Workshop on Economic Complexity to Inform Policy
Joint Research Center–European Commission

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Assessing EU green technological potential through Economic Complexity

Angelica Sbardella

Scuola Superiore S. Anna, Pisa

- Impact of human systems of production at the center of public and scholarly debate

- Eu Green Deal & Sustainability Transition top priorities of EU political agenda:
  Inclusive approach, fostering innovation, opening up new mkts, creating new jobs…

- Climate change is a complex phenomenon → requires radical revision of current economic thinking and policy design

GREEN CAPABILITIES

EFC offers practical data-driven methodologies that can help countries identify which green sectors offer greater potential for diversification and growth in emerging green mkts

- Green Technology Fitness (national/local): identify geographical patterns of green competitiveness
- Green Technology space: target green industrial policies in sectors more likely to produce competitive gains

ECONOMIC COMPLEXITY & THE GREEN ECONOMY

Identifying Green Productive or Technological Capabilities & Green Competitiveness

Recent exploratory studies on…

Green Products

- **Huberty & Zachmann (2011)**
- **Fankhauser *et al.* (2013)**
- **Hamwey, Pacini & Assunção (2013)**
- **Mealy & Teytelboym (2017)**

★ **Green Product Space**: selecting which green sectors to promote based on export performance and product relatedness

★ **Green ECI**:

★ accumulation of green capabilities path-dependent

Green Technologies

- **Barbieri, Marzucchi & Rizzo (2020)**

green techs: distinctive features + higher cost & uncertainty → need for policy intervention

- **Bergamini, Tokuyamay, & Zachmannz (2019)**
- **Perruchas, Consoli & Barbieri (2019)**
- **Sbardella *et al.* (2018)**
- **Napolitano *et al.* (2019)**

★ **Green technological complexity (EFC or ECI)**: development of green technological capabilities over space & time

★ green techns related to existing capabilities

FROM COUNTRY EXPORT TO GREEN NATIONAL INNOVATION SYSTEMS

Green Technological Fitness and Complexity

TRANSLITERATION OF THE CONCEPT OF CAPABILITIES

What are the green technological capabilities needed by a country to patent successfully in complex green technological domains?

Balland & Rigby (2017); Mealy & Teytelboym (2017);
Sbardella, Pugliese & Pietronero (2017); Pugliese et al. (2019)

Motivation Green Technologies

- **Limitation of GHG emissions**
- **Climate change mitigation**
- **Great acceleration in their development (especially energy & transports)**
  OECD (2011) 1999–2008:
  + 24% for renewable energy,
  + 20%, for electric & hybrid vehicles

- **Heterogeneous**
  encompass many domains of know-how & distinctive features wrt non-green & across space
- **Data availability**
  - As opposed to products, identifying environmentally-relevant technologies within existing patent classifications clearer, possible to go into detail with textual analysis/citations
  - Existing hierarchical green patent classifications

BUT…

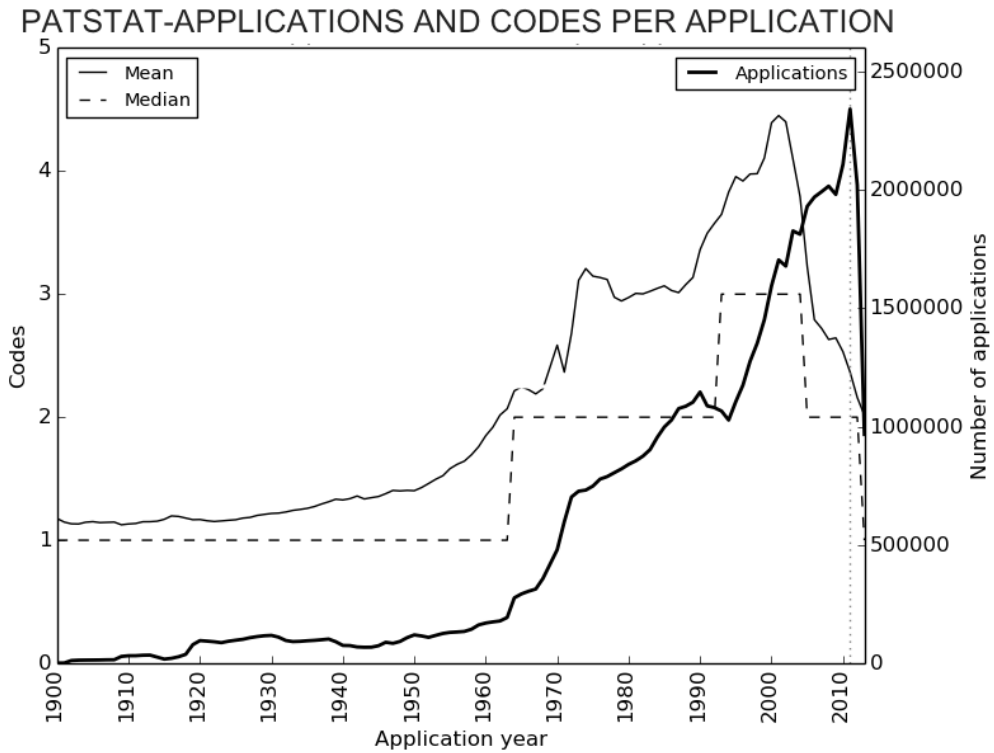
Beware the big technological fix!

Sarewitz & Nelson, 2008 + Parkinson, 2010

PATENT DATA

Eco-innovations proxied by geo-localized patent data

- **Patent main source: PATSTAT (EPO)**
- Patent applications by CPC technology field



- **Green technologies: ENV-Tech classification (OECD)**
  - subset of CPC classification
  - hierarchical:

    2-digit: 36 classes
    3-digit: 100 classes

- **Sample**
  - 1M patent families
    (2.5M patent applications)
  - 30 years: 1970–2010
  - 60 countries
    (from recorded inventor addresses)

EnvTech Examples

1 Environmental management

1.1 Air pollution abatement
1.3 Waste management

2 Water-related adaptation technologies

2.1 Demand-side technologies (water conservation)
2.2 Supply side technologies (water availability)

4 CCMTs related to energy generation, transmission or distribution

4.1 Renewable energy generation
4.4 Nuclear energy

5 Capture, storage, sequestration or disposal of greenhouse gases

5.1 CO_2 capture or storage
5.1 Capture or disposal of GHG other than CO_2

6 CCMTs related to transportation

6.1 Road transport
6.2 Rail transport

7 CCMTs related to buildings

7.1 Integration of renewable energy sources in buildings
7.2 Energy efficiency in buildings

8 CCMTs related to waste water treatment or waste management

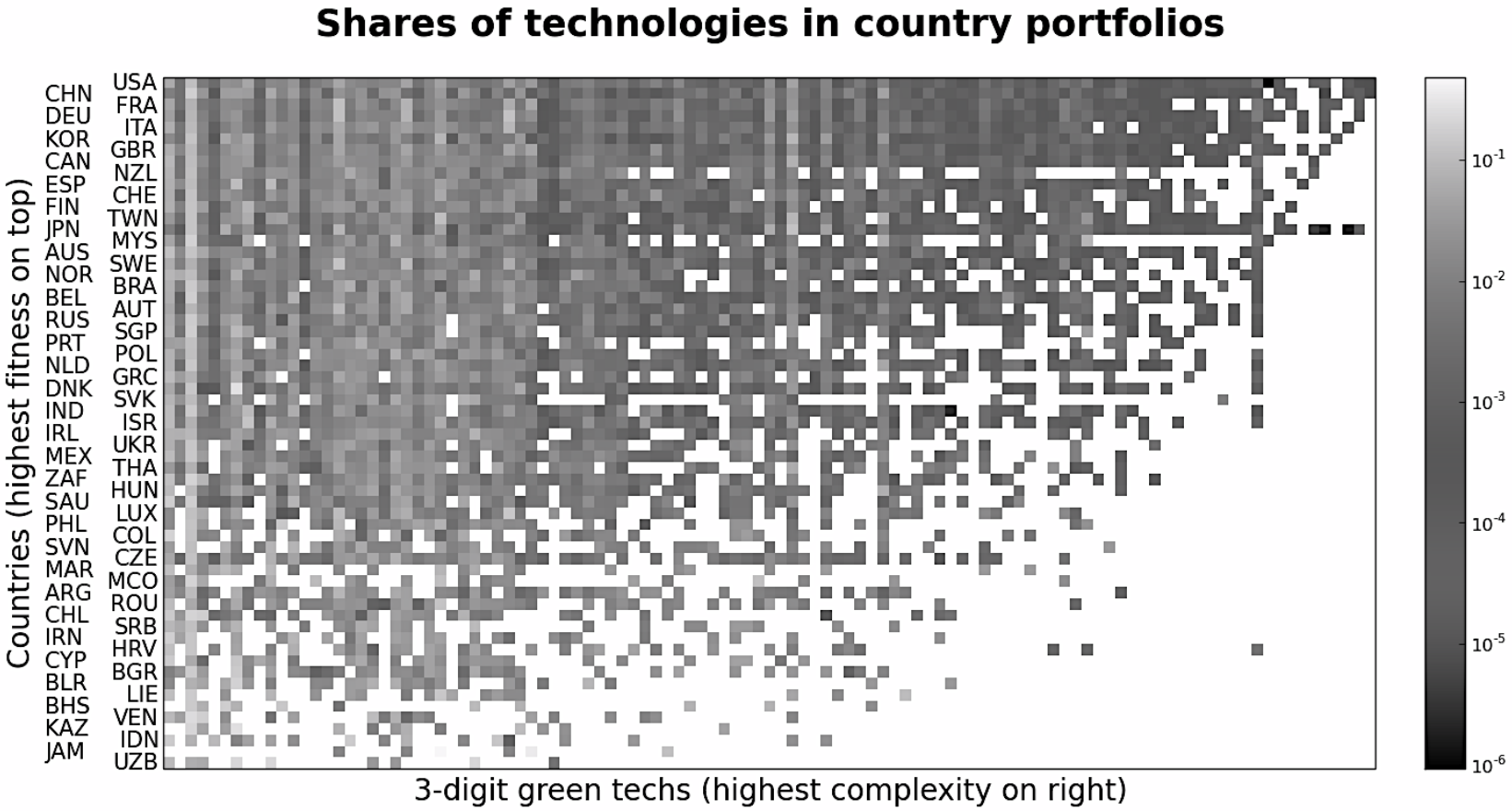
8.1 Wastewater treatment}
8.2 Solid waste management

9 CCMTs in the production or processing of goods

9.2 Technologies relating to chemical industry
9.7 Climate change mitigation technologies for sector-wide applications

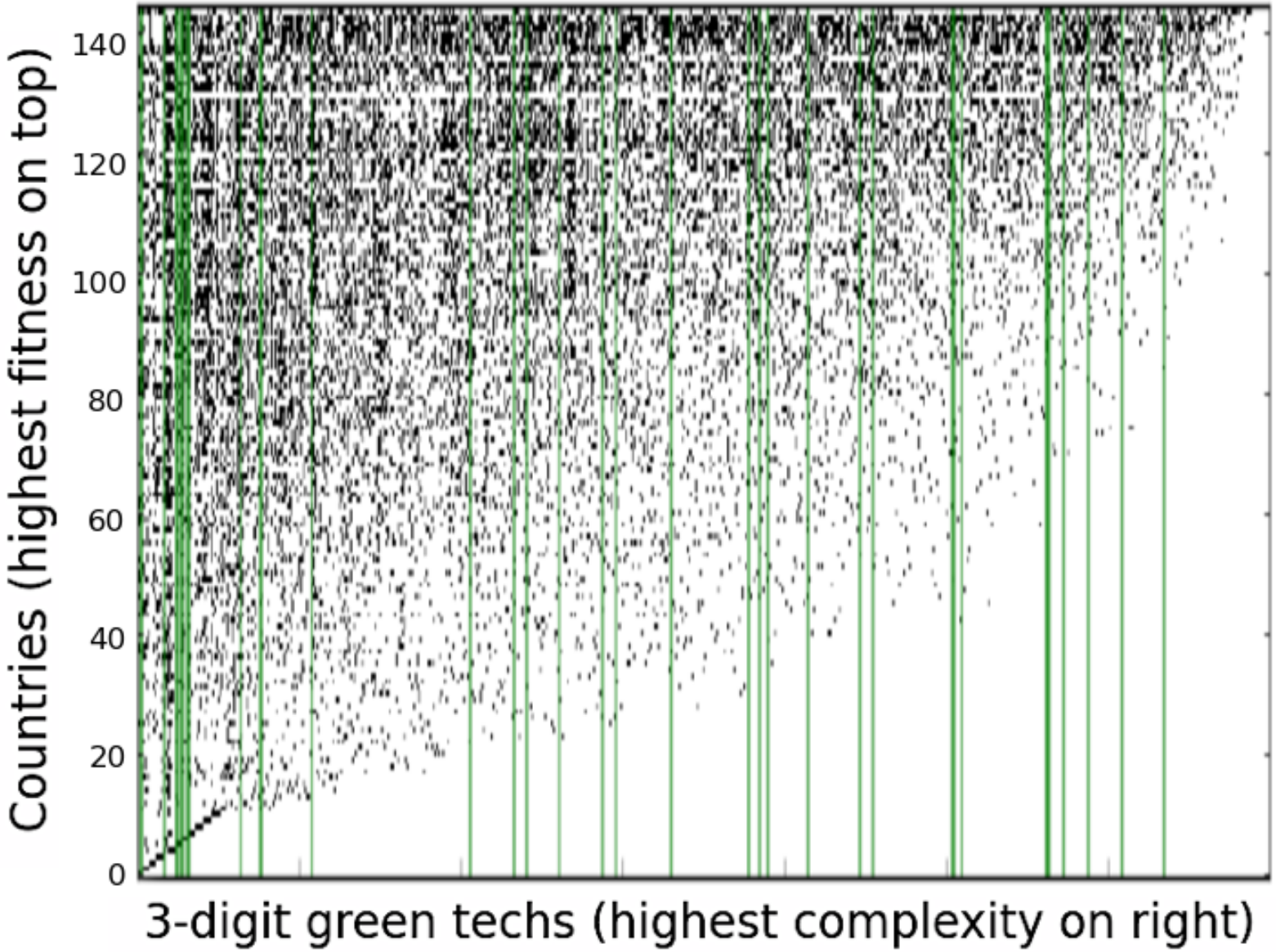
Green Technological portfolios

Nested country-green technology matrix
Less complex technologies are prevalent in less complex national portfolios



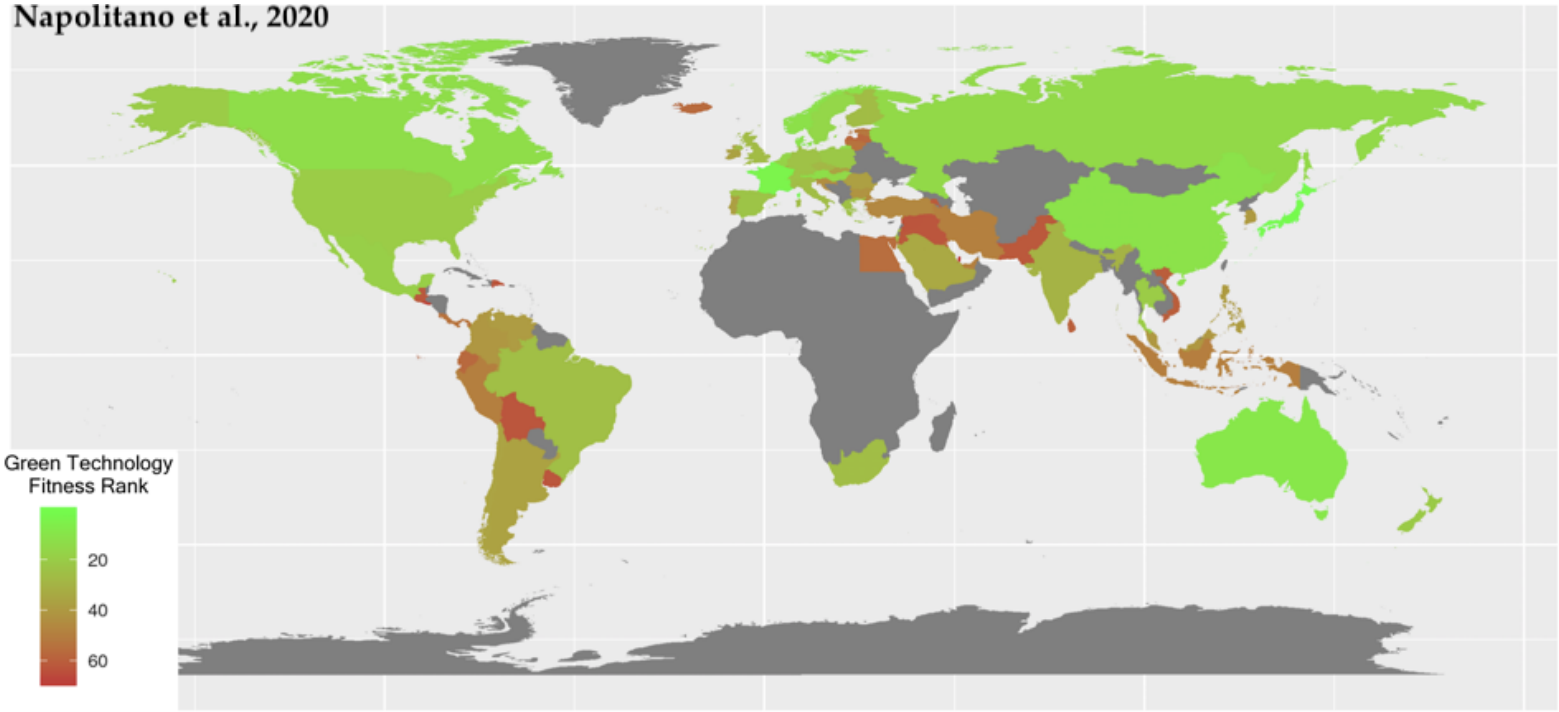
Source of the figure: Sbardella *et al.* 2019

Green technologies are spread over the whole technological spectrum



Green Technology Fitness: Geography

Napolitano et al., 2020



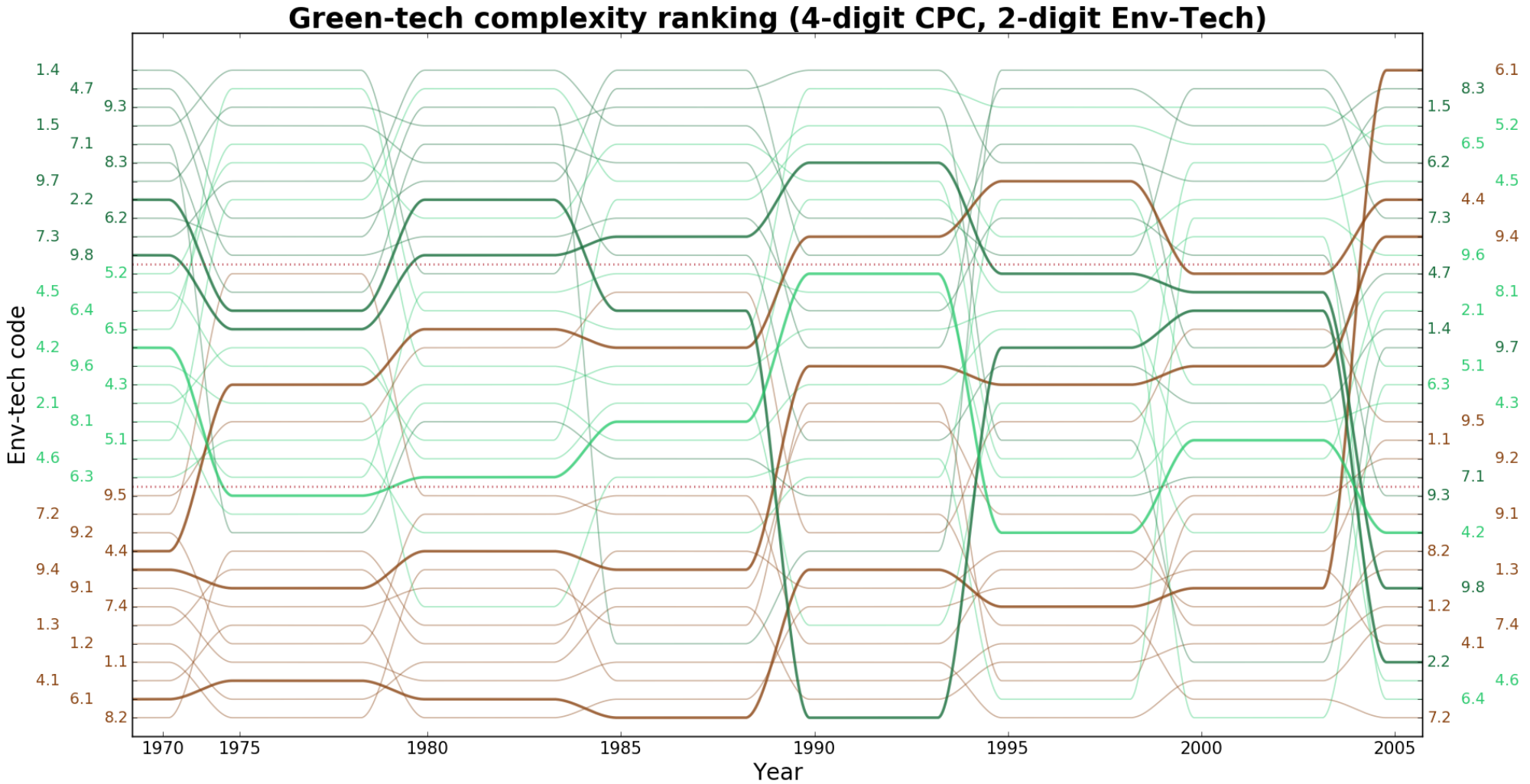
Stable leaders	Increasing Fitness	Decreasing Fitness
★ Japan	★ China	★ US
★ France	★ Brazil	★ UK
★ Germany	★ Spain	★ Israel/Netherlands

Long-term trends: Israel & US start high & constantly drop, China gradually reaches top

Stable ranking & smooth variations: imitation in mature fields can lead to quick catching up by capability-poor countries, but global set of capabilities result of long accumulation process

Green technologies: Complexity

Complexity has varied substantially over 1970–2010



Most and Least complex technologies

Stable leaders

- ⋆ Enabling Technologies for GHG Mitigation
- ⋆ Environmental Monitoring
- ⋆ Rail Transport

Increasing Complexity

- ⋆ Road Transport Technologies (non-monotonic!)
- ⋆ Nuclear Energy
- ⋆ Technologies for the processing of minerals (e.g. cement, glass)

Decreasing Complexity

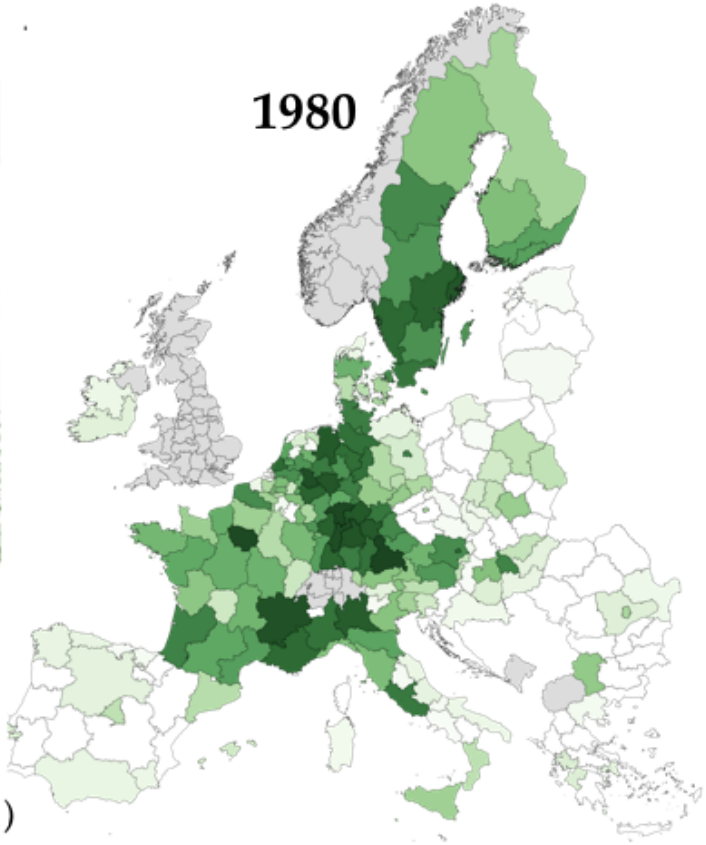
- ⋆ Supply-Side Technologies for Water Availability (non-monotonic!)
- ⋆ Enabling Technologies for Greenhouse Gas Mitigation
- ⋆ Energy generation from fuels of non-fossil origin

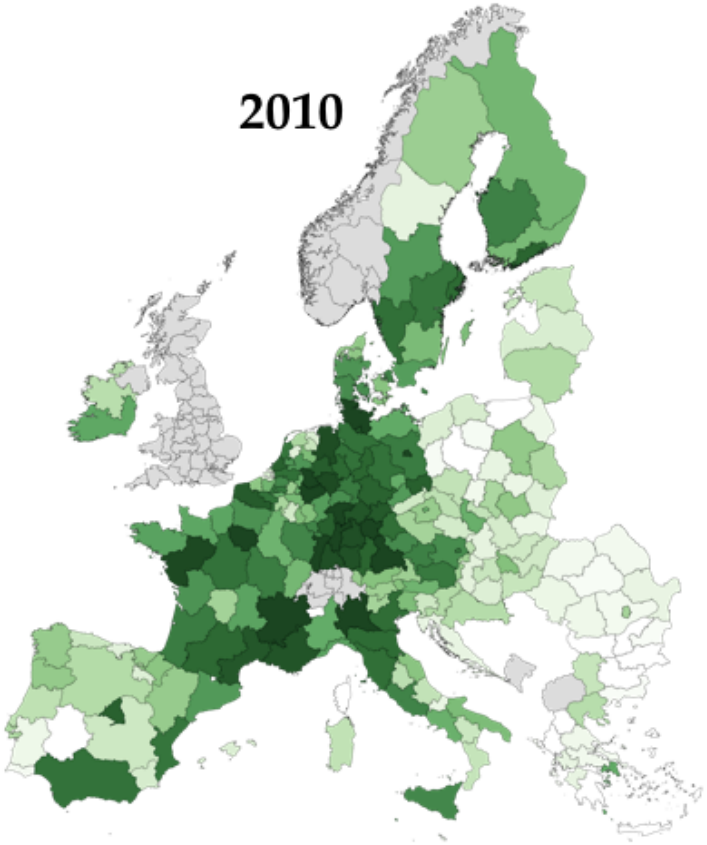
Complexity ranking resonates with green technology life cycle

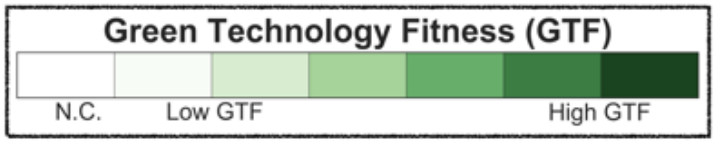
established fields: higher ubiquity, mature knowledge base → bottom
ex. Renewable Energy Generation

early stage fields: higher complexity, lower ubiquity → top
ex. Capture/Disposal of GHG other than CO_2

The Green Technological Fitness of EU NUTS2 Regions







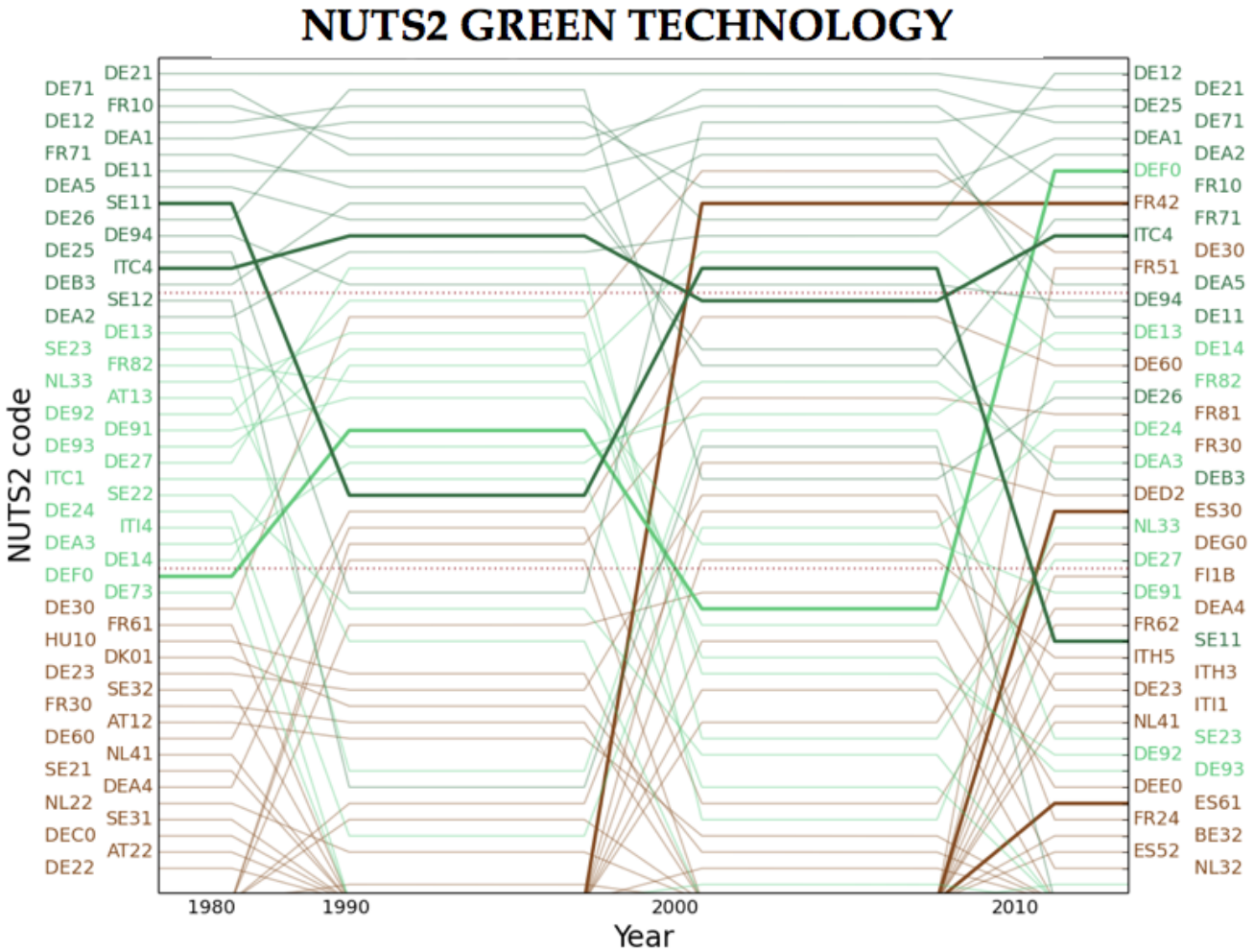
Stable leaders

- ★ Karlsruhe (DE12)
- ★ Oberbayern (DE21)
- ★ Dusseldorf (DEA1)

- ★ Ile de France (FR10)
- ★ Rhone-Alpes (FR71)
- ★ Lombardia (ITC4)

- ★ Persistent core of top competitive innovators
- ★ Dichotomy between Southern and Northern + Central Western Europe
- ★ Slight fitness drop in some regions of Denmark and Sweden
- ★ New entrants

NUTS2 Green Technology Fitness, Top 50 , 1980–2010



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Increasing Fitness, Top 1980–2010

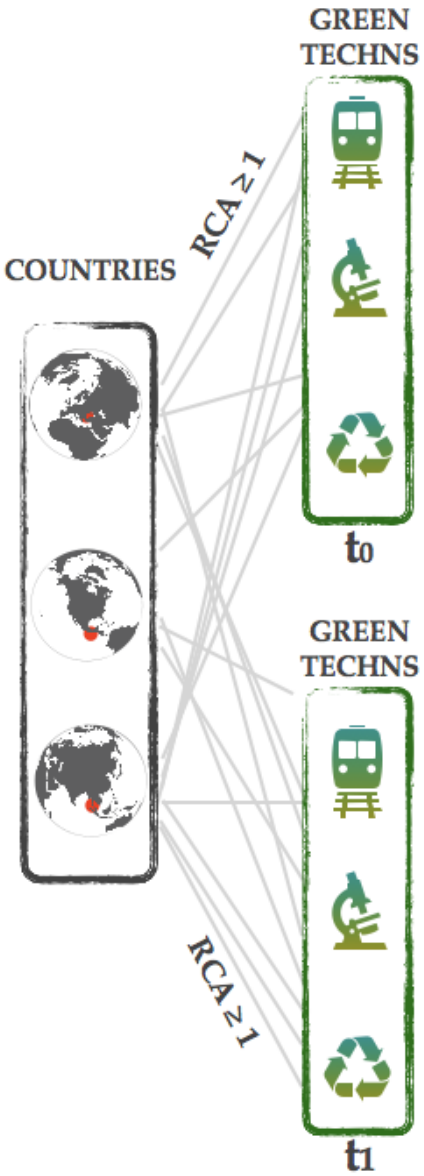
- ★ Andalucia (ES61)
- ★ Madrid (ES30)
- ★ Dresden (DED2)
- ★ Campania (ITF3)
- ★ Alsace (FR42)
- ★ Brandenburg (DE40)

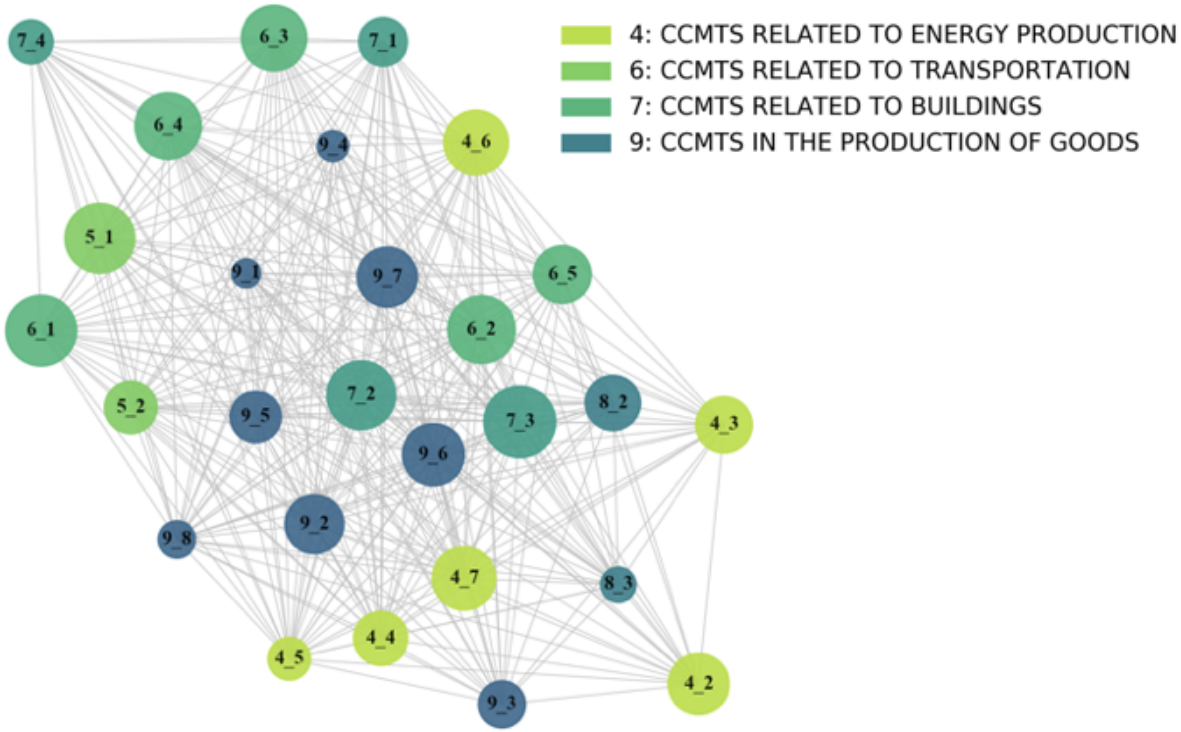
Decreasing Fitness, Top 1980–2010

- ★ Opolskie (PL52)
- ★ Sud-Muntenia (RO31)
- ★ Kozep-Magyarorszag (HU10)
- ★ Kozep-Dunantul (HU21)
- ★ Mellersta Norrland (SE32)

The Green Technology Space

Network that measures the relatedness of green techs through patterns of co-patenting





Relatedness = statistical measure of the "distance" between T1 & T2 in the space defined through the observation of their empirical co-occurrence

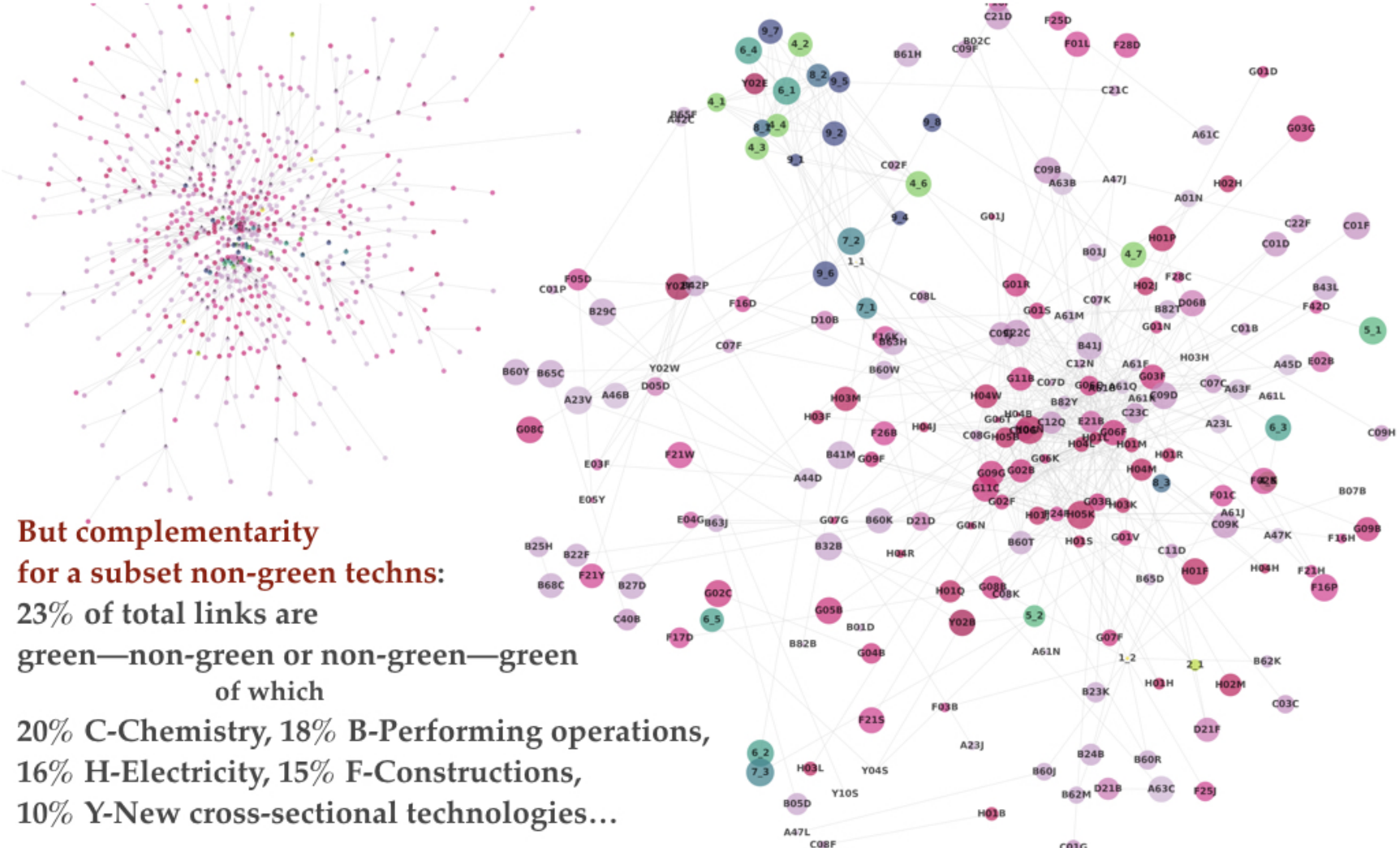
↓

- ★ probability that having a comparative advantage in T1 will lead to a comparative advantage in T2
- ★ proximity ⇔ similar underlying inputs & high probability of jumping from T1 to a neighbouring one

THE GREEN + NON-GREEN TECHNOLOGY SPACE

The majority of non-green CPCs has no connection with green techs (77% of non-green CPCs)

- 1: ENVIRONMENTAL MANAGEMENT
- 2: WATER MANAGEMENT
- 4: CCMTS RELATED TO ENERGY PRODUCTION
- 5: CAPTURE, STORAGE, DISPOSAL OF GHG GASES
- 6: CCMTS RELATED TO TRANSPORTATION
- 7: CCMTS RELATED TO BUILDINGS
- 8: CCMTS RELATED TO WASTE-WATER AND WASTE MANAGEMENT
- 9: CCMTS IN THE PRODUCTION OF GOODS
- A: HUMAN NECESSITIES
- B: PERFORMING OPERATIONS; TRANSPORTING
- C: CHEMISTRY; METALLURGY
- D: TEXTILES; PAPER
- E: FIXED CONSTRUCTIONS
- F: MECHANICAL ENGINEERING; LIGHTING; HEATING
- G: PHYSICS
- H: ELECTRICITY
- Y: NEW CROSS-SECTIONAL TECHNOLOGICAL DEVELOPMENTS



But complementarity for a subset non-green techns:

23% of total links are green—non-green or non-green—green

of which

20% C-Chemistry, 18% B-Performing operations, 16% H-Electricity, 15% F-Constructions, 10% Y-New cross-sectional technologies…

LINKS

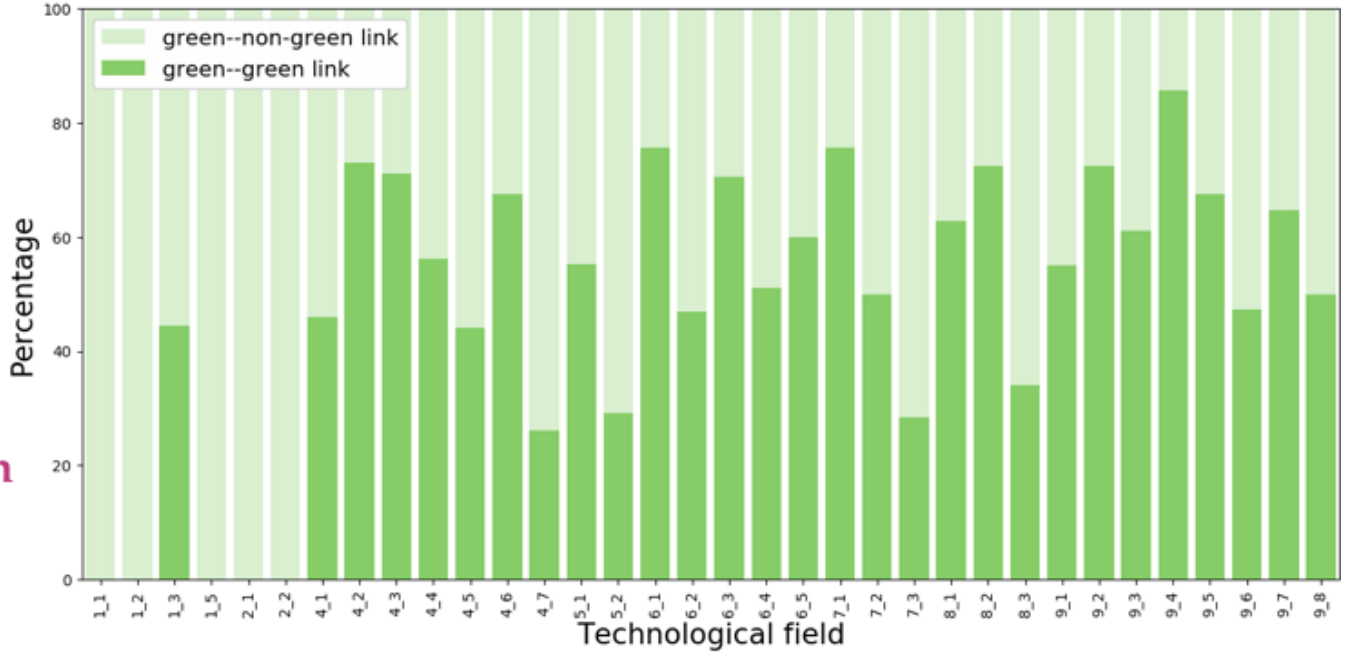
Green — Green
52%

Green — Non-Green
48%

Non-Green — Non-Green
90%

Non-Green — Green
10%

Significant links for each ENV-TECH (99.0%)



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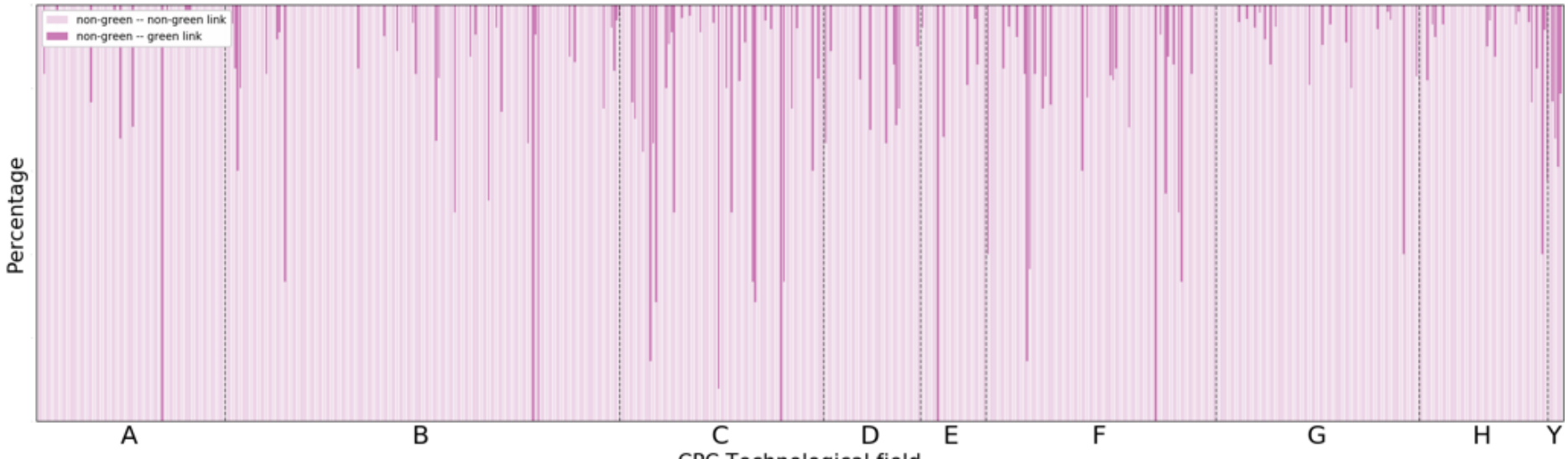

TOP 10 CPC Non-Green Techns anticipated by Green Techns

B60 Vehicles in general
Y02 Technologies or applications for climate change mitigation or adaptation
Y04 Information or communication technologies

B01 Physical or chemical processes or apparatus
B82 Nanotechnology
F21 Lighting
G02 Optics
G09 Education; cryptography; display; advertising; seals
H04 Electric communication technique
H05 Electric techniques

TOP 10 CPC Non-Green Techns that anticipate Green Techns

B60 Vehicles in general
Y02 Technologies or applications for climate change mitigation or adaptation
Y04 Information or communication technologies having an impact on other technology areas

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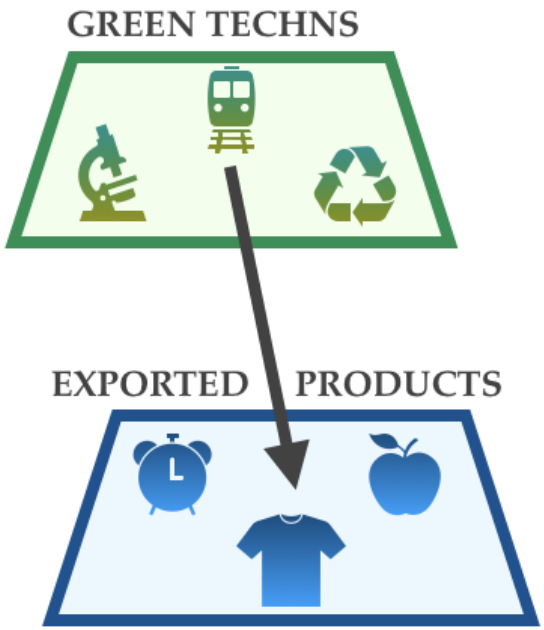
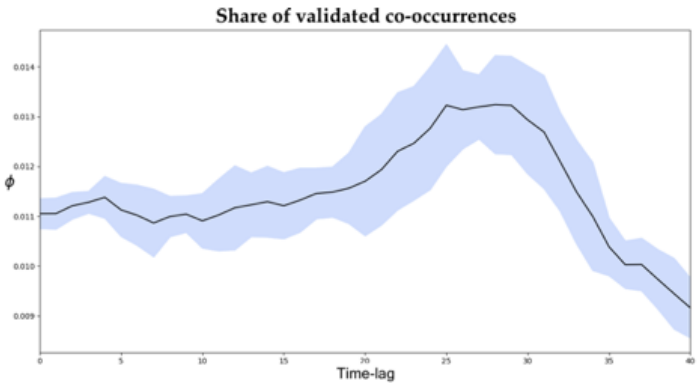
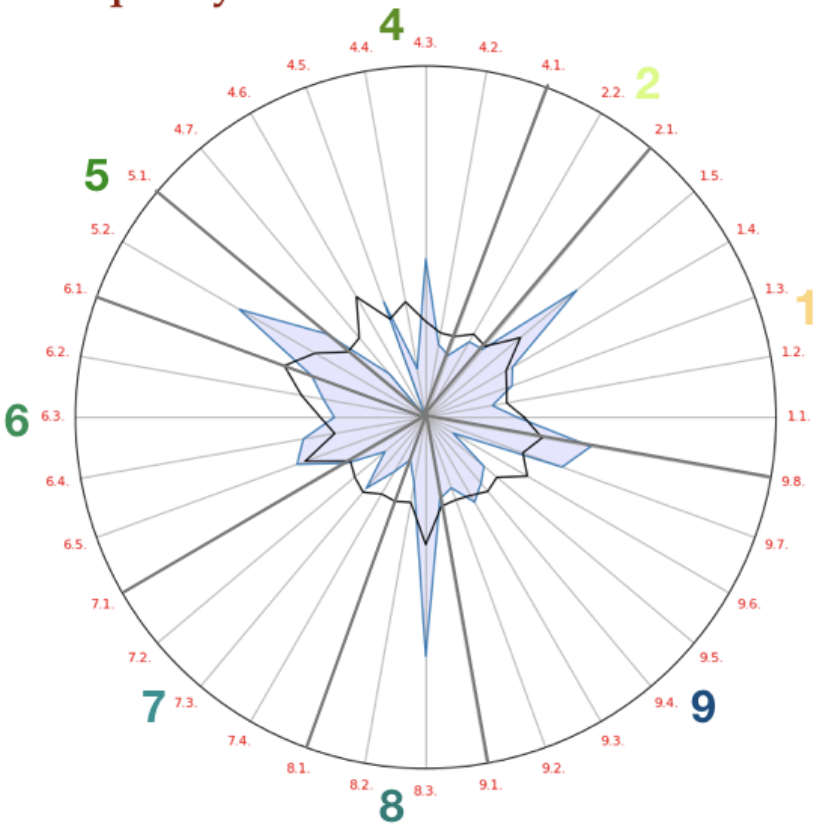
C02 Treatment of water, sewage, or sludge
C11 Animal or vegetable oils, fats, fatty substances or waxes
C10 Petroleum, gas or coke industries; technical gases containing carbon monoxide; fuels; peat
E03 Water supply; sewerage
F01 Machines or engines in general; engine plants in general; steam engines
F05 Indexing schemes relating to engines or pumps
G08 Signalling

Next steps 1: Green Techns–Products Multilayer Network

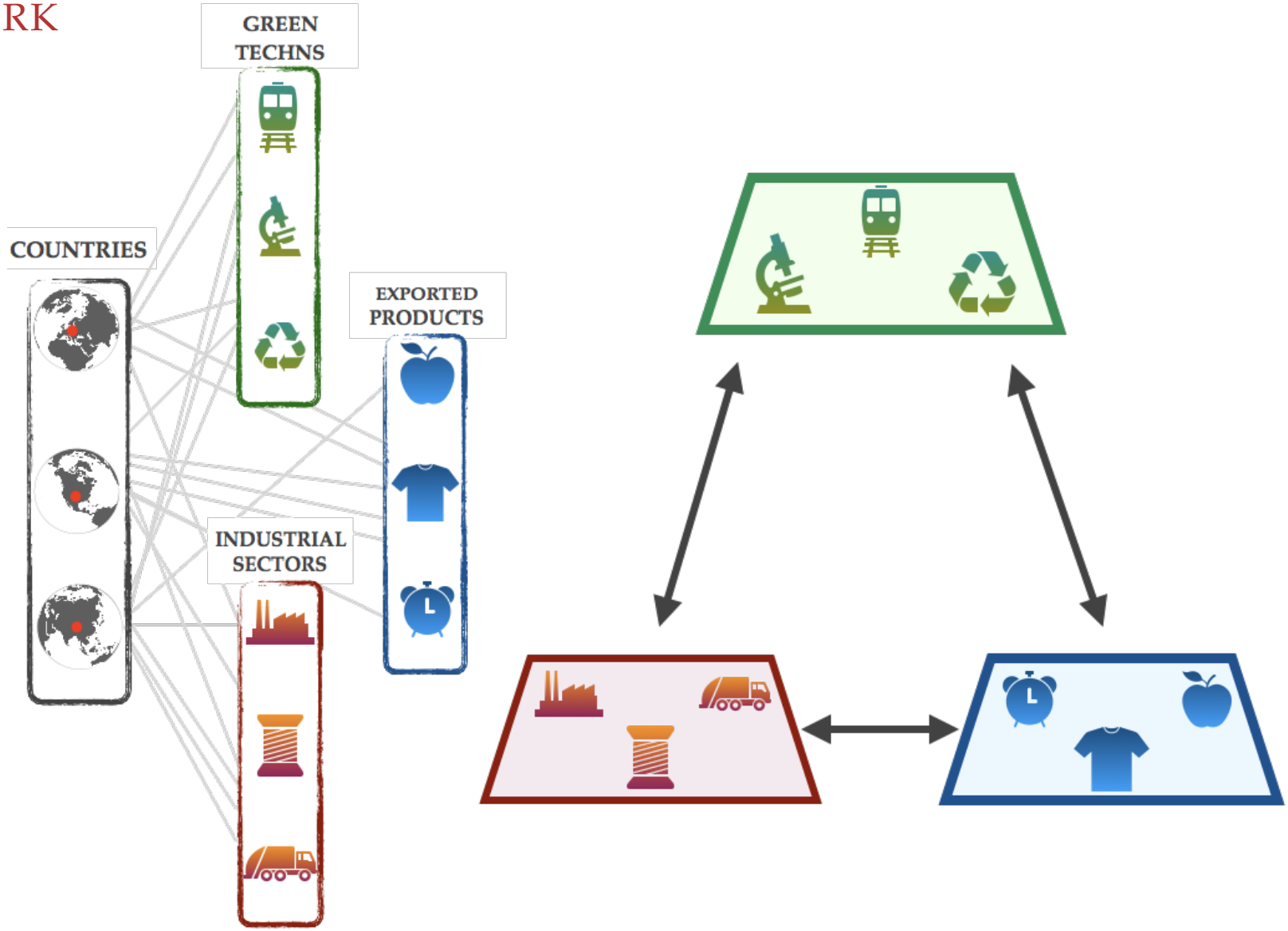




Product 902610
Air quality and dust emissions monitors



Significant links with Env techs

- 1_5 Environmental monitoring
- 4_3 Combustion technologies with mitigation potential
- 5_2 Capture or disposal of greenhouse gases other than CO2
- 6_5 Enabling technologies in transport
- 8_3 Enabling techns or indirect contribution to GHG mitigation
- 9_8 Enabling techns with a potential contribution to GHG emissions mitigation

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