International Carbon Cooperation:

The Diffusion of Clean Development Mechanism over Time and Across Countries

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Team members (2006-2008)

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The UN Framework on Climate Change Convention (UNFCCC) and the Kyoto Protocol

- **The UNFCCC divides countries in two main groups:**
  - **Annex I parties that include the industrialized countries and countries with "economies in transition" (EITs (the Russian Federation, the Baltic States and several other Central and Eastern European countries)**
  - **All the others are called non-Annex I countries**
- The Kyoto Protocol commits Annex I Parties/countries to individual, legally binding, targets that limit or reduce their GHG emissions
- The individual targets for Annex I countries are listed in the Kyoto Protocol's Annex B (= Annex I to the UNFCCC)
- Annex I countries have several mechanisms to meet their obligations

Kyoto's Flexible Mechanisms

- Designed for helping Annex 1 (=B) countries reduce the cost of meeting their emission reduction targets in 2008-2012
  - ***International Emission Trading*** permits countries to transfer parts of their 'allowed emissions' ("assigned amount units" (AAUs))
  - ***Joint Implementation (JI)*** allows countries to claim credit for emission reductions that arise from investment in other industrialized countries, which result in a transfer of equivalent "emission reduction units" (ERUs) between the countries
  - **The *Clean Development Mechanism (CDM)*** allows emission-reduction projects that assist in creating sustainable development in developing countries to generate "certified emission reductions" (CERs) for use by the investor
    - **Activities Implemented Jointly (AIJ)** PILOTS between 1990-2002
      - to test novel aspects of the project-related provisions
      - to benefit in the post treaty activities
- Public and private sector companies authorized to participate

Purpose and Advantages of CDM

- Purpose
  - Encourages efforts aimed at reducing emissions in two ways
    - Through implementation of efficient activities, technologies and techniques in Southern countries
    - Through the possibility for entities subjected to GHG emission targets to make additional emission reduction at lesser economic cost
- Advantages
  - Environmental advantages (both locally and globally)
  - Development advantages (economic and social for host country)
  - Economic advantages (for host and investor countries)
    - Also via a global market for exchange carbon certificates.

The Opportunity

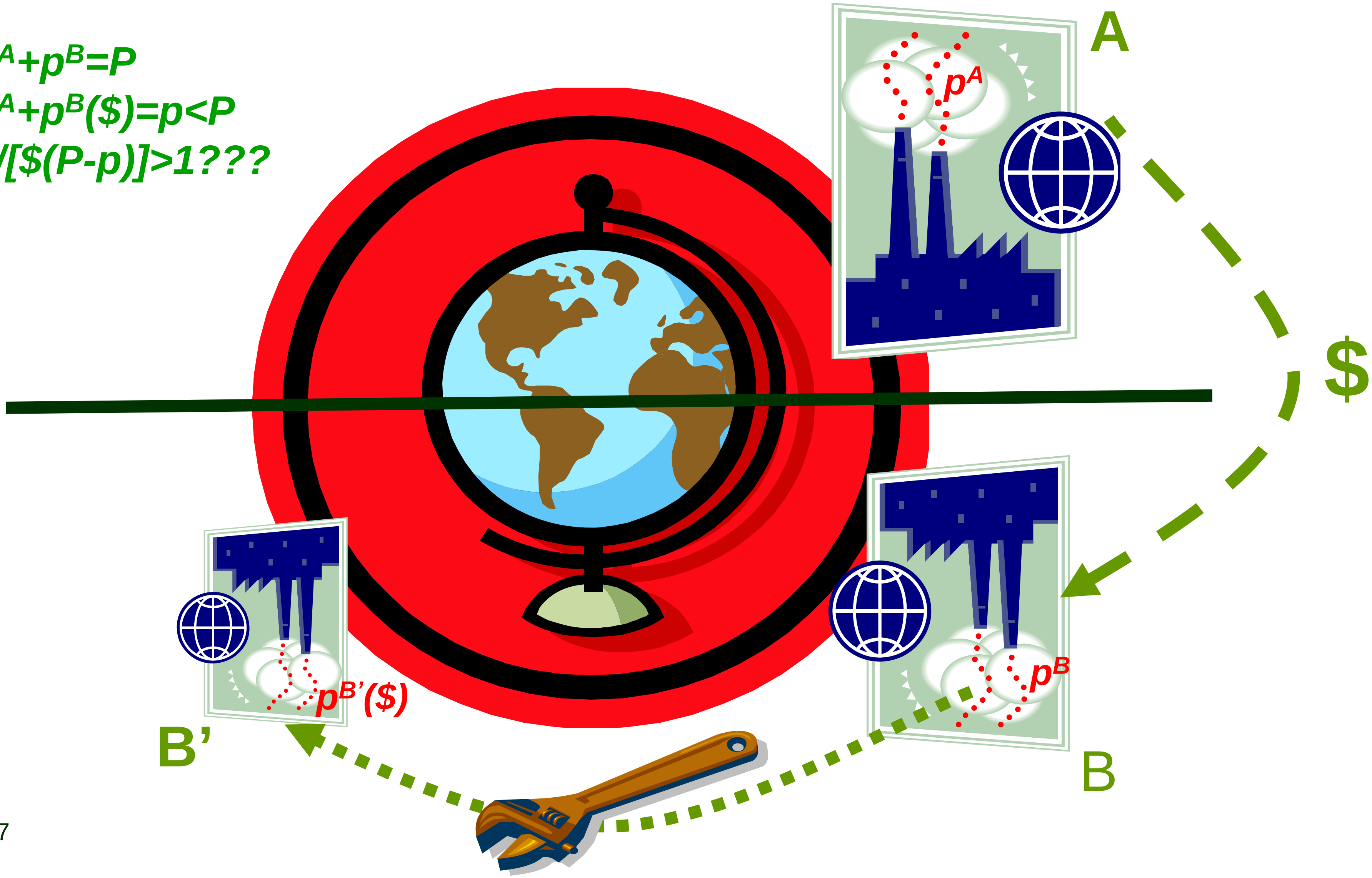
- An intrinsic comparative advantage of developing countries →opportunity for international trade in emission reductions
  - In 1997 prices:
    - Developed countries could reduce carbon emissions at costs ranging from $25 to well over $50 per ton of CO_2
    - Many developing countries could do the same at costs below $5 per ton of CO_2
- This trade could result, over the longer term, in considerable new and additional sources of finance for developing countries for <u>low carbon energy</u> and <u>infrastructure development</u> and improved <u>land management</u>

The CDM Mechanism

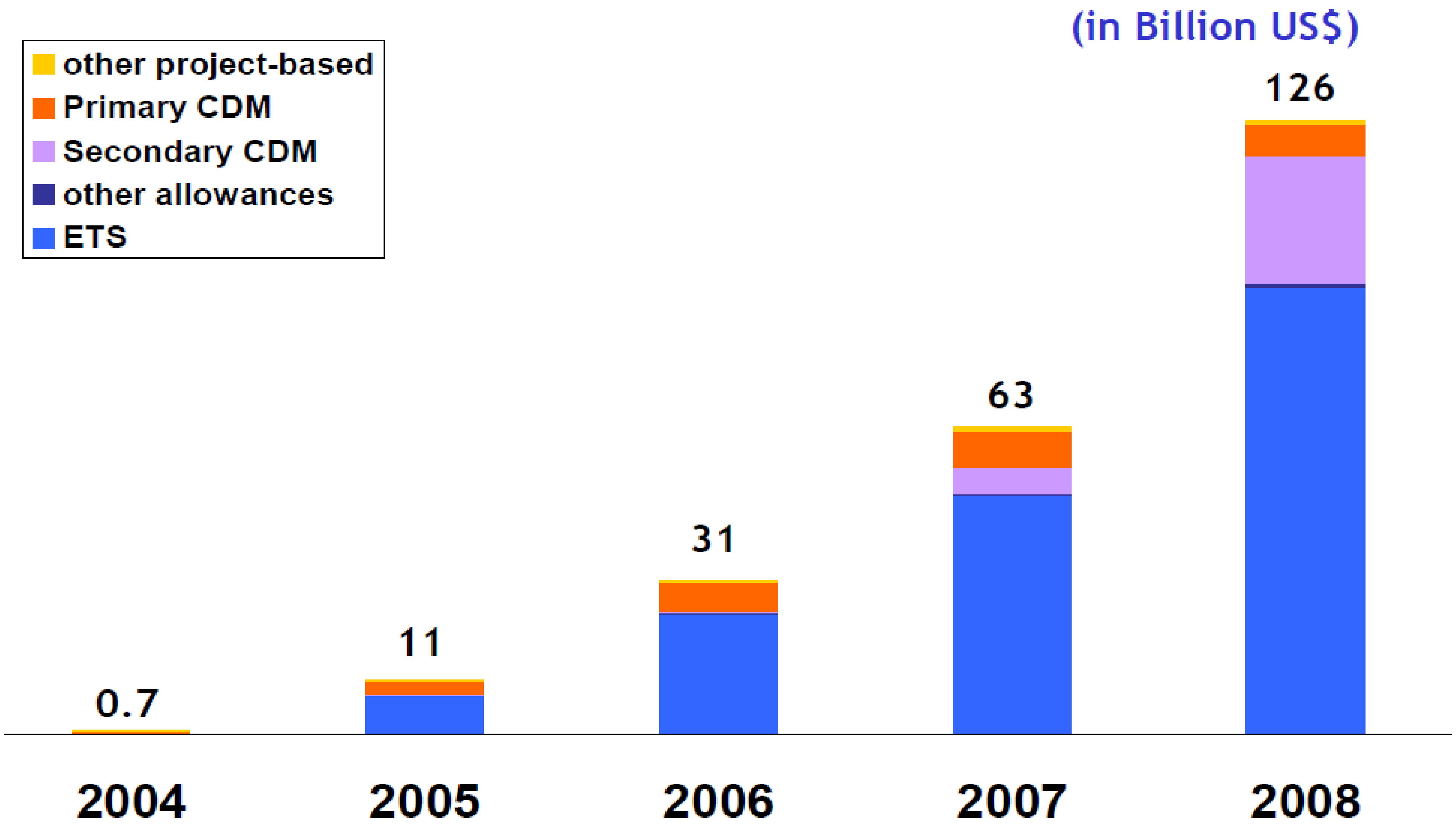
$p^A + p^B = P$

$p^A + p^B(\$) = p < P$

$\$/[\$(P-p)] > 1???$

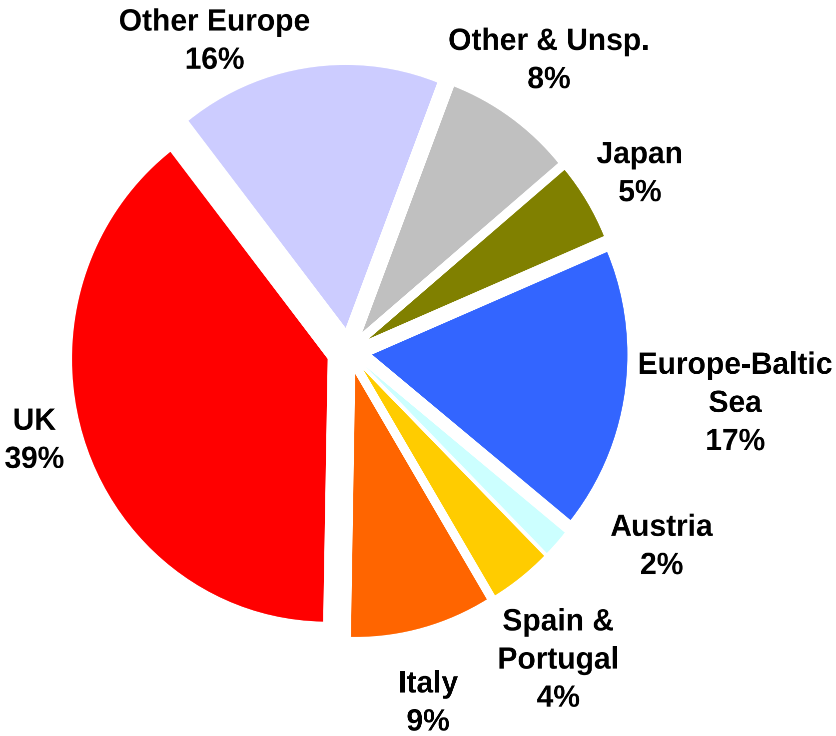


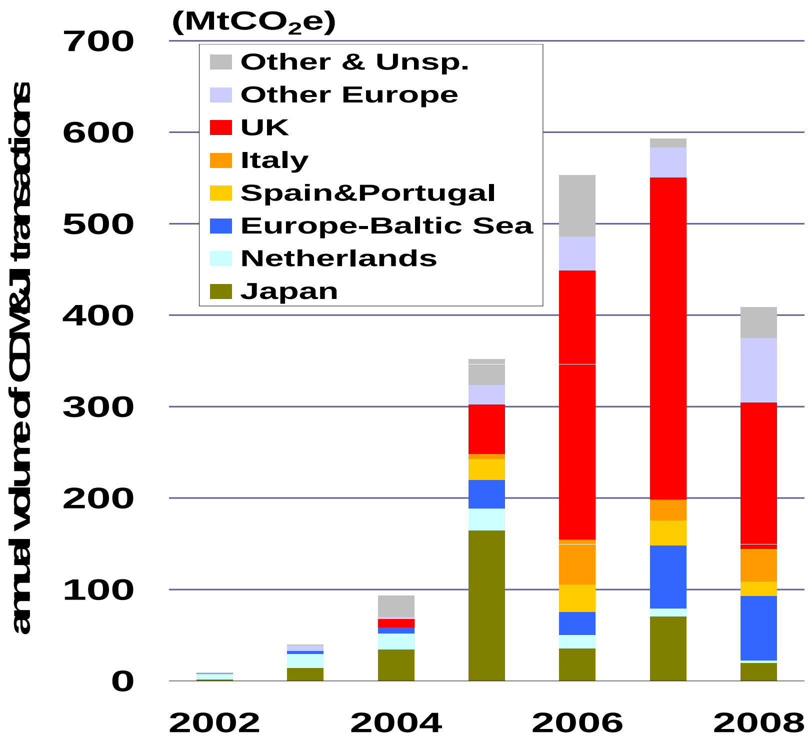
Overall market doubles but CDM share declines



(source: State and trend of the carbon Market 2009, Karan Capoor and Philippe Ambrosi, World Bank)

Primary market buyers



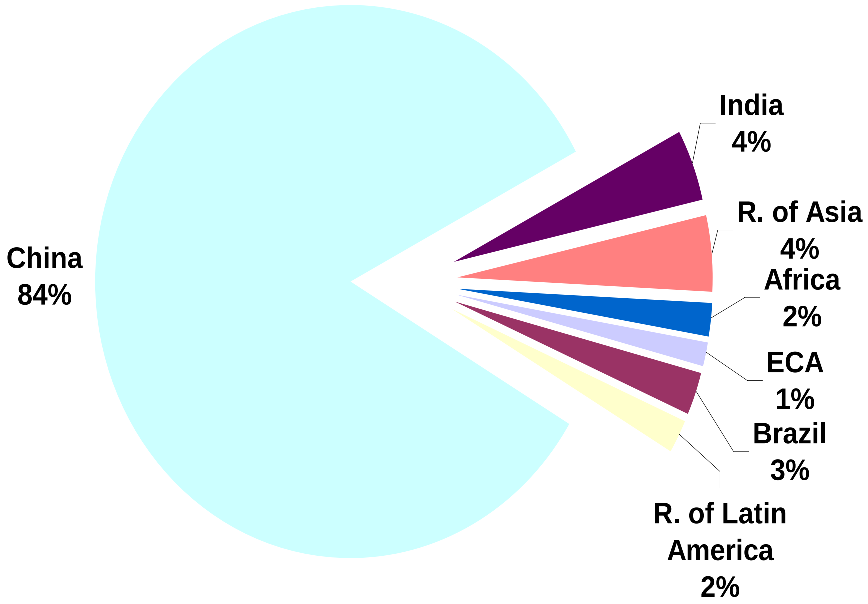


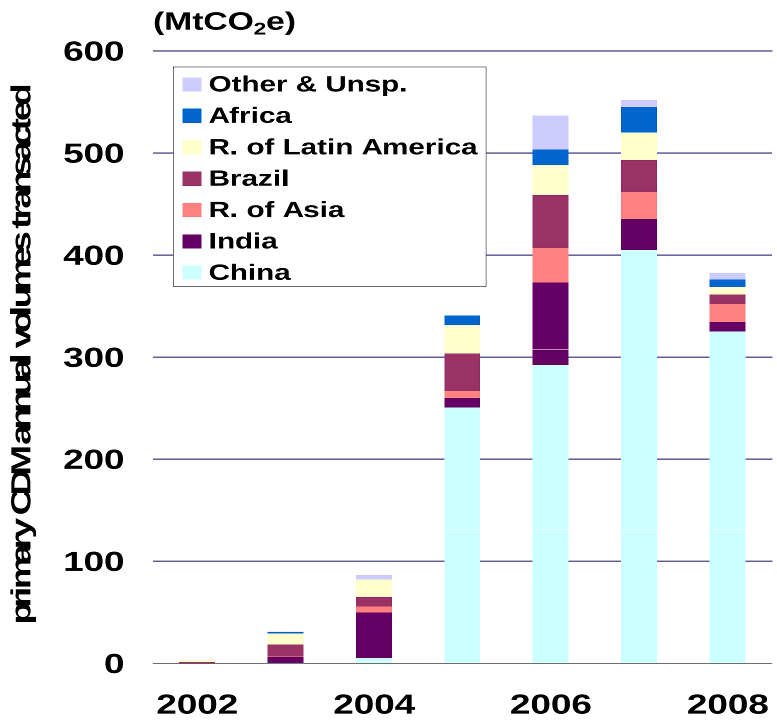
2008
Overall volume 409 $MtCO_2e$

2002-08

Source: Capoor and Ambrosi, 2009. State and Trends of the Carbon Market 2009

Primary market sellers (hosts)





2008

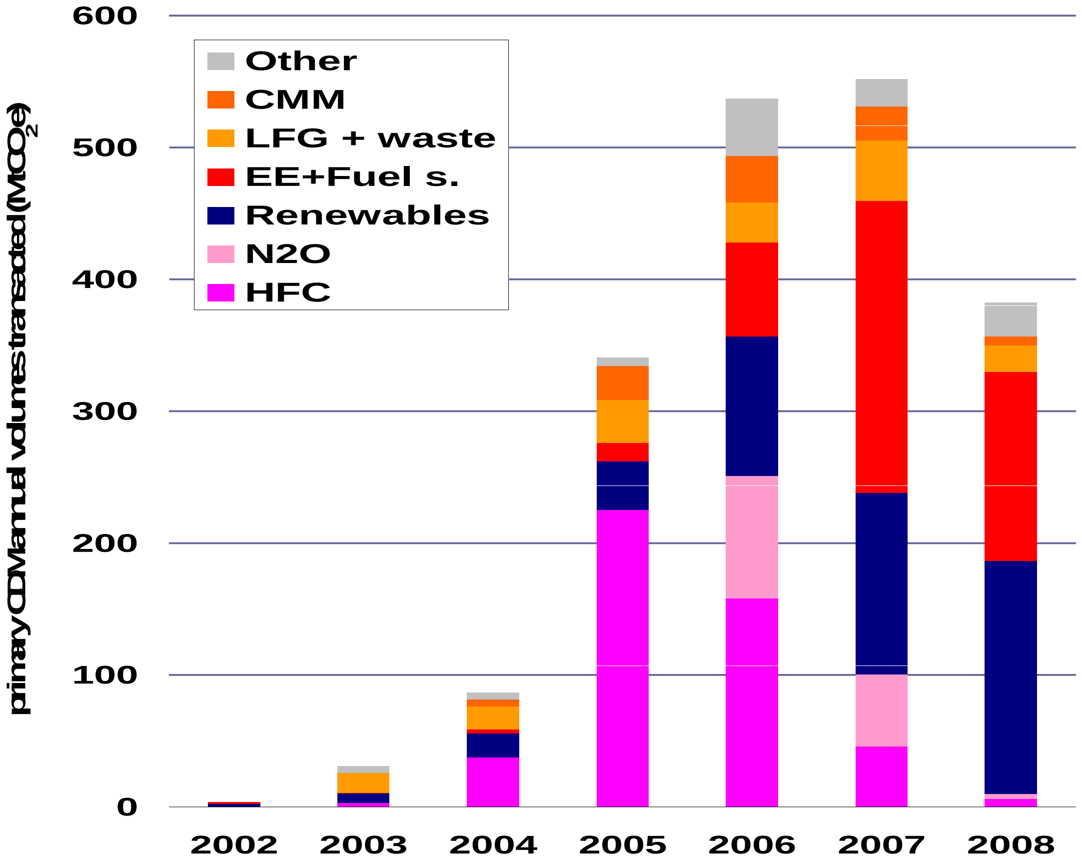
(as a share of volumes supplied)

2002-2008

Numbers may not add up to 100% due to rounding-up.

Source: Capoor and Ambrosi, 2009. State and Trends of the Carbon Market 2009

CDM project types

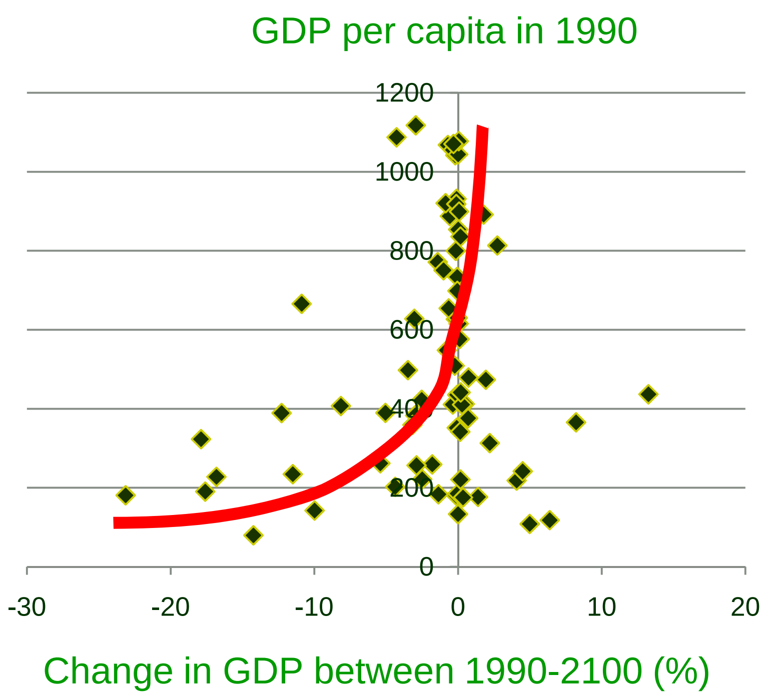


Source: Capoor and Ambrosi, 2009. State and Trends of the Carbon Market 2009

What did CDM achieve/not achieve

Achieved

- Significant # of projects
- Significant amount of CERs
- Reasonable cost effectiveness to investors



Questionable achievement

- Market concentration
- Uneven distribution geographically and by sector
- Impact on development and economic growth of hosts
  - Project clearance process cumbersome
    - Biased towards large vs small scale projects
    - Biased towards more- vs. less developed countries
- Leakage effects
- Additionality condition

Research questions

- CDM market 2002-2010 and 2012+

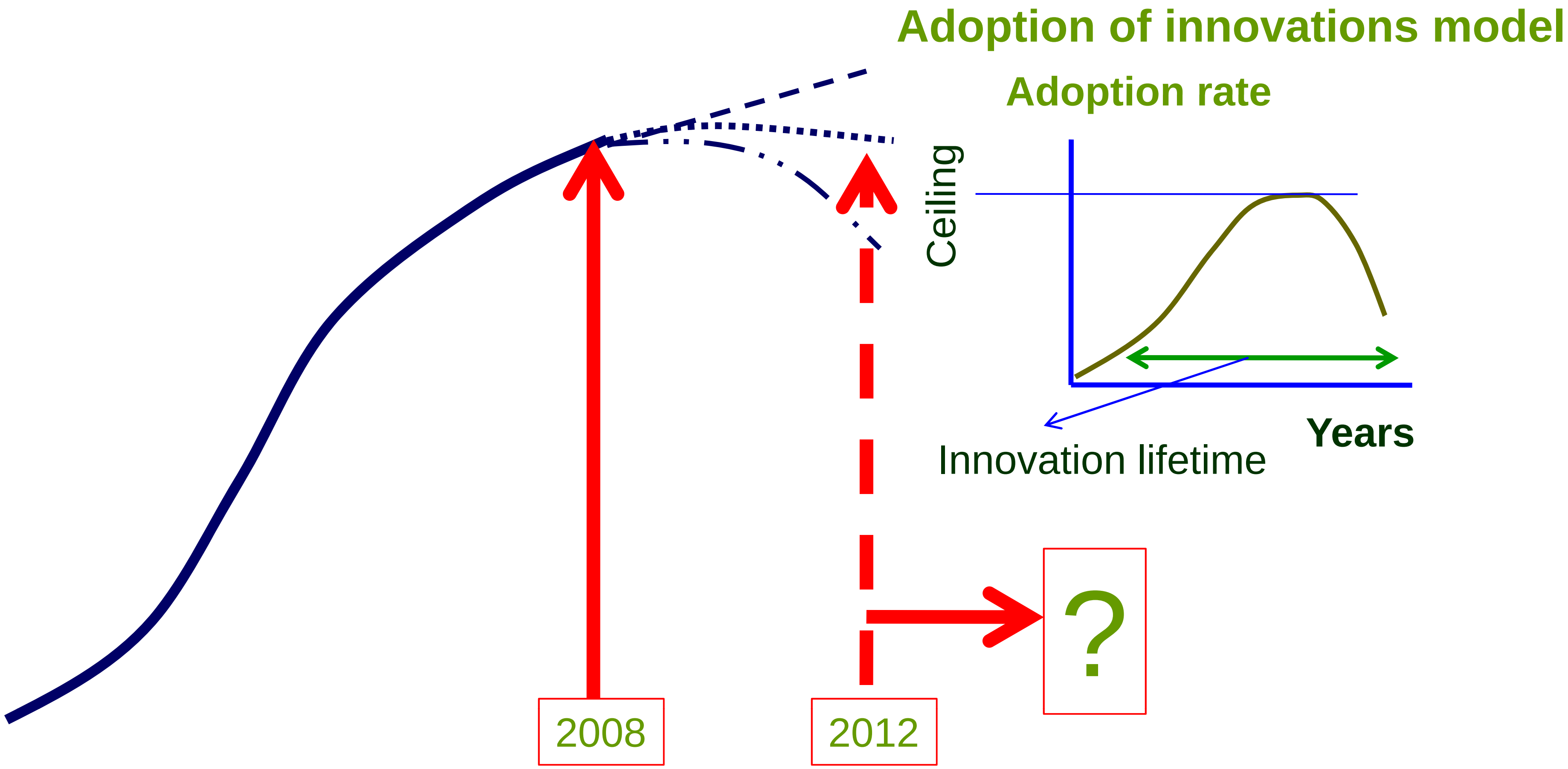
  What can we observe in the CDM Stages?
  - Global diffusion
- Cost of abatement
  - Difference between projects and over time
- Adoption by ‘investor’ and ‘host’ countries
  - Country level adoption
- Some dyad countries have more projects than others
  - The int’l relation explanation—Cooperation

Structure of the presentation

- Global Diffusion
- Inter-country adoption
- International Cooperation
- Abatement cost
- Conclusion

Global Diffusion

Global diffusion of CDM projects

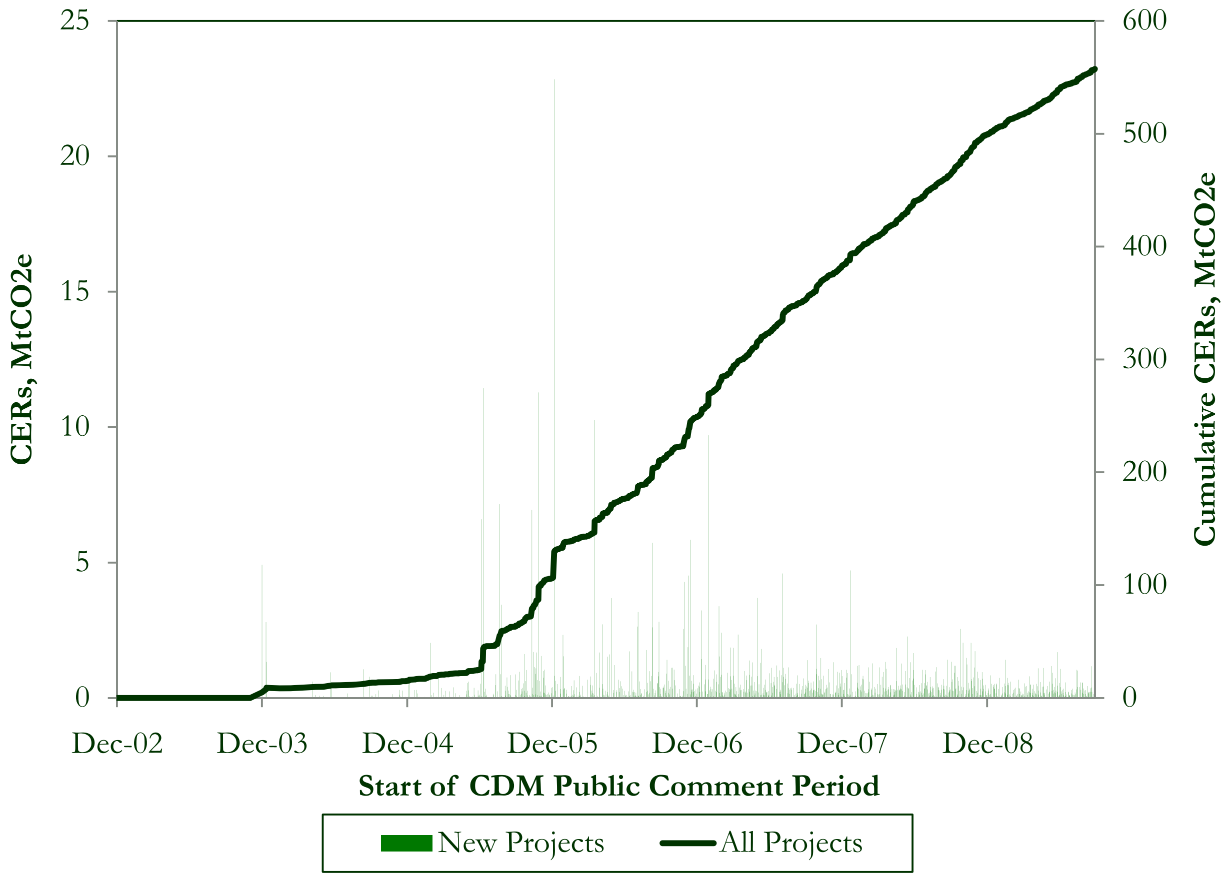


Selected sample summary statistics

Project start	Number of projects	New CERS mtCO2e 2008-2012	New CERS mtCO2e 2008-2020	Stock of CERs mtCO2e 2008-2012	Stock of CERs mtCO2e 2008-2020	Withdrawn CERs Share of 2012 stock
2003 (1 month)	4	9.08	8.92	9.08	8.92	-
2004	48	7.91	7.14	16.98	16.05	0.028
2005	441	120.70	120.86	137.68	136.92	0.025
2006	664	131.93	159.62	269.61	296.55	0.067
2007	1165	124.50	171.34	394.11	467.88	0.132
2008	1464	111.55	174.55	505.66	642.43	0.139
2009 (9 months)	845	51.70	99.22	557.36	741.64	0.122

Source: UNEP Risoe CDM/JI Pipeline Analysis and Database, March 1st 2009 and authors' calculations

CERS from new projects and total CERs from all projects in pipeline from December 2003 to September 2009

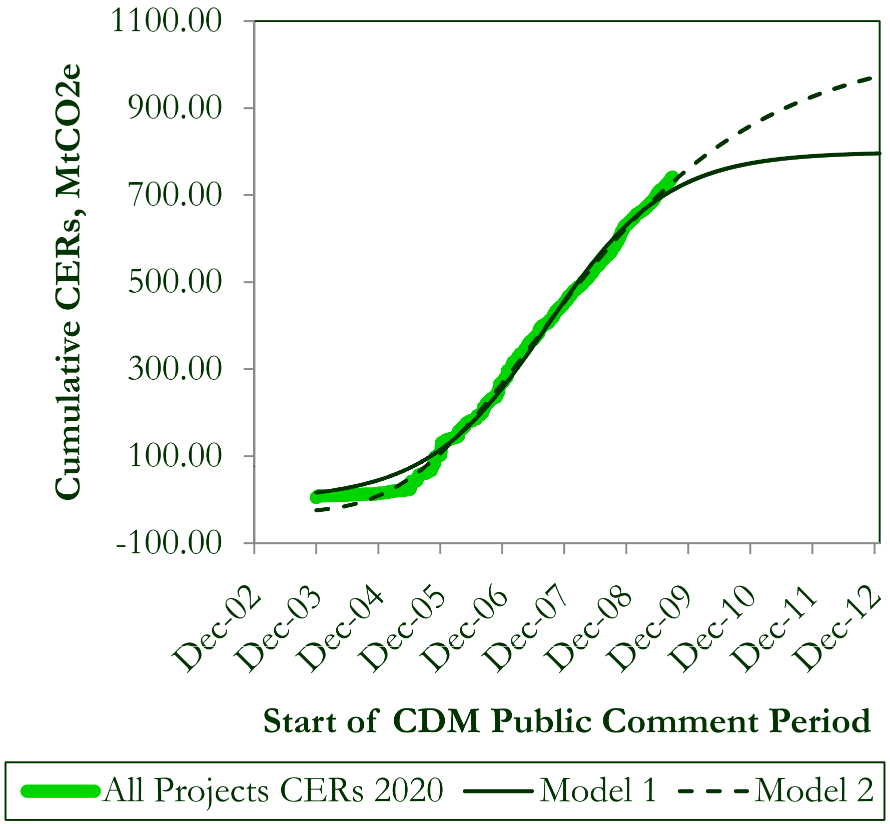


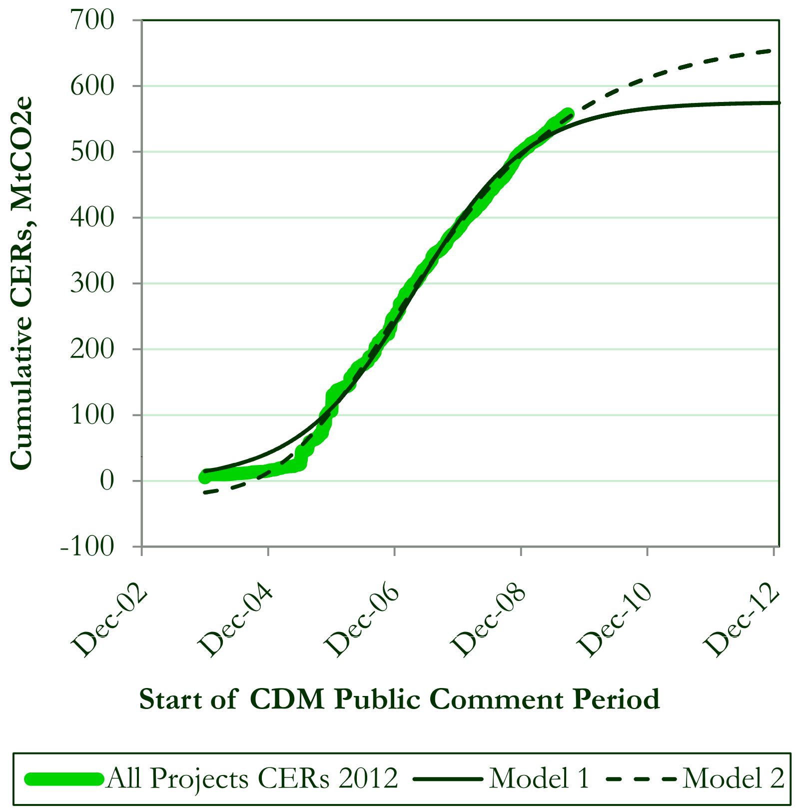
Estimation results: Logistic adoption functions

	2008-2012		2008-2020	
	Estimate	Std. error	Estimate	Std. error
	Symmetric 3-parameter model			
m	575.414[a]	7.002	799.071[a]	14.280
b_0	-3.638[a]	0.089	-3.852[a]	0.090
b_1	0.003[a]	0.0001	0.003[a]	0.0001
	Asymmetric 4-parameter model			
m	694.776[a]	21.338	1,078.38[a]	48.620
b_0	-20.705[b]	9.178	-29.608[b]	12.334
b_1	0.002[a]	0.00007	0.001[a]	0.00007
b_2	17,104.28[a]	5.430	17,330.63	11.856

Superscripts [a] and [b] indicate significance at the one and ten percent level, respectively.

Actual and predicted annual 2008-2012 CERs (right) Actual and predicted annual 2008-2020 CERs (left)





Cost of Abatement

What is at stake?

- Cost effectiveness?
  - Increase of the CDM projects indicate that it aligns the incentives of the Annex B and non-Annex B parties
  - Potential gains from CDM are yet to be explored
  - Potential gains depend on the costs of abatement, which significantly vary across different types of abatement technology and sizes of the operations

Hypotheses

- There exist economies of scale in emission abatement through the CDM projects, which significantly vary across different types of abatement technologies
  - Distinction of project cross types, location and time
- The marginal cost (as well as the average cost) of abatement through CDM decreases over time due to experience or learning by doing

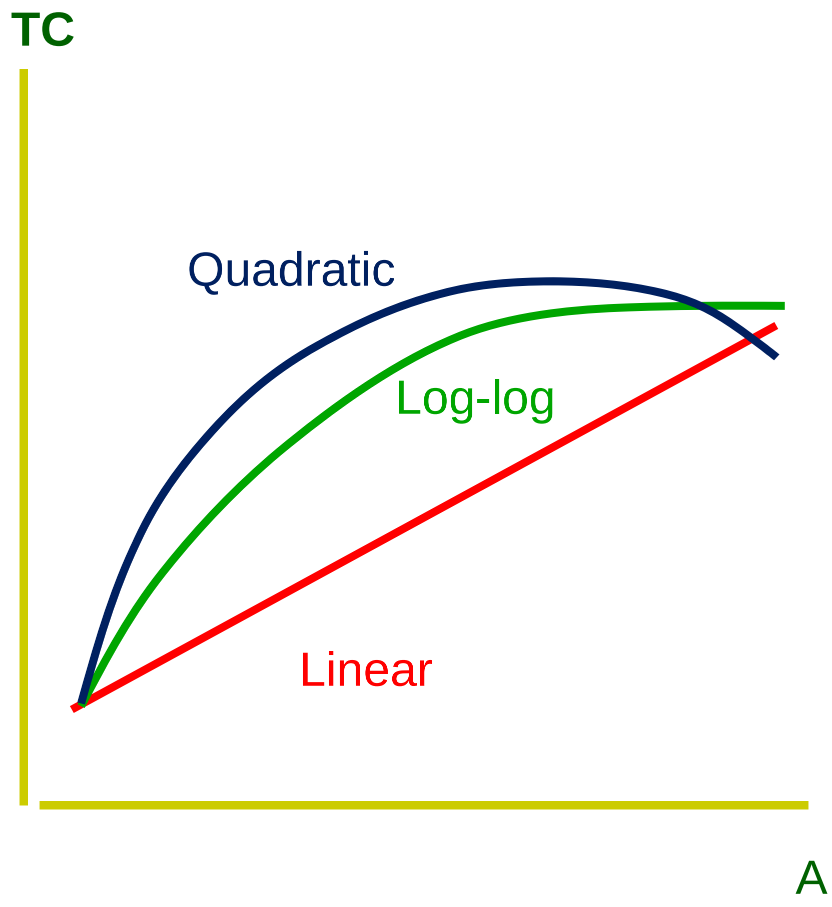
The functional forms

Three alternative specifications of the emissions abatement cost function:

Linear (not appropriate)

Quadratic (not appropriate)

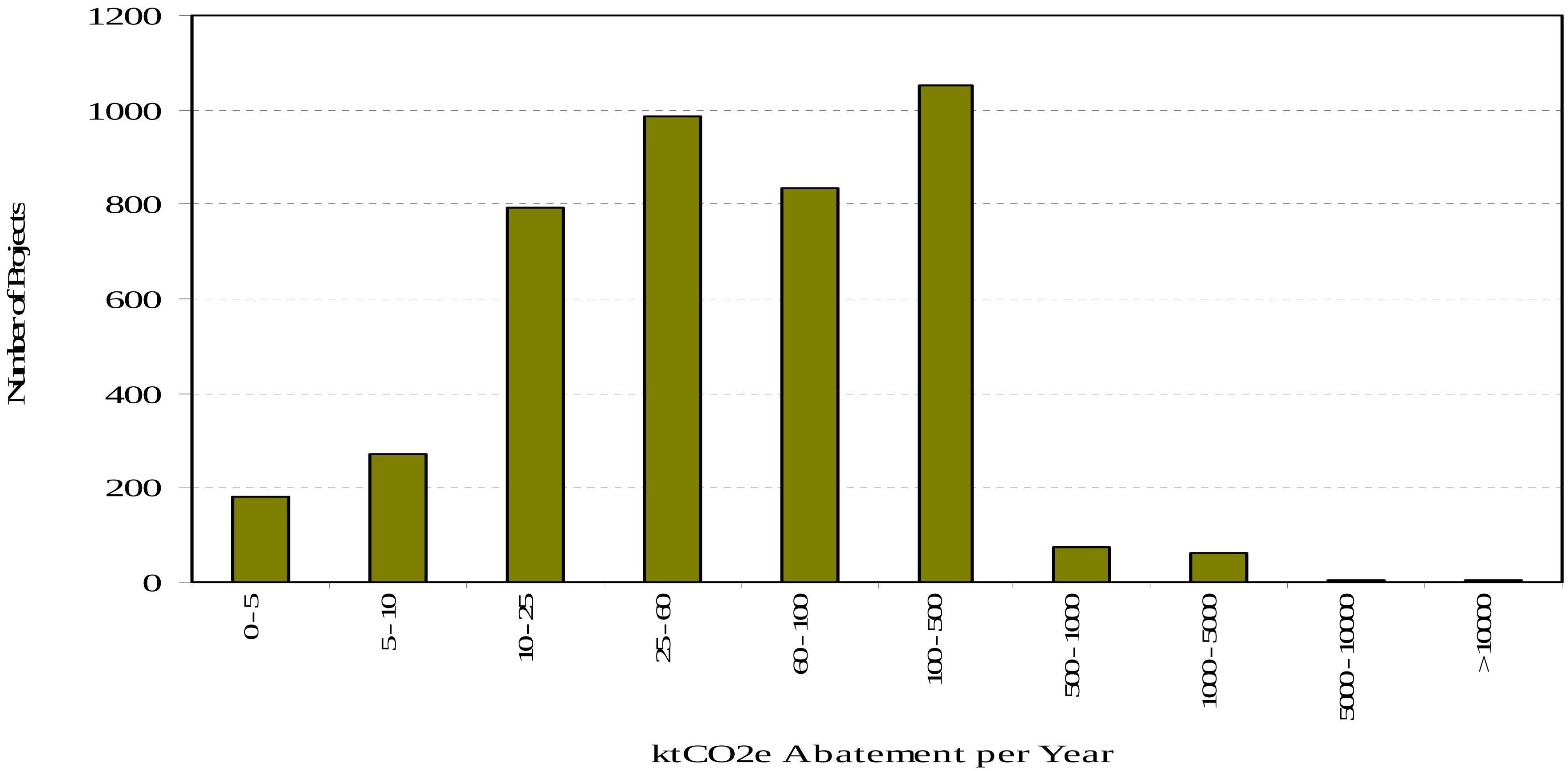
log-log (appropriate)



CDM project types

1. renewable resource based (63%)
2. methane reduction, coal bed/mine and cement (16%)
3. supply-side energy efficiency (10%)
4. demand-side energy efficiency (5%)
5. hydrofluorocarbon (HFC), perfluorocarbon (PFC) and nitrous oxide (N2O) reduction (2%)
6. fossil fuel switch (3%)
7. Forestation (0.8%)
8. transport (0.2%)

CDM project sizes
Sizes also vary within project types



Annual total cost

- 1200 projects with capital investment cost data → calculation of annual capital investment cost
  - Of which 120 projects with annual O&M cost data
  - Of which 840 projects with data on annual electricity generation data
  - Cost of electricity generation subtracted

Abatement cost estimation results

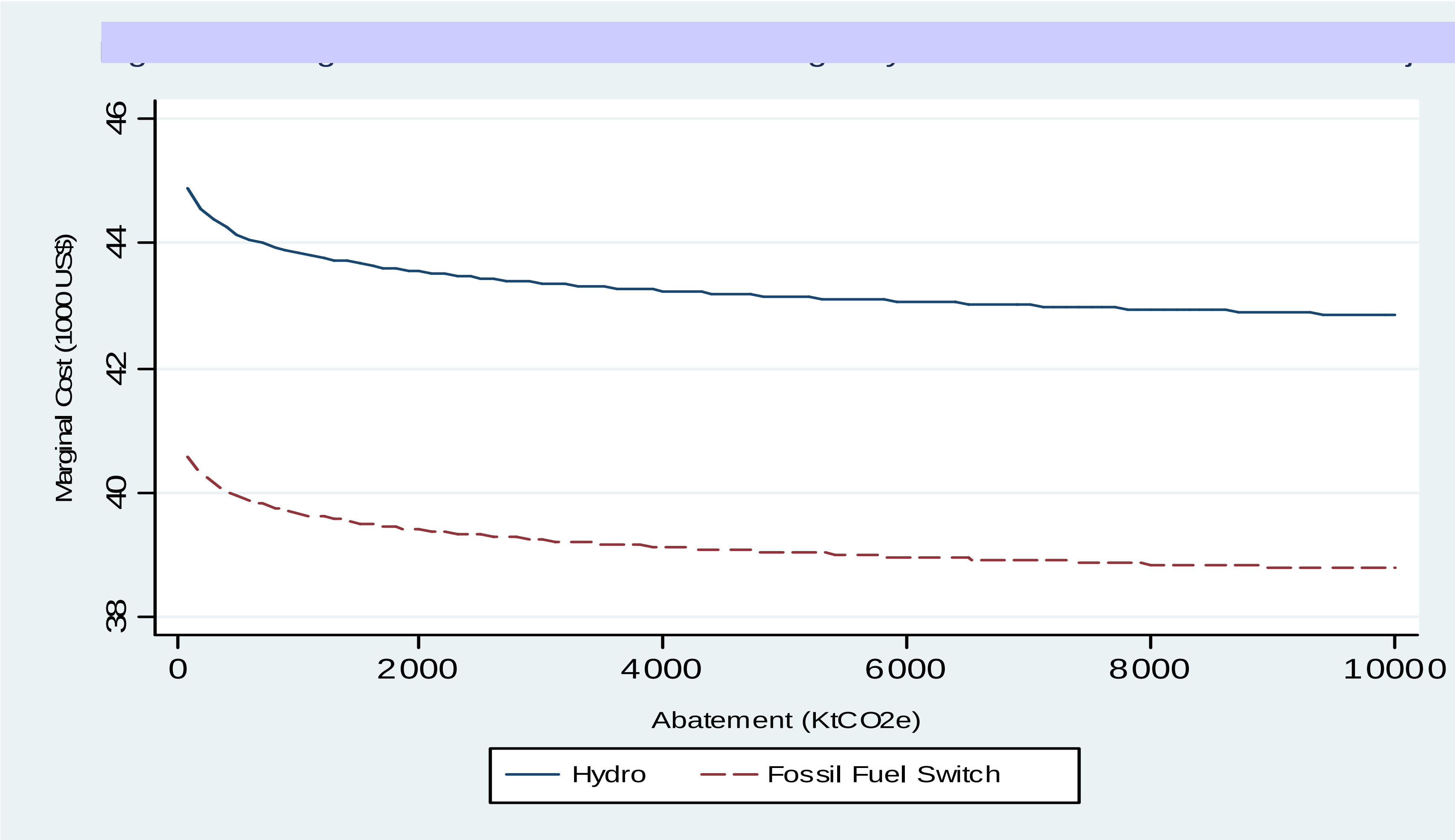
Forestation used as benchmark

Log-Log Specifications	I	II	III	IV
Continuous Variables				
Log of Abatement (ktCO2e)	0.97***	0.99***	0.97***	0.96***
	(0.038)	(0.028)	(0.038)	(0.028)
Log of Year			0.26	1.08***
			(0.231)	(0.173)
Project Type Dummies				
Renewables	− 1.09		− 1.09	
	(0.830)		(0.830)	
Biogas		− 1.18*		− 1.21*
		(0.660)		(0.645)
Biomass		− 0.05		− 0.002
		(0.634)		(0.62)
Hydro		− 2.07***		− 2.12***
		(0.629)		(0.615)
Wind		− 0.13		− 0.09
		(0.630)		(0.616)
Geothermal		− 0.55		− 0.52
		(0.886)		(0.866)
HFC, PFC & N2O Reduction	− 4.88***	− 4.92***	− 4.86***	− 4.84***
	(0.984)	(0.744)	(0.984)	(0.727)
CH4, Coal Bed/Mine & Cement	− 2.85***	− 2.86***	− 2.80***	− 2.67***
	(0.836)	(0.632)	(0.837)	(0.619)
Supply-Side Energy Efficiency	−1.30	−1.31**	−1.31	− 1.37**
	(0.835)	(0.631)	(0.835)	(0.617)
Demand-Side Energy Efficiency	− 1.00	− 0.98	− 0.99	− 0.96
	(0.872)	(0.659)	(0.872)	(0.644)
Fossil Fuel Switch	− 2.17**	− 2.19***	− 2.15***	− 2.11***
	(0.865)	(0.654)	(0.865)	(0.639)
Constant	5.99***	5.93***	5.63***	4.42***
	(0.843)	(0.637)	(0.902)	(0.668)
No. of Observations	821	821	821	821
F-value	116.07	185.30	101.75	181.02
Adjusted R-squared	0.50	0.71	0.50	0.73

Results

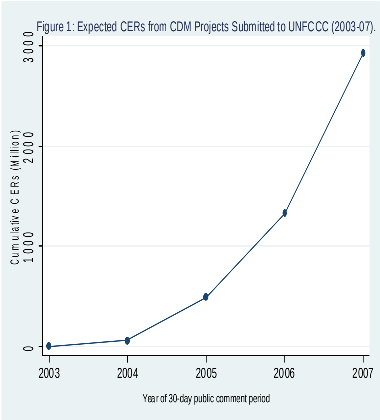
- Cost of abatement increasing with volume but in a decreasing rate (economies of scale)
- Inclusion of dummy variables improves the estimates: intercept of the cost functions for all other projects type is smaller than that for forestation projects
- Cost of abatement increases with time in an increasing rate

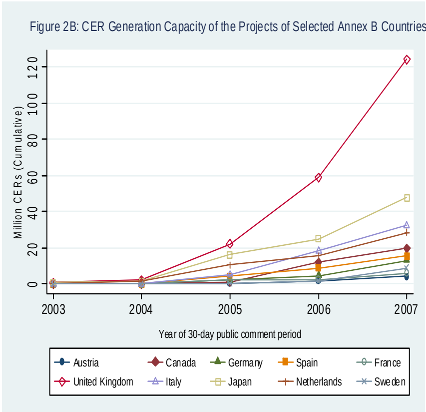
Marginal cost of abatement for hydro and fossil fuel switch projects abatement (at project means)

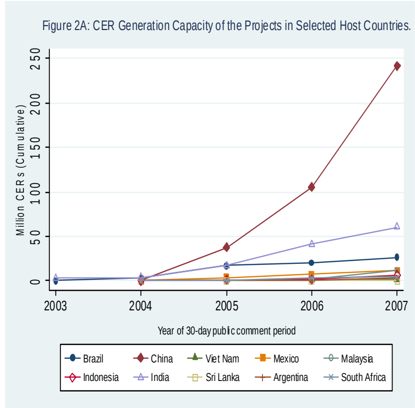


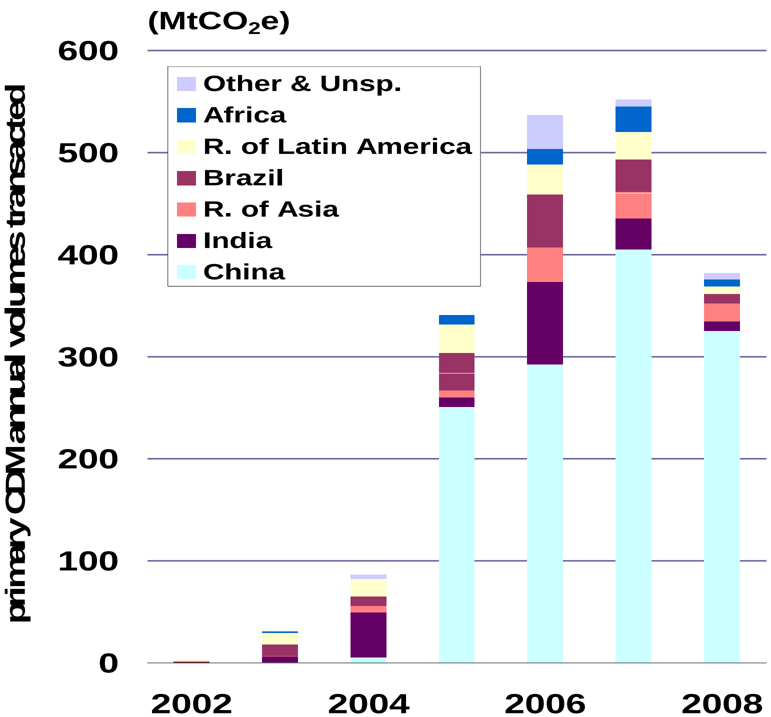
Inter-country Adoption

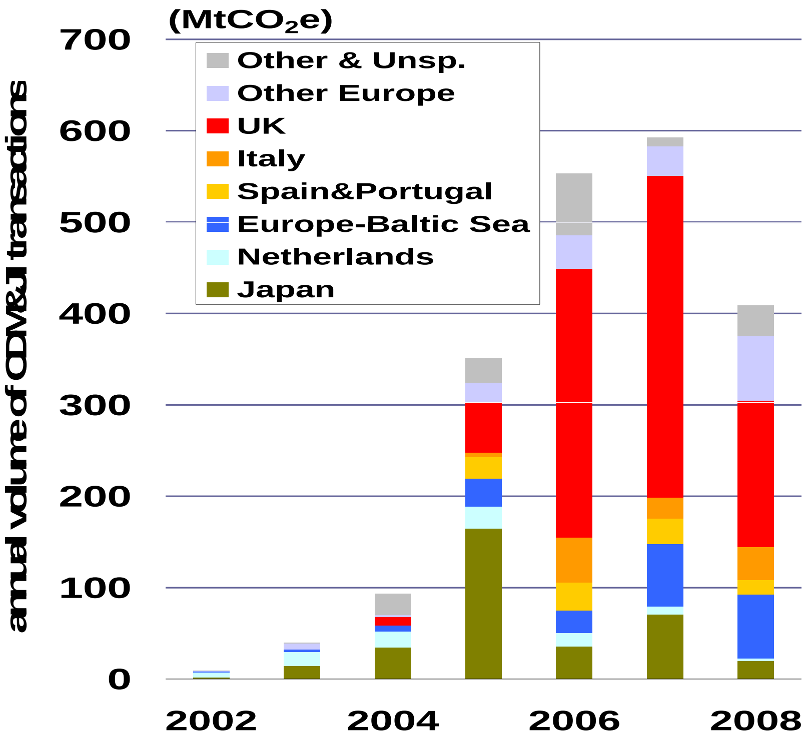
Certified Emission Reductions (CER) generation capacity in selected host countries











Incidence, extent, growth?

- Market concentration
  - 19 of 39 Annex B countries
  - 66 of 175 Non-annex B countries
- Extent
  - CDM projects per country 1-720 in Annex B
  - CDM projects per country 1-960 in Non Annex B
- Growth
  - Greatly varies across Annex B and Non Annex B

Research questions

- What makes adoption of CDM differ across countries?
- What are the factors that affect the level of CDM adoption?
- What motivates early adopters and late adopters? And the speed of adoption?
- Different set of determinants for host and for investor countries due to different objectives

Measuring incidence, extent, and speed

- =1 if at least one CDM project
- Incident
- =0 if no CDM project
- Extent = the ratio of total expected CO_2 abatement (i.e., CERs) through its projects to its total CO_2 emissions in the final year of the first commitment period of the Kyoto Protocol
- Speed = variation of extent over time, using year dummies

Determinants of incident, extent, and growth (based on the literature)

- adoption increases with
  - size of the economy (represented by GDP, CO_2 emission, and energy and electricity use)
  - per capita GDP
  - intensity of carbon emission
  - energy and electricity use
  - manufacturing value added
  - gross capital formation
- adoption decreases with
  - agricultural value added as shares of GDP

Estimation procedures

- Incident estimated by *logit* or *probit* (probability)
- Extent estimated using Fixed Effect *tobit*
- Speed (Extent over time) estimated using the Random Effect *tobit*

Expected impact of variables

Developing Countries

Continuous Variables

Per Capita GDP (2000 constant 1000 US$) (-)

Sq. Per Capita GDP (2000 constant 1000 US$) (+)

Manufacturing Value Added (% of GDP) (+)

Foreign Direct Investment (% of GDP) (+)

Costs of Business Start. Proc. (% of PC GNI) (-)

Source Vulnerability Index (1-100) (+)

Years of AIJ Experience (+)

Regional and Time Dummies

Developed Countries

Continuous Variables

Capital Cost Per Unit of CERs (US$) (+)

CO2 Abatement Target (share of emissions) (+)

Manufacturing Value Added (% of GDP) (+)

Volume of Trade (% of GDP) (+)

Costs of Business Start. Proc. (% of PC GNI) (-)

Source Vulnerability Index (1-100) (-)

Years of AIJ Experience (+)

Regional and Time Dummies

Main results

- The rate of CDM adoption by individual countries (both industrialized and developing) increases as the first commitment period of the Kyoto Protocol approaches
- Because of the binding Kyoto restriction, the rate of adoption over time is higher for the industrialized countries compared to the rate of adoption of the developing countries
- The average cost of CO_2 abatement has a negative but significant effect on CDM adoption, with the magnitude of the effect being higher for the developing countries.
- CDM adoption is higher (lower) for the developing countries (industrialized countries) with larger renewable energy resource potentials.
- CDM adoption is higher for the developing countries with more AIJ experience. AIJ experiences of the Annex B countries, however, do not have any effect on their CDM adoption decision.
- he potential impact of climate change does not significantly influence developing countries' CDM adoption decision.

Factors affecting CDM adoption

- Per Capita GDP
- Manufacturing Value Added
- Costs of Business Start
- Source Vulnerability Index (1-100)
- Years of AIJ Experience
- Regional and Time Dummies
  - Sub Saharan Africa

International Cooperation

The research questions

- Why some countries are heavily involved while others are not
- What explains cooperation
  - Incidence of cooperation
  - Extent of cooperation

How cooperation is measured?

- Dyads of countries
- Incident =1 if any CDM dyadic project exists; =0 if no CDM dyadic project exist
- Extent
  - Number of dyadic projects
  - CO_2 abatement of Dyadic projects
  - Volume of investment of dyadic projects

Determinants of International Cooperation for Global Emission Reduction (1)

- Global institutions
  - **Appropriate incentives for both host and investor countries**
  - **Guarantees of investments**
- Local institutions
  - **Investment climate**
    - **Policies**
    - **Expected taxes**
- Other cooperation mechanisms (War-Peace lit)
  - **Trade**
  - **FDI**

Determinants of International Cooperation for Global Emission Reduction (2)

- Need
- Size
- Proximity
- Similarity in culture and regimes
- Colonial history
- Openness and accountability of host
- Political stability
- Corruption, Government effectiveness, Governance

Main results

- *hst_Average Annual Energy Use (+)*
- *inv_Average Annual Energy Use (+)*
- *hst_Ease of Doing Business (+)*
- *inv_Ease of Doing Business (-)*
- *hst_Governance (+)*
- *inv_Governance (+)*
- *hst_Renewable Energy (+)*
- *inv_Renewable Energy (-)*
- *hst_Impact Vulnerability (+)*
- *inv_Impact Vulnerability (+)*
- *Trade (+)*

Conclusion (1): Global diffusion

- The CDM mechanism is on track to deliver an average annual flow of roughly 700 million CERs by the close of 2012 and nearly 1,100 million tons by 2020.
- Parameter tests suggest that currently identified CDM investments will exceed early model predictions of the potential market for CDM projects.

Conclusion (2): Cost of abatement

- The CDM market operates efficiently and sends the right signals to the investors, which further explains the shying away from costly carbon sequestration projects funded by many international development agencies, such as the World Bank.
- Contrary to the hypothesis that that the marginal costs of abatement through CDM decrease over time due to experience or learning by doing, empirical results show non-decreasing marginal cost of abatement over time.
- This finding suggests that there may be other incentives to invest in certain types of CDM projects in specific locations, thus implying location-specificity of various investment opportunities.
- While non-decreasing marginal cost of abatement over time implies a tougher prospect for CDM in future commitment periods, the current growth pattern of the CDM suggests that this flexibility provision of the Kyoto Protocol is still highly attractive for the host and investor countries

Conclusion (3): Adoption by host and investor countries

- Determinants of adoption of CDM differ between host and investor countries—Different incentives
- Significant number of unilateral CDM projects, market concentration--consideration of whether or not policies should be designed even with focus on individual countries such as India, China, Brazil, and UK and Japan
- FDI doesn't explain adoption in developing countries. A distinction between FDI-type investment and CDM-type investments could channel more CDM investment with sufficient spillover for development

Conclusion (4): Cooperation

- Three factors have positive impacts, increasing future viability of the CDM.
  - better business environment
  - higher level of governance
  - stronger international relations
- Scopes of both state-level and international–level policy interventions
  - governments and international development institutions have already identified them as important directions for their future commitment

Relevant Publications

1. Larson, D. F., P. Ambrosi, A. Dinar, S. M. Rahman and R. Entler, **A Review of Carbon Market Policies and Research.** *International Review of Environment and Resource Economics* **2(3): 177-236, 2008. http:/dx.doi.org/10.1561/101.00000016**

2. Rahman, S. M., A. Dinar and D. F., Larson, Diffusion of the Clean Development Mechanism. In ***Nanotechnology and Microelectronics: Global Diffusion, Economics and Policy.*** Ndubuisi Ekekwe (Ed.), IGI Publishers (Accepted for publication, July 28, 2009).

3. Rahman, S. M., A. Dinar and D. F., Larson, ***Diffusion of Kyoto's Clean Development Mechanism***. World Bank, Working paper (in production, 2009).

4. Rahman, S. M., D. F., Larson, and A. Dinar, ***THE COST STRUCTURE OF EMISSIONS ABATEMENT THROUGH THE CLEAN DEVELOPMENT MECHANISM***. Draft paper 2009.

5. Rahman, S. M., A. Dinar, and D. F., Larson, ***CROSS-COUNTRY ADOPTION OF THE CLEAN DEVELOPMENT MECHANISM: INCIDENCE, EXTENT AND GROWTH***. Draft paper 2009.

6. Dinar, A., S. M Rahman, D. F. Larson, and F. Ambrosi. ***Factors Affecting Levels of International Cooperation in Carbon Abatement Projects***. World Bank Policy Research Working Paper No. 4786 November 2008.