Economic Impact of Induced Technology Progress in Global Emission

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Why Technology is important?

- **Interconnection between policy change and technological change**
  - Co2 abatement Policy ➪ raising the prices of conventional fuels➪ increase in R&D research ➪ progress in technology toward reducing reliance on conventional fuels and producing alternative fuels, non-carbon-based fuels
  - technological progress ➪ change in carbon abatement cost ➪ change in abatement policy or change in reduction target
  - The modeling of abatement policy - R&D - technological progress interactions is very important issue to investigate economic impacts of the climate change

Previous Work

- **Most works Based on Neoclassical Growth Model**
  - SGM, EPPA, GREEN, Bernstein et al(1999), Cho(2000)
    - treat technological progress as exogenous process
    - But, technological progress is outcomes of economic decision.
- **New Models for the GHG abatement Policy**
  - Goulder and Schneider(1999), van der Zwaanet al(2002)
  - Two characteristics of technological progress
    - competitive technology : [Jones and Manualli(1990), Rebelo(1990)]
    - non-rival technology such as public goods : [Arrow(1962), Lucas(1988), Romer(1986)]

Model in this Work

- **Based on Goulder and Schneider Model**
  - Integrate competitive technology and non-rival technology
- **Differences from Goulder and Schneider Model**
  - generalize model
    - detailed energy sector by fuel type
    - labor & leisure choice
    - including international trading(small open economy)
  - technology shock
  - apply Korean economy
  - MPSGE program

Model in this Work

- **Sectors**
  - non energy sector
    - agriculture, energy intensive, other service and goods
  - energy sector
    - coal, coal products, crude oil, refined oil, natural gas, city gas, electricity
  - investment
    - physical capital
    - knowledge capital
- **time period**
  - 1995 - 2030
  - perfect foresight (fully dynamic model)

Model in this Work

- **Technological Progress**

$$Y_{i,t} = \phi(\overline{A}_t)[\alpha AKLE_{i,t}^{\rho} + (1-\alpha)XA_{i,t}^{\rho}]^{1/\rho}$$

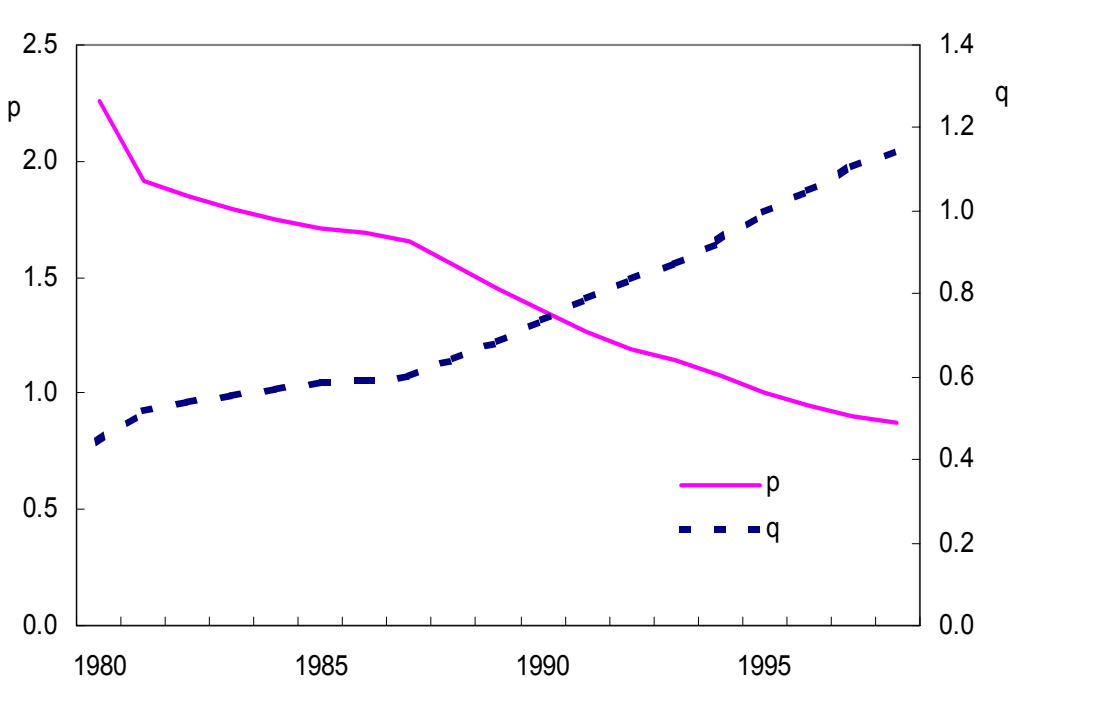
$$A_{i,t+1} = (1-\delta_A)A_{i,t} + \nu_A RD_{i,t}$$

$$\phi(\overline{A}) = (\overline{A})^{\gamma} / \gamma$$

$$\overline{A_{i,t+1}} = (1-\delta_{\overline{A}})\overline{A_{i,t}} + \nu_{\overline{A}}\overline{RD_{i,t}}$$

Model in this Work

- **Technological change in Korea**
  - Greenwood and Jovanovic(1988): relative price of capital
    - p = 1/q where p : relative price of capital to consumer price index
  - reasonable assumption $\phi(\tilde{A})$ as increasing function



Model in this Work

- **Labor and Leisure Choice**

$$U_t(Z_t) = \sum_{t=0}^{\infty} \beta^t \frac{Z_t^{1-\theta}}{1-\theta}$$

$$Z_t = [C_t^{\rho_z} + \alpha_z (1-H)_t^{\rho_z}]^{1/\rho_z}$$

Scenarios

Scenarios	Induced Technology Change
Scenario I: 20% reduction below BaU emission level from 2008	No
	Yes
Scenario II: 40% reduction below BaU emission level from 2008	No
	Yes

Scenarios

- **CO2 emission and reduction by scenarios**

	BaU (million TC)	Scenario I 20% reduction	Scenario II 40 % reduction
2008	167.1	33.4	66.9
2009	172.4	34.5	68.9
2010	177.8	35.6	71.1
2011	180.8	36.2	72.3
2012	183.9	36.8	73.5
2015	193.4	38.7	77.4
2020	208.2	41.6	83.3

Results

- **Reduction Cost**

	Scenario I			Scenario II		
	No ITC Won / TC	YES ITC Won / TC	% Change	No ITC Won / TC	YES ITC Won / TC	% Change
2008	75672	74218	-1.92	275052	271345	-1.27
2009	75644	73572	-2.74	275553	267640	-2.41
2010	75353	73047	-3.06	274306	264556	-2.89
2011	74952	72619	-3.11	272294	261965	-3.02
2012	74530	72274	-3.03	270163	259823	-3.01
2015	73365	71592	-2.42	264108	255365	-2.59
2020	72001	71136	-1.20	257041	251892	-1.69

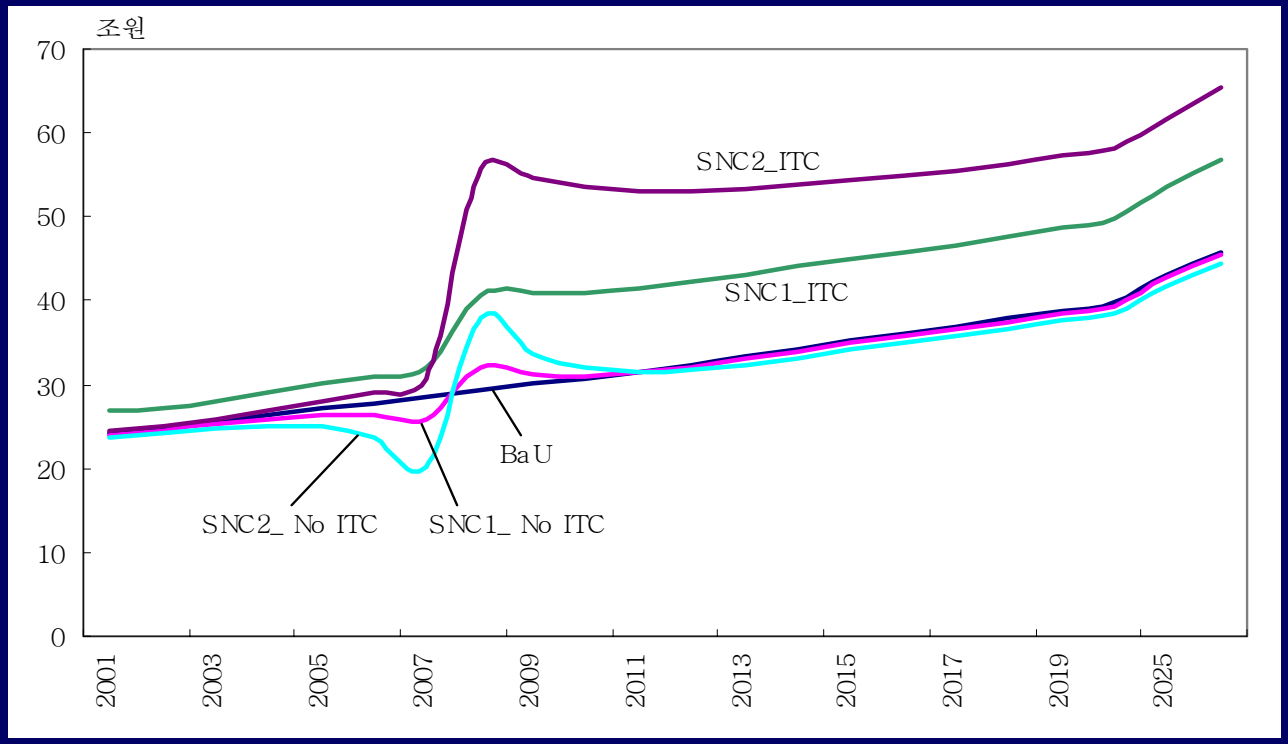
Results

- **Change in GDP (%)**

	Scenario I		Scenario II	
	No ITC	Yes ITC	No ITC	Yes ITC
2008	-1.92	-1.05	-5.88	-4.46
2009	-2.03	-1.14	-6.26	-4.77
2010	-2.12	-1.21	-6.56	-5.03
2011	-2.20	-1.27	-6.80	-5.26
2012	-2.27	-1.32	-7.01	-5.45
2015	-2.42	-1.42	-7.49	-5.85
2020	-2.60	-1.49	-8.02	-6.17

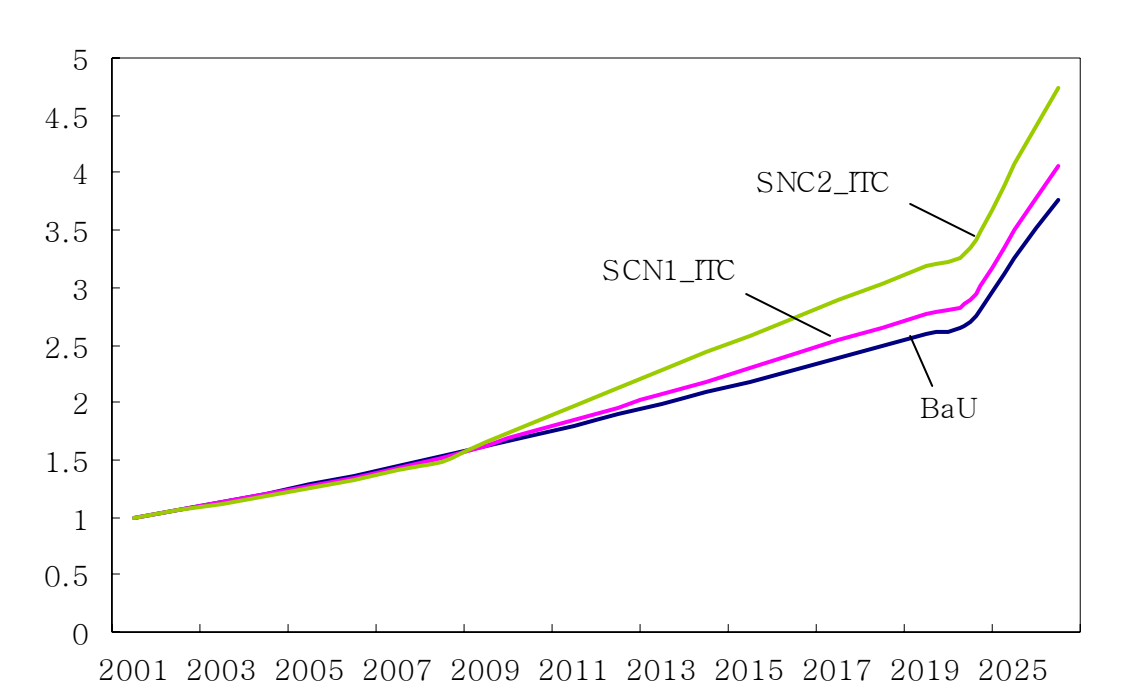
Results

- **Change in R&D Investment (%)**



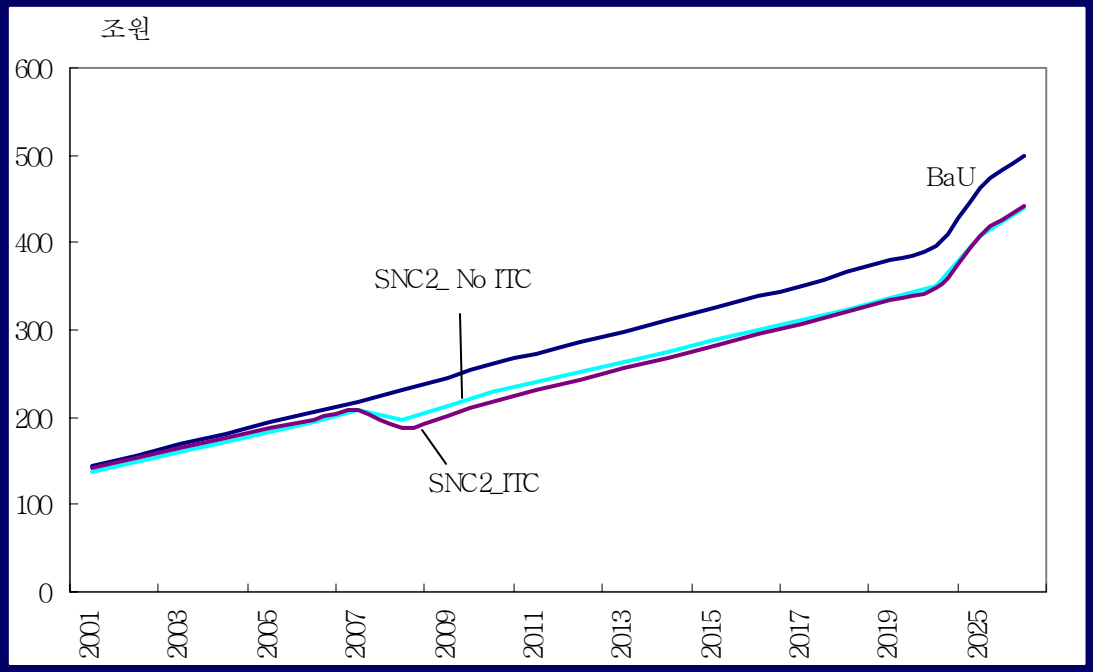
Results

- **Change in Knowledge Stock (%)**



Results

- **Change in Physical Capital Investment (%)**



Technology Shock

- **Technology Shock**

$$\overline{A_{i,t+1}} = (1-\delta_{\overline{A}})\overline{A_{i,t}} + \nu_{\overline{A}}\overline{RD_{i,t}} + \varepsilon_t$$

  - Assume that technological shock occurs in only 2008
  - Random Shocks with normal distribution
    - mean value 1 and Standard deviation 0.007
  - Conduct 30 times of simulation

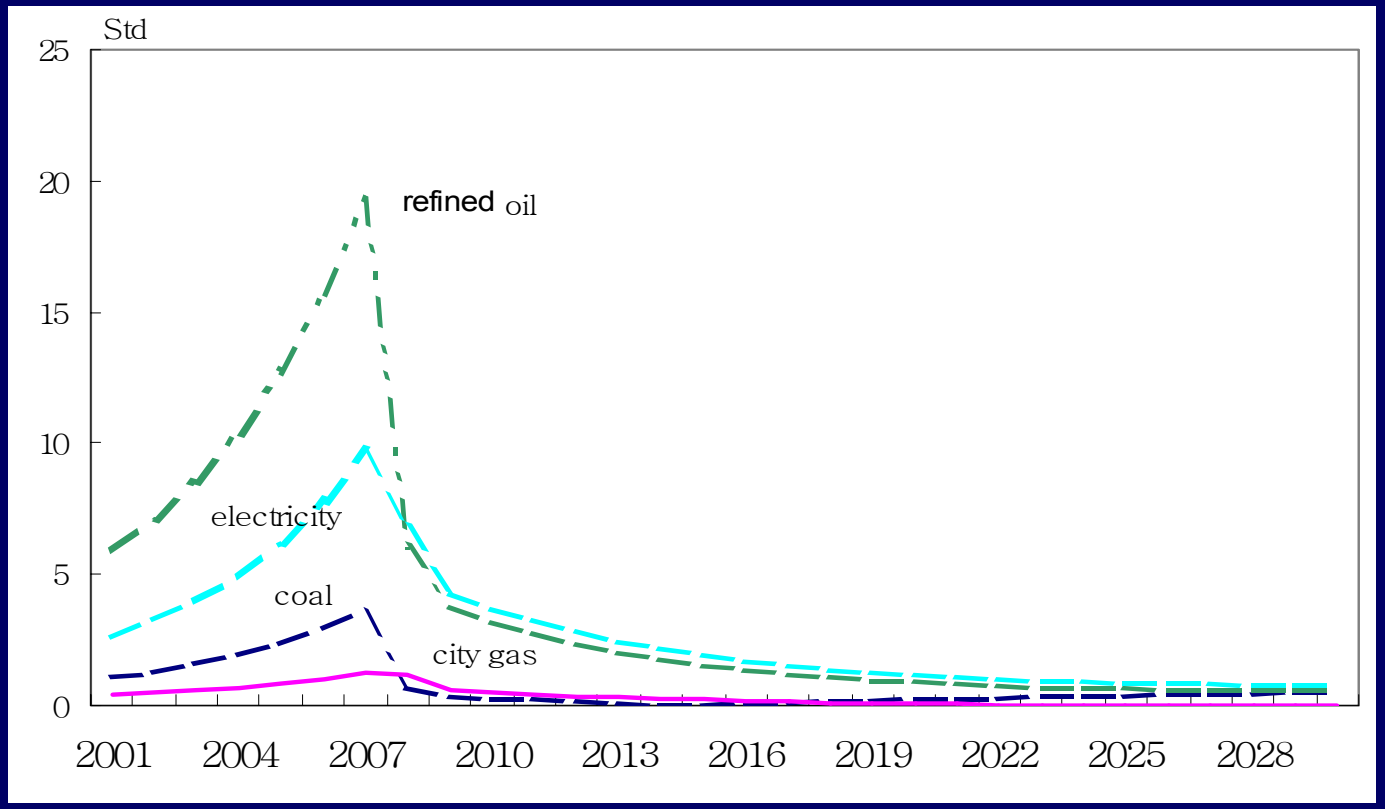
Technology Shock

- **Average SD of 30 times simulations for 2008 ~2030**

	Scenario I	Scenario II
GDP	0.24	0.24
Consumption	0.06	0.06
Labor	0.05	0.05
Total Investment	0.26	0.26
Physical Investment	0.09	0.09
R&D Investment	0.28	0.28
Reduction Cost	3.96	6.04

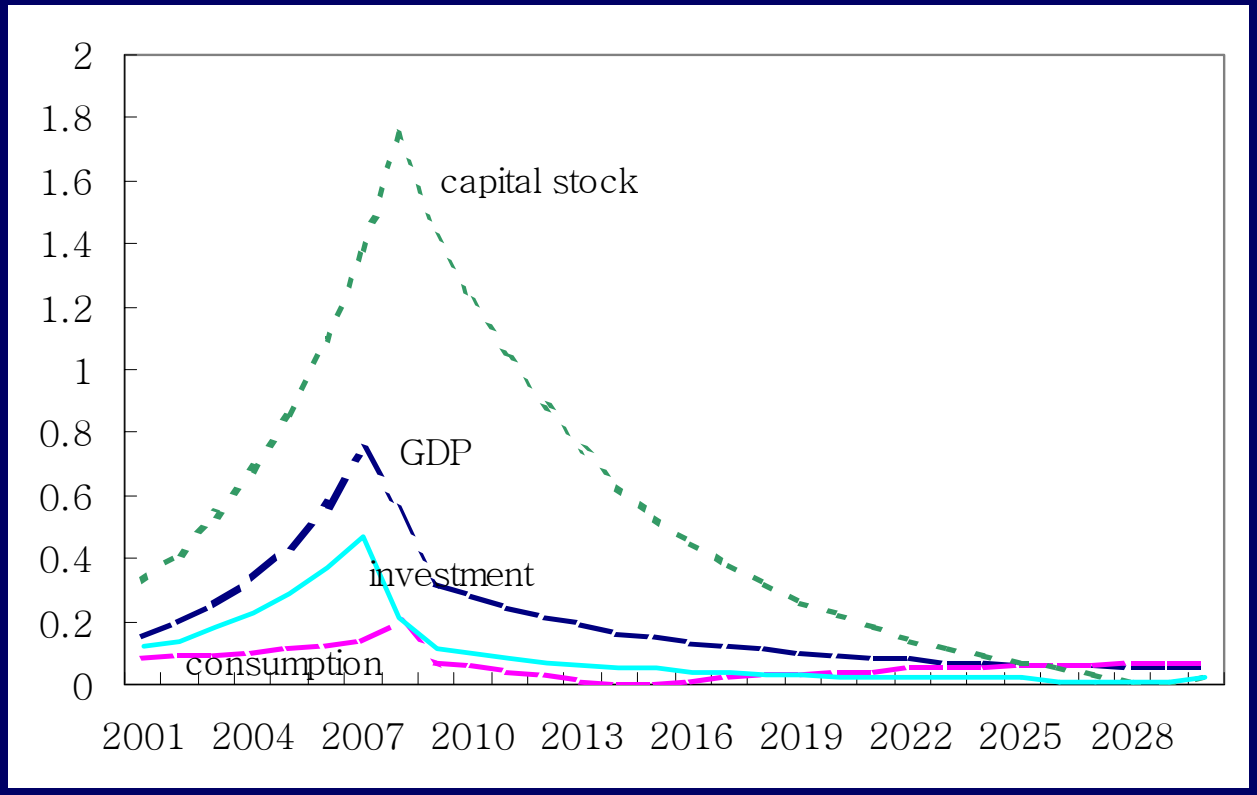
Technology Shock

- **Impulse Response of Energy**



Technology Shock

- **Impulse Response of Aggregate Variables**



Conclusion

- **The presence of ITC lowers costs of archiving the reduction target**
  - Lower emission reduction cost by about 2 ~3%
  - Mitigate GDP losses by 0.9%p~1.5%p compared with the absence of the ITC
- **Technology Shocks**
  - leads the reduction cost to widely vary, in terms of SD 3.96 ~ 6.04
  - Ignoring uncertainty might leads to significant policy errors
  - The possibility of policy misleading rises as the Carbon abatement target goes up.