Environmental Policy and Environmental Innovation: Recent Evidence on Climate Change Mitigation Technologies based on Patent Data

Nick Johnstone and Ivan Hascic

Empirical Policy Analysis Unit
National Policies Division
OECD Environment Directorate
(www.oecd.org/env/cpe/firms/innovation)

at

Fondazione Edison Conference on
"Environment and Energy Innovations in Economics Dynamics"
Rome, May 21st, 2009

OECD OCDE

Structure of Presentation

- Patents as a measure of technological innovation and transfer of climate change mitigation technologies
- Determinants and of innovation of climate change mitigation technologies
- Impacts of innovation of climate change mitigation technologies
- Empirical analysis of the extent and determinants of transfer of climate change mitigation technologies

Acknowledgements

- Joint work with:
  - David Popp (Syracuse Univ., USA)
  - Sebastian Voigt (ZEW, Germany)
  - Elisa Lanzi (FEEM, Italy)
  - Neelakshi Medhi (Syracuse Univ., USA)
  - Neil Odam (Stirling Univ., UK)
  - Frans de Vries (Stirling Univ., UK)
  - Elena Verdolini (FEEM, Italy)

- Results of numerous models summarised in ENV/EPOC/WPNEP(2009)3 (restricted access) & http://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=88415

On-Going Research on Environmental Patents

- Development of a methodology for the identification of environmentally-sound technologies (EST) and innovation

- Empirical assessment of the relationship between environmental policy and technological innovation, drawing upon patent data

- Empirical analysis of the extent and determinants of transfer of EST (particularly climate change mitigation technologies)

Patents as a Measure of Innovation

- Pros
  - output measure
  - quantitative/commensurable
  - widely available
- Cons
  - variable quality
  - one of many ‘protection’ strategies
  - dependent upon local conditions

Patents as a Measure of Environmental Innovation

- Possible to identify distinct 'environmental' innovation – i.e. under WIPO IPC scheme over 70,000 technology classifications (http://www.wipo.int/classifications/ipc/en/)
- Application-based - and thus broad population of potentially relevant classes (preferable to commodity or sectoral classifications)
- Two possible types of error – inclusion of irrelevant patents and exclusion of relevant patents from classifications selected
- Distinction between changes-production-processes and end-of-pipe investments: latter more readily identifiable but perhaps less 'innovative'

Use of PATSTAT Database

• Allows for richer ‘search strategies’ in all environmental spheres with inclusion of abstracts

• Possible to develop more accurate indicators of EST innovation using keyword searches

• Worldwide coverage (data from 80 national and regional patent offices – i.e. all OECD countries, BRICs, etc.)

• Time series for over 30 years, that can be revised and updated at very low cost

•Also - possibility to develop indicators of technology transfer (international patent families)

IPC Hierarchy – An Example

Subdivision	Number of subdivisions	Example of an IPC code	
		Symbol	Title
Section	8	F	Mechanical Engineering; Lighting; Heating; Weapons; Blasting
Subsection	21	F0	Engines or Pumps
Class	120	F03	Machines or Engines for Liquids; Wind, Spring, or Weight Motors; Producing Mechanical Power or a Reactive Propulsive Thrust, Not Otherwise Provided For
Subclass	628	F03G	Spring, Weight, Inertia, or Like Motors; Mechanical-Power-Producing Devices or Mechanisms, Not Otherwise Provided For; or Using Energy Sources Not Otherwise Provided For
Main group	ca. 6,900	F03G 6	Devices For Producing Mechanical Power From Solar Energy….
Subgroup	ca. 62,100	F03G 6/08	With Solar Energy Concentrating Means

Sample ‘Environmental’ Patent Application

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : F03D 7/04	A1	**(11) International Publication Number:** WO 94/04820 **(43) International Publication Date:** 3 March 1994 (03.03.94)

(21) International Application Number: PCT/DK93/00279

(22) International Filing Date: 26 August 1993 (26.08.93)

(30) Priority data:
1059/92 26 August 1992 (26.08.92) DK

(71)(72) Applicant and Inventor: ULLERSTED, Hans [DK/DK]; Kauslundevej 65, DK-5500 Middelfart (DK).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : HANSEN, Per [DK/DK]; Erantisvænget 3, DK-5856 Ryslinge (DK). NIELSEN, Arne [DK/US]; P.O. Box 8972, Palm Springs, CA 92263 (US).

(74) Agent: K. SKØTT-JENSEN PATENTINGENIØRER A/S; Lemmingvej 225, DK-8361 Hasselager (DK).

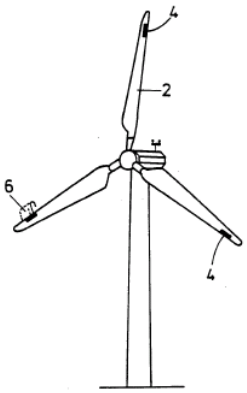
(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
In English translation (filed in Danish).

(54) Title: WINDMILL, WING FOR SUCH A MILL, AND ADD-ON ELEMENT TO BE MOUNTED ON A MILL WING

(57) Abstract

Generally speaking, stall-regulated mill blades have a lower propulsive effect at higher than at lower temperatures because the air density at any given wind velocity is lower, the higher the temperature is. This condition is critical at the stall-wind velocity where the mill produces the maximum effect at which it is designed to perform. If the wings are regulated for maximum performance at high temperatures, then overload will occur at low temperature stall-wind velocity conditions. In consequence, the wings are normally adjusted to low temperature conditions, in return for which it becomes necessary to relinquish the maximun effect at high temperatures. With the invention, an air temperature sensor (10, 16, 22, 34) is provided which by means of connected actuator means (14, 20, 32) can change the wing structure such that the wing becomes generally less effective at decreasing temperatures. Hereby it is possible to increase the effect of the mill, in that it will be able to better exploit the high wind velocity at high temperatures without incurring problems at low temperatures in terms of overload.

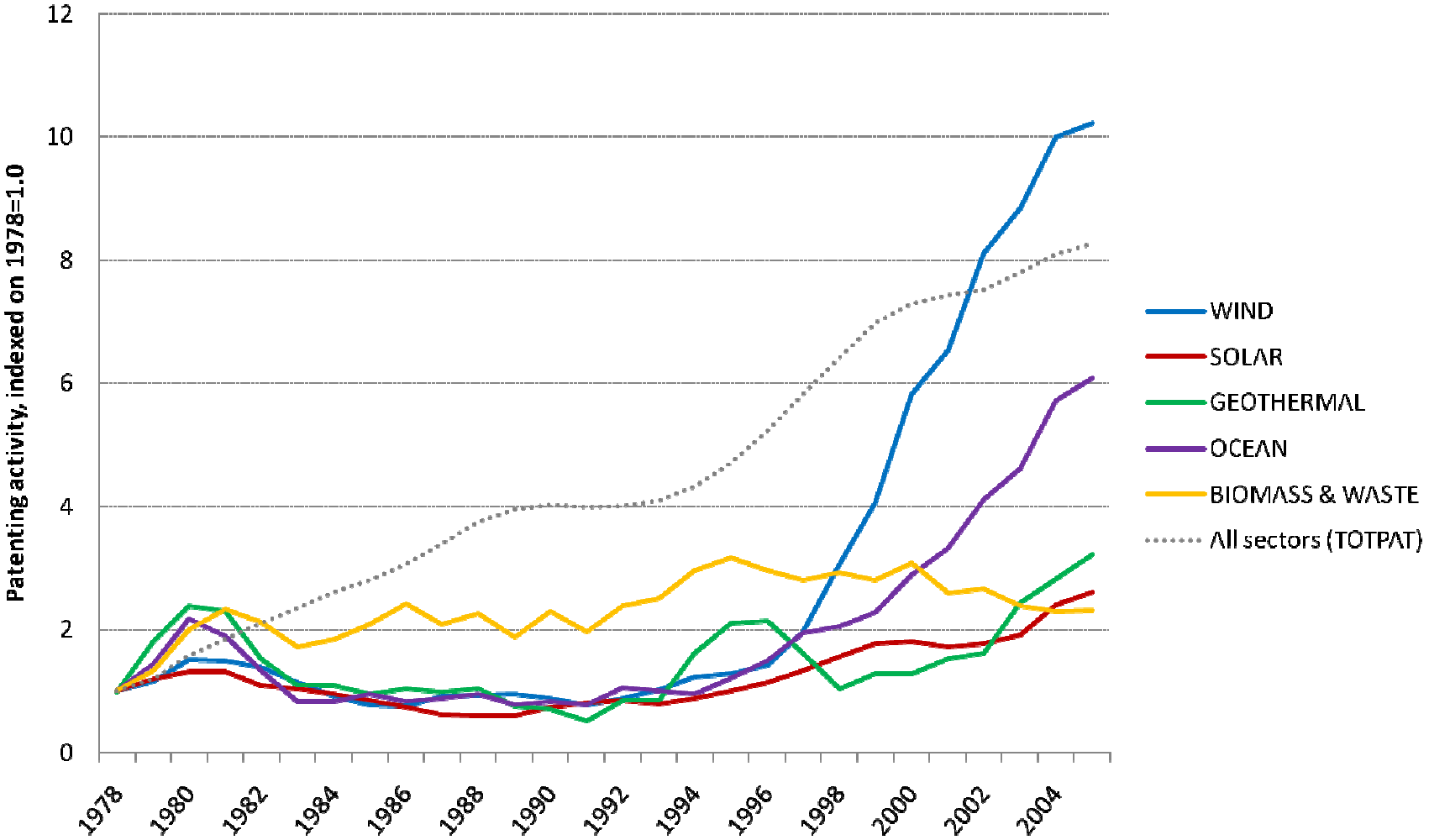


OECD OCDE

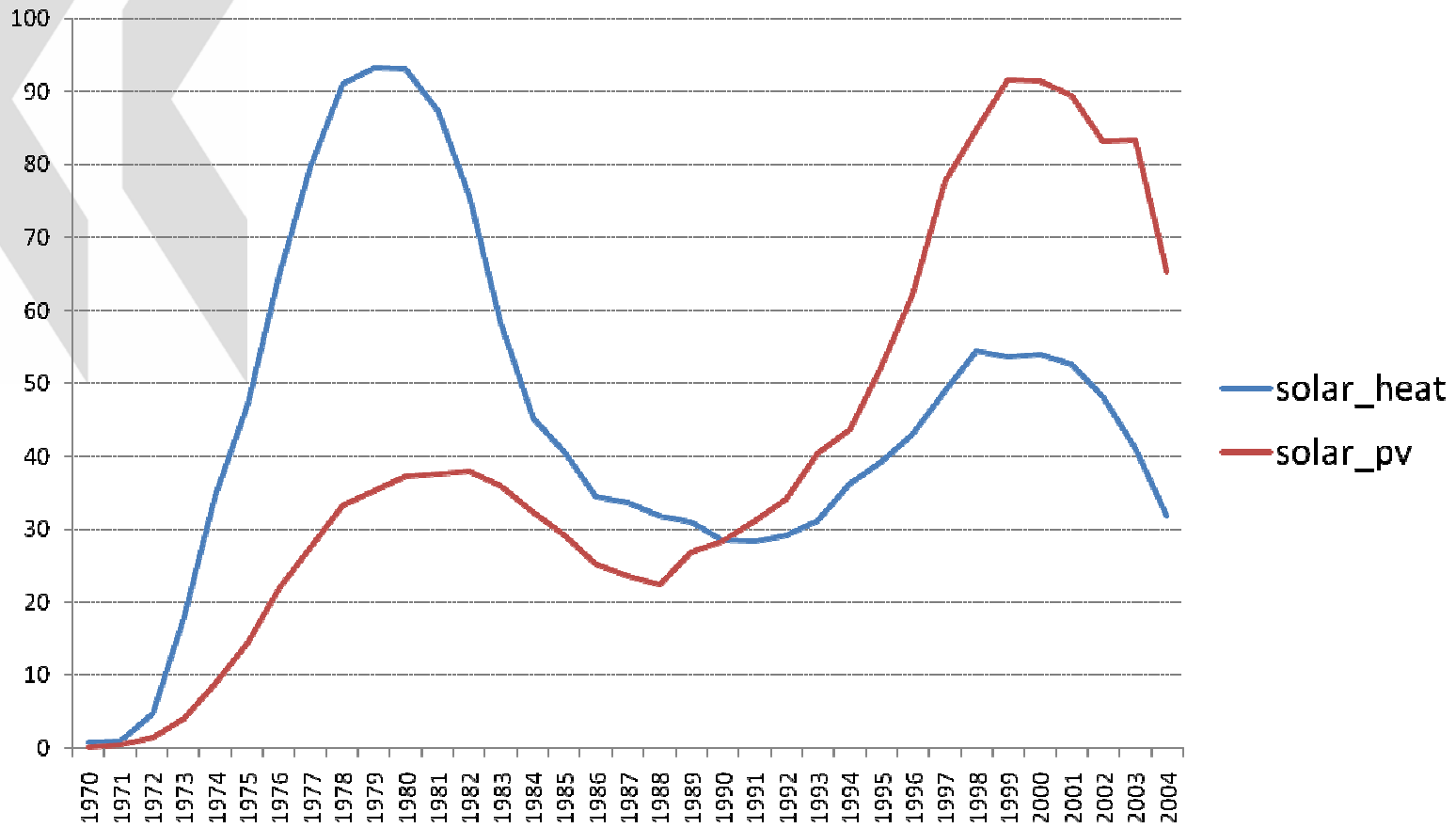
Areas of Application for Climate Change

- Renewable energy
- Vehicle fuel efficiency
- Vehicle fuel choice (e.g. hybrid vehicles)
- Fuel cells
- Building energy efficiency (e.g. insulation, heating)
- Lighting technologies
- Clean coal technologies (e.g. IGCC, FBC, PCC)
- Carbon capture and storage
- Methane capture
- Energy efficiency in manufacturing (e.g. cement)

Inventive Activity in Renewable Energy Technologies (EPO patent applications, 3-year moving average, indexed on 1978=1.0)



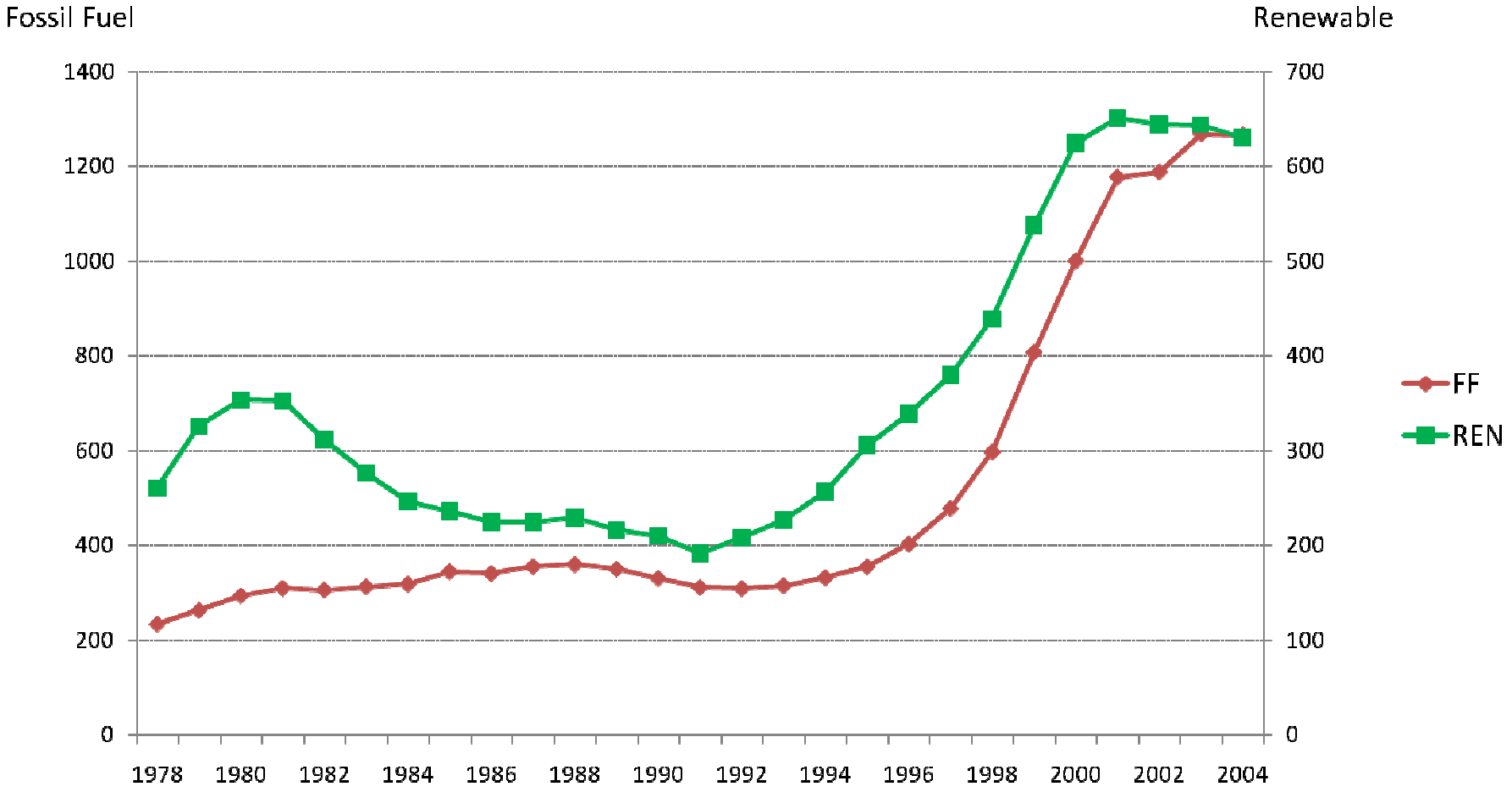
Technological 'Generations': The Case of Solar Power



OECD OCDE

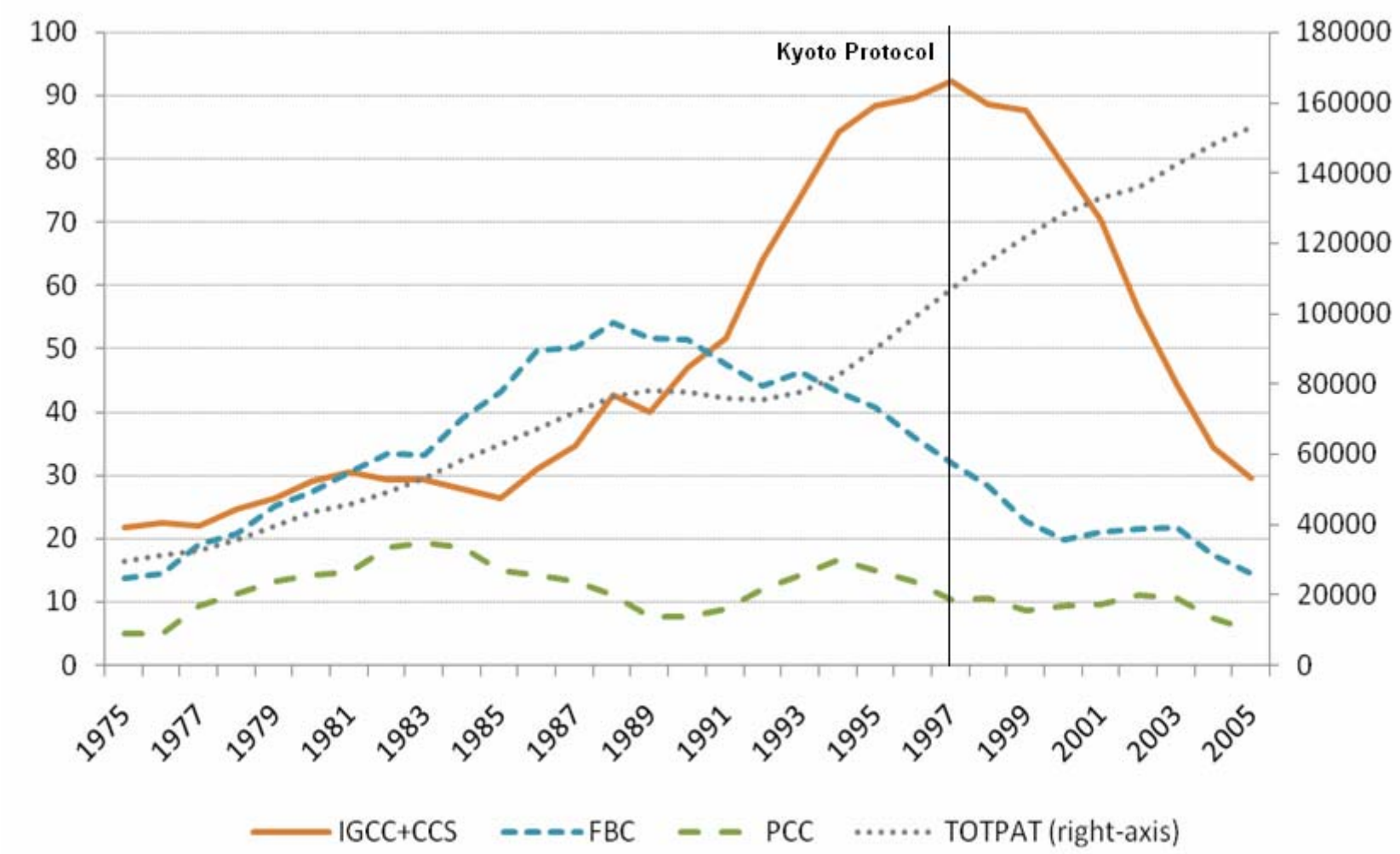
Electricity Generation Innovations

(claimed priorities worldwide)



Inventive Activity in ‘Clean Coal’ Technologies

(Number of claimed priorities worldwide, 3-year moving average)

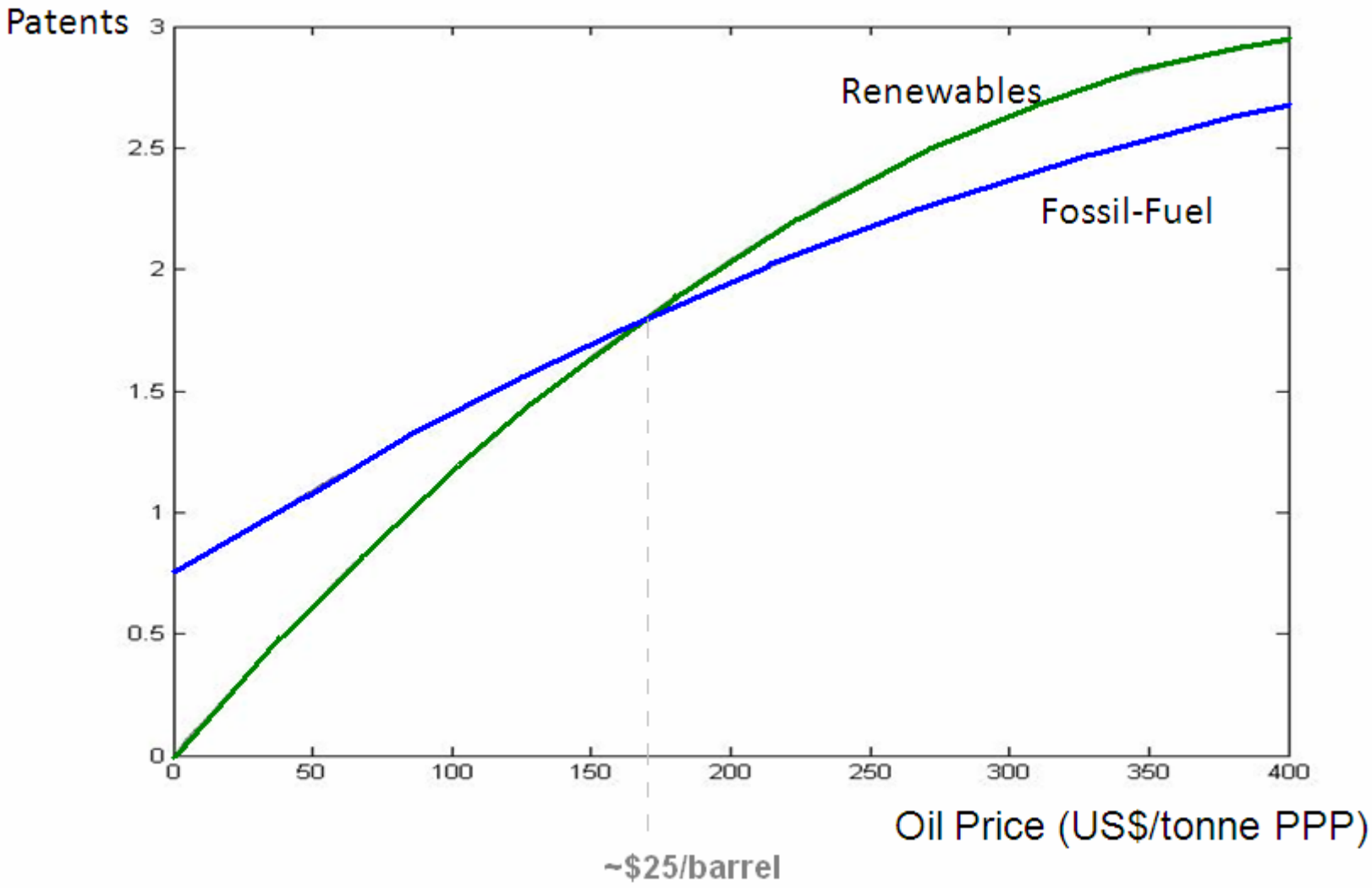


What Encourages Innovation in CC Technologies? Evidence from Renewable Energy

	Wind	Solar	Geothemal	Ocean	Biomass & Waste	All Renewables
Electricity Price	1.465	14.140***	-7.405	-4.015	-7.097	2.861
Growth of Electricity Cons.	-0.012	0.012	0.036	-0.035	0.015	-0.004
Total EPO Filings	0.063**	0.062***	-0.036	-0.011	-0.022	0.014
Specific R&D Expenditures	14.858**	3.224***	4.084*	12.355	-0.387	0.830***
Feed-in Tariff levels	-0.046**	0.042***	0.023	-0.041	-0.071	0.005
REC targets	0.205**	-0.028	28.630**	0.023	0.019	0.102*
Kyoto Protocol	0.605***	0.381***	-0.461	0.061	-0.045	0.585***
Investment Incentives	-0.249	0.228	0.925*	0.086	0.765***	0.201*
Tax Measures	0.222	0.140	0.048	1.078	0.152	0.091
Guaranteed Price	-0.920***	0.899***	-0.938	-0.339	-0.194	-0.386*
Voluntary Programs	0.186	0.009	0.201	0.405	0.220	-0.117
Obligations	1.029***	-0.027	-0.031	0.599	-0.283	0.333**

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1088674

Oil Price and Inventive Activity



Summary of Preliminary Evidence on Determinants of Innovation

- Prices matter – i.e. barrel of oil for renewable energy generation and fuel price for motor vehicles

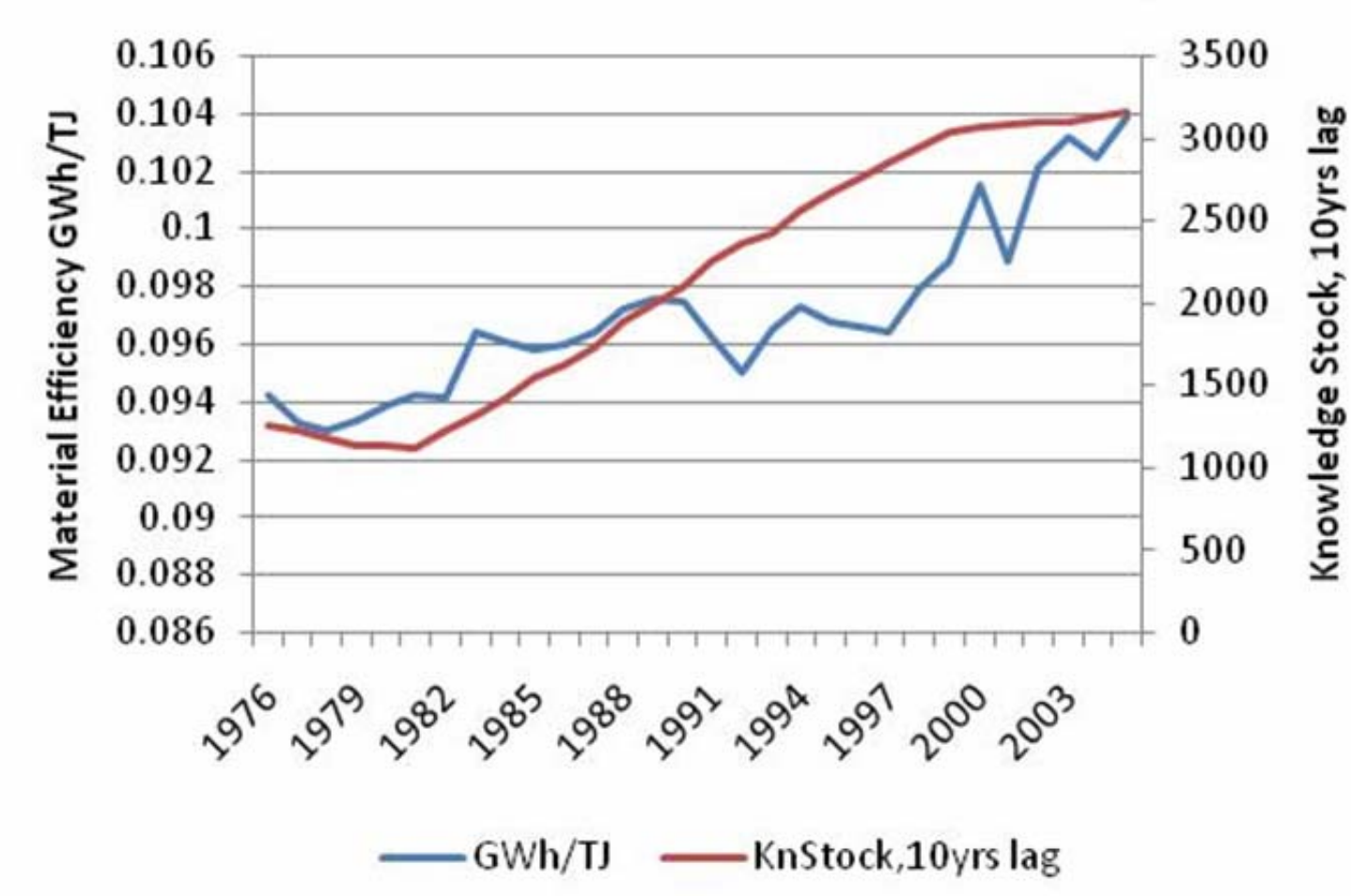
- But for technologies which are less mature (e.g. solar concentrating power or electric vehicles) public expenditures on R&D are important

- In addition – less mature technologies require 'certainty' in policy incentives in order to induce innovation (e.g. price vs quantity incentives, and general policy stability) – see http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1370336

- General scientific capacity in all areas is the biggest 'driver' of innovation

Downstream Effects of Innovation

Knowledge Stock and Energy Efficiency in Power Plants



Effect of Innovation of Energy Efficiency in the ESI Sector

	(1)	(2)	(3)
Coal Share / Total Input	-0.0209***	-0.0197***	-0.0195***
Capacity Utilization Ratio	0.0762***	0.0677***	0.0655***
Average Capacity Increase from t-5	0.0108***	0.0102***	0.0098***
Knowledge Stock (CP)	0.0472***		
Knowledge Stock (CP - SIN)		0.0432***	
Knowledge Stock (CP - SIN - DUP)			0.0392***
Constant	-1.2495***	-1.2655***	-1.2592***
Adj.R-Square	0.83	0.84	0.84
N	535	535	535

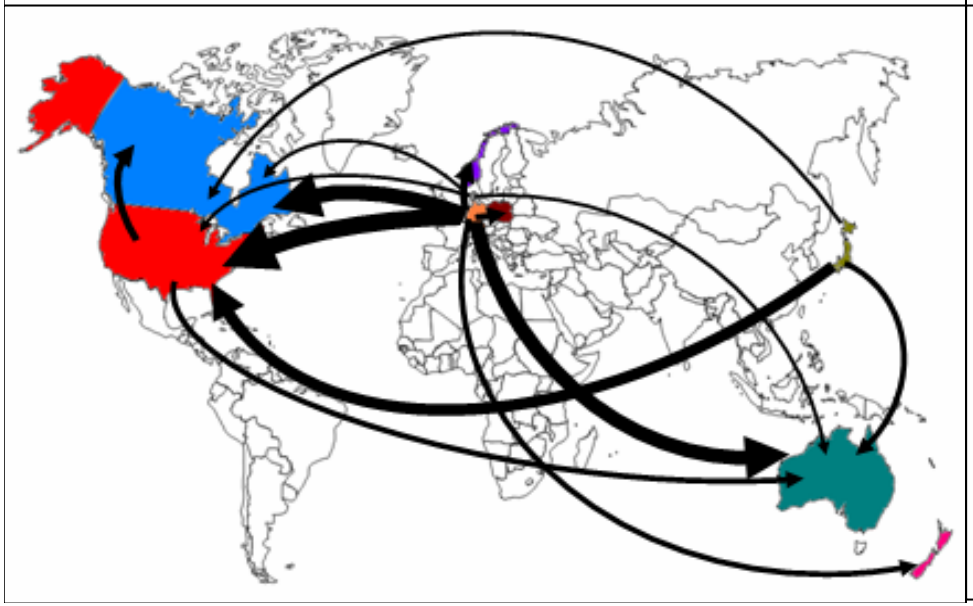
Top Ten Source and Recipient Countries of CC Technologies

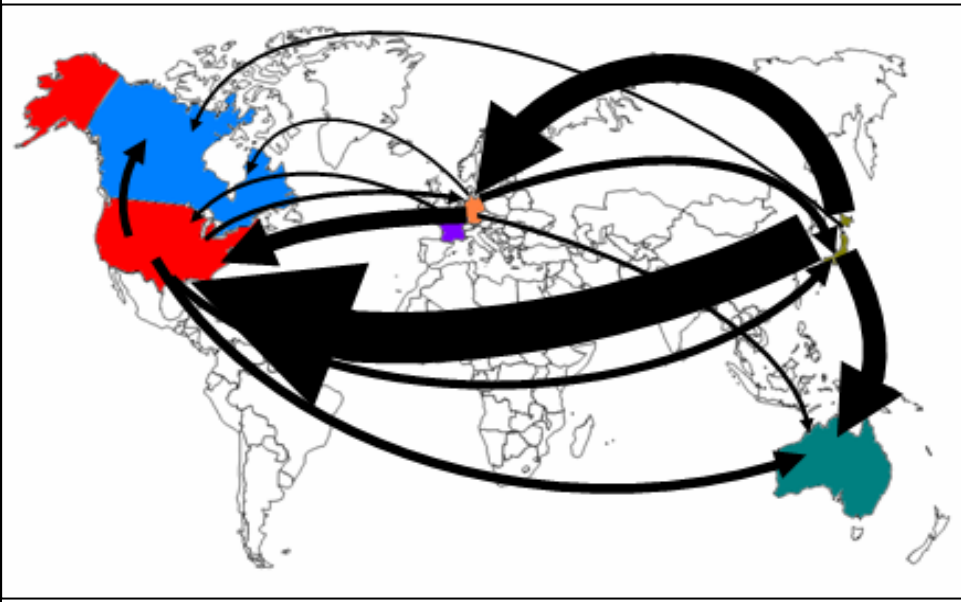
(Number of duplicate patent filings, 1985-2004)

Source \ Recipient	US	DE	JP	CN	CA	KR	AU	BR	TW	GB
JP	6504	2641	-	2040	505	1891	412	67	902	302
DE	3589	-	1976	938	772	380	441	509	111	476
US	-	1815	1826	823	1925	370	818	460	206	375
GB	780	526	350	149	291	65	205	88	24	-
KR	812	69	777	619	14	-	48	5	74	33
FR	363	389	186	99	190	43	101	98	9	13
IT	210	199	89	59	49	9	34	67	8	22
NL	140	145	65	45	69	13	54	34	2	7
AT	115	228	44	24	32	10	30	20	3	5
SE	113	95	23	28	47	6	48	27	4	5

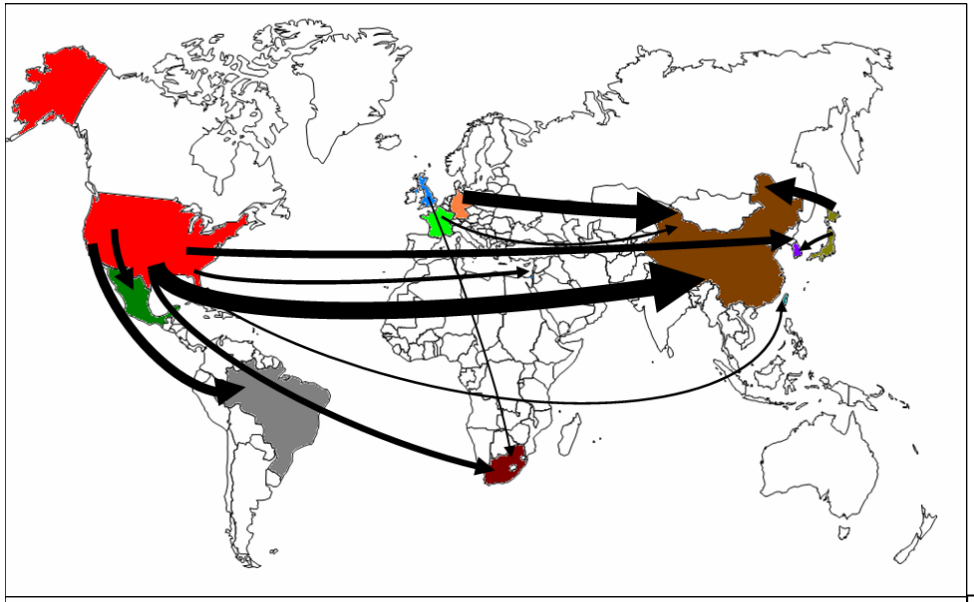
Transfer of Climate Change Mitigation Technologies amongst Annex 1 Countries

- IGCC/CCS
  - Wind power
    - Solar photovoltaics

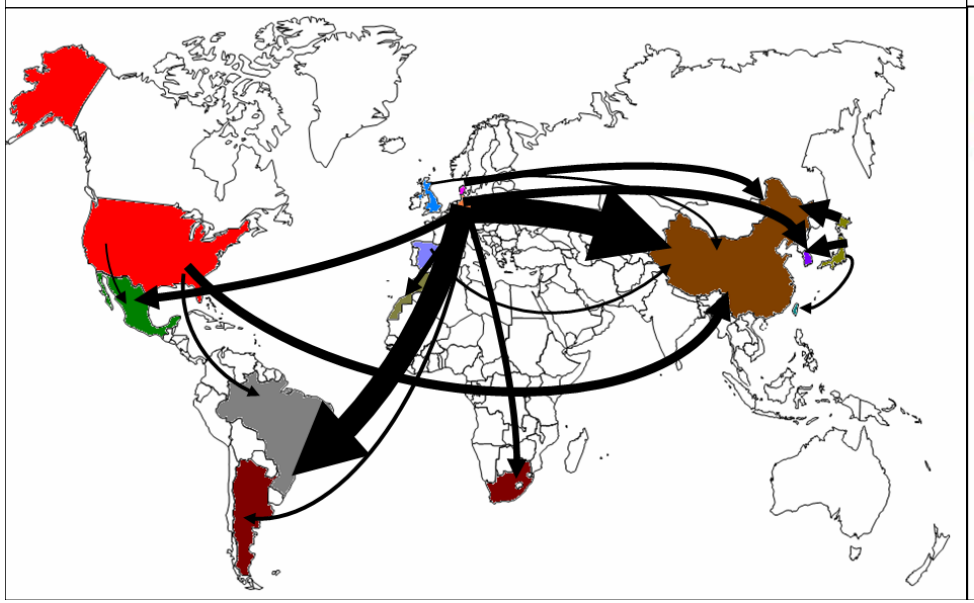


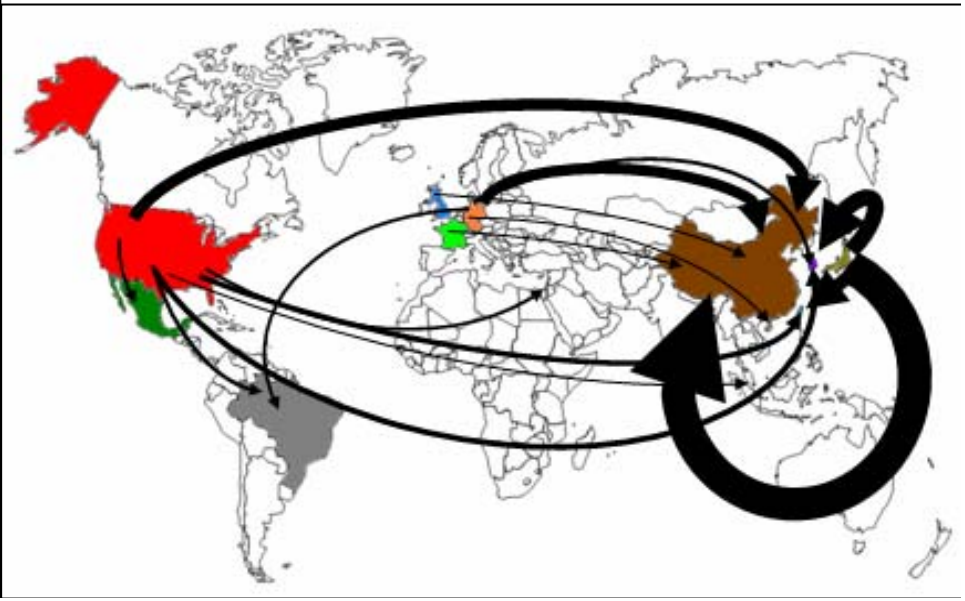


Transfer of Climate Change Mitigation Technologies to non-Annex 1 Countries



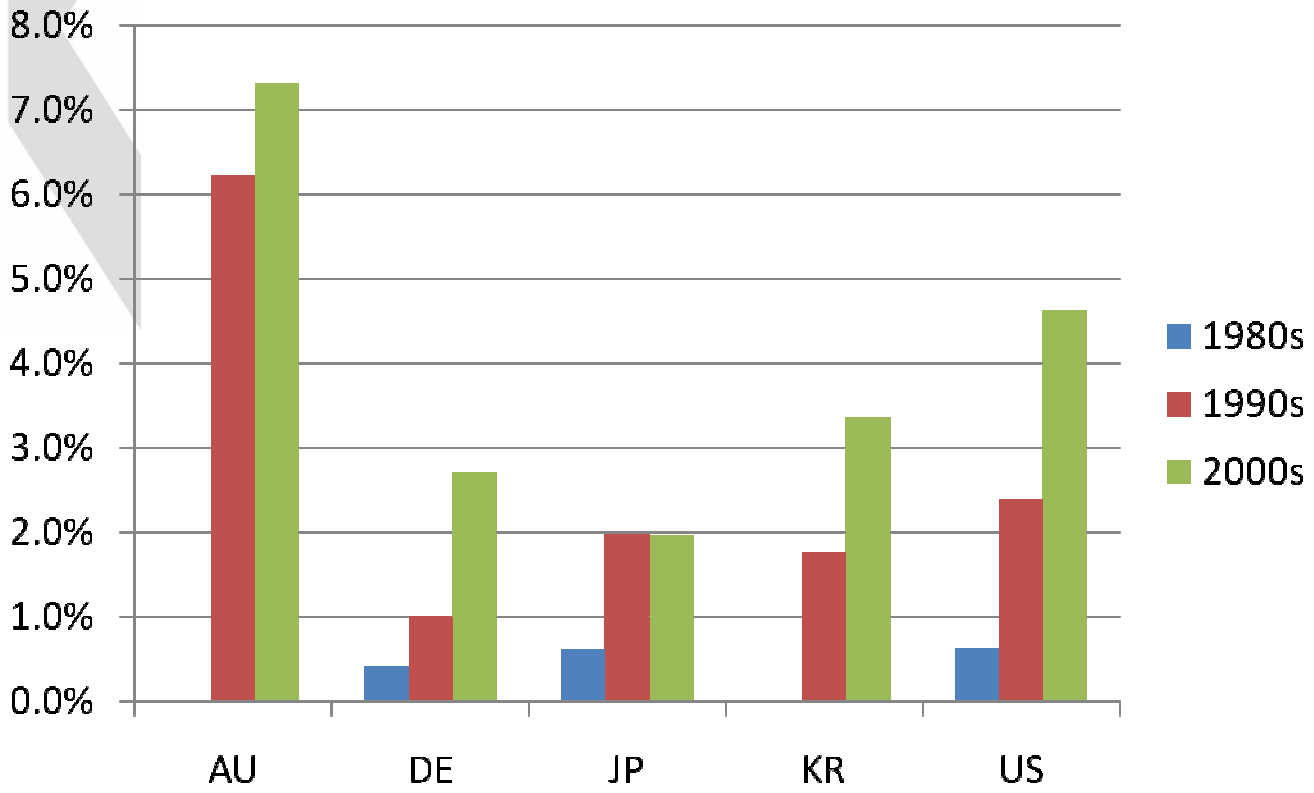
- IGCC/CCS
  - Wind power
    - Solar photovoltaics





Transfer of Solar Power Technologies to China

(% of country's worldwide transfer)



OECD OCDE

Climate Change Policies and Transfer
(Negative binomial regression, with fixed effects)

Dependent variable: CCTT_ijt	*i* = Annex1 *j* = non-Annex1 with DNAs *t*=2000-2006
Degree of Involvement in CDM Projects (CDM_ijt)	3.97E-07*
Absorptive Capacity (CCPAT_jt)	2.40E-03***
Available Stock of Inventions (ASTOCK_it)	6.41E-04***
Electricity Consumption (CONS_jt)	2.16E-06***
Total Technology Transfer (TOTALTT_ijt)	8.38E-04
Intercept	-6.5121***
N	8440
Log pseudolikelihood	-509.47
(Prob > Chi2)	0.000

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1370362

Related Work and Next Steps

- Further assessment of the determinants (including policy design) of innovation in CC mitigation technologies in different areas;
- Analysis of the economic (e.g. energy efficiency) and environmental (e.g. CO2 emissions) implications of such innovation;
- Analysis of the determinants of transfer of CC mitigation technologies – relative prices, climate policy, int'l cooperation, absorptive capacity, economic 'openness', IPRs, etc.; and,
- Use of micro-data (Orbis/Amadeus) to analyse firm-level determinants of innovation and transfer