Colloquium EJC - ICT 2012
November 19-20, 2012 - Lyon (CNRS Theater, Villeurbanne)

Ecodesign issues and challenges in the ICT sector: A patent-based perspective

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Outline

1. Introduction
2. Literature
3. Methodology & Data
4. Results
5. Implications for future research

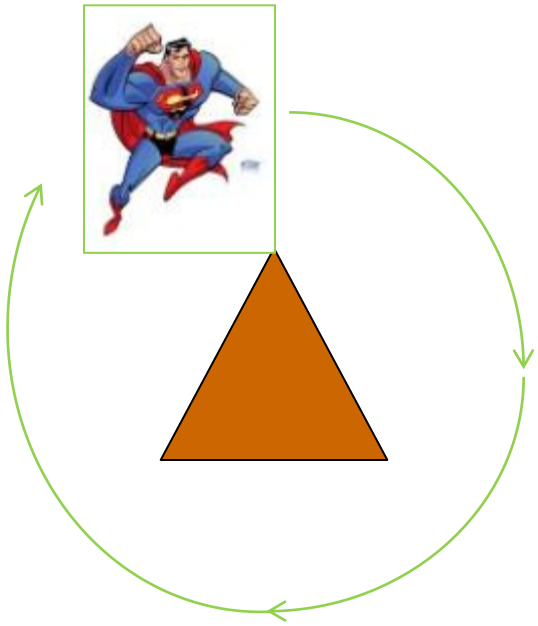
Introduction

- Period of crises: not only economic...
- Way out: eco-innovations?
- Ecoinnovations: within ICTs?
- ICTs: significant ecological impacts.
- ICTs: decoupling potential (green ICTs) + job creation.
- **Research challenge**: integration of ecological issues into innovation studies.

http://ecoinfo.cnrs.fr

Comment nos résultats vont-ils sauver la planète ?

Changer la théorie de l'intérieur...



... mais sans être trop loin du centre au risque d'être inaudible !

La théorie de l'innovation

- Joseph Alois SCHUMPETER (1883-1950):

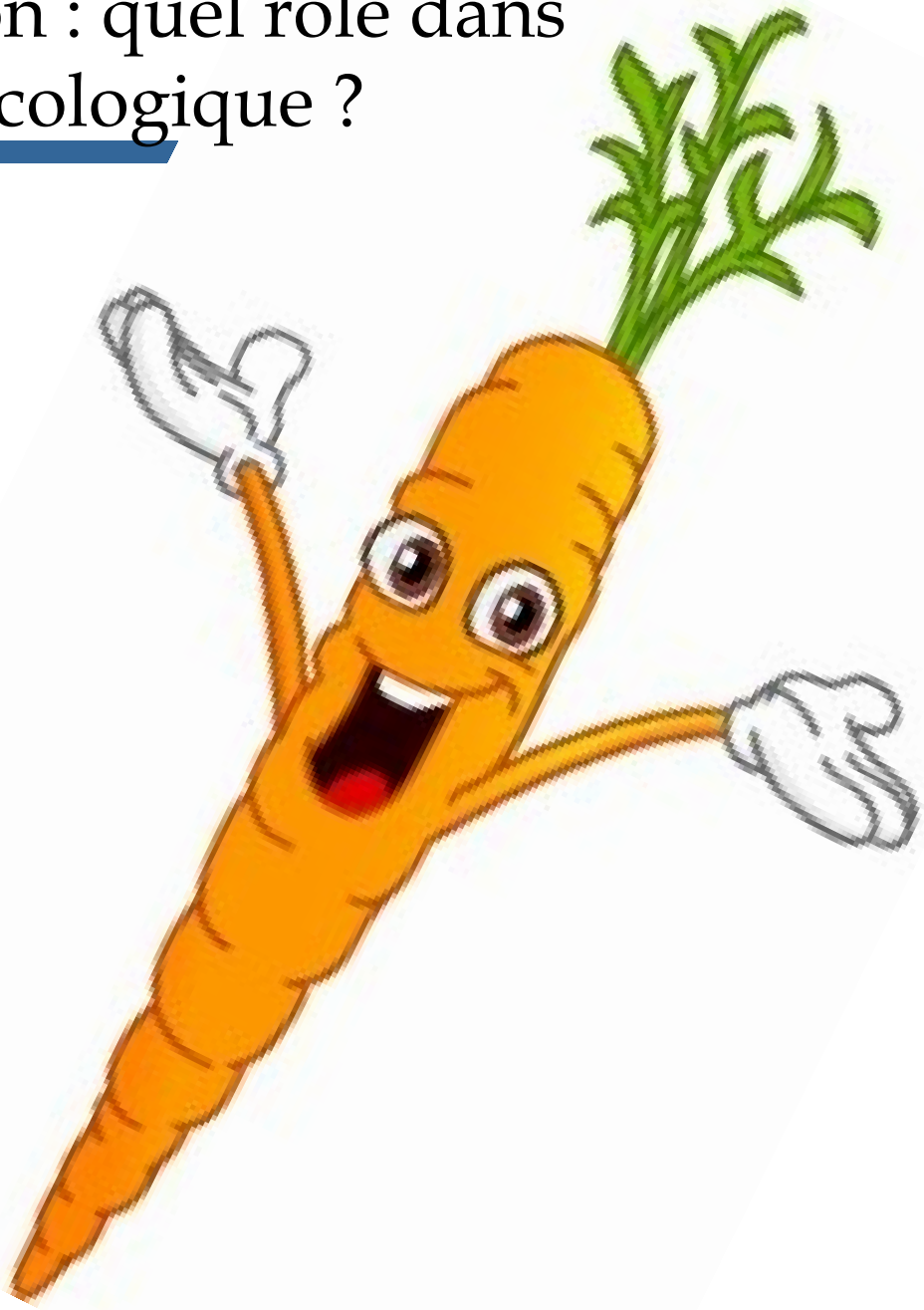
Innovation = source déterminante de compétitivité, de développement économique, et de transformation de la societé.

- Nelson & Winter (économie évolutionniste) :

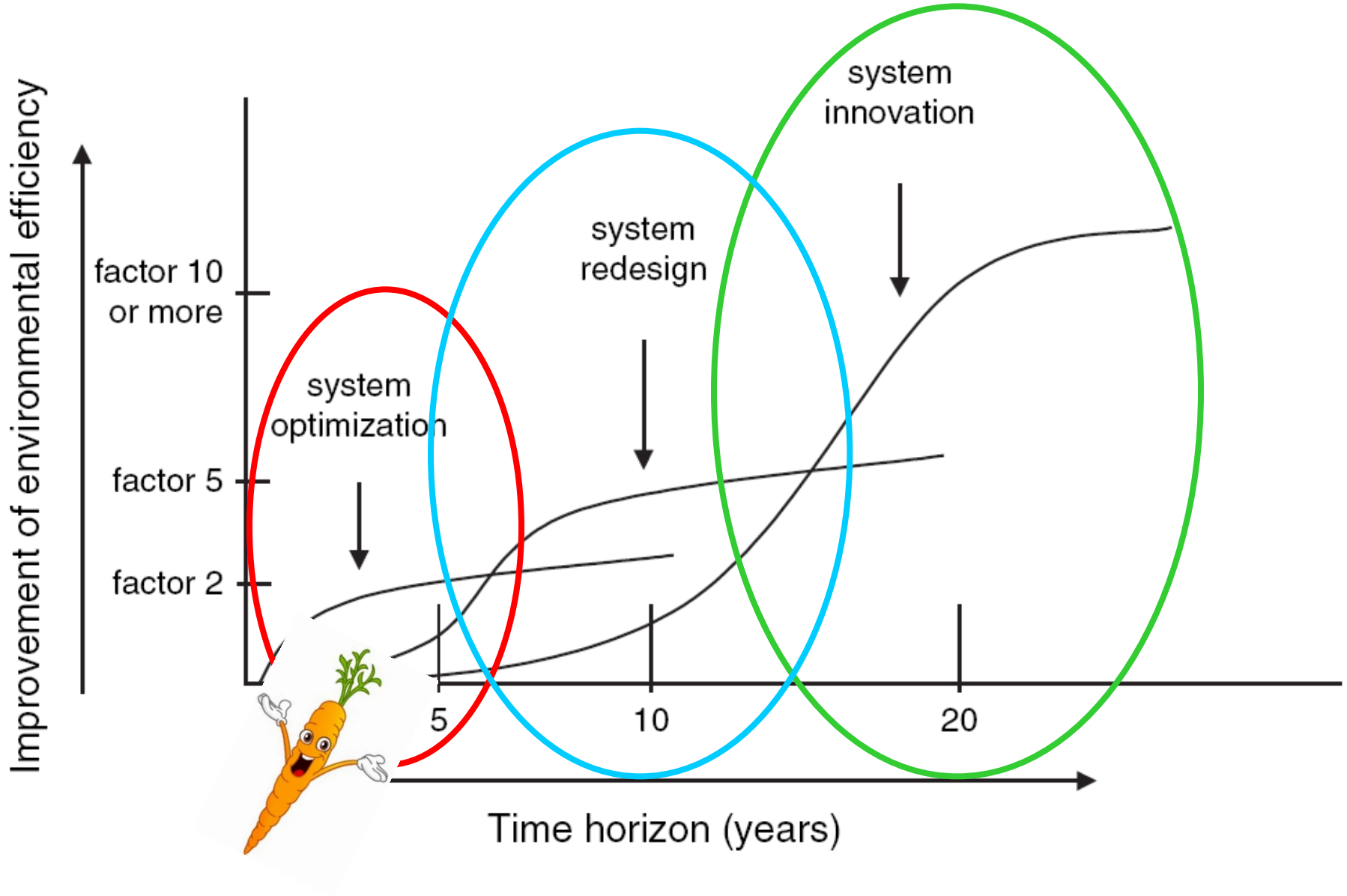
Principales forces de la croissance = innovation & sélection.

* Nelson, R.R., and Winter, S.G. (1974), 'Neoclassical vs Evolutionary Theories of Economic Growth: Critique and Prospectus',

Eco-innovation : quel rôle dans la transition écologique ?

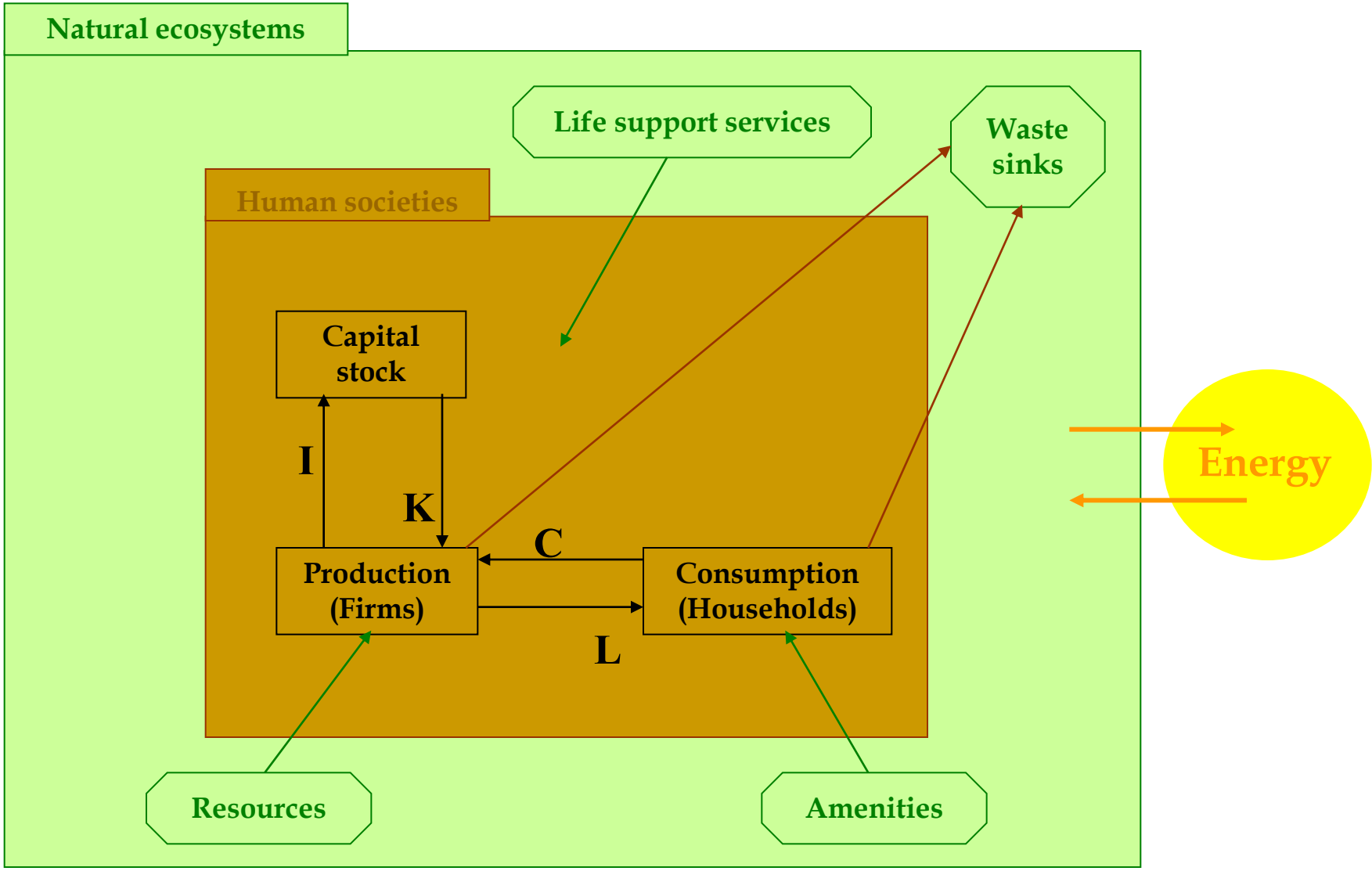


Systemic changes towards absolute decoupling



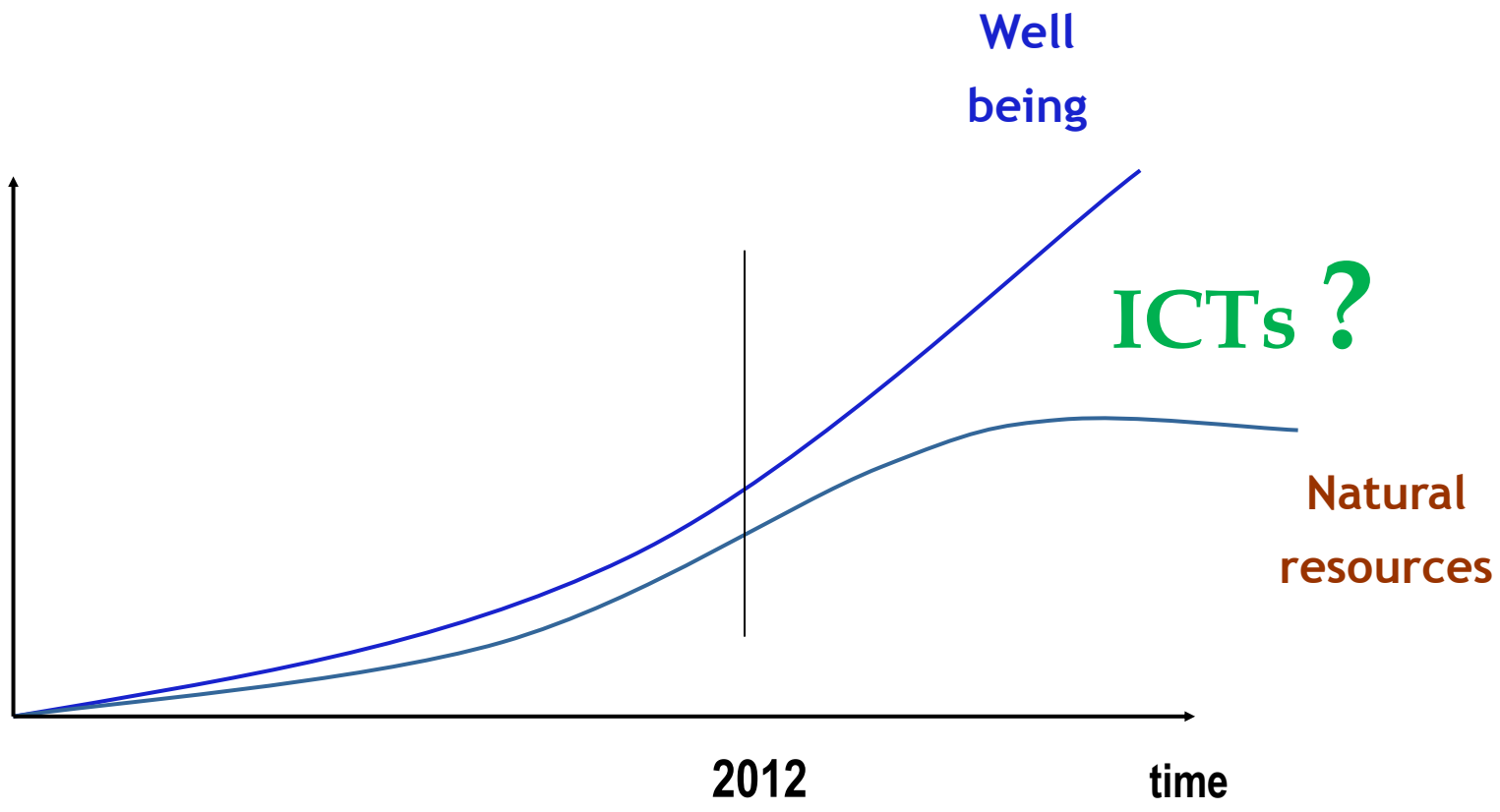
Source: Tukker, A. and M. Butter (2007). "Governance of sustainable transitions: about the 4(0) ways to change the world." Journal of Cleaner Production 15(1): 94-103.

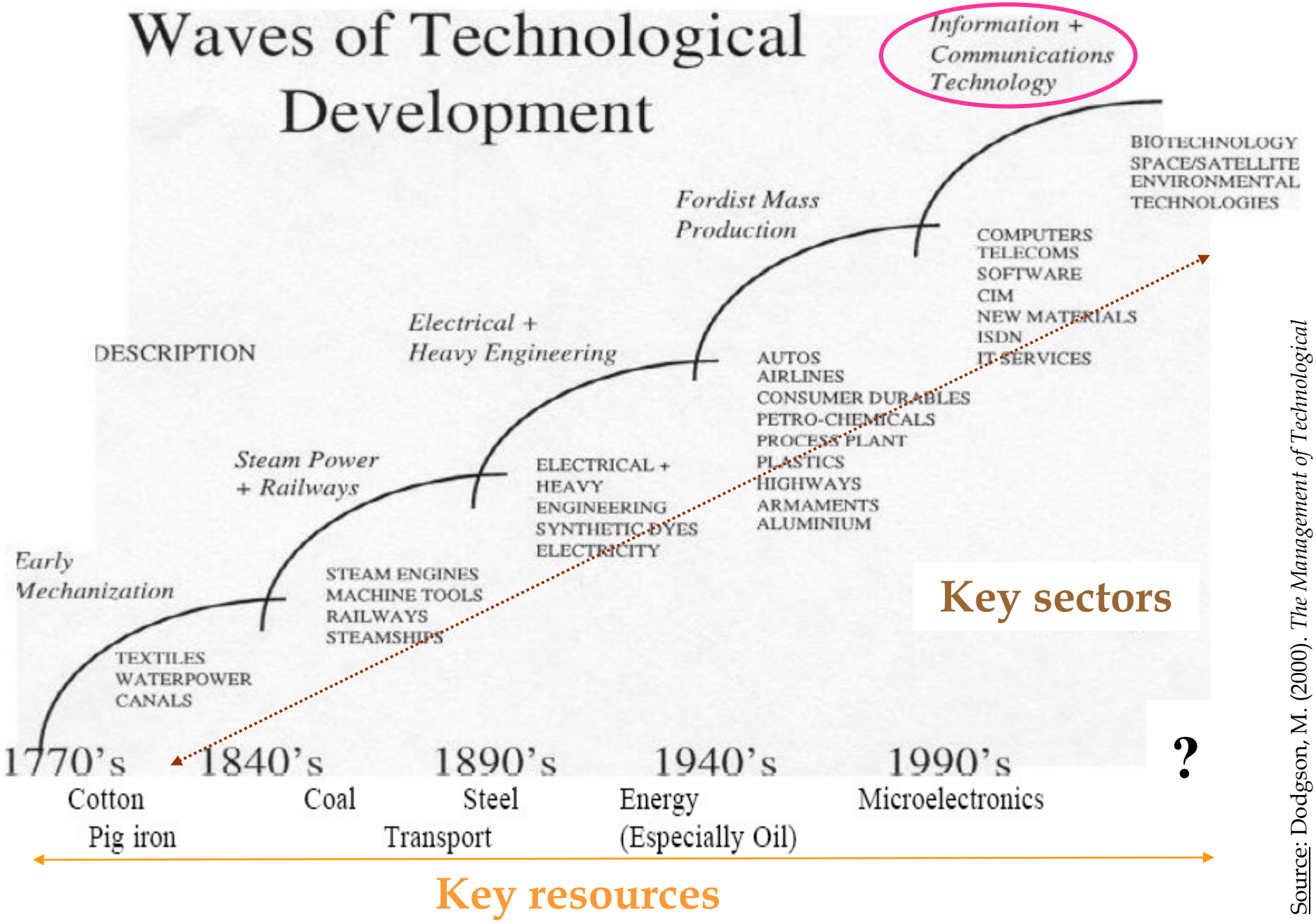
Human societies are embedded in natural ecosystems



Source: Common & Stagl (2006), *Ecological Economics*, p. 87.

Decoupling: Role of (green) Information & Communication Technologies?





Source: Dodgson, M. (2000). *The Management of Technological Innovation*. New York: Oxford University Press, p. 19.

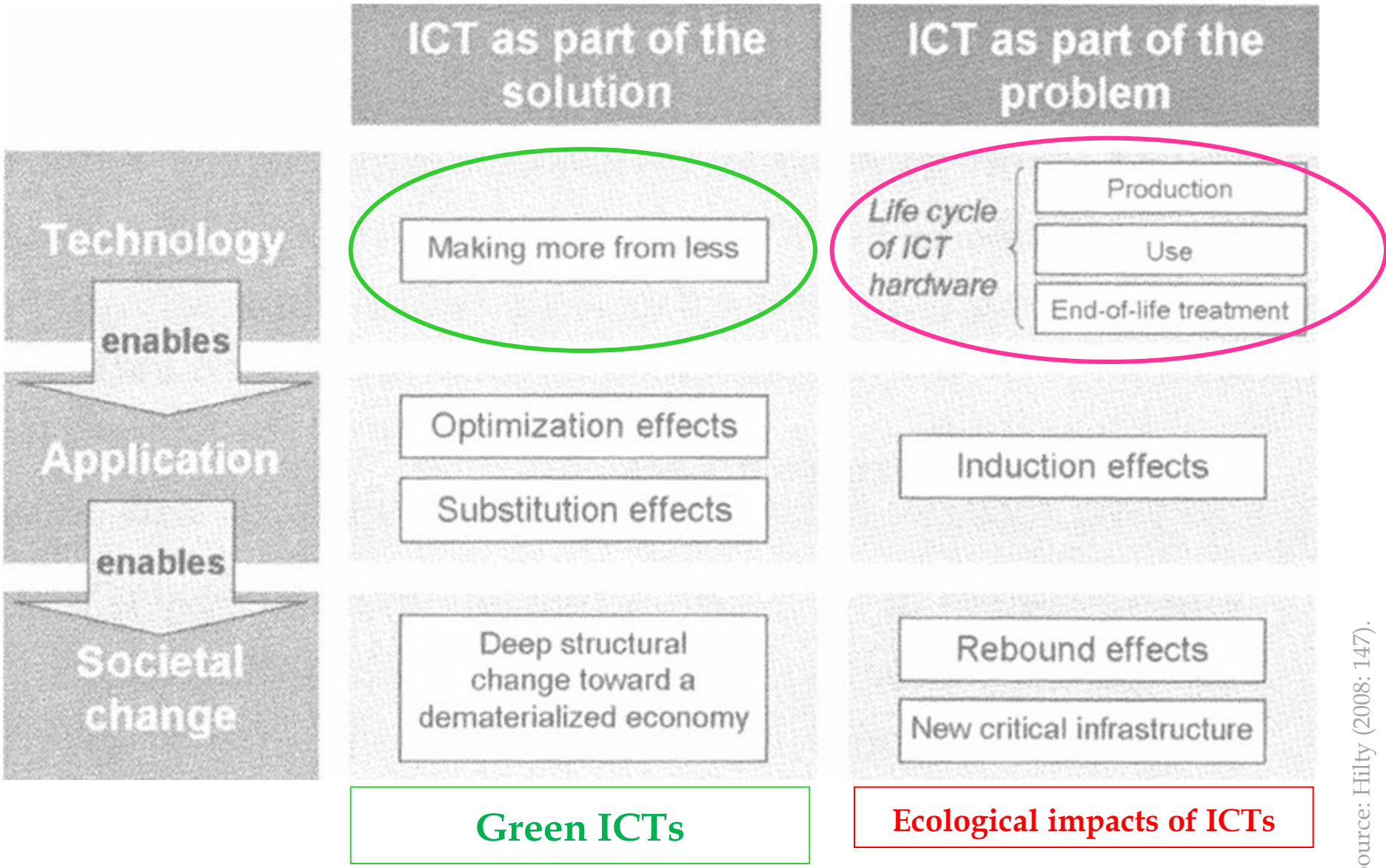
Green ICTs (hardware + software)

Reduce negative ecological impacts + create jobs:

1. **Direct impacts**: ICTs reduce their own ecological impacts.
2. **Enabling impacts**: ICTs are used by other sectors to reduce ecological impacts.
3. **Systemic impacts**: The diffusion of ICTs enable structural changes towards sustainable development (absolute decoupling).

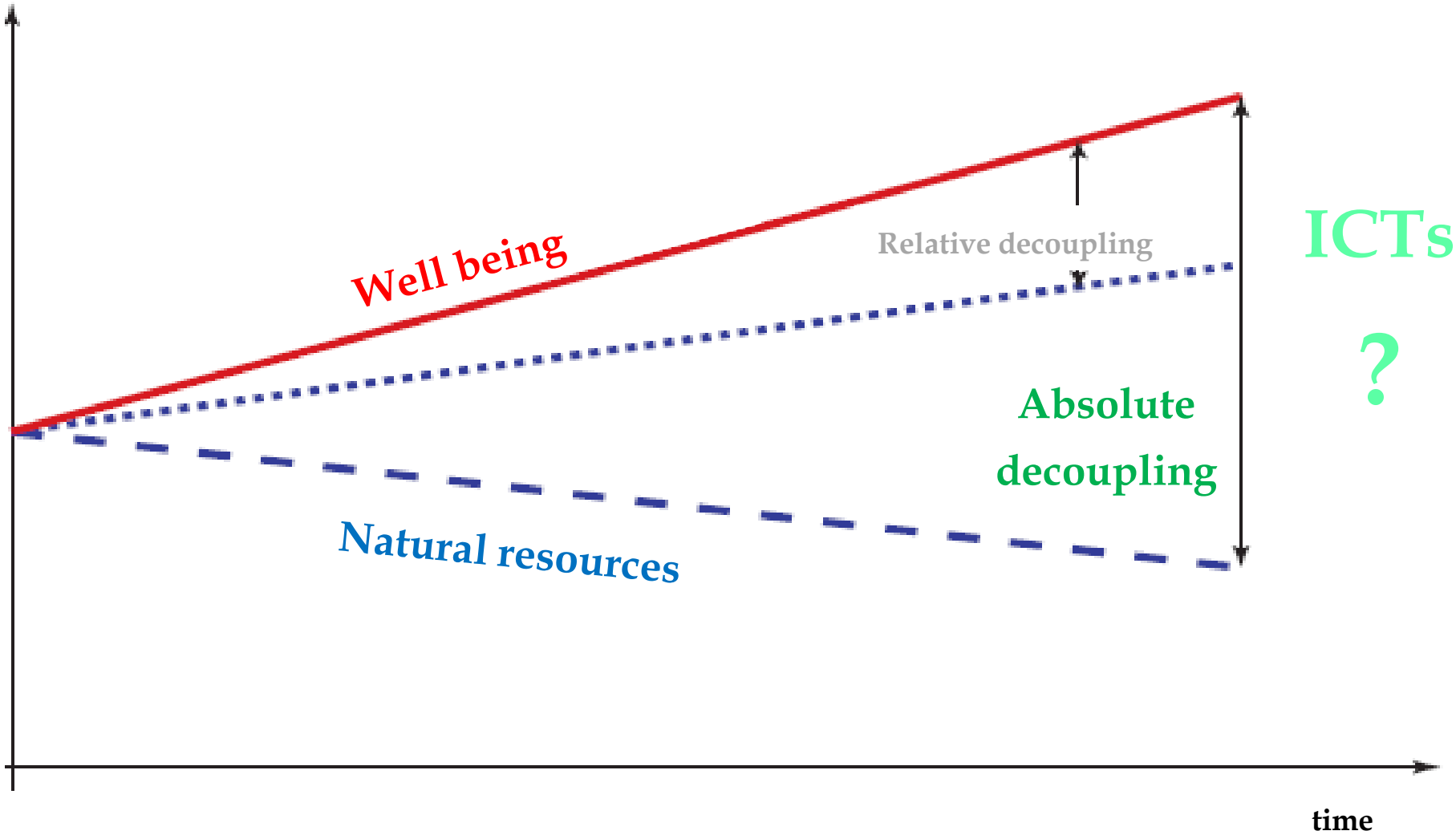
Source: Hilty, L. (2008), *Information Technology and Sustainability: Essays on the Relationships between Information Technology and Sustainable Development*, Norderstedt: Books on Demand.

ICTs & the environment



Source: Hilty (2008: 147).

Long term impacts of green ICTs:
Absolute decoupling



Ecoinnovation & patents

1. Increasing number of studies using patents to analyse ecoinnovation (cf. lit. rev. in our paper: http://ssrn.com/abstract=2117831).

2. The propensity to patent varies across sectors including for ecotechnologies (=> which ones are the most dynamic?).

3. Ecoinnovation studies cover different technological domains, e.g. automobile, waste, water, air cleaning (not ICTs).

Objective & Questions

- **Objective**: Examine the emergence and dynamics of green ICT technological domains.

- **Question**: What are the patterns of innovative activity in green ICT technological domains, notably in terms of:
  - Growth of patents
  - Concentration of innovative activities by organizations and countries
  - Entry of firms
  - Technological pervasiveness
  - Sources of knowledge

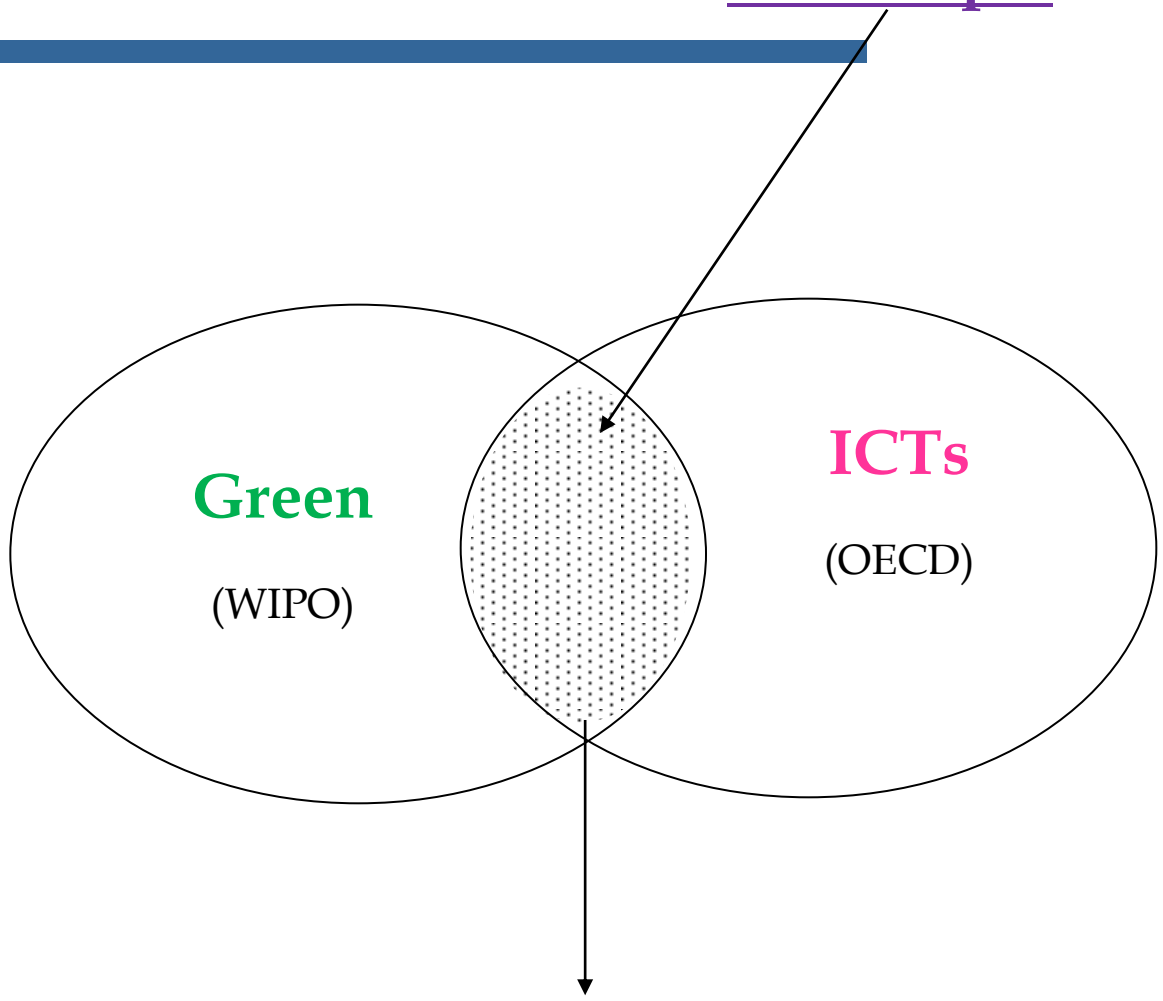
Data

Construction of our green ICT technological domain:

1. **WIPO Green Inventory** - includes all IPC classes associated with environmentally friendly technologies in different fields
   (6 technological fields: alternative energy production, transportation, energy conservation, waste management, agriculture/forestry, administrative/regulatory as well as design aspects, and nuclear power generation).

2. **OECD classification of ICTs** - includes IPC classes referring to telecoms, consumer electronics, computer and office machinery, other ICTs.

International Patent Classification (IPC) codes: 3 sets of IPC classes to construct our sample



Methodology (3 steps)

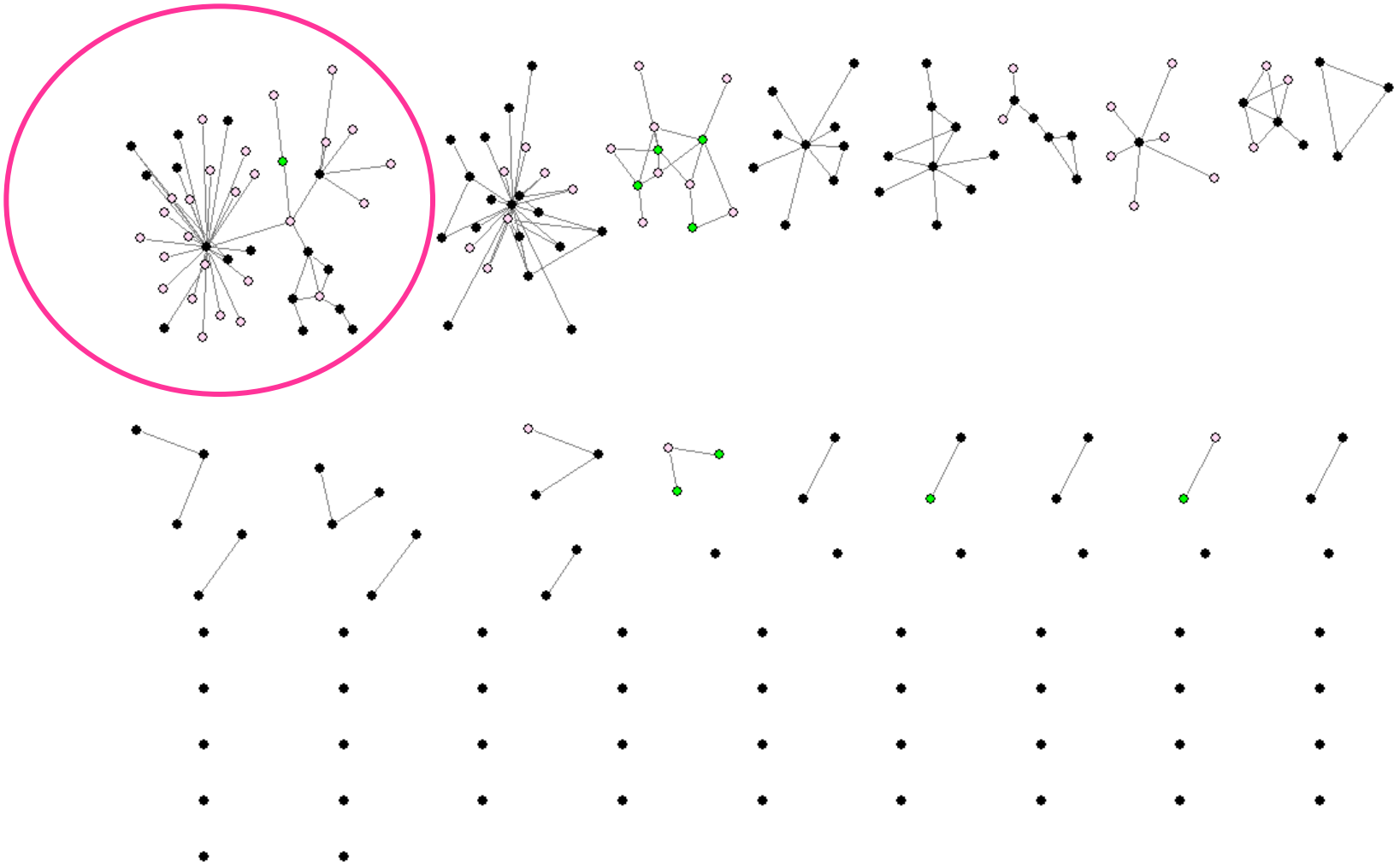
1. Select EPO patents that have at least 1 green and 1 ICT technological class (at 7 digit level) granted between 1986 and 2006 (=> 4157 classes: 1151 Green ICT, 3442 ICT, 436 Pure Green ICT; 16601 patents).

2. Select couples of IPC classes that have at least 55 patents (top 1% couples in order to consider the most relevant fields) => **13210 patents**.

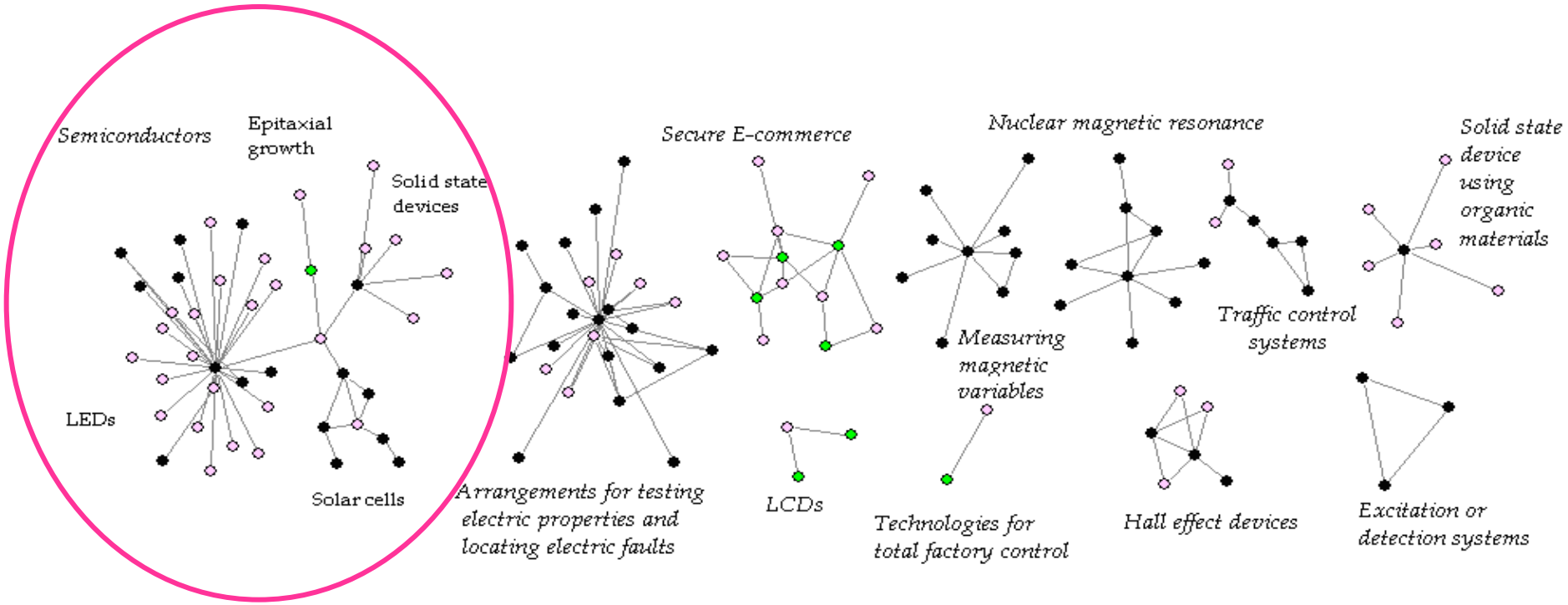
3. Analyse Green ICT technological domains & components (network analysis on the classes + explore what are the sources of knowledge used in Green ICTs).

Results: Network analysis

65 green ICT technological fields (1 node = 1 pair of classes; 1 line = 1 patent)



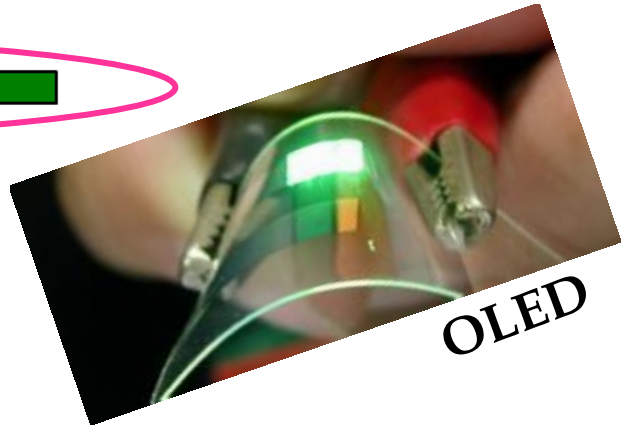
The components of green ICT technological fields

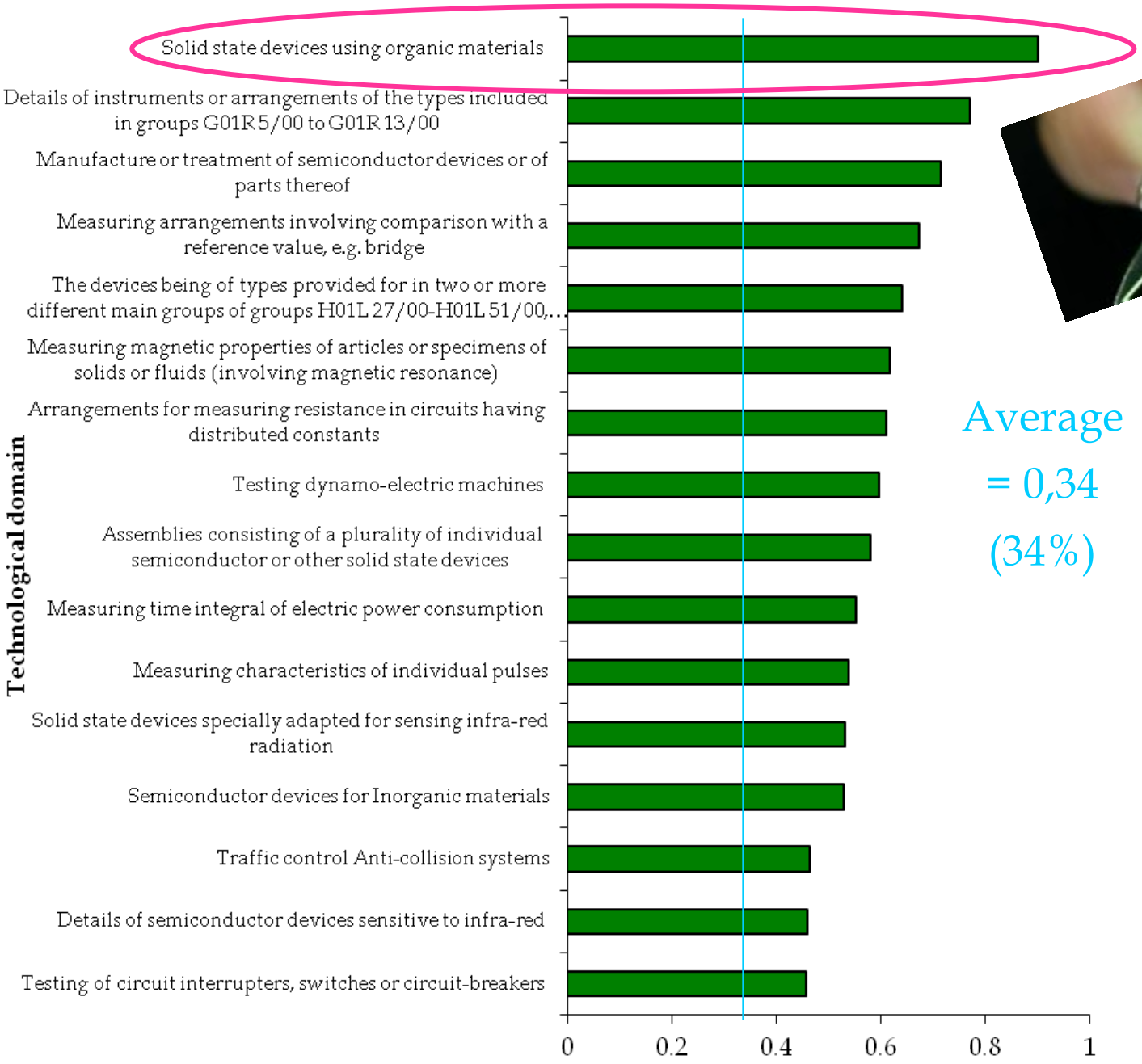


Patents & IPC classes in green ICT fields

Technological component	Number of Patents	Number of IPC classes	ICT classes	Green classes	Pure Green ICT	Other classes
Semiconductors	2058	1248	33%	2.4%	4.7%	59.9 %
Arrangements for testing electric properties and locating electric faults	2849	1085	34.8%	2.3%	4.7%	58.2%
Secure electronic commerce	669	406	48.1%	1.7%	0.2%	50%
Arrangements or instruments for measuring magnetic variables	705	370	7.3%	2.4%	4.6%	85.7%
Nuclear magnetic resonance technologies	658	160	12.5%	2.5%	10%	75%
Solid state devices using organic materials	470	489	9.6%	1%	0	89.3%
Traffic control systems	899	335	38.8%	1.2%	2.4%	57.6%
Hall effect devices	284	126	55.5%	0.8%	5.5%	38.2%
Liquid crystal displays	209	643	1.7%	0.2%	0	98.1%
Technologies for total factory control	75	77	23.4%	3.9%	0	72.7%
Excitation or detection systems	360	68	20.6%	0	13.2%	66.2%

Annual growth rate of patents in Green ICTs (1987-2006)





Average
= 0,34
(34%)

Firms with the highest number of Green ICT patents

Firm	*Number of patents*
SIEMENS BUILDING TECHNOLOGY AS	857
IBM	694
HEARTSTREAM	341
HEWLETT-PACKARD	339
BUDERUS HEIZTECHNIK	323
KONINKLIJKE PHILIPS ELECTRONICS	272
ADVANCED CERAMICS	271
CANDESCENT TECHNOLOGIES	250
NIPPON TELEGRAPH AND TELEPHONE	237
FUJIKIN	211
FUJI ELECTRIC	208
TEKTRONIX	191
AT & T	190
MATSUSHITA ELECTRIC INDUSTRIAL	189
FUJITSU	188
CENTRAL JAPAN RAILWAY	169
AGILENT TECHNOLOGIES	163
ADVANCED MICRO DEVICES	143
ERICSSON	139
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	123

Top 3 organisations by Green ICT technological component

Technological component	Total n° of organisations	Top 3 organisations	Number of patents
Semiconductors	537	CANDESCENT TECHNOLOGIES	120
		NIPPON TELEGRAPH AND TELEPHONE (NTT)	112
		IBM	105
Arrangements for testing electric properties and locating electric faults	785	IBM	122
		SIEMENS BUILDING TECHNOLOGY AS	160
		HEWLETT-PACKARD	128
Secure electronic commerce	315	IBM	36
		FUJITSU	28
		FRANCE TELECOM	22
Arrangements or instruments for measuring magnetic variables	191	ADVANCED CERAMICS	103
		HEARTSTREAM	38
		SIEMENS BUILDING TECHNOLOGY AS	36
Nuclear magnetic resonance technologies	166	ADVANCED CERAMICS	68
		HEARTSTREAM	64
		KONINKLIJKE PHILIPS ELECTRONICS	42
Solid state devices using organic materials	141	EASTMAN KODAK	52
		CAMBRIDGE DISPLAY TECHNOLOGY	35
		3M INNOVATIVE PROPERTIES	33
Traffic Control Systems	253	BUDERUS HEIZTECHNIK	109
		SIEMENS BUILDING TECHNOLOGY AS	71
		AISIN AW	51
Hall effect devices	101	IBM	44
		BUDERUS HEIZTECHNIK	14
		CNRS	12
Liquid crystal displays	39	CELANESE	63
		CHISSO	36
		F. HOFFMANN-LA ROCHE	14

Top 3 innovative countries in Green ICT technological domains

Technological domain	Number of patents	Country
Semiconductors	*716* *704* *177*	*US* *JAPAN* *GERMANY*
Arrangements for testing electric properties and locating electric faults	*1151* *472* *329*	*US* *JAPAN* *GERMANY*
Secure electronic commerce	*329* *220* *130*	*US* *JAPAN* *FRANCE*
Arrangements or instruments for measuring magnetic variables	*345* *89* *66*	*US* *UNITED KINGDOM* *JAPAN*
Nuclear magnetic resonance technologies	*329* *81* *62*	*US* *UNITED KINGDOM* *SWITZERLAND*
Solid state devices using organic materials	*170* *109* *74*	*US* *JAPAN* *GERMANY*

Top 3 innovative countries in Green ICT technological domains (cont.)

Technological domain	Number of patents	Country
Traffic control systems	295	JAPAN
	252	GERMANY
	115	US
Hall effect devices	92	US
	50	JAPAN
	44	GERMANY
Liquid crystal displays	89	GERMANY
	36	HUNGARY
	24	UNITED KINGDOM
Technologies for total factory control	25	JAPAN
	17	GERMANY
	13	US
Excitation or detection systems, e.g. using radiofrequency signals	173	US
	53	UNITED KINGDOM
	48	SWITZERLAND

EU

Patterns of innovative activity in Green ICTs

- **Growth of patents over time**
- **Different types of indices:**
  - Country concentration (HHI index)*
  - Organization concentration (HHI index)*
  - Entry of new patenting firms
  - Technological pervasiveness: the extent to which domains spread across different IPC classes (Jaffe et al., 1993)*
  - Knowledge source across technological classes-variety of knowledge (Trajetenberg et al., 2002)*
  - Internal knowledge sources
  - Academic sources of knowledge

* *Using the method suggested by Hall (2002).*

Descriptive statistics (1987-2006)

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Number of patents	65	252.2	435.0559	6	2849
Number of technological classes	65	818.4	1850.121	110	11687
Share of ICT classes	65	.5082421	.0411233	.4182306	.7400442
Share of green classes	65	.4917579	.0411233	.2599558	.5817695
GROWTHi	65	.3475701	.1669447	.0971514	.8044047
ENTRYi	65	.0350057	.0378638	.0099174	.2595041
H_{ORGi}	65	.0281049	.0299088	.0055423	.2123942
$H_{COUNTRYi}$	65	.2016453	.0537544	.1264003	.4248914
$Pervaniseness\_{TECHi}$	65	.0192141	.0151048	.0041719	.0966121
$SELF_CITATION_i$i	65	.0720965	.0339153	.0216138	.1959799
$ACADEMIC\_KNOW_i$	65	.0038859	.0095034	0	.0527638
$Variety\_{CITTECH}$	65	.0396431	.0277021	.0014406	.1556497

Cluster analysis: 3 different clusters of technological domains

Variables	CLUSTER 1 (25 domains) GREEN	CLUSTER 2 (11 domains) EMERGING	CLUSTER 3 (29 domains) ESTABLISHED
Average nb of patents	172.32	128.09	368.14
Average nb of tech. classes	236.60	207	731.04
Share of ICT classes	.503	.522	
Share of green classes	.497	.478	
GROWTHi*		.649	.212
ENTRYi*	.030		.044
H_{ORGi}*	.022		
$H_{COUNTRYi}$*	.190		
$Pervaniseness\_{TECHi}$	.040		
$SELF_CITATION_i$i*	.062		
$ACADEMIC\_KNOW_i$*			.004
$Variery\_{CITTECH}$*			.024

Examples: Traffic control systems/ Electricity storage & measurement

Examples: Semiconductors/ Electronic commerce

Examples: SSD organic / Tech. fc

Little innov fas

Continuous opportunities for the entry of new actors

=> New knowledge acquired outside?

→ High level of opportunity

Low degree of knowledge cumulativeness

=> Radical changes?

*Indicates statistically significant differences across clusters.

Conclusions about innovation dynamics in Green ICTs

1. Green ICTs cover 65 technological domains (different combinations of green & ICT classes).
2. Fastest growing domain = SSD using organic materials (Germany strongest EU country).
3. France: strong in Secure electronic commerce & Hall effect devices (thanks to CNRS).
4. LEDs = promising Green ICT: potential for job creation in Europe? (cf. FP7 cycLED project: http://www.cyc-led.eu).
5. Current set of technological classes in Green Inventory neglects important green ICT domains that stem from the combination of existing green and ICT classes.
6. 3 main clusters of green ICT domains (Green, Emerging, Established) that differ substantially in the structure of their innovative activity.

Thank you for your attention.

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