^{-\rho t} dt \quad (4.1)$$

$$s.t. \quad \dot{N}_1 = \frac{1}{\eta_1} \left[A_1 \cdot E_1^{\frac{1}{1-\alpha}} \cdot N_1 \cdot X_1^\alpha - C_1 - N_1 \cdot X_1 \right] \quad (4.2)$$

$$\dot{S}_1 = aE_1' - bS_1 \quad (4.3)$$

$$E_1' = \overline{E}_1 + R \quad (4.4)$$



Clean Development Mechanism, Technological Diffusion Effect, and Economic Growth Rate

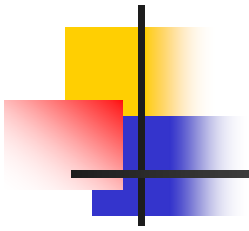
■ The Model of Host Country

$$\max_{\{C_2, S_2, N_2\}} U_2 = \int_0^{\infty} \frac{\left(\frac{C_2}{S_2^\beta} \right)^{1-\sigma} - 1}{1-\sigma} \cdot e^{-\rho t} dt \quad (4.5)$$

$$s.t. \quad \dot{N}_2 = \frac{1}{\nu_2} \left[A_2 \cdot \overline{E}_2^{\frac{1}{1-\alpha}} \cdot N_2 \cdot X_2^\alpha - C_2 - N_2 \cdot X_2 \right] \quad (4.6)$$

$$\dot{S}_2 = a \overline{E}_2 - b S_2 \quad (4.7)$$

$$E_2 = \overline{E}_2 \quad (4.8)$$



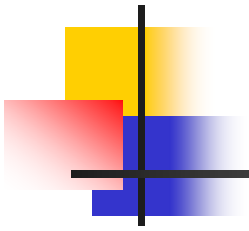
Clean Development Mechanism, Technological Diffusion Effect, and Economic Growth Rate

- The Economic Growth Rate of Investing Country

$$\frac{\dot{C}_1}{C_1} = \frac{1}{\sigma} \left[\frac{1}{\eta_1} \cdot \left(\frac{1-\alpha}{\alpha} \right) \cdot \alpha^{\frac{1}{1-\alpha}} \cdot A_1^{\frac{1}{1-\alpha}} \cdot E_1^{\frac{1}{(\alpha-1)^2}} - \rho \right] = \frac{1}{\sigma} (r'_1 - \rho) \quad (4.9)$$

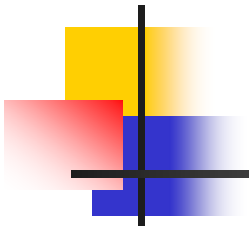
- The Economic Growth Rate of Host Country

$$\frac{\dot{C}_2}{C_2} = \frac{1}{\sigma} \left[\frac{1}{\nu_2} \cdot \left(\frac{1-\alpha}{\alpha} \right) \cdot \alpha^{\frac{1}{1-\alpha}} \cdot A_2^{\frac{1}{1-\alpha}} \cdot \bar{E}_2^{\frac{1}{(\alpha-1)^2}} - \rho \right] = \frac{1}{\sigma} (r'_2 - \rho) \quad (4.10)$$



Discussion (III)

- The economic growth rate of investing country would be increased after joining C.D.M..
- The economic growth rate of host country would be lower than that of investing country.



Dynamic Path and Convergence

- Cost Function of Innovative CO₂ Abatement Technology:

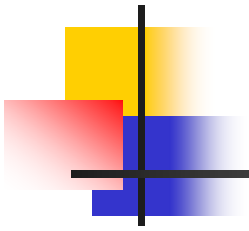
$$v_2(t) = \pi_2 \cdot \int_t^\infty \exp\left[-\int_t^s r'_2(v) \cdot dv\right] \cdot ds$$

- Where

$$v_2 = v_2\left(\frac{N_2}{N_1}\right)$$

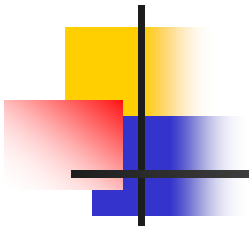
- Stable Economic Growth Rate

$$\left(\frac{\dot{C}_2}{C_2}\right)^* = \frac{\dot{C}_1}{C_1} \Rightarrow r_2'^* = r_1' \Rightarrow \frac{\pi_2}{v_2^*} = \frac{\pi_1}{\eta_1}$$



Discussion (IV)

- The rates of return of intermediate goods' investment for two countries are equal when the stable equilibrium is reached.
- The host country has no incentives for new technological innovation.
- The output level for host country is lower than that of the investing country.



Dynamic Path and Convergence

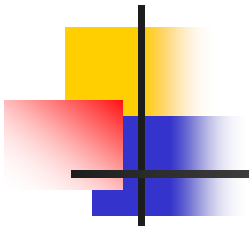
- Let $v_2 = \eta_2 \cdot \left(\frac{N_2}{N_1} \right)^\omega$ and $\theta_2 = C_2 / N_2$
- The Economic Growth Rate Becomes

$$\frac{\dot{C}_2}{C_2} = \frac{1}{\sigma} \cdot \left\{ \frac{1}{v_2} \cdot \left[\pi_2 \cdot \left(1 + \frac{\omega \cdot (1 + \alpha)}{\alpha} \right) - \omega \theta_2 \right] - \rho - \omega \cdot \frac{\dot{C}_1}{C_1} \right\}$$

- Dynamic Path

$$\frac{\dot{\hat{N}}}{\hat{N}} = \left(\frac{1}{v_2} \right) \cdot \left[\pi_2 \cdot \frac{1 + \alpha}{\alpha} - \theta_2 \right] - \frac{\dot{C}_1}{C_1} \quad (5.6)$$

$$\frac{\dot{\theta}_2}{\theta_2} = \left(\frac{1}{\sigma v_2} \right) \cdot \left\{ \pi_2 + (\sigma - \omega) \cdot \left[\theta_2 - \pi_2 \cdot \frac{1 + \alpha}{\alpha} \right] \right\} - \frac{1}{\sigma} \cdot \left(\omega \cdot \frac{\dot{C}_1}{C_1} + \rho \right) \quad (5.7)$$

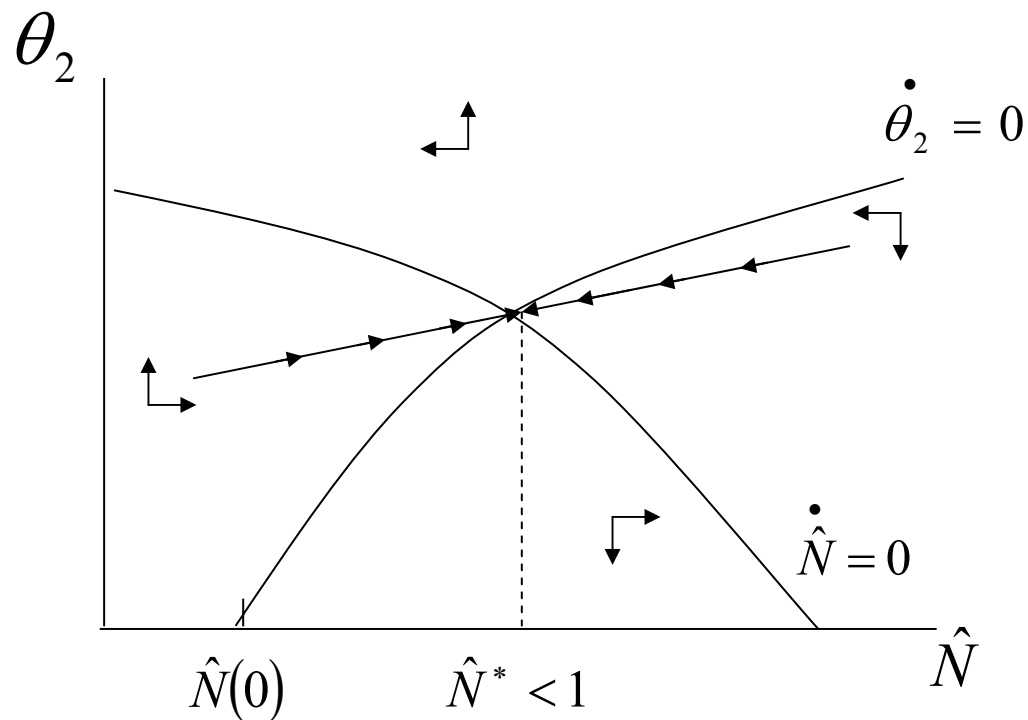


Discussion (V)

- There is a stable equilibrium shown on Fig. 3, with contrast to an upward saddle path shown on each of the other three figures.
- The economic growth rate of the host country will be increased with increasing rate that is higher than that of in the investing country.
- Both of the investing country and host country will have the same economic growth rate when the stable equilibrium is reached.

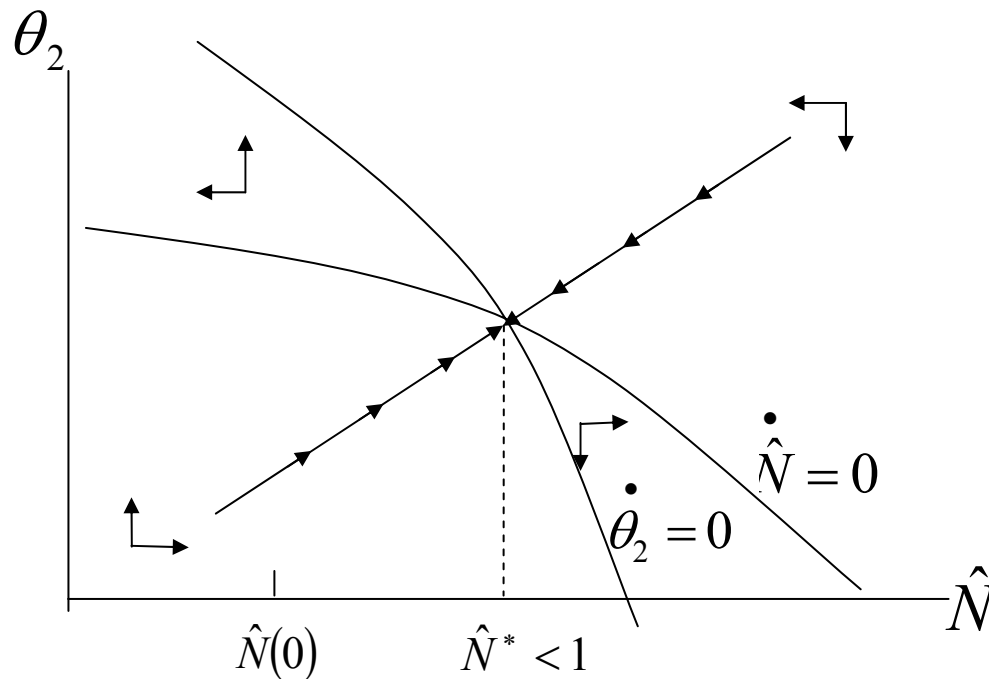
Dynamic Path and Convergence

- Figure 1 、 The Dynamic Path of Host Country $(\sigma - \omega) > 0$



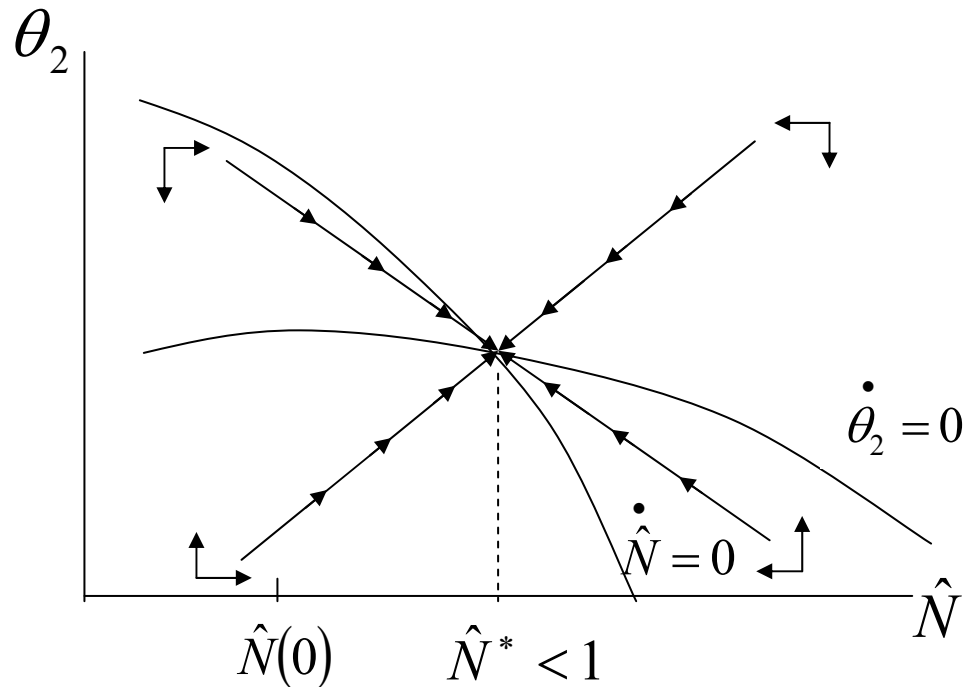
Dynamic Path and Convergence

- Figure 2 、 The Dynamic Path of Host Country $(\sigma - \omega) < 0$, The Slope of $\dot{\hat{N}} = 0$ is Larger Than $\dot{\theta}_2 = 0$



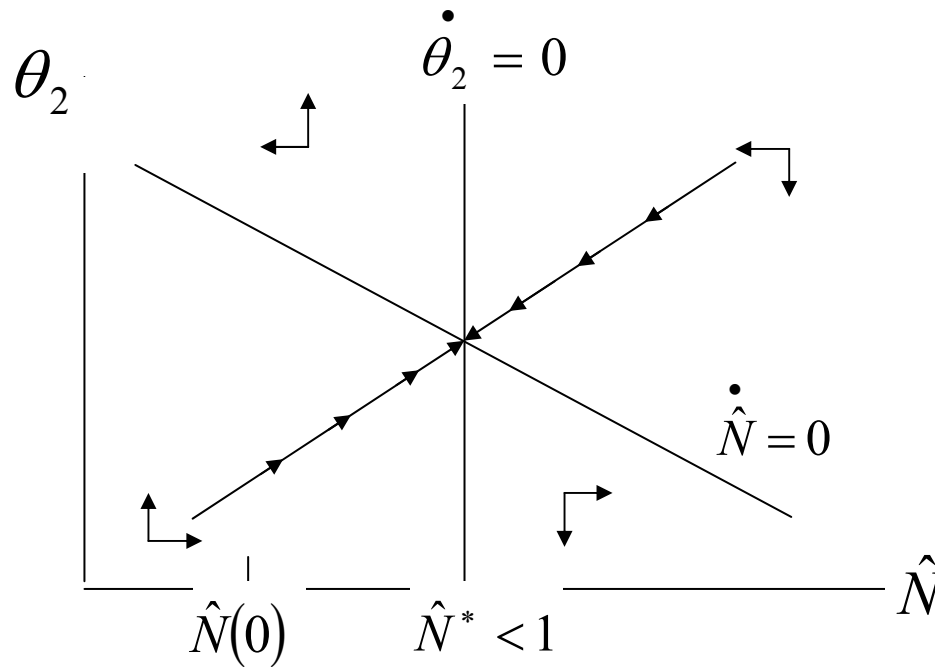
Dynamic Path and Convergence

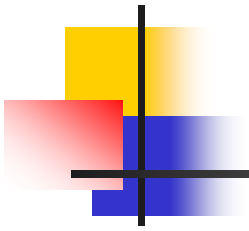
- Figure 3 、 The Dynamic Path of Host Country $(\sigma - \omega) < 0$, The Slope of $\dot{\hat{N}} = 0$ is Small Than $\dot{\theta} = 0$



Dynamic Path and Convergence

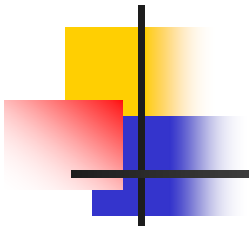
- Figure 4 、 The Dynamic Path of Host Country $(\sigma - \omega) = 0$





Conclusion (I)

- The investing country has more CO₂ emission and also has higher economic growth rate under C.D.M..
- The country with advanced technology of CO₂ abatement has higher economic growth rate before joining the C.D.M..



Conclusion (II)

- The aggregation commitment level of two countries' CO₂ emission can be reached under the C.D.M.. Meanwhile, the economic growth rate of each country also can be increased, respectively.
- The economic growth rate will be increased with increasing rate for the host country. Both of the investing country and host country will have same economic growth rate when the stable equilibrium is reached.