Global Impacts of the Kyoto Mechanisms: Results from KEEI CGE Models

Gyeong Lyeob Cho

Korea Energy
Economics Institute

KEEI CGE Model - I

- **Global Trade and Environment Model-Korean (GTEM-KOR)**
  - Based on Global Trade and Environment Model(GTEM) developed by ABARE
    - GTAP database and GEMAPCK
  - Multi-commodity, multi-region, dynamic, computable general equilibrium model
    - 50 commodities and 45 regions (maximum)
    - 19 commodities and 23 regions (current application)
    - dynamic components on debt, capital and population
  - Accounts for carbon dioxide, methane and nitrous oxide emissions
  - Detailed representation of technologies used for electricity and iron and steel production

KEEI CGE Model - I

- **Korean Trade and Environment Model (KORTEM)**
  - Multicommodity, dynamic, computable general equilibrium model
  - Accounts for carbon dioxide, methane and nitrous oxide emissions
  - Detailed representation of sectors, taxation system and government budget accounting
  - Detailed Sectoral Representation
    - 103 commodities and industries: 19 energies and 10 margins (4 transport)
    - 3 primary factors (labour, capital, and land)
    - 1 private consumer household and 1 government
  - Flexibly Nested Production Structure

KEEI CGE Model - I

- **Korean Trade and Environment Model (KORTEM)**
  - Income transfer between sectors and agents for allowing domestic emission trading
  - Detailed taxation system
    - income tax: labour and non-labour income tax
    - non-commodity indirect tax: payroll tax and other non-com. Tax
  - Detailed government budget accounting

KEEI CGE Model - II

- **KEEICGE V. 1.0**
  - Global and National CGE Model
  - Using MPSGE in GAMS language
  - Global Model:
    - Based on the benchmark data set and economy structure of GREEN and EPPA
    - 13 regions, 8 production sectors, 4 consumption goods, 2 back stop technologies, government and investment producing sectors
    - Bilateral trade model
    - Sequential Dynamic Model over time period(1985 - 2030) with 5 year time interval

KEEI CGE Model - II

- **KEEICGE V. 1.0**
  - National Model:
    - 35 production sectors, 4 consumption goods, 2 backstop technologies, government and investment producing sectors
    - 16 energy sectors: Anthracite, Bituminous, Crude Oil, Natural Gas, Coal product, City gas, Heat, Refined Oil(8 of petroleum), Hydro & Nuclear power generation, and fossil fuel power generation
    - Flexible exchange rate
    - Sequential Dynamic Model over time period(1995 - 2030) with 5 year time interval

KEEI CGE Model - III

- **KEEICGE V2.0**
  - Based on the benchmark data set and economy structure of GTAP-EG and MS-MRT model
  - Fully Dynamic Model
    - Saving and investment decisions based on full intertemporal optimization
  - Based on GTAP-EG data developed by University of Colorado
    - GTAP data modified to have a consistent data set with energy prices and quantities in IEA statistics
    - 45 regions, 22 sectors, 5 primary factors
    - Freely aggregated into fewer regions, sectors, and primary factors
  - 13 regions , 16 sectors, and 2 primary factors

KEEI CGE Model - III

- **KEEICGE V. 2.0**
  - The elasticity of substitution between energy and other factors in consumption and production varies over time
    - to reflect capital stock turnover and the ease of developing new technology
    - OECD: 0.25 in 2010 and rises linearly to 0.5 by 2030
    - non-OECD: 0.2 in 2010 and rises linearly to 0.4 by 2030
  - Benchmarked to IEO's international forecasting for GDP, energy consumption and carbon emissions, except for Korea
  - Access through the internet will be provide at www.keei.re.kr

GDP and Energy Outlook of Korea

<Table 1> GDP and Energy Consumption of Korea

	1995 (10 billion US$, 10 EJ)	Growth Rate (%)						
		2000	2005	2010	2015	2020	2025	2030
GDP	45.8	4.8	5.5	5.0	4.4	4.0	3.5	3.0
Coal	12.8	7.6	3.9	3.0	1.3	1.5	1.2	1.2
Refined Oil	46.6	2.3	3.1	2.7	1.9	1.5	0.7	0.7
Natural Gas	5.3	14.2	7.6	5.2	2.7	3.1	2.5	2.4

Source: Long-Term Energy Outlook and Strategy Development for the 21st Century in Korea, 2000, Korea Energy Economics Institute

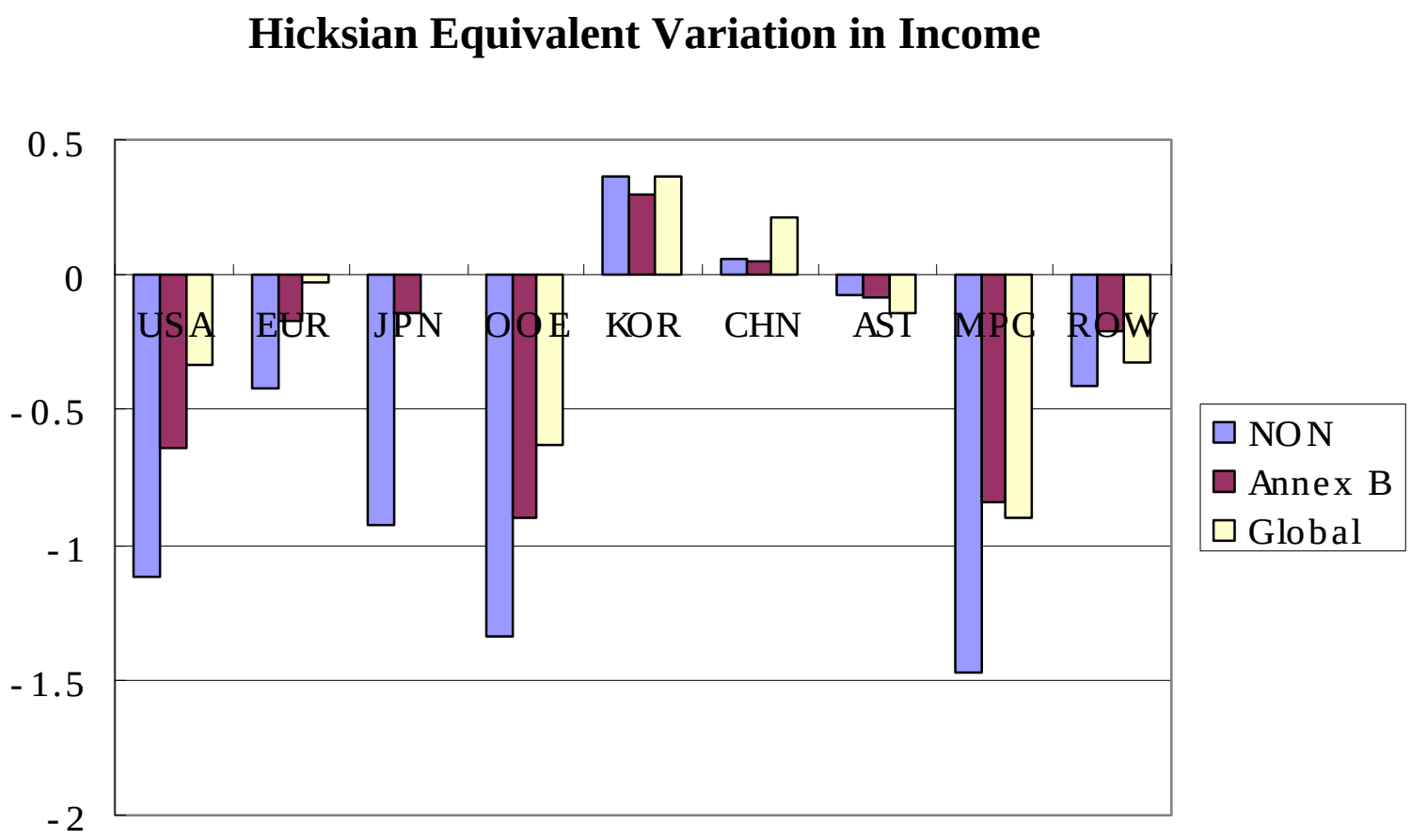
Applying KEEICGE 2.0 on Kyoto Mechanisms

Scenarios

	Countries included in Trading	CDM allowed	Supplementarity	Hot Air Allowed	Transaction Cost
Scenario 1	None	No	No Limits	Yes	No
	Annex B	No	No Limits	Yes	No
	Global	No	No Limits	Yes	No
Scenario 2	None	Yes	No Limits	No or Yes	No or Yes
	Annex B	Yes	No Limits	No or Yes	No or Yes
	Global	Yes	No Limits	No or Yes	No or Yes
Scenario 3	None	Yes	50%	No or Yes	No or Yes
	Annex B	Yes	50%	No or Yes	No or Yes
	Global	Yes	50%	No or Yes	No or Yes

- Korea reduces emissions by 30% against BAU

Impact of Annex B commitment under Kyoto on Welfare



Impact of Annex B commitment under Kyoto on Welfare

- **Spillover effect of Annex B Commitment**
  - Income effect
    - Reduced incomes will tend to reduce demand for most imports
  - Substitution effect
    - Raise the cost of producing goods in Annex B countries
    - World oil price falls
    - Fall the cost of producing energy intensive goods in non Annex B countries but raise it in Annex B countries
  - Net effect for non Annex B countries
    - Beneficial for large oil importing non- Annex B countries with large infrastructure of energy intensive production
    - Harmful for small oil importing non-Annex B countries with large dependence on import from Annex B

Impact of Annex B commitment under Kyoto on Welfare

- **Spillover Effect of Global Trading**
  - Equalizing the price of carbon and energy price across all countries, non Annex B countries would lose out competitively
  - Non-Annex B countries benefit from sales of permit

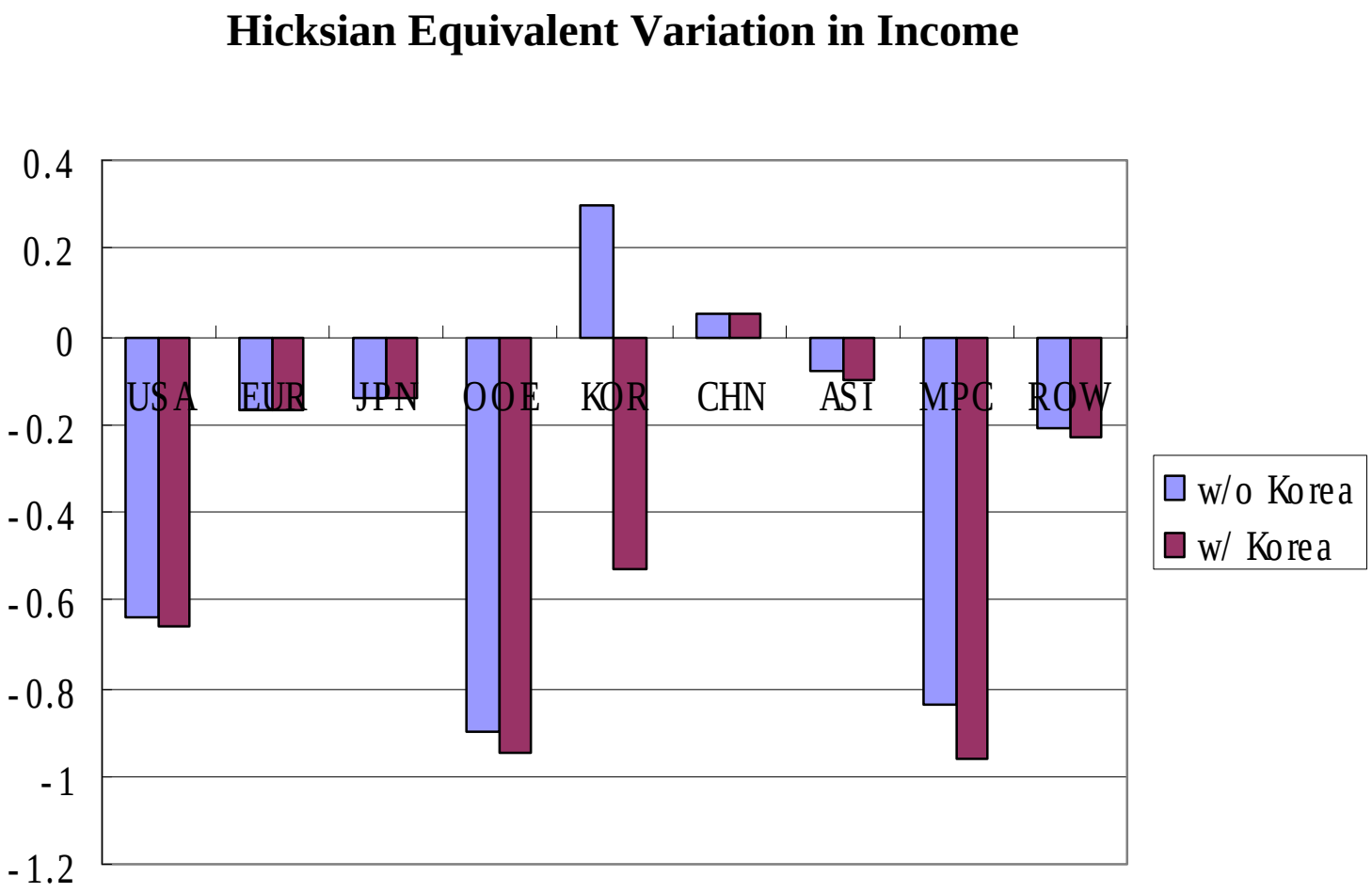
Participation of Korea Under Scenario 1

– The participation of Korea increases the marginal cost of abatement cost for Annex B

Unit: 1995 US$/metric ton

	0% reduction target for Korea			30% reduction target for Korea		
	Non	Annex B	Global	Non	Annex B	Global
KOR	0	0	41	238	94	45
USA	297	89	41	299	94	45
EUR	270	89	41	274	94	45
JPN	527	89	41	527	94	45
OOE	230	89	41	234	94	45

Participation of Korea Under Scenario 1



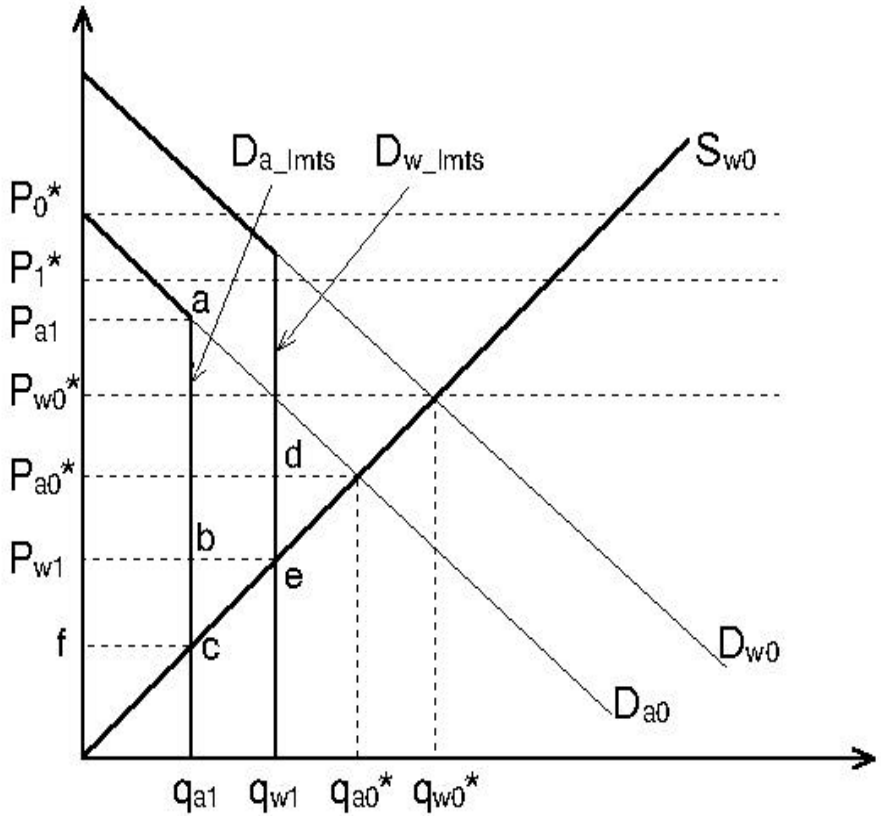
Implementation of CDM

- **Previous works**
  - Treat CDM as a form of limited global trading
  - Ignore “supplementarity” which is one of the most controversial issues at the climate change negotiation
- **This study assumes:**
  - CERs are generated by investment on non-Annex B countries’ electricity sectors only
  - CERs only contribute to part of compliance of Annex B countries
  - CERs created by based on the difference in emission between use of indigenous technology and Annex B technology
  - Annex B countries pay the host country the prevailing market price for CERs generated by CDM project
  - Transaction costs and fees applied to CDM activities

Restriction on CDM

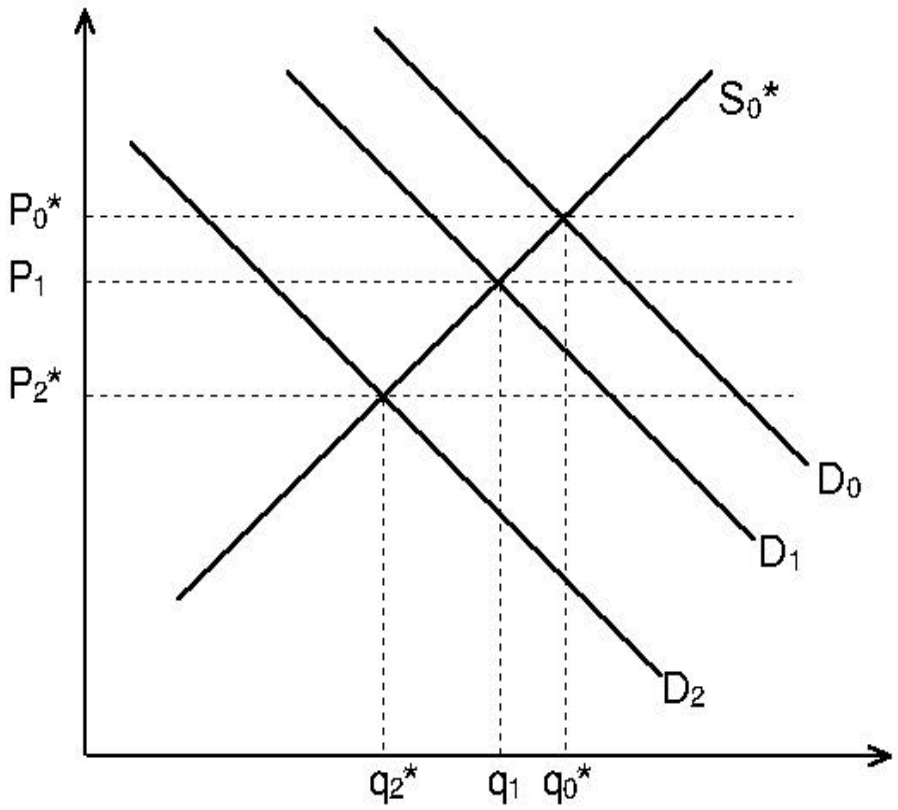
<Figure 1>

< World CERs Market >



<Figure 2>

<Marginal cost of abatement for investor country A>



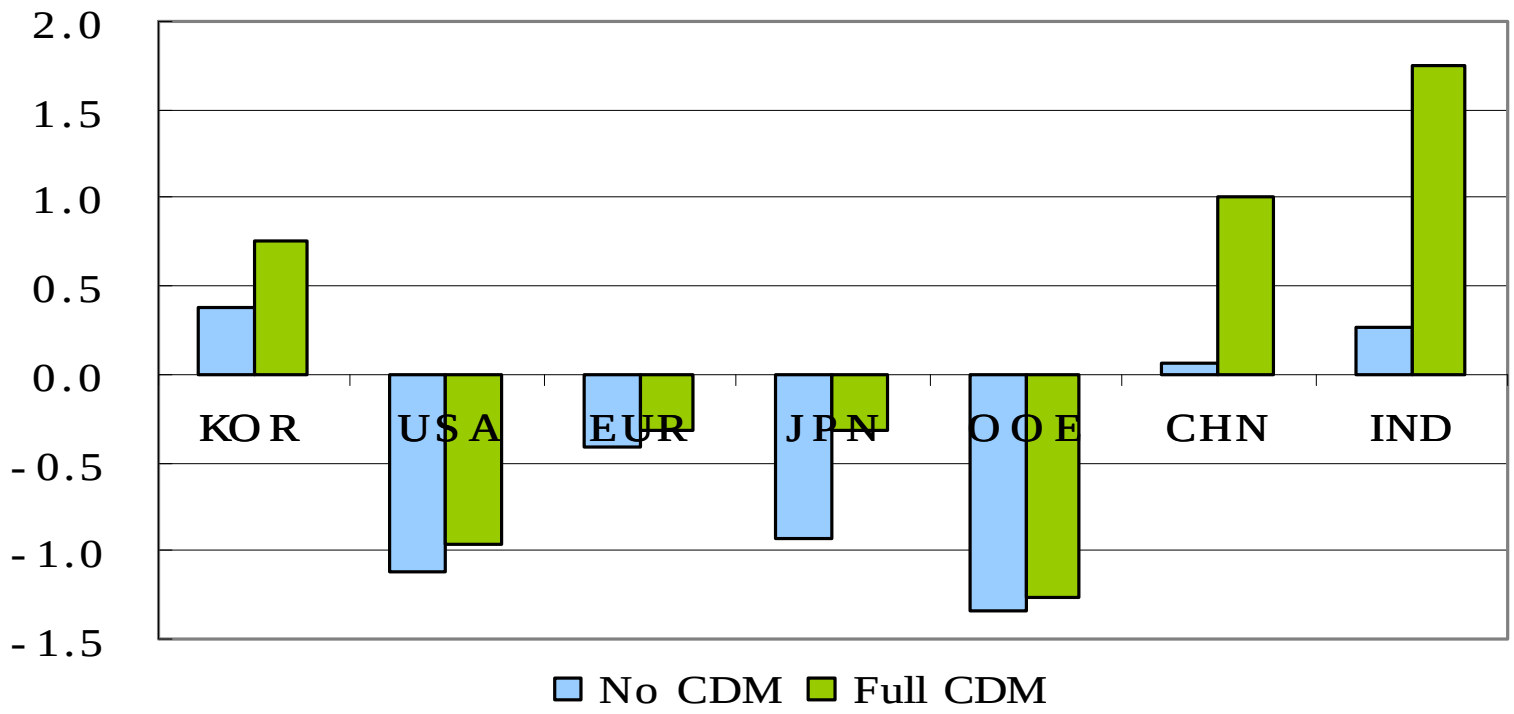
Results of implementing CDM

- Without restriction on CDM, the marginal carbon tax rate and the permit price from emission trading will be equalized .
- CDM lowers marginal carbon tax rate and permit trading price
- Quota restriction on CDM creates gap between marginal carbon tax rate(or permit trading price) and prevailing price of CERs in the world market

	No CDM	Unrestricted CDM	Restricted CDM		
	P_0^*	$P_2^* = P_{w0}$	P_{w1}	P_{a1}	P_1
USA	297	166	41	199	240
EUR	270	166	41	178	220
JPN	527	166	41	486	527
OOE	230	166	41	149	191

Impact of CDM on Hicksian Equivalent Variation in Income

– CDM tends to offer a “win-win” opportunity to both Annex B and non Annex B



Trade Balance for CERS under Unrestricted CDM

- China and India are most attractive country for CDM
- Those countries account for 70% of total CERs

	USA	EUR	JPN	OOE	Total
KOR	13.9	0.0	2.7	0.2	16.9
CHN	65.6	45.6	30.6	4.9	146.7
IND	25.5	5.5	10.7	2.7	44.4
BRA	1.0	0.0	0.0	0.3	1.3
ASI	9.3	0.0	2.7	0.4	12.4
MPC	14.2	0.0	5.6	1.2	20.9
ROW	22.6	2.6	8.6	1.6	35.4
Total	152.0	53.6	61.0	11.3	277.9

Unrestricted CDM with Transaction Cost

- Transaction cost(US$ 25/MTC) increases the price of CERs and shrinks CDM activity

	Price of CER (US$/mtc)		Traded amount of CER (million mtc)	
	No Cost	Cost of 25$	No Cost	Cost of 26$
Non	166	174	278	259
Annex b	65	71	154	112
Global	29	34	145	109

Participation of Korea in CDM as Investor

– The participation of Korea increases the price of CERs and shrinks CDM activity

	Price of CER (US$/mtc)		Traded amount of CER (million mtc)	
	No participation of Korea	Participation of Korea	No participation of Korea	Participation of Korea
Non	166	175	278	268
Annex b	65	71	154	149
Global	29	33	145	144

Future Development

- Simulations with More Realistic Scenarios
- Development of Model
  - Increase of GHG Coverage
  - Inclusion of Sinks and Land Use Components
  - More Flexible and Practical Set of CDM Activities
  - Others
- Incorporation of Important Bottom-Up Components to the Model
- Cooperation with Other Modeling Specialists