Innovations in Energy Technologies and their Externalities: How Improve Economic Modeling

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Introduction

- In order to address the problem of global warming:
  - Policies have to target the development and the diffusion of some technologies (Green tech., SET plan);
  - Innovation in energy related technologies is a major challenge.

- The ex-ante macro-economic impact assessment requests making the links between technological innovation and the socio-economic performances (productivity, employment, etc.)

- An important main indirect effect of innovation:

  Knowledge spillovers

Introduction

- Main indicators of technology innovation according to technological classification (Patent acc. to IPC)
- Main economic indicators according to economic sector classification (R&D, employment, productivity, etc.)
- Neither injection nor surjection between the two types of classification

Introduction

- Aim of the study:
  - Assess international and intersectoral knowledge spillovers specific to energy technologies
  - Implementation of the result in the NEMESIS model

Introduction

- There are several channels for knowledge spillovers:
  - Economic transactions, e.g.:
    - Trade (Input-Output)
    - Foreign Direct Investment (FDI)
  - Disembodied, e.g.:
    - Patent citations
    - Labor mobility

Introduction

- Some recent related literature
  - Pillu & Koléda (2009): induced innovation and knowledge spillovers (*intratechnology*)
  - Verdolini et al. (2009): induced innovation and knowledge spillovers (*intratechnology*)
  - **Braun et al. (2010): international and intersectoral spillovers based on patent data and concordance table**
  - Dechezleprêtre et al. (2012): international technological transfert of CCMT based on patent data
  - OECD (2012): descriptive analysis of CCMT innovation at international level

Methodology

- The construction of international/intersectoral knowledge flow matrices based on patent citations and on a technology-sectors concordance table.

  (Meijers & Verspagen, Demeter Project 2010)

- Specific matrices for each energy technology

Methodology

- PATSTAT database
  - approx. 64 million patents and nearly 90 million citations;
  - Among other information, inventors are known by country.
  - Patents are classified according to the International Patent Classification;

- OECD concordance table (Johnson, 2002) (OCT thereafter)

  Allocates each patent classes both to the most likely
  - Industries Of Manufacturing (IOM);
  - Sectors Of Use (SOU).

  (Other concordance tables were done, e.g. Schmoch et al., 2003)

Methodology

- Sample
  - Only patent families
  - Fix citation window of 5 years
  - USPTO, EPO and WIPO
    (JPO does not provide country of inventor for most patents)
  - By country (EU27+NO+JP+US+RoW) and by sector (34 sectors)
  - From 1990 to 2003 for cited patents (1990 to 2007 for citing patents)

An update with new PATSTAT database (Oct. 2012) is going to be done

Methodology

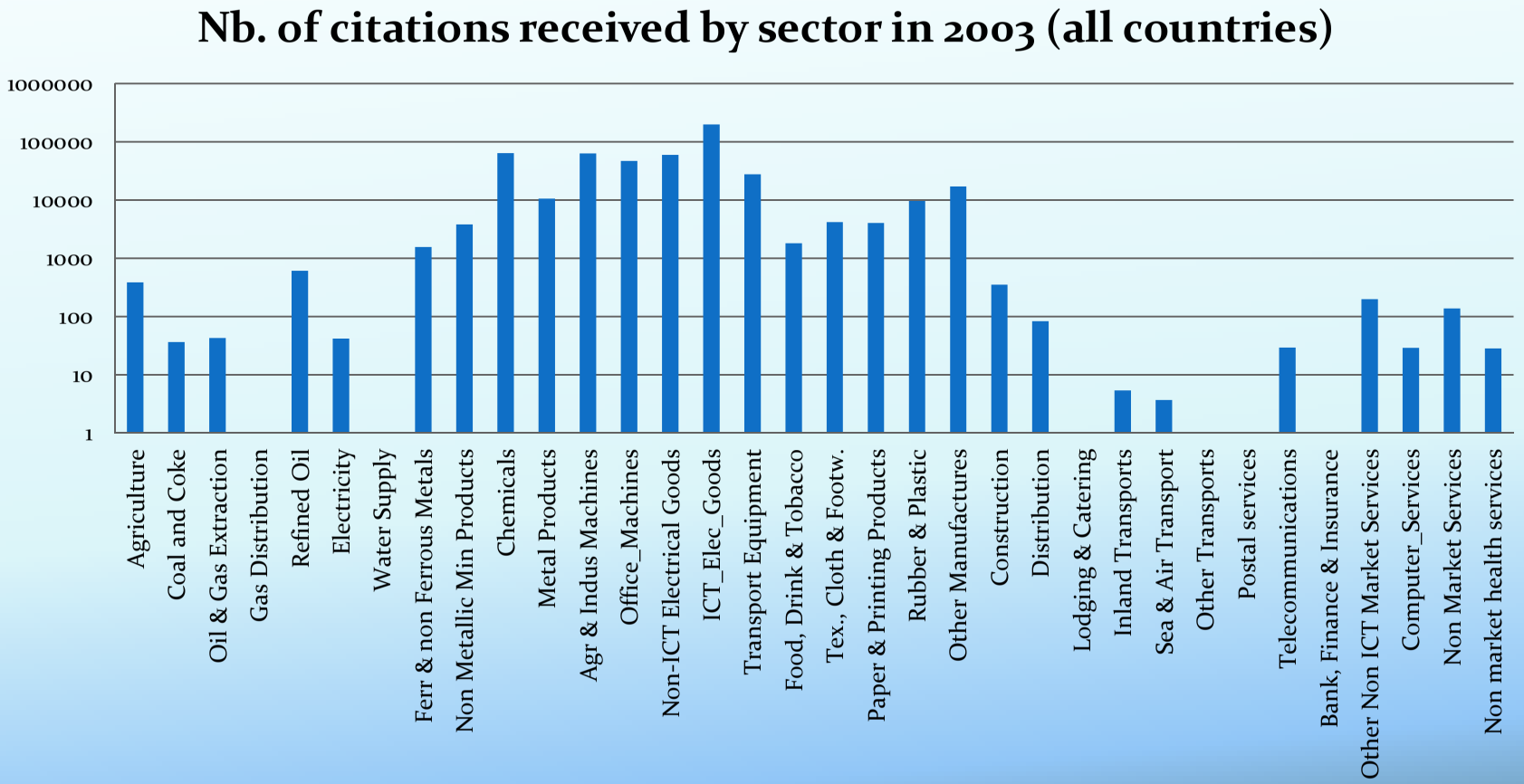
- The country of ***origin (resp. destination)*** of the knowledge spillover is defined by the country of residence of the inventor of the ***cited (resp. citing)*** patent family
- Each cited and citing IPC is distributed to its IOMs according to the OECD Concordance Table
- Each citation is spread according to the number of
  - Countries of inventors (for both cited and citing invention);
  - IOMs which IPC belongs to (for both cited and citing side).

Methodology

X_{qikj} : Number of citations received by patents with IOM "i" in country "q" issued from patents with IOM "j" in the country "k" (size = $(P*N)^2$)

Countries		C_1			...			C_k			...	C_P		
	IOM	S_1	...	S_N	...	S_1	...	S_i	...	S_N	...	S_1	...	S_N
C_1	S_1													
	...													
	S_N													
...	...													
C_q	S_1													
	...													
	S_i							X_{qikj}						
	...													
	S_N													
...	...													
C_P	S_1													
	...													
	S_N													

Results for all technologies



Isolation of energy technologies

- The construction of the matrices can also be done by taking technological subclasses or even one single subclass into account.

- Ex.: Isolation of energy technology:
  - 2 submatrices for each technology taking into account only the relevant IPC
    - In cited side (spillovers generated by these technologies)
    - In citing side (spillovers received by these technologies)

Isolation of energy technologies

- A first focus on Wind technology
  - Submatrices taking into account only wind-energy related patent family
    - In cited side: which sectors/countries benefit from innovation in wind-energy technology?
    - In citing side: which sectors/countries create knowledge useful for wind-technology innovation?

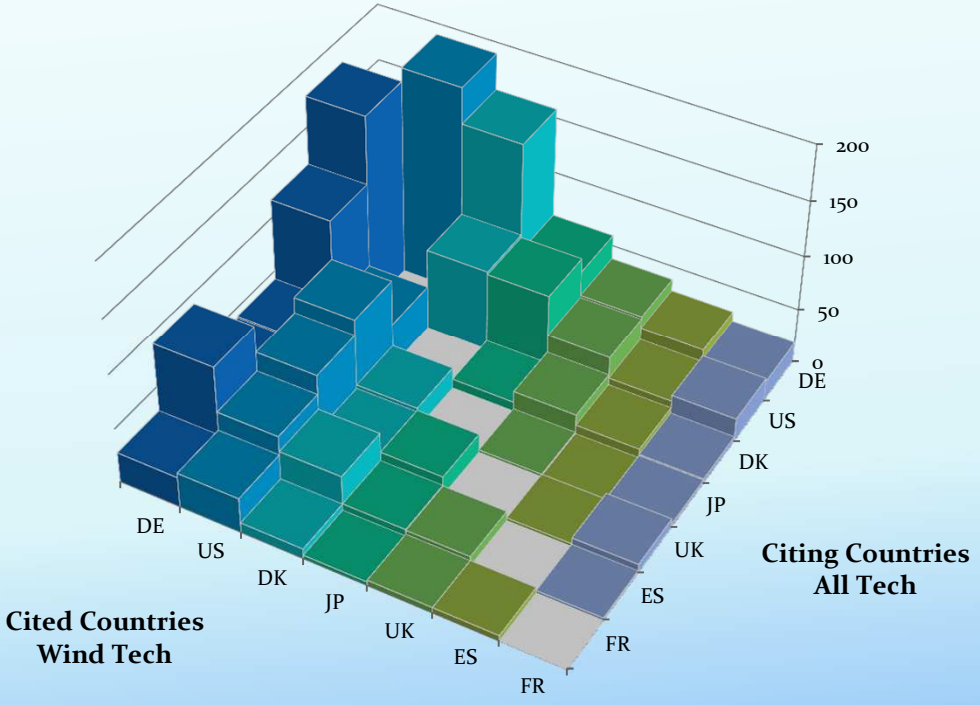
Isolation of energy technologies

- A first focus on Wind technology
  - Selection of IPC: F03D (wind motors)

IPC for wind energy technologies	
F03D001	Wind motors with rotation axis substantially in wind direction
F03D003	Wind motors with rotation axis substantially at right angle to wind direction
F03D005	Other wind motors
F03D007	Controlling wind motors
F03D009	Adaptations of wind motors for special use; Combinations of wind motors with apparatus driven thereby
F03D011	Details, component parts, or accessories not provided for in, or of interest apart from, the other groups of this subclass

- A first focus on Wind technology
  - A first raw observation on international citations

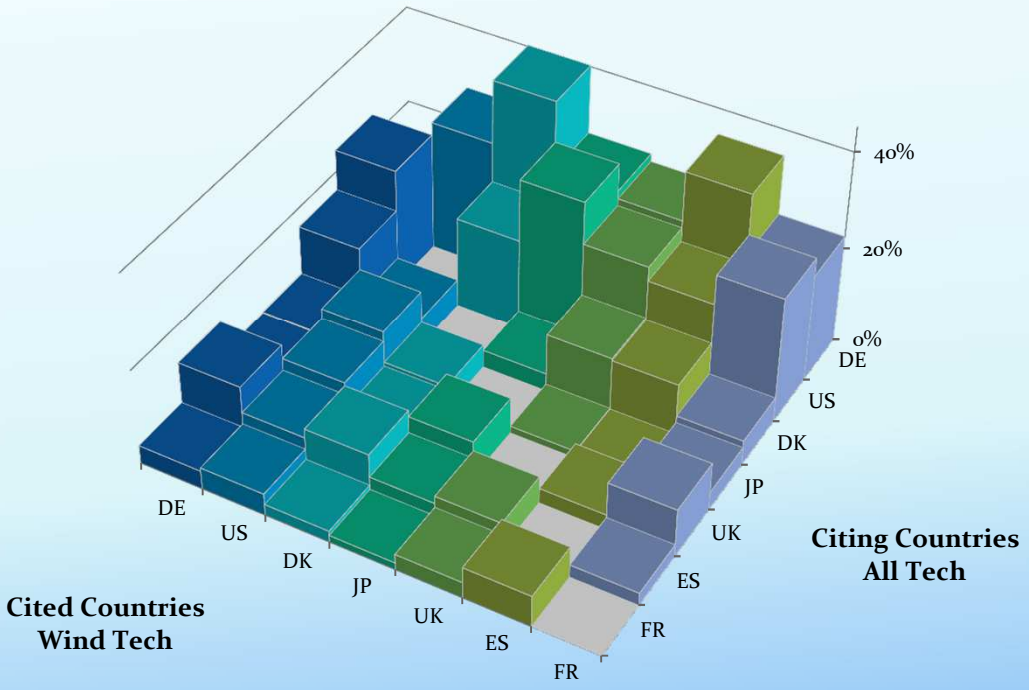
Period 1990-2003



Note: Intranational citations set to 0

- A first focus on Wind technology
  - normalization w.r.t. intranational citations

Period 1990-2003



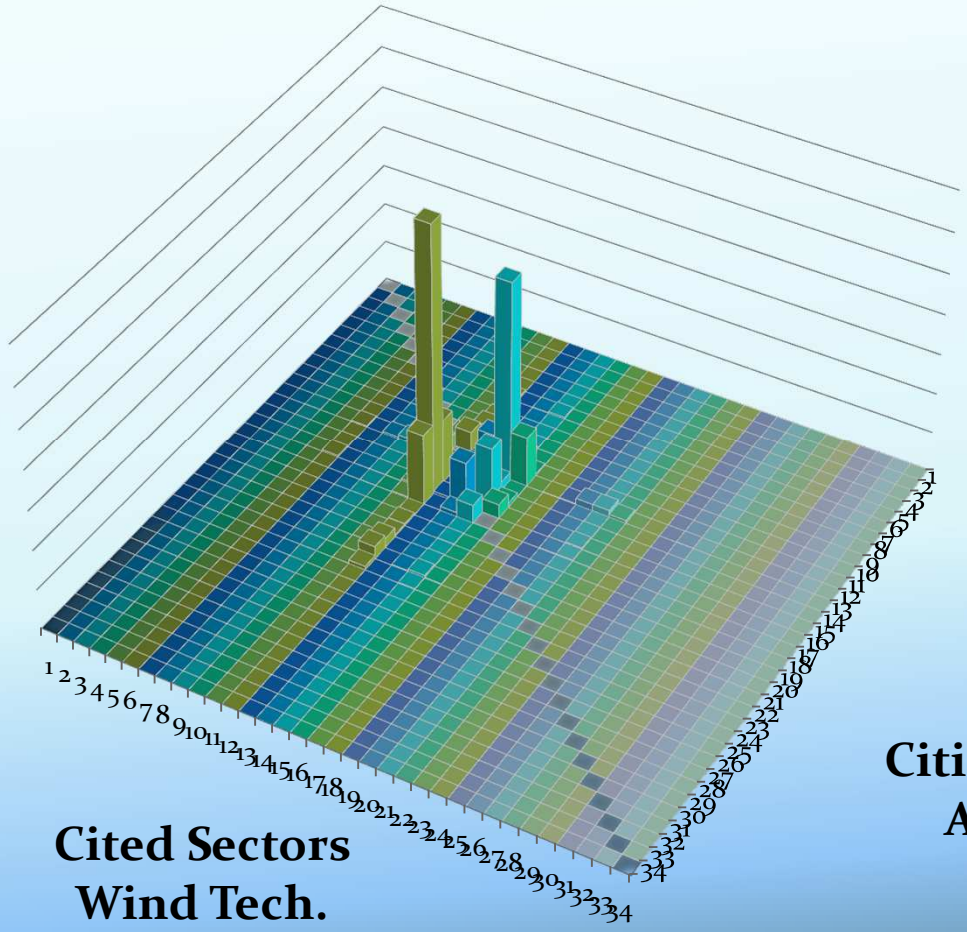
Isolation of energy technologies

- A first focus on Wind technology
  - Sectors (IOM) involved in wind-energy related technology:

Johnson's IOM in SIC-E classification	Our classification
3111 Agricultural Implement *(only 2% of the class F03D003)*	
3190 Other Machinery and Equipment Industries	
3191 Compressor, Pump and Industrial Fan	12 Agr & Indus Machines
3194 Turbine and Mechanical Power Transmission Equipment	
3199 Other Machinery and Equipment Industries n.e.c.	
3379 Other Electrical Industrial Equipment Industries	14 Non-ICT Electrical Goods
3911 Indicating, Record. and Control. Instrument *(5% of F03D007)*	15 ICT Electrical Goods

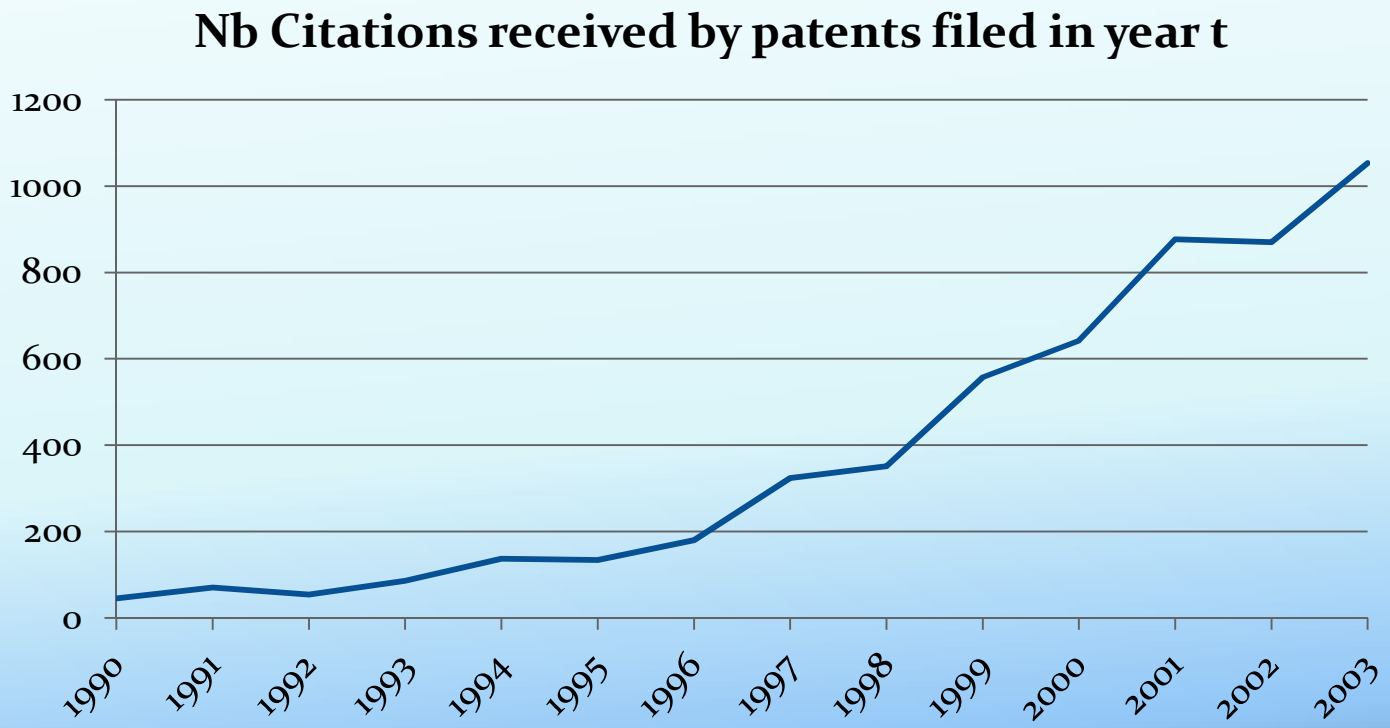
- A first focus on Wind technology
  - A first raw observation on intersectoral citations

F03D on the cited side



Isolation of energy technologies

- A first focus on Wind technology



Isolation of energy technologies

- Technology groups that can be isolated

ENERGY SOURCES	**TRADITIONAL ENERGY**	**FOSSIL FUEL ENERGY**
	RENEWABLE ENERGY	***SOLAR***
		WIND
		BIOFUELS
		GEOTHERMAL
		OCEAN
	OTHER ENERGY PRODUCTION FOR EMISSION MITIGATION	***HYDROENERGY***
		HYDROGEN & FUEL CELLS
		NUCLEAR
ENERGY SAVING/EFFICIENCY	ENERGY MANAGEMENT	ENERGY STORAGE
		OTHER ENERGY EFFICIENCY
	ENERGY DEMAND	TRANSPORTATION
		CONST. & APP. & EQUIP.
POLLUTION CONTROL		CARBON CAPTURE AND STORAGE

Isolation of energy technologies

- Sectors (IOM) involved in solar-energy related technology (not only PV)

10	Chemicals
11	Metal Products
12	Agr & Indus Machines
13	Office_Machines
14	Non-ICT Electrical Goods
15	ICT_Elec_Goods
16	Transport Equipment
22	Construction

Limits and comments

- Patent data:
  - Do not cover all inventions;
  - Patent citations are not the only channel of knowledge spillovers;
  - However they provide very detailed data and cover a large range of material innovation (Guellec and Pottelsberg, 2002)
    It should be relevant for energy technologies we want to study

Limits and comments

- Some biais on patent citations
  - The propensity to patent differs across sectors, countries and over time;
  - The propensity for a given sector to cite/to be cited depends of its weigh in term of patent number;
  - → some corrections must be made using the number of patents

Limits and comments

- Concordance table:
  - The Johnson's concordance is based on Canadian patents from 1975 to 1995, therefore is old and cannot necessarily be applied generally (despite the author's checks) (results may be check using another concordance table: Schmoch et al., 2003 for instance)
  - Renewable energy technologies are relatively recent
  - However the relatively weak level of sectoral breakdown (34 sectors) limit the potential errors

Conclusion

- The innovations in energy technologies is not only the matter of energy sectors. Many industries are involved, especially industrial equipment industries.
- This study try to transfer knowledge interaction between technologies to knoweldge interaction between sectors
- Upcoming developments:
  - Correction of patent citations matrices
  - Estimation of knowledge flows linked to energy technologies
  - Calibration of R&D/energy technology for NEMESIS

Thank you

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