Environmental Policy Design for Technological Innovation and Economic Growth

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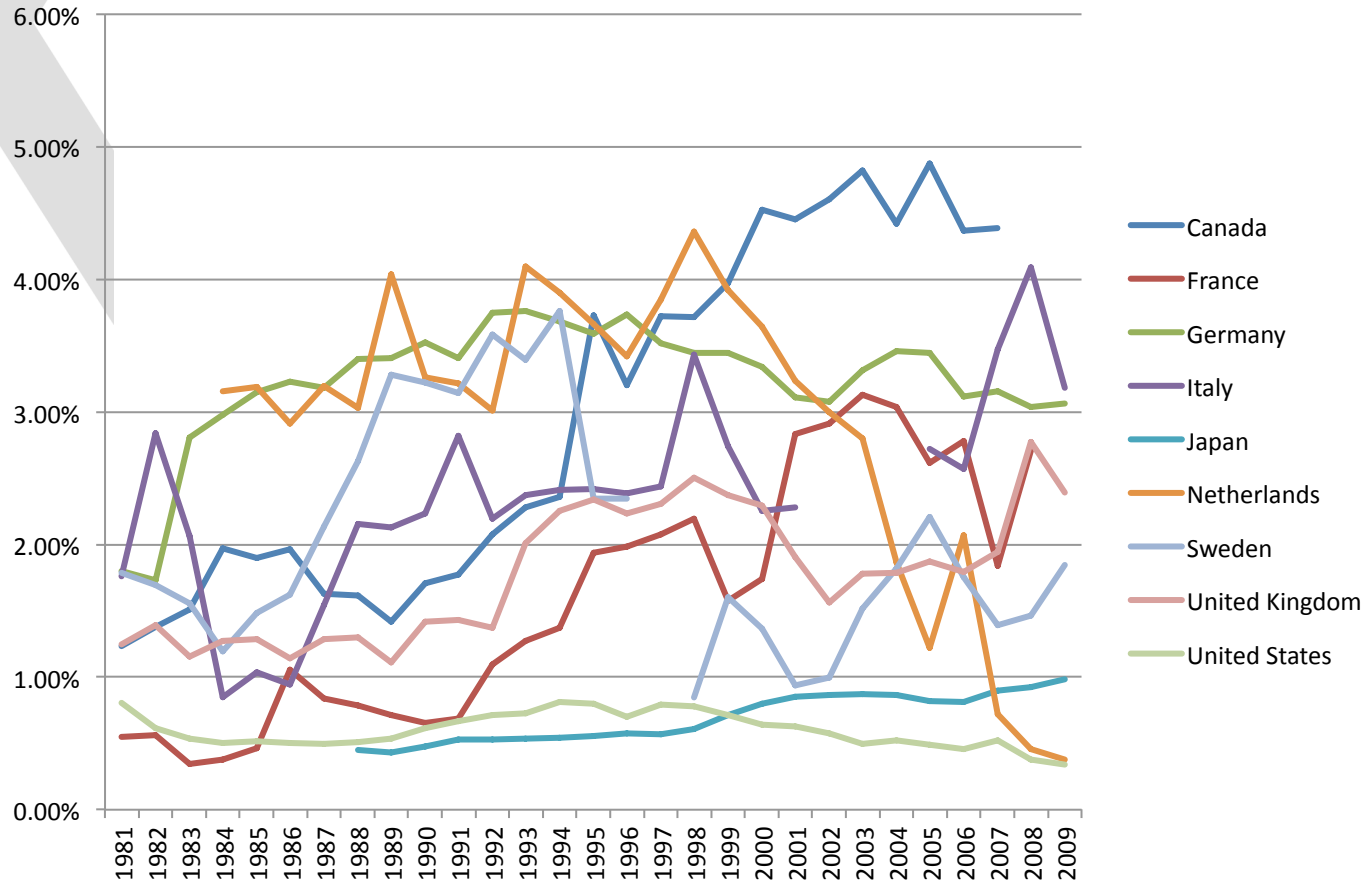
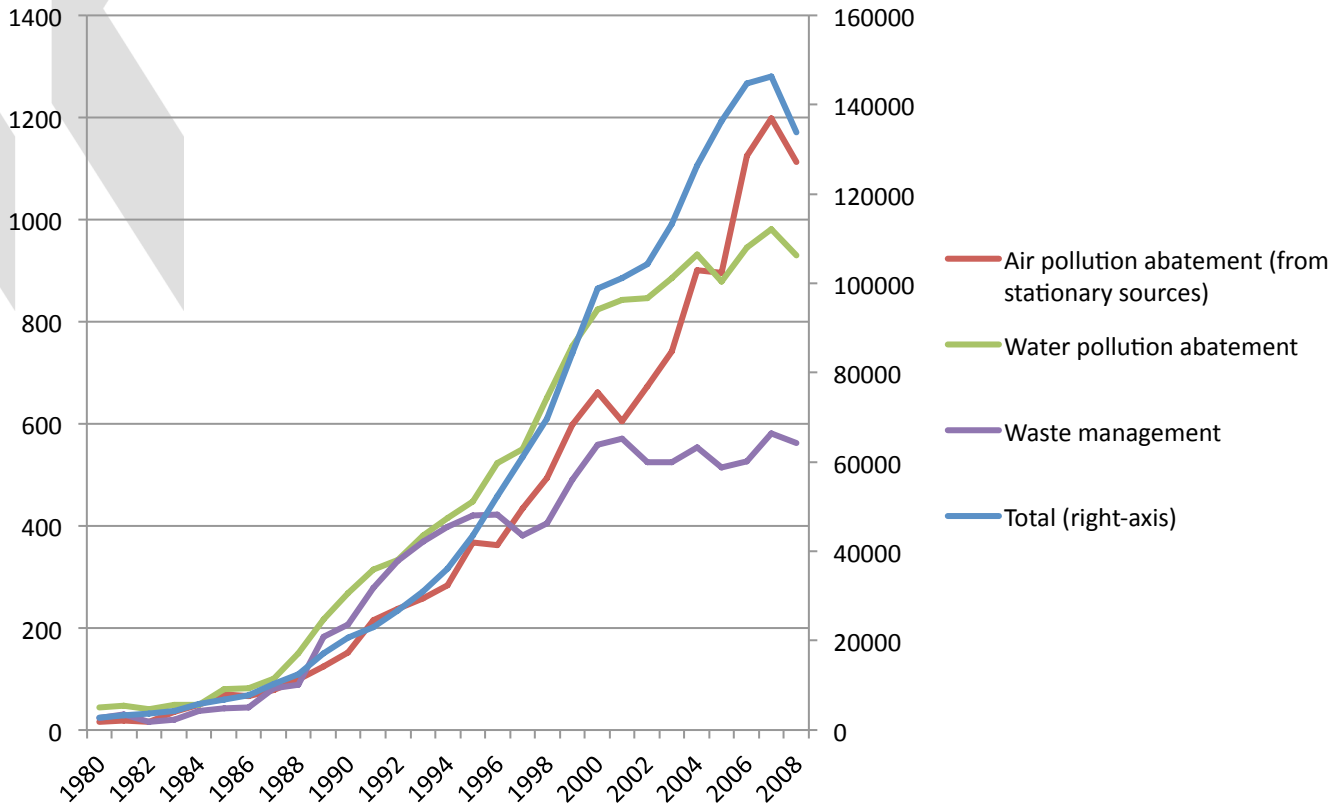
Public 'Environmental' R&D as % of Total R&D



Source: OECD.Stat "Government budget appropriations or outlays for RD"

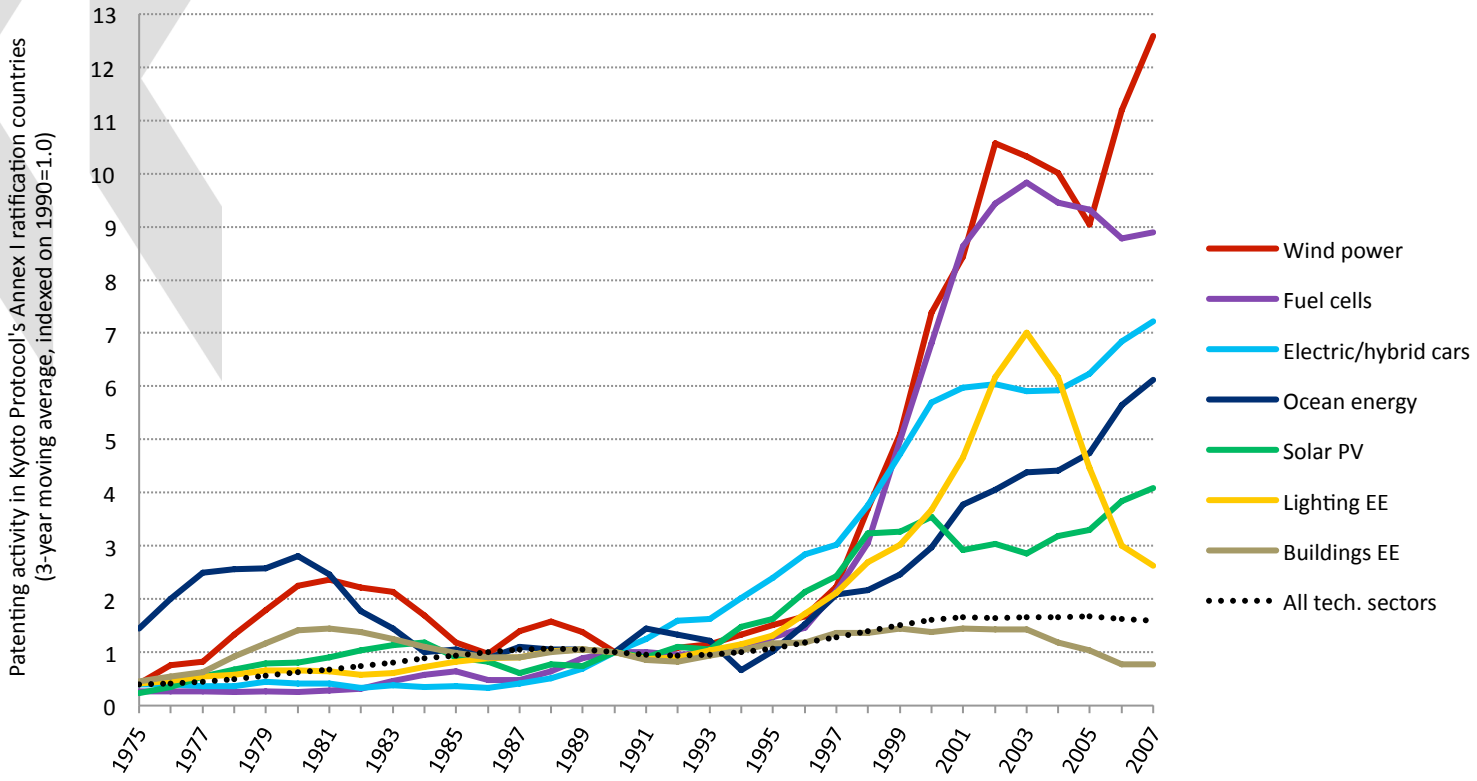
Environment-Related Patents in OECD Countries

(Number of patent applications - claimed priorities, worldwide)



Source: OECD, *Invention and Transfer of Environmental Technologies* (2011)
www.oecd.org/environment/innovation

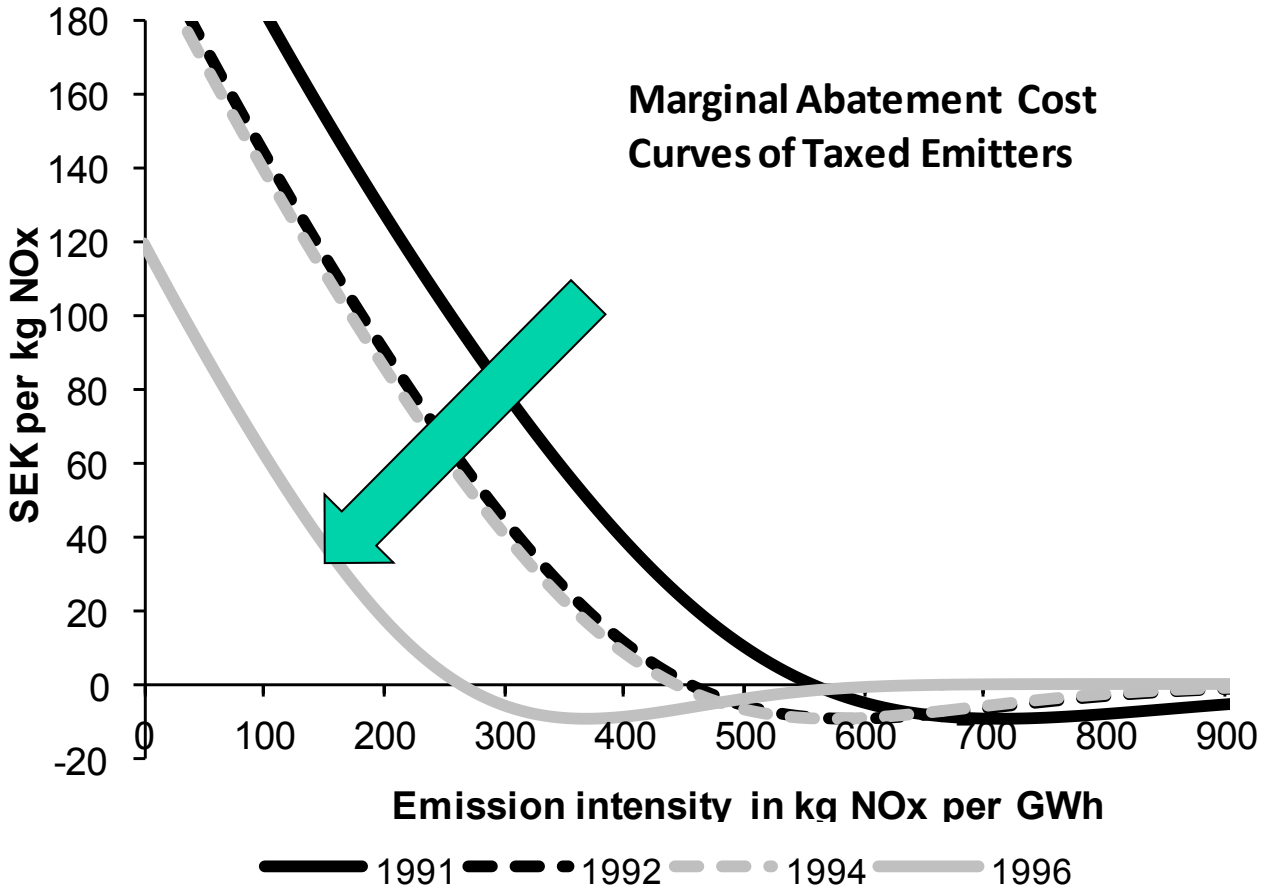
Climate Change Mitigation Technologies
(Number of patent applications - claimed priorities, worldwide)



Source: Haščič, I. *et al. (2010),* "Climate Policy and Technological Innovation and Transfer: An Overview of Trends and Recent Empirical Results", OECD Environment Working Papers, No. 30 http://dx.doi.org/10.1787/5km33bnggcd0-en

Prices matter – and spur innovation

The Effect of the NOX Charge in Sweden



Source: Hoglund-Isaksson (2005) cited in OECD (2011) *Taxation, Innovation and the Environment*
Note: based on observations from 55 plants in the energy sectors over the period 1992-1996

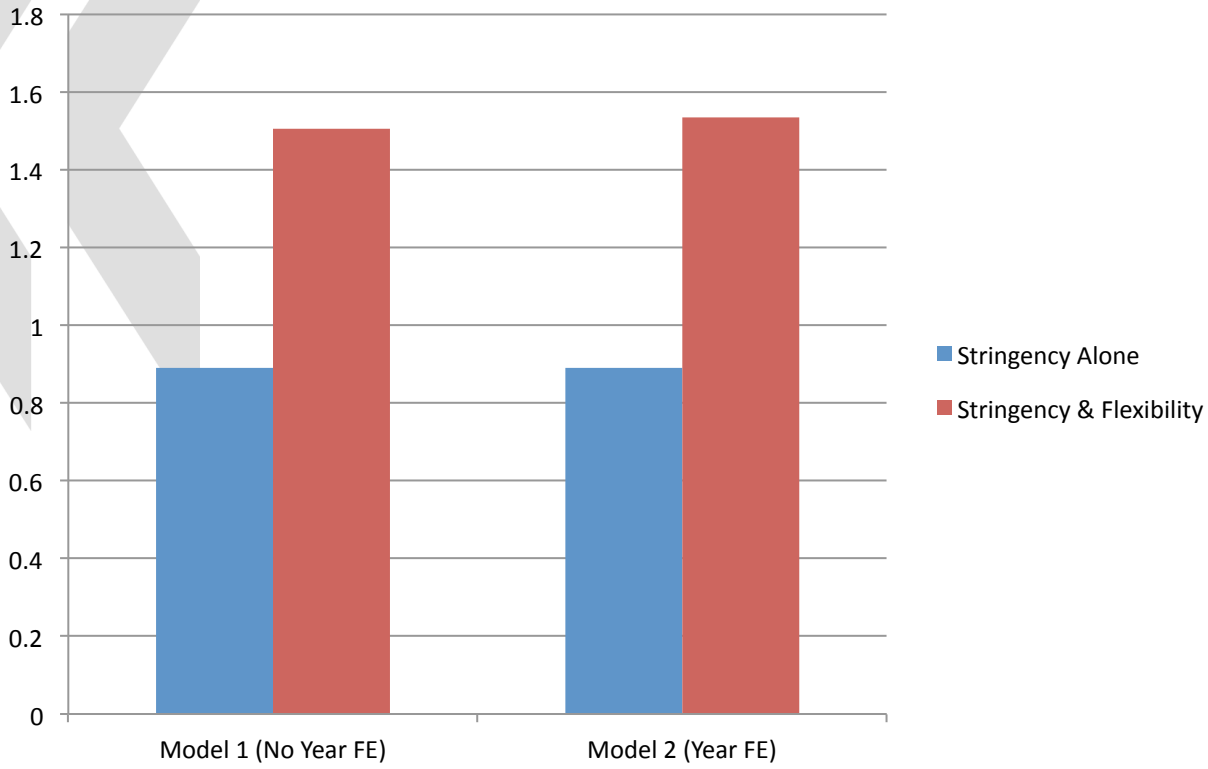
Pricing as a Necessary but not Necessarily Sufficient Condition

- Difficulty of targeting environmental 'bad' directly and excessive administrative costs – i.e. environmental policy and transaction costs
- Secondary 'non-environmental' market failures – i.e. information failures, split incentives, network externalities
- 'Credibility' of policy-induced price signals over the longer term may not be sufficient for risky investments
- Inertia in the market which can favour incumbent firms and technologies – "deadweight of past" may correlate with environment-intensity"

Principles of environmental policy design in order to encourage 'green' innovation

- Stringency – how ambitious is the policy objective relative to “BAU”
- Predictability – how certain and credible is the signal given by the policy
- Flexibility – how much space is provided to identify new technologies and methods

The Role of Policy Flexibility: The Effect on Patented Environmental Inventions



Note: Figure shows the estimated importance of different characteristics of environmental policy framework (policy stringency, policy flexibility) in encouraging inventive activity in environmental technologies. Measured as the number of patent applications (claimed priorities) deposited during 1975-2006.

Source: OECD (2011) *Invention and Transfer of Environmental Technologies*
www.oecd.org/environment/innovation

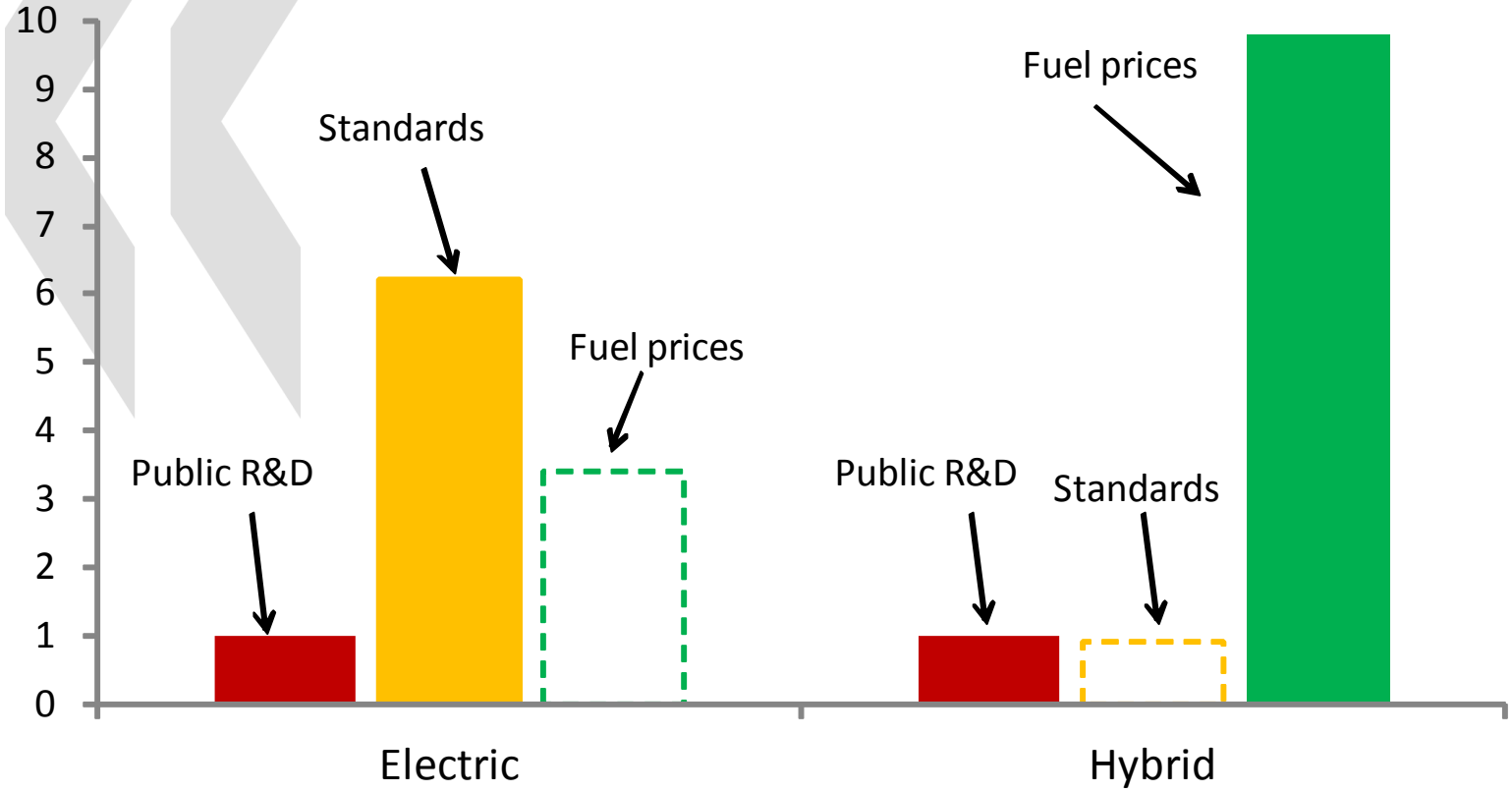
The Role of Policy Predictability:

Effect of Volatility in Public R&D on Inventive Activity

Note: Figure shows the estimated response to a 1% increase in the level and volatility of public R&D in encouraging inventive activity in environmental technologies, measured as the number of patent applications (claimed priorities) deposited during 1975-2007 in a cross-section of OECD countries.

Source: Kalamova, Johnstone and Hascic (2012) in V. Constantini and M. Mazzanti (eds.) *The Dynamics of Environmental and Economic Systems* (Springer, forthcoming).

The Need for a Mix of Policies:
Sequencing and Complementarity in AFV Technologies



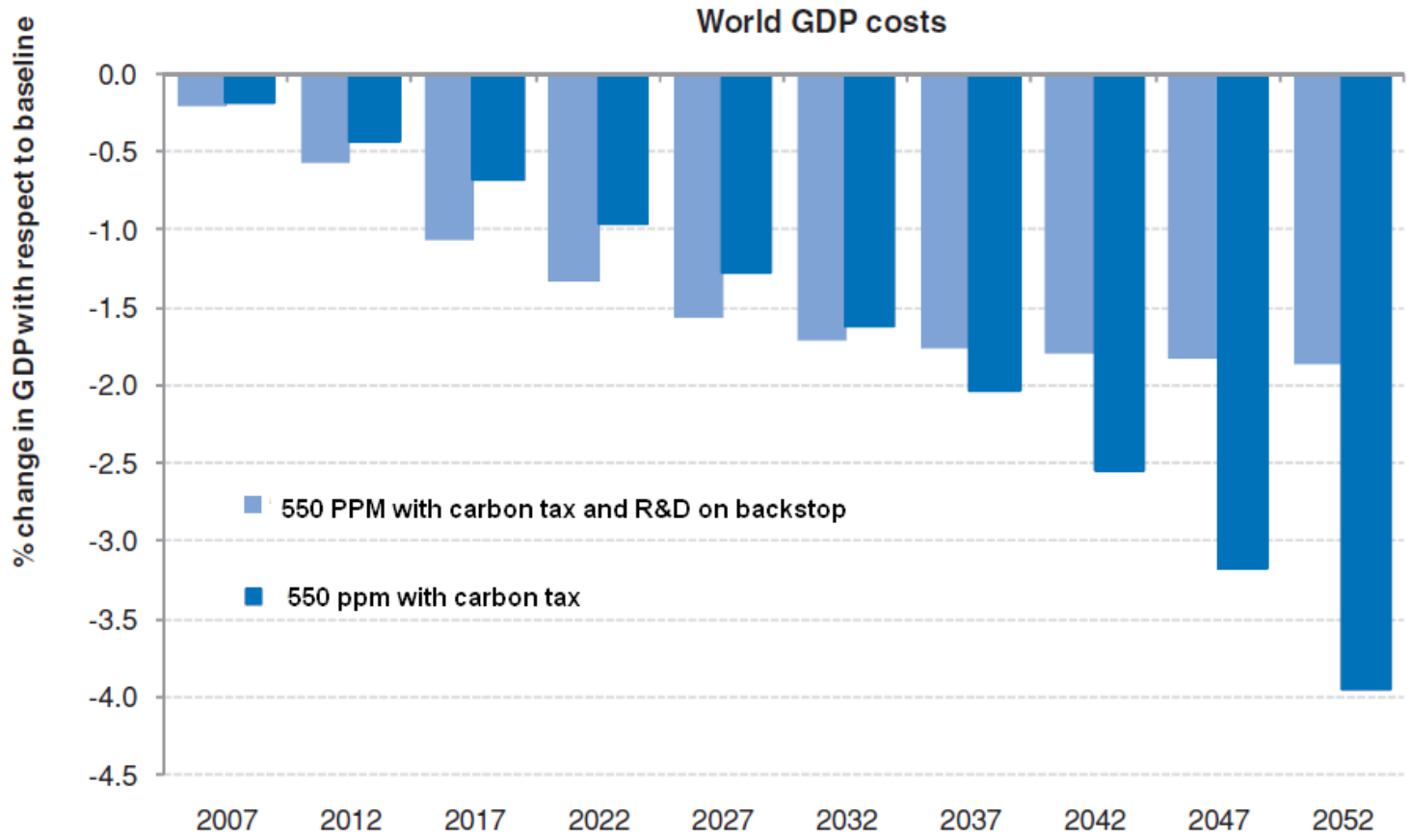
Note: For ease of interpretation elasticities have been normalised such that effect of R&D=1. Unfilled bars indicate no statistical significance at 5% level.

Source: OECD (2011) *Invention and Transfer of Environmental Technologies*.

Policy Impacts and Distance from "Market"

- To induce a 1% increase in electric vehicle innovations, the alternatives are:
  - Increase R&D by 14% (i.e. $26 mln instead of $23 mln per year per country, on average)
  - Increase fuel price by 63% (i.e. $1.30 instead of $0.80, on avg)
- To induce a 1% increase in hybrid vehicle innovations, the alternatives are:
  - Increase R&D by 53% (i.e. $35 mln instead of $23 mln per year per country, on average)
  - Increase fuel price by 5% (i.e. $0.84 instead of $0.80, on avg)

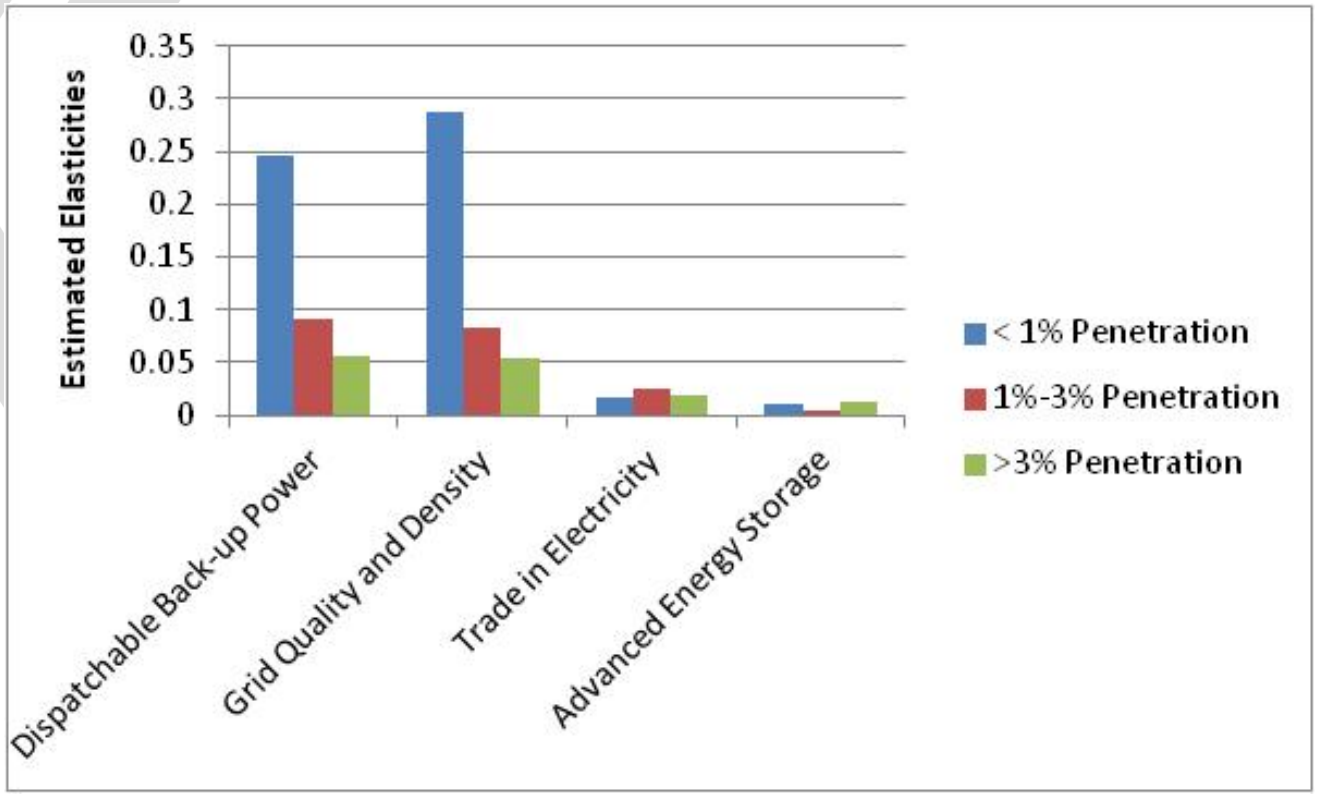
Climate Change Mitigation Costs With and Without Research on "Backstop" Technologies



Note: Assumptions concerning backstop technologies based on expenditures on technologies which are under research but not yet viable (e.g. advanced biofuels, nuclear and fuel cells)

Source: OECD *Economics of Climate Change Mitigation.* Based on research undertaken by V. Bosetti et al. (2010) in http://www.feem.it/userfiles/attach/2010471754234NDL2010-042.pdf

Effects of Different Strategies to Overcome Intermittency on "Productivity" of Wind Power Plants



Note: Productivity measured as delivered power over potential capacity. Estimates based on unbalanced sample of 32 countries over 20 years.

Source: D. Benatia, N. Johnstone and I Hascic "Making the Most of Wind Power Plants" (forthcoming)

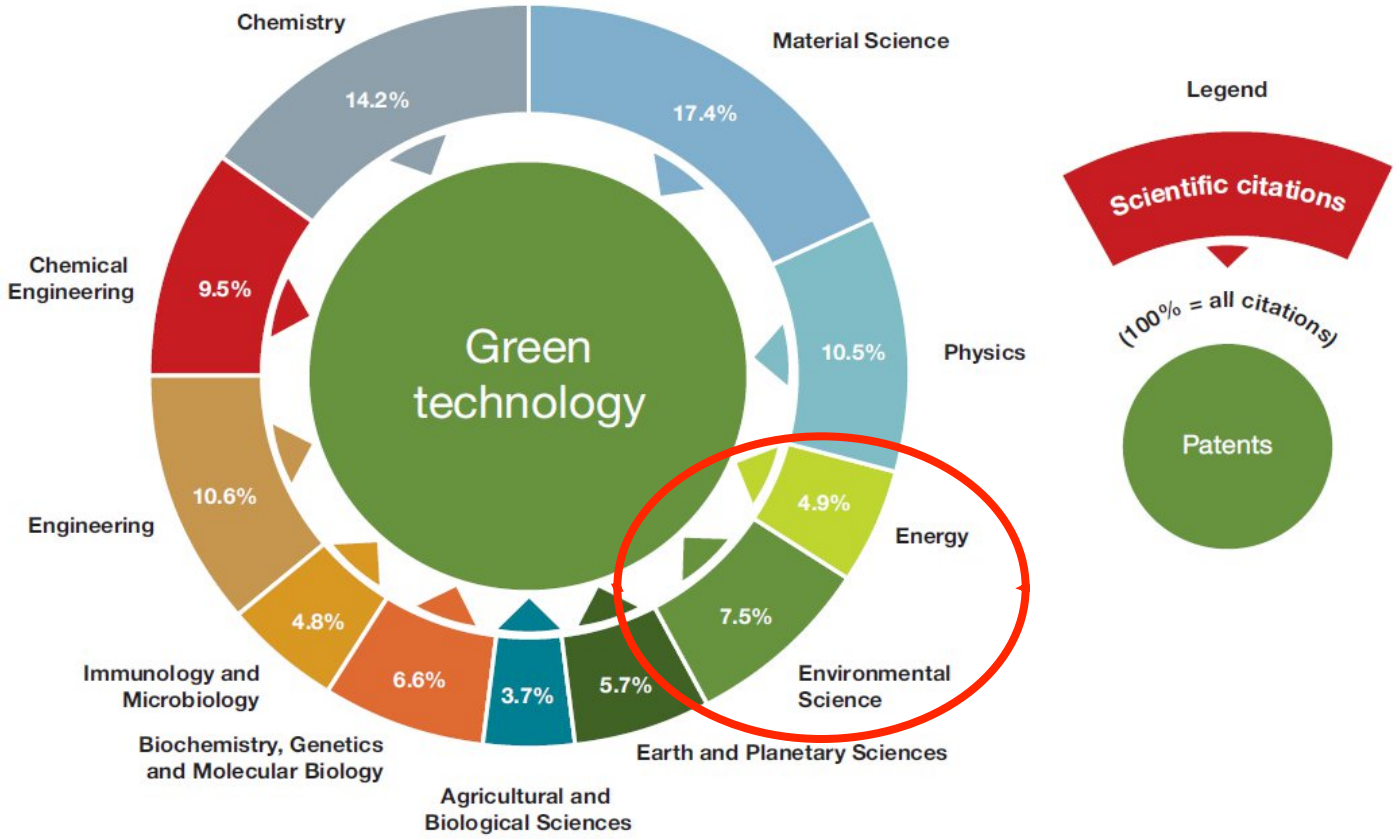
Directing Change Without "Picking Winners"

- Since technology-neutral pricing of externality is not 'sufficient' = > necessity to be 'prescriptive' (at least to some extent) => main challenge for policy makers
- Some general principles:
  - Support a 'portfolio' of technologies to diversify risk of getting it "wrong"
  - Benefits of chosen portfolio should be robust with respect to information uncertainty (i.e. ancillary benefits)
  - Identify "local general purpose technologies' which complement a variety of emission-reducing strategies

Breadth of Sources of Environmental Innovation

The innovation-science link in selected green technologies

Patent-science link via citations, 2000-07



Source: OECD (2010), *Measuring Innovation – A New Perspective*, based on Scopus Custom Data, Elsevier, July 2009; OECD, Patent Database, January 2010; and EPO, Worldwide Patent Statistical Database, September 2009.

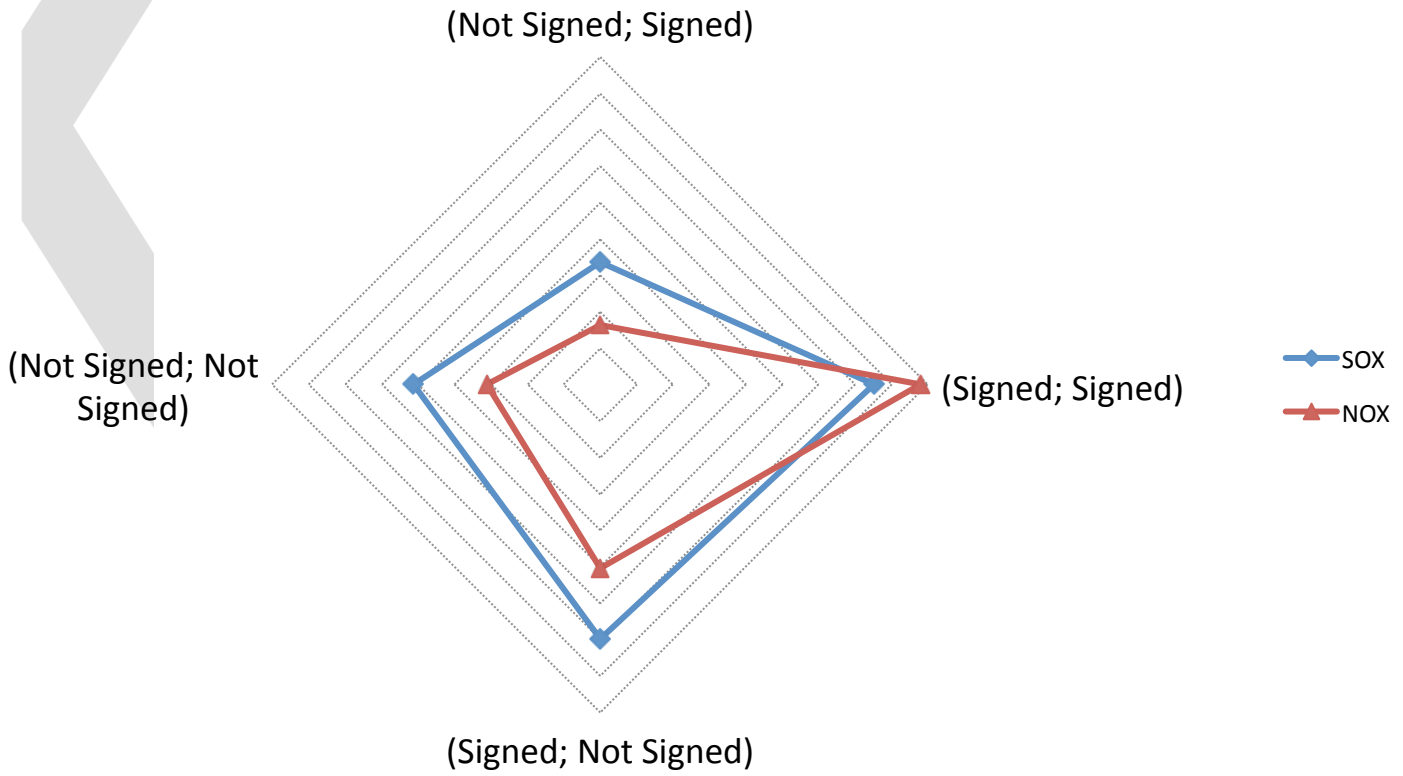
International technology co-operation for green innovation

- Remove barriers to global trade and investment flows ⇒ to help underpin sustained growth and diffusion of green technologies and services (‘red herring’ of IPRs)

- More concerted approaches to accelerate technology development and diffusion:
  - build research and aborptive capacity in developing countries through international cooperation
  - identify technologies appropriate for local ecological and economic conditions (i.e. ‘neglected’ analogy)

MEAs and Technology Diffusion

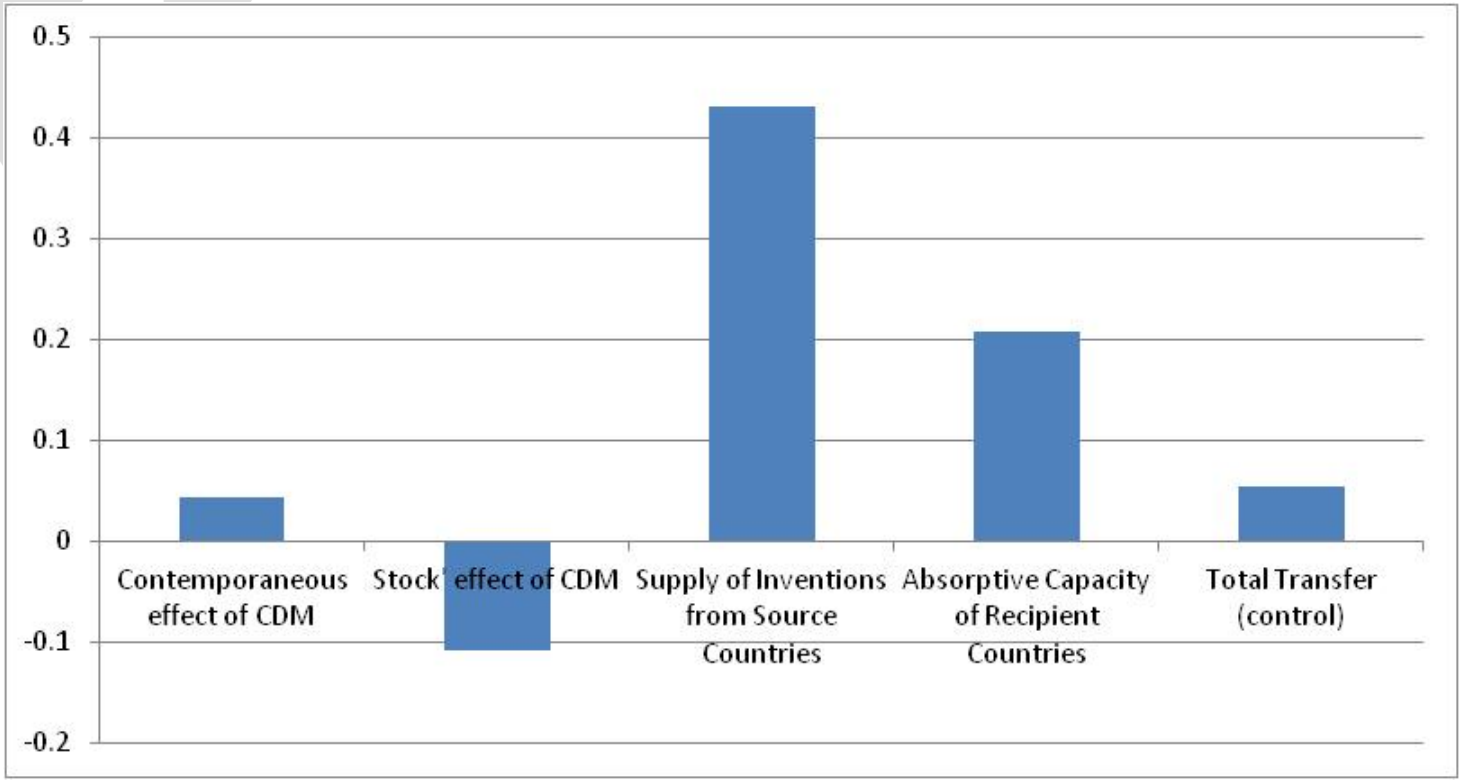
The LRTAP and Transfer between Signatories



Note: The Figure shows the relative importance of cross-border transfer of SOx and NOx emissions abatement technologies in cases when both the source and the recipient country have signed the Protocols, when only either side signed, and when neither side signed. Measured as the number of duplicate patent applications from the 'source' country (priority office) to the recipient country (duplicate office) during 1980-2008.

Source: OECD (2011) *Invention and Transfer of Environmental Technologies* www.oecd.org/environment/innovation

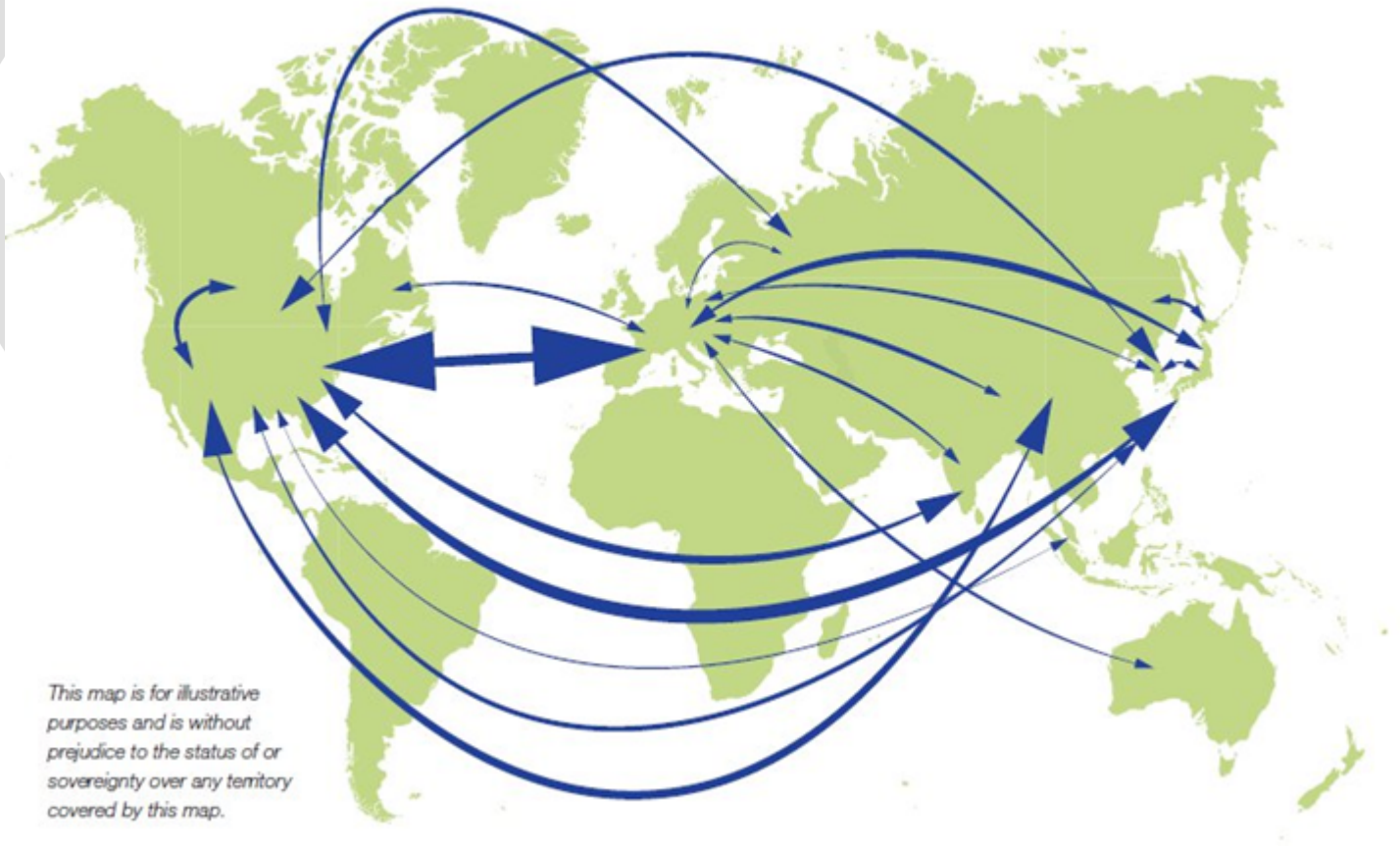
What Is Driving Transfer and Spillovers? CDM and the Case of Wind Power



Note: The histogram shows the relative importance of different determinants of transfer of wind power technologies, from Annex I to non-Annex I countries.

Source: Haščič, Ivan and Nick Johnstone (2011) *"The Clean Development Mechanism and International Technology Transfer: Empirical Evidence on Wind Power"* in *Climate Policy* 11(6)

Research Cooperation in CC Mitigation Technologies
(Co-invention of Solar Photovoltaic Technologies)



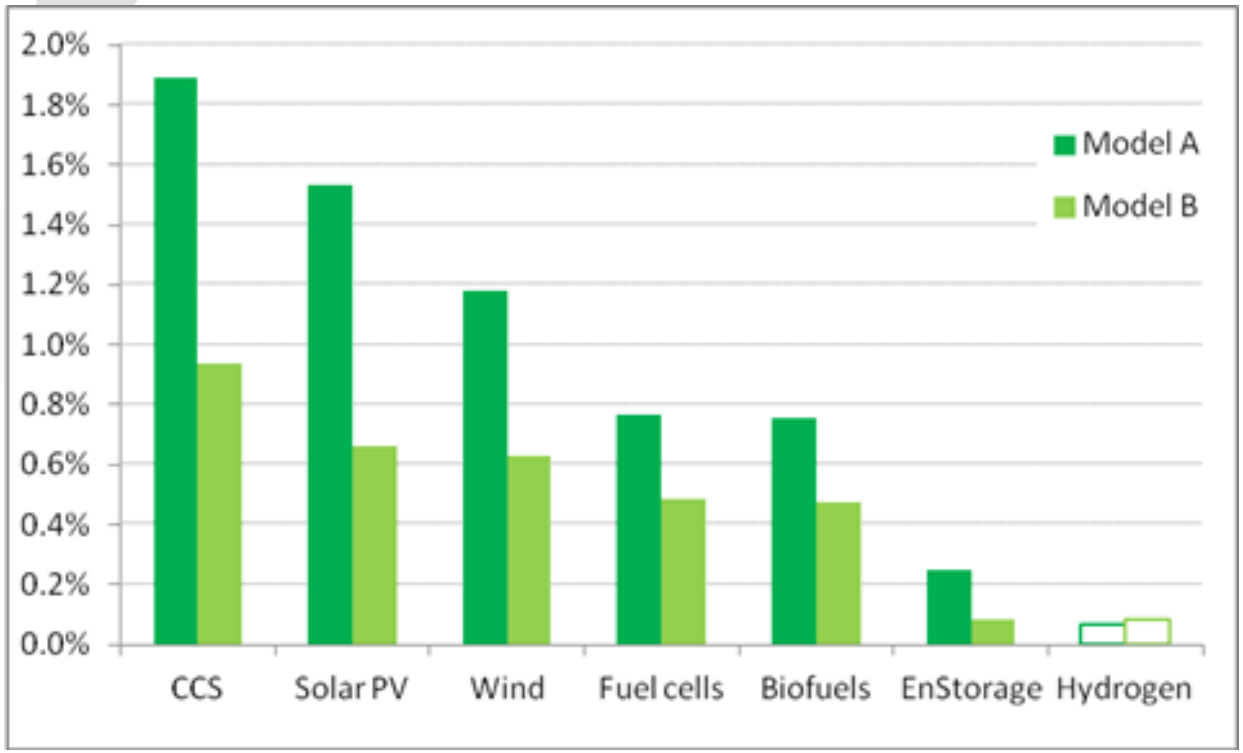
Source: OECD (2012) *Energy and Climate Change Policy and Innovation* (forthcoming).

International Research Collaboration in CC Mitigation Technologies

Sector	1	2	3	4	5	6	7	8	9	10
All Technologies	GB-US	DE-US	CA-US	CH-DE	JP-US	FR-US	NL-US	DE-FR	CH-FR	CH-US
Wind	DK-GB	DE-US	CA-US	DE-NL	NL-US	DE-DK	IN-US	**BE-ZA**	**RU-US**	DK-ES
Solar PV	JP-US	DE-US	GB-US	CH-DE	AT-DE	CA-US	**CN-US**	DE-FR	DE-NL	GB-IT
Advanced Storage	GB-US	CA-US	DE-US	JP-US	JP-KR	FR-US	CH-DE	CA-FR	**CN-US**	KR-US
Electricity T'mission	DE-US	JP-NZ	CH-DE	IT-US	CA-US	CH-US	FI-SE	DE-FR	DE-GB	**IN-US**
CCS	CA-US	NL-US	GB-US	FR-US	DE-US	AU-NL	DE-GB	GB-NL	NO-US	**CN-US**
Advanced Biofuels	DK-US	NL-US	CA-US	DE-US	**CN-DK**	DE-GB	GB-US	CH-DE	GB-NL	JP-US
Fuel Cells	JP-US	CA-US	DE-US	GB-US	**CN-US**	KR-US	FR-US	CH-DE	CA-FR	CA-DE

Note: The table shows the most important co-inventing country pairs (country of residence of inventor) in patent applications.
Source: Kahrobaie, Haščič, Johnstone (2012) "International Research Collaboration in Climate Technologies", OECD Environment Working Paper Series (forthcoming).

Technology Agreements and International Research Collaboration



Note: The values represent the proportional change in research collaboration for a discrete change (equal to 10% of the 'treated' sample) in joint membership in an IA.

Source: Kahrobaie, Haščič, Johnstone (2012) "International Research Collaboration in Climate Technologies", OECD Environment Working Paper Series (forthcoming).

Conclusions: Research and Policy Challenges

- Providing policy predictability in conditions of imperfect and changing information
- Providing a mix of incentives that induce solutions from 'close-to-market' up to 'breakthrough'
- Directing technological change onto a green trajectory without being "unduly" prescriptive
- Building international cooperative solutions for environmental problems which stretch widely across space and time

Thank You!

(www.oecd.org/environment/innovation)