Innovations in Energy Technologies and Knowledge Spillovers

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I. Introduction

- In order to address the problem of global warming:
  - Policies have to target the development and the diffusion of some technologies and to provide incentives for the energy transition (Green tech., SET plan, DNTE);
  - In order to overcome the problem of the cost of the energy transition, innovation in energy-related technologies is a major challenge.

I. Introduction

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

I. Introduction

- Innovations have:
  - Direct effects:
    - Improve quality/ decrease prices
    - Increase productivity
  - Indirect effects:
    - Changes of the production/demand structure
    - **Knowledge spillovers**

I. Introduction

- Knowledge spillovers:
  - "*The development of thin, long and strong steel wires for use in the lining of radial tires*" inducing the "*emergence of wire saws that could slice ingots of silicon crystals into increasingly thin wafers*" which benefit to the production of photovotaic cells.
  - Contribution of the knowledge from marine and aerospace to wind power technology

I. Introduction

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

I. Introduction

- Aim of this research program:
  - Establish indicators of innovation by technology at macro and sectoral level (private R&D not available by technology; patents not related to sectors)
  - Assess international and intersectoral knowledge spillovers specific to energy technologies for a macro-sectoral analysis and impact assessment

II. Methodology

- 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
  - Nemet (2012): Inter-technology knowledge spillovers for energy technologies

II. Methodology

- PATSTAT database
  - approx. 64 million patents;
  - 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)

II. Methodology

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

  (Meijers & Verspagen, Demeter Project 2010)

II. 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													

II. Methodology

- Specific matrices for 12 energy-related technology groups:

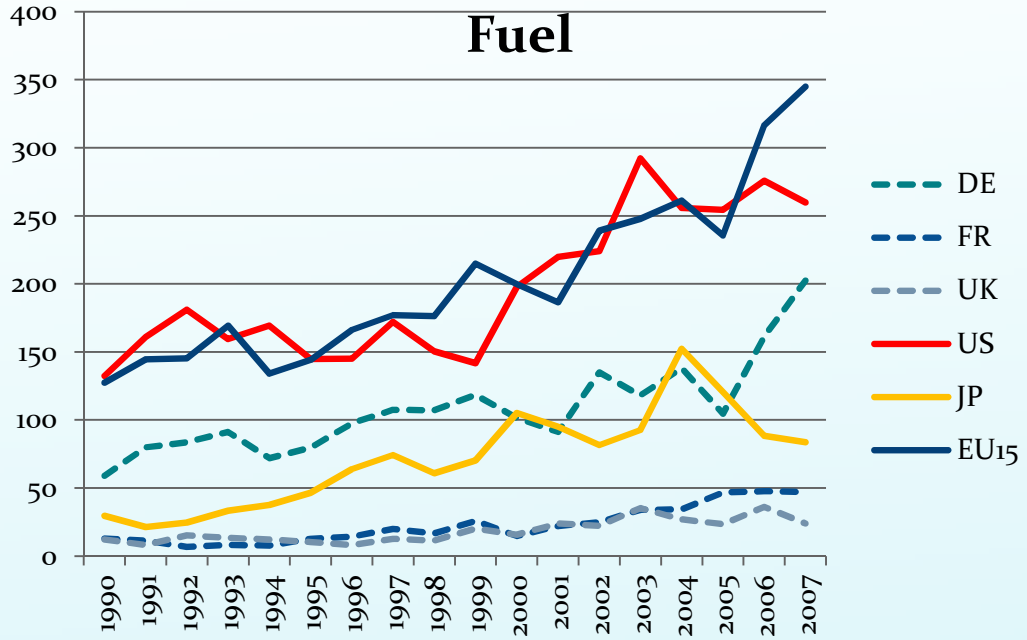
1. Biofuels
2. Building
3. CCS
4. Energy Storage
5. Fuel Based
6. Fuel Cells
7. Geothermal
8. Nuclear (Reactor and other)
9. Ocean Hydro
10. Solar (PV & CSP)
11. Transport
12. Wind

III. Innovation in Energy-related technologies

- Indicator of innovation :

The number of patents filed at USPTO or EPO and cited at least ones by patents filed in these same offices during the 5 following years

- Results at macro level: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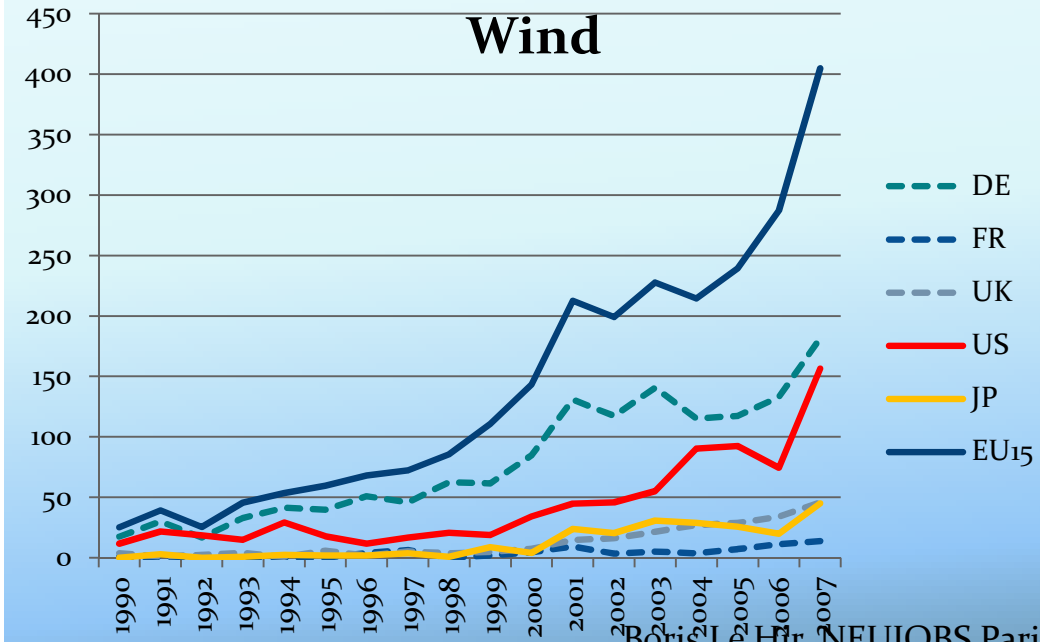
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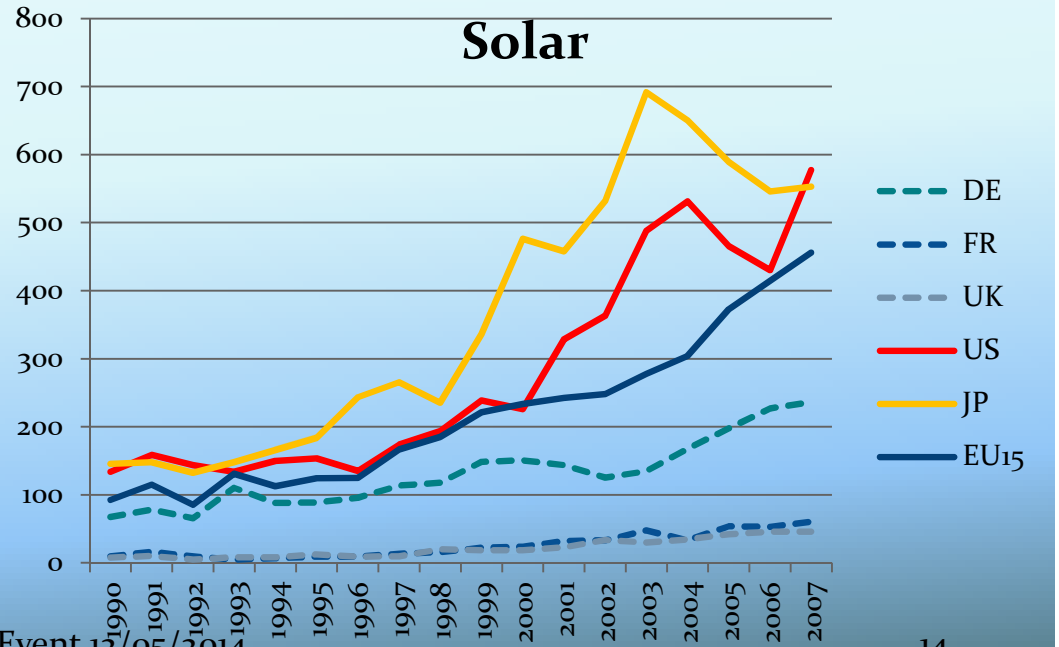
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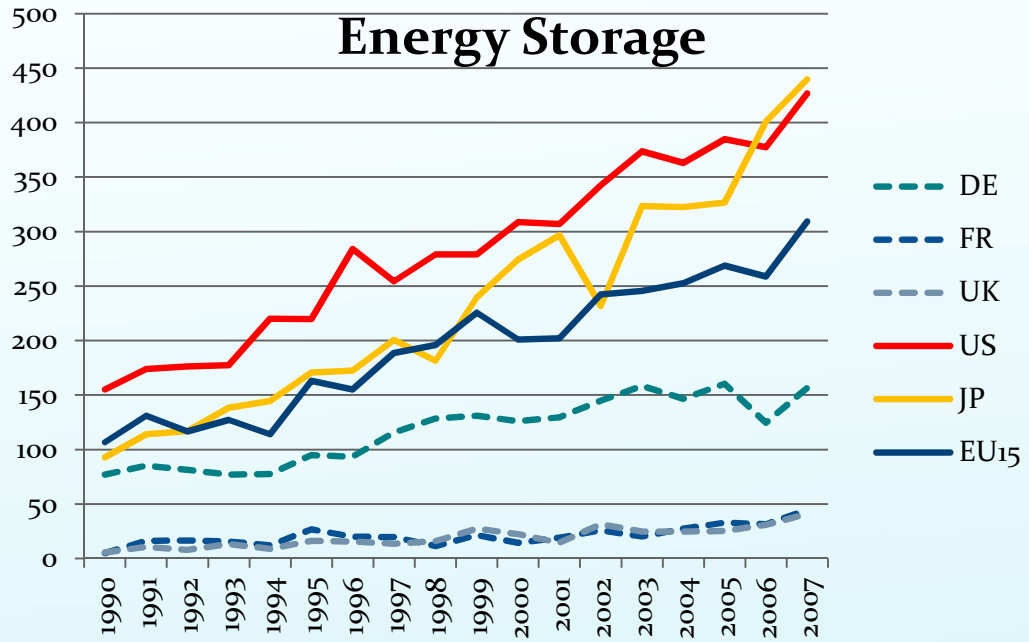
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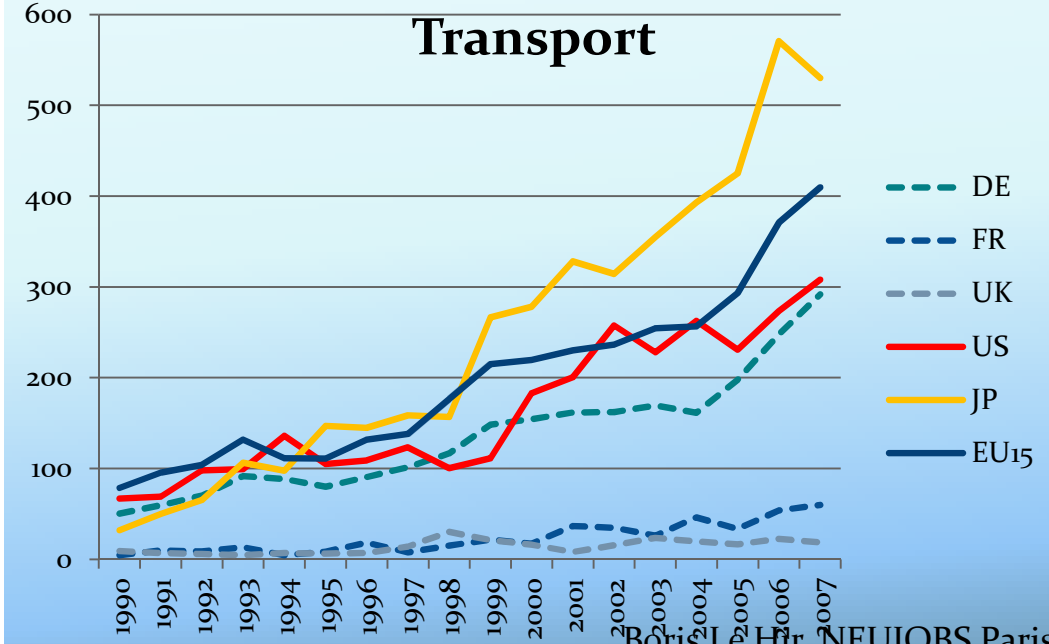
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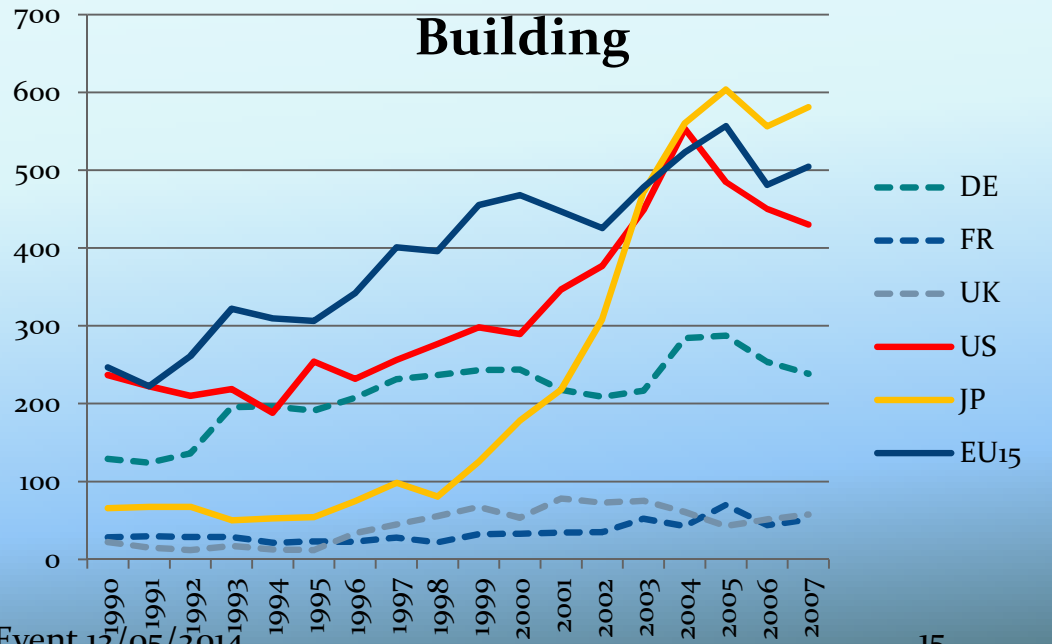
Building
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1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
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JP
EU15

III. Innovation in Energy-related technologies

- Indicator of innovation at macro level:
  - Similar trends among countries/regions but with different degrees
  - EU15 relatively close to the U.S.
  - Germany is a leading country in EU

III. Innovation in Energy-related technologies

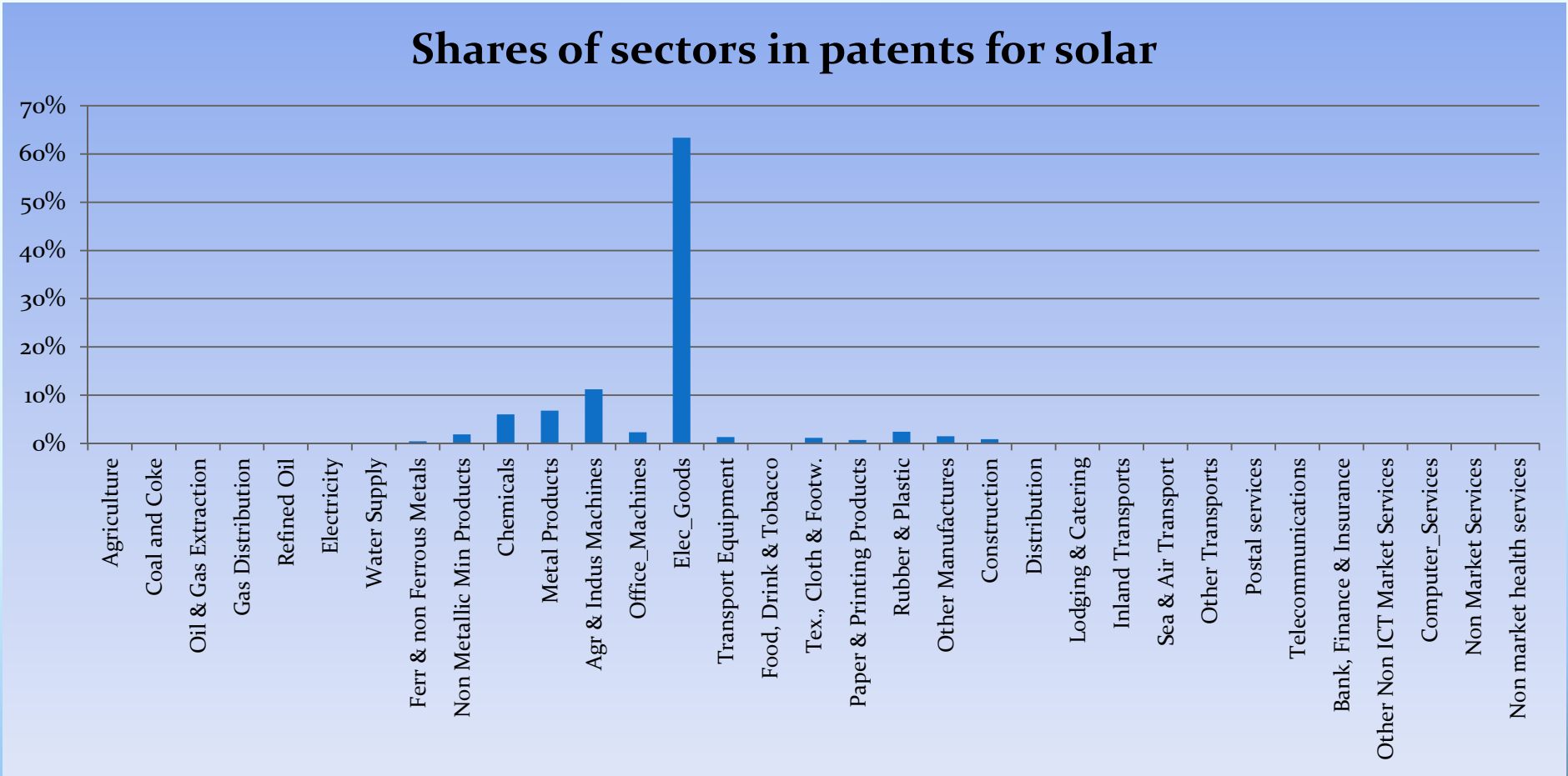
- Indicator of innovation at macro level:

Another indicator may consist in taking the share of the previous indicator for each energy related technology with respect to all technologies

- Similar observations with an increase of the innovation in energy efficiency and in ER

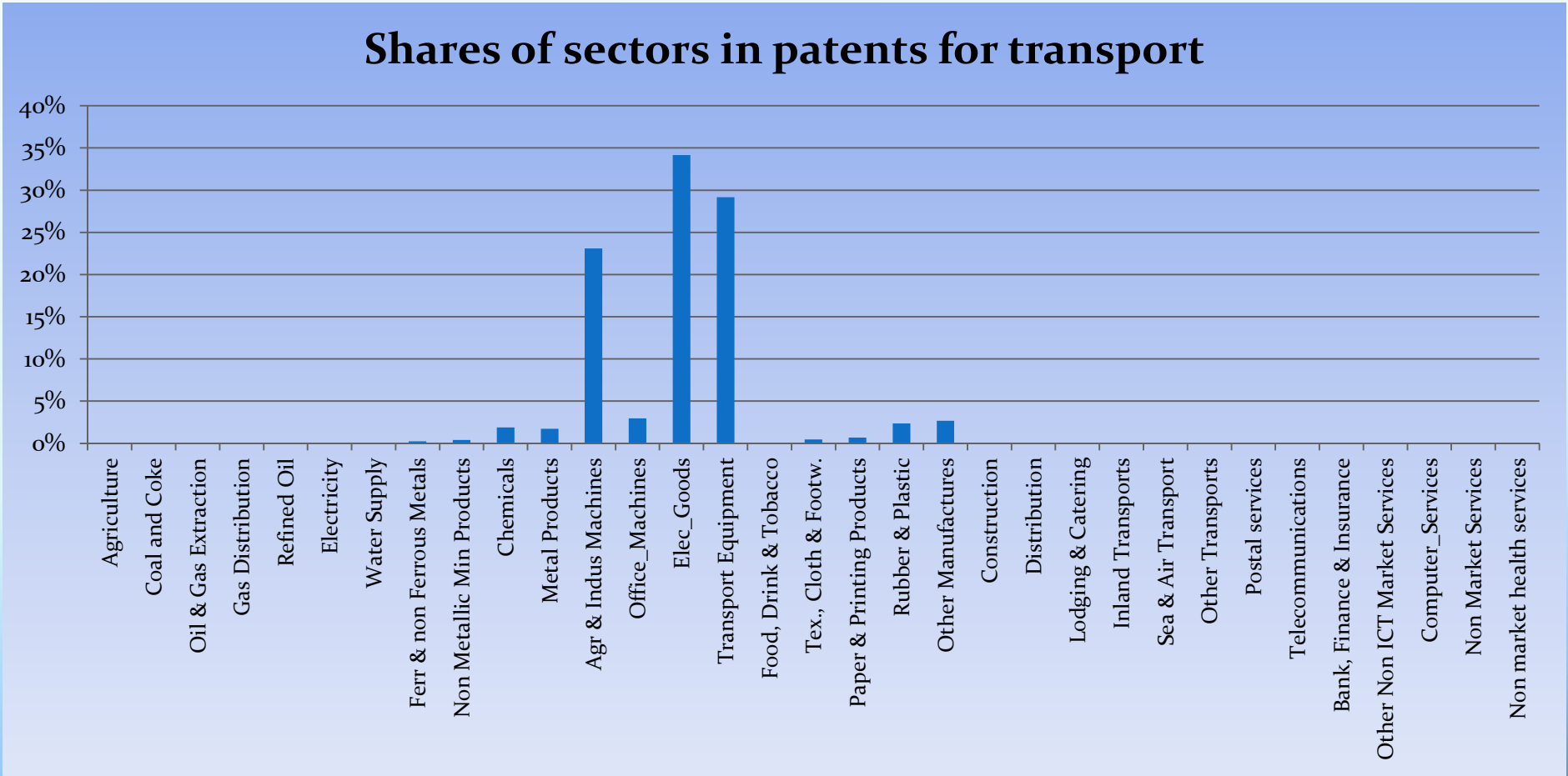
III. Innovation in Energy-related technologies

- At sectoral level



III. Innovation in Energy-related technologies

- At sectoral level



III. Innovation in Energy-related technologies

- At sectoral level

Even if the results strongly depends on the method for the allocation of patent among sectors:

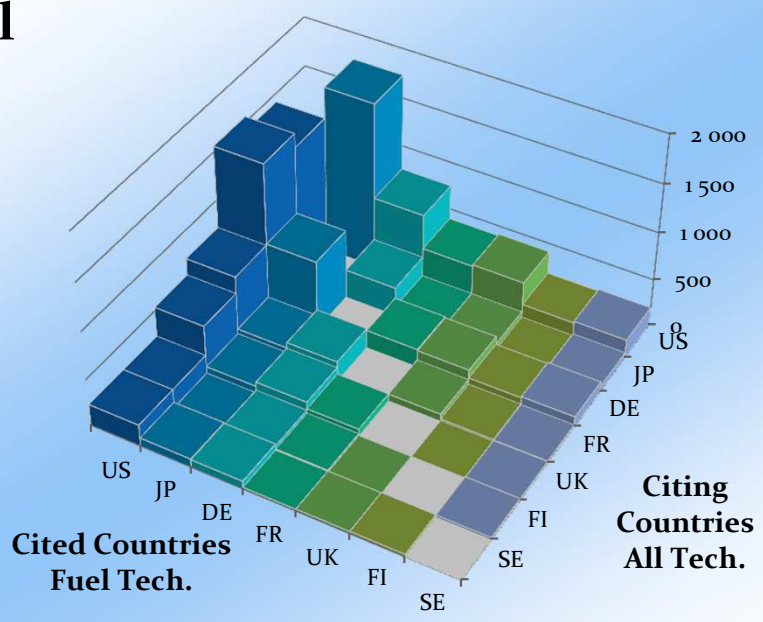
- The energy producer sectors are not necessary the main sectors where the innovations occur
- Innovation in energy-related technology involves a large range of sectors

IV. Knowledge spillovers

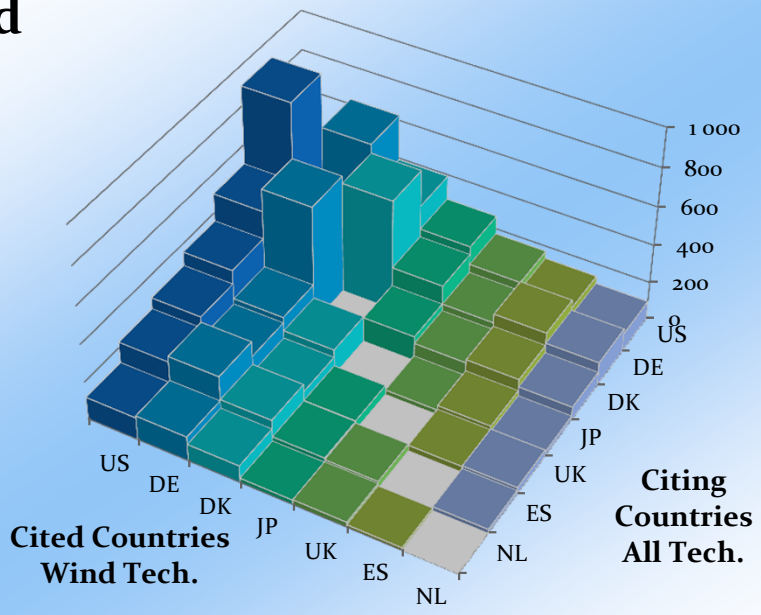
- Indicator of knowledge spillovers based on patent citations

- Results at macro level:

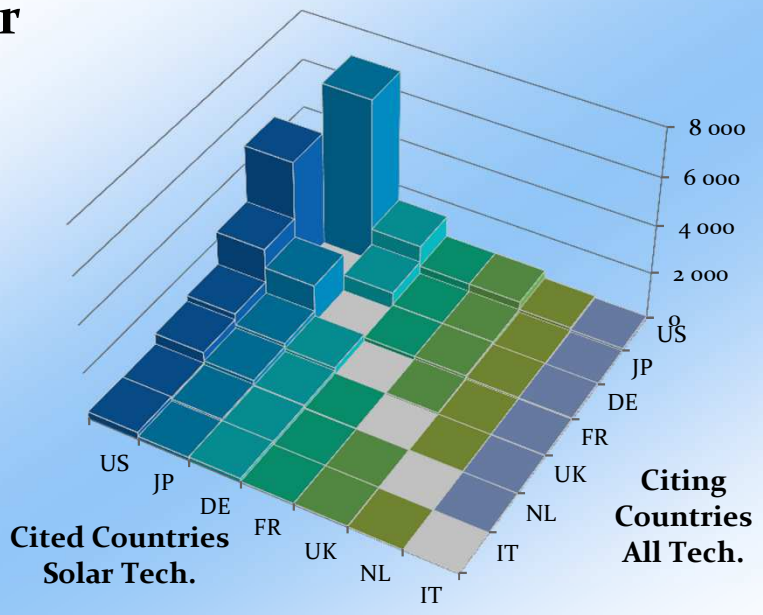
Fuel



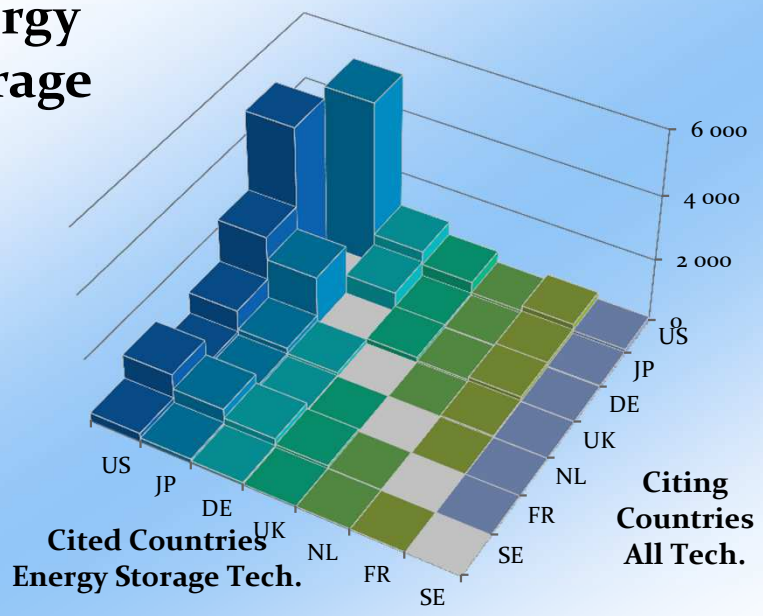
Wind



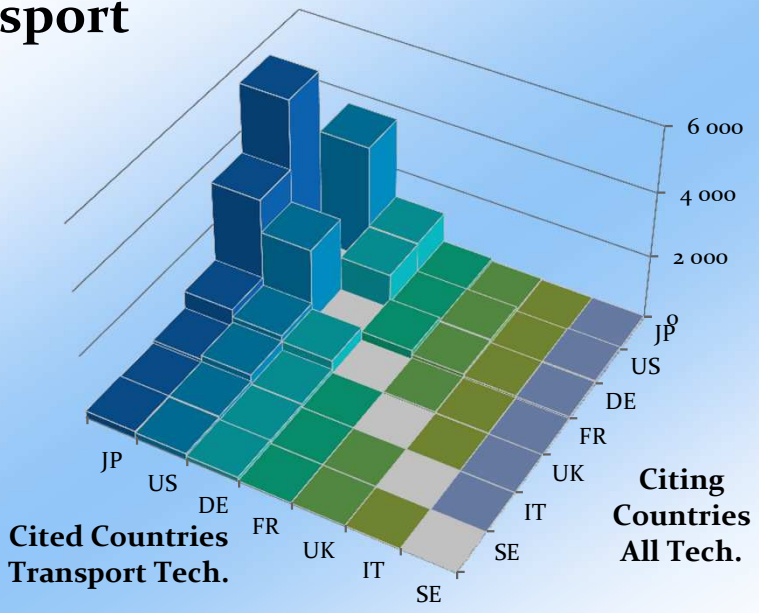
Solar



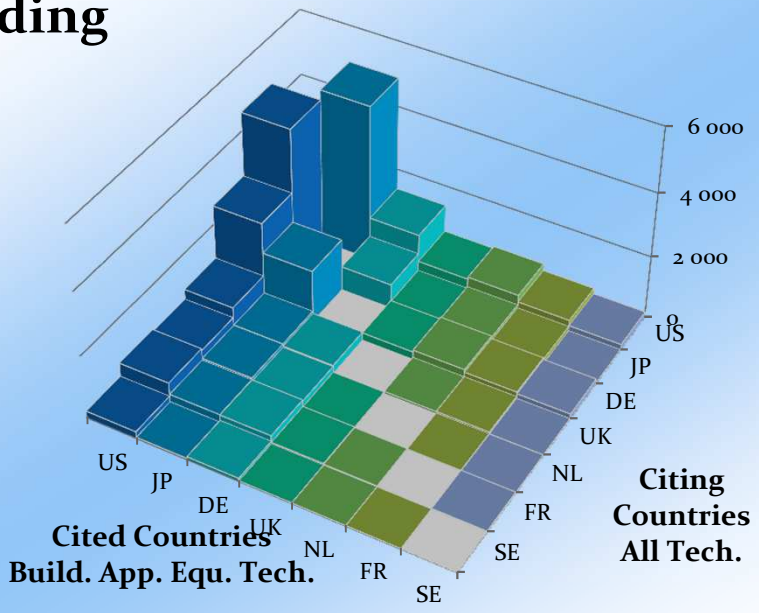
Energy Storage



Transport



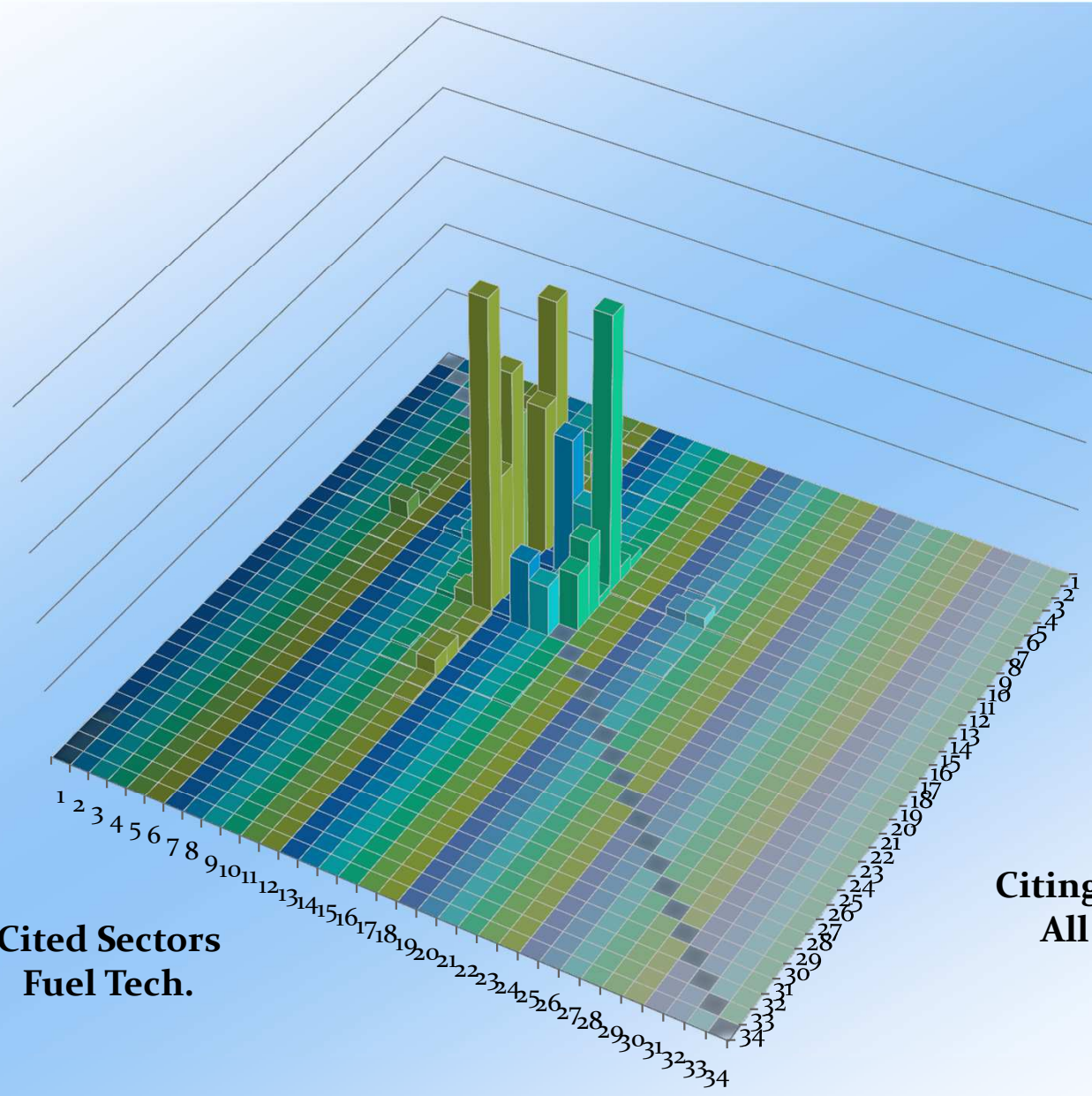
Building



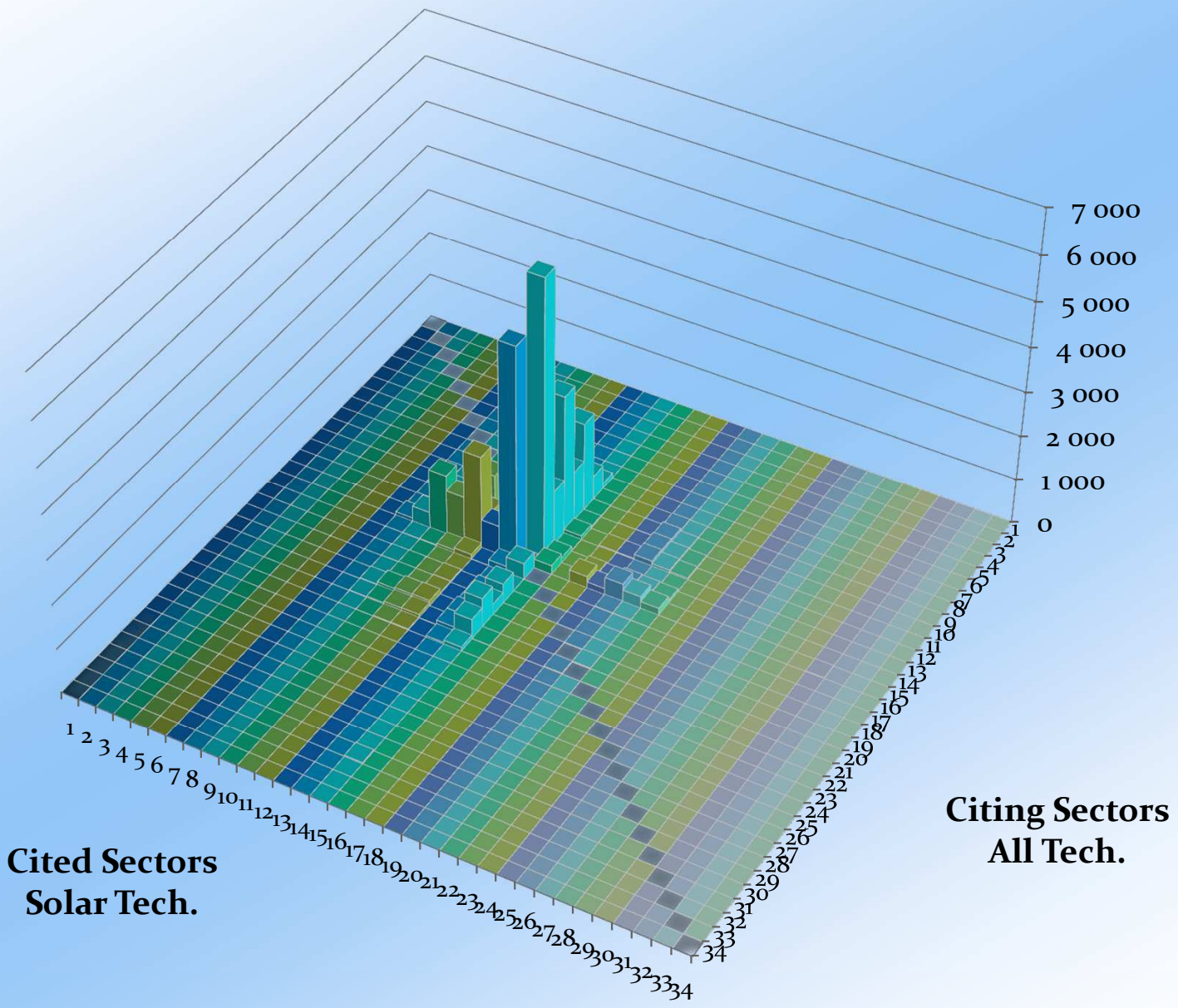
IV. Knowledge spillovers

- At sectoral level

Fuel


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Cited Sectors
Fuel Tech.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Citing Sectors
All Tech.

Solar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Cited Sectors
Solar Tech.
Citing Sectors
All Tech.

IV. Knowledge spillovers

Distribution of forward citations in energy technologies compared to all technologies

	Intra National		Extra National	
	Intra Sectoral	Extra Sectoral	Intra Sectoral	Extra Sectoral
Biofuels	33.5%	16.6%	33.3%	16.5%
Solar	31.7%	18.8%	31.1%	18.4%
Ocean-Hydro	26.7%	24.1%	25.8%	23.5%
Wind	26.0%	24.5%	25.3%	24.1%
Fuel	25.9%	24.3%	25.6%	24.2%
All Technologies	*25.5%*	*24.7%*	*25.3%*	*24.6%*
Building	24.6%	26.2%	23.7%	25.6%
Fuel Cells	23.1%	27.1%	22.9%	26.9%
Geothermal	22.9%	27.9%	22.0%	27.2%
CCS	22.3%	27.8%	22.2%	27.7%
Energy Storage	22.1%	28.1%	21.9%	27.9%
Nuclear	17.8%	32.4%	17.7%	32.2%
Transport	15.6%	34.5%	15.5%	34.4%

V. Conclusion

- EU, US and JP are overall nip and tuck
- DE strong leader in EU in most of the technologies
- The innovations in energy technologies is not only the matter of energy sectors. Many industries are involved, especially industrial equipment industries.
- Despite of the limits of the measurements through patents only, this approach helps to determine which sectors/countries are involved in each technology and, thus, helps to determine where aids should be localized

Thank you

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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 2007 for cited patents (1990 to 2011 for citing patents)

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).