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Dipartimento di
Scienze Politiche e Sociali

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Digital and Green Transitions: Opportunities and Challenges for Europe and China

Roberta Rabellotti
Università di Pavia

In collaboration with Davide Bonaglia, Rasmus Lema & María de las Mercedes Menéndez

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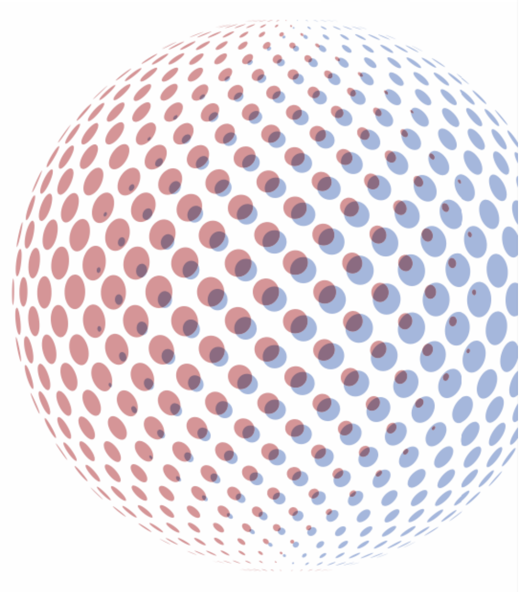
Digital Power China

A European research consortium



REVERSE DEPENDENCY:

MAKING EUROPE'S DIGITAL TECHNOLOGICAL STRENGTHS INDISPENSABLE TO CHINA

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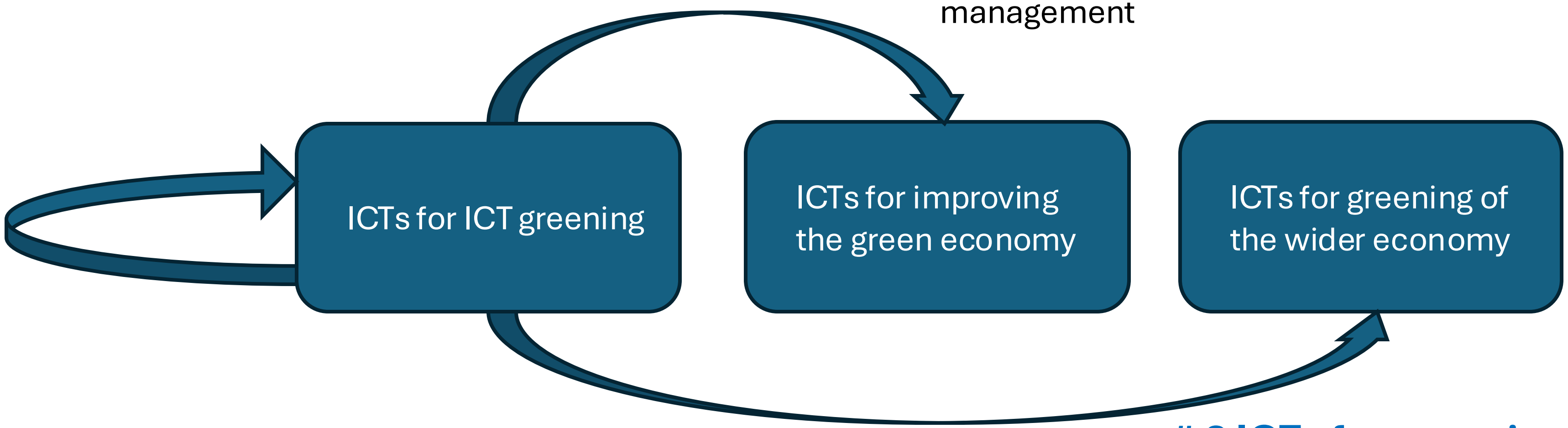
What are the twin transition technologies (TTTs)?

- Twin transition technologies (TTTs) emerge when digital technologies meet sustainability objectives.
- There are three types of digital innovations developed (or applied) for direct or indirect environmental gains.

 # 2 ICTs for improving the green economy
e.g. ICTs innovation for improving the performance of solar parks or waste management

 # 1 ICTs for ICT greening
e.g. ICT innovation for reducing energy consumption in data processing or for reducing e-waste



 # 3 ICTs for greening the wider economy
e.g. ICTs for improving the environmental performance of manufacturing production

Methodology

Patents analysis

Database: 66.648 patent applications filed at USPTO, EPO and JPO from 2000 to 2022

Green technologies: Y02/Y04S technological codes for climate change mitigation technologies

Digital technologies: based on WIPO identification of General Purpose Technologies (GPTs) including artificial intelligence (AI) and machine Learning (ML), autonomous systems, big data, cloud computing, internet-of-things (IoT) and robotics.

Green technologies and TTT classes

TABLE 1: Climate change mitigation technologies and smart grids

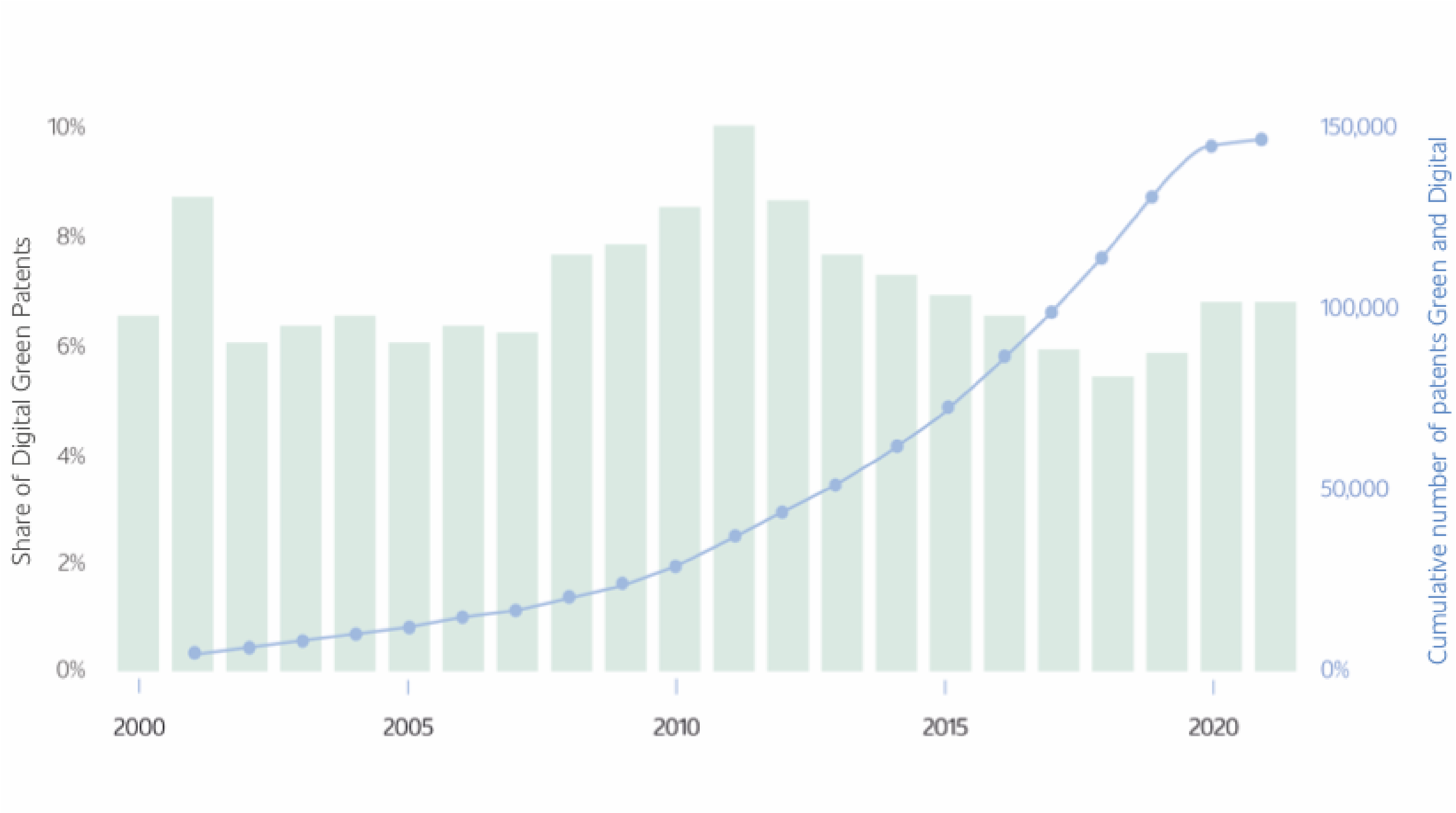
CPC	DESCRIPTION	KEYWORDS
Y02	Technologies or Applications for Mitigation or adaptation against climate change	
Y02A	Technologies for adaptation to climate change	Adaptation
Y02B	Climate change mitigation technologies related to buildings	Buildings
Y02C	Capture, storage, sequestration, or disposal of greenhouse gasses	Greenhouse gas capture and storage
Y02D	Climate change mitigation technologies in information and communication technologies	Green-ICT
Y02E	Reduction of greenhouse gas emissions related to energy generation, transmission, or distribution	Energy
Y02P	Climate change mitigation technologies in the production or processing of goods	Production
Y02T	Climate change mitigation technologies related to transportation	Transports
Y02W	Climate change mitigation technologies related to wastewater treatment or waste management	Waste
Y04	Information or communication technologies with an impact on other technology areas	
Y04S	Systems integrating technologies related to power network operation, communication, or information technologies for improving electrical power generation, transmission, distribution, management or usage, i.e. smart grids	Smart Grids

ICTs for ICT greening (TTT1)	• Green-ICT
ICTs for improving the green economy (TTT2)	• Adaptation • Greenhouse gas capture and storage • Energy • Waste • Smart grids
ICTs for greening the wider economy (TTT3)	• Buildings • Production • Transport

AI-Driven TTTs: an example

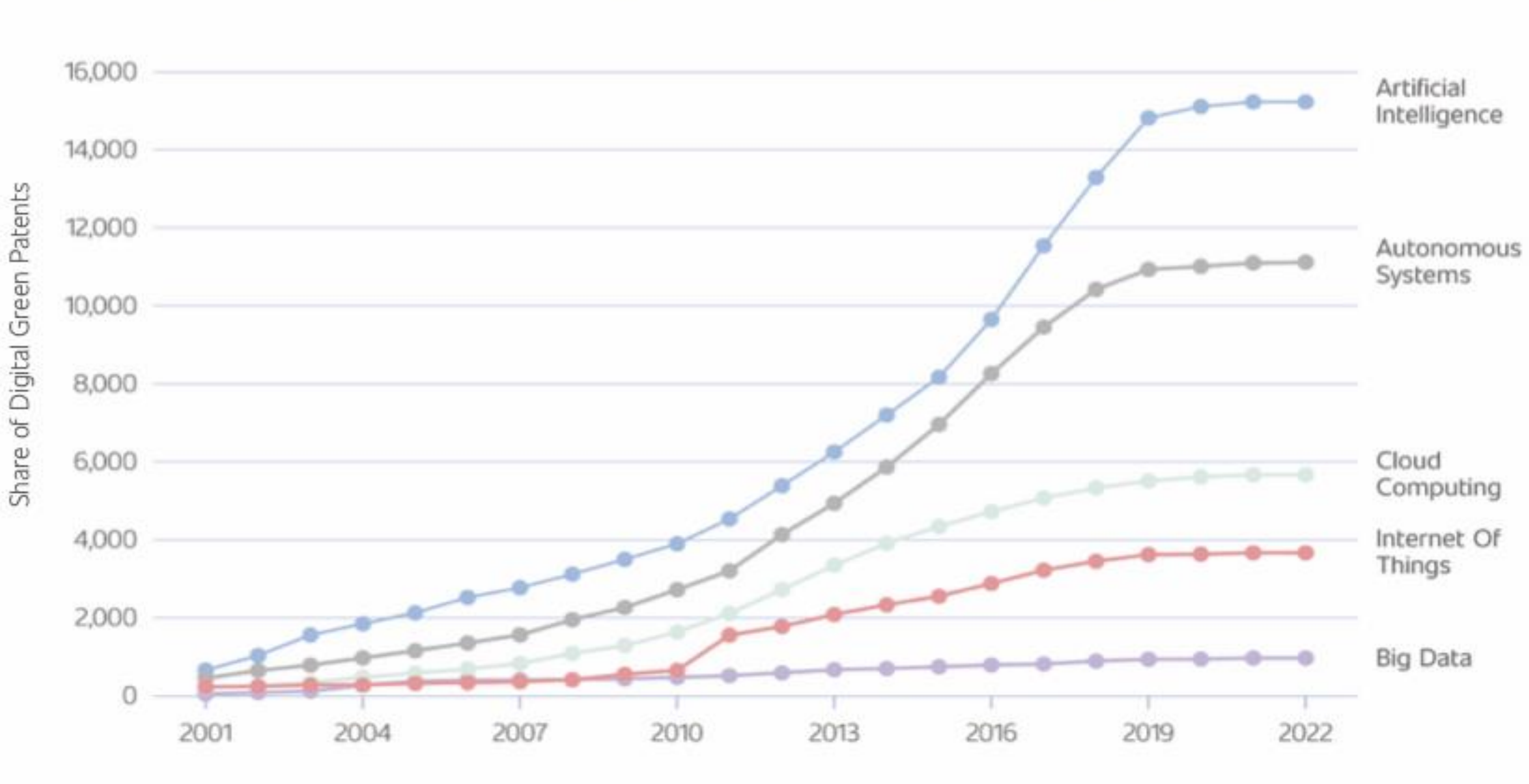
Type of TTT	Domains	Examples
AI for ICT greening (TTT1)	• Computing • Communication networks • ICT equipment	• Optimize cooling and energy use in data centers • Dynamic allocation of computational resources
AI for improving the green economy (TTT2)	• Adaptation • Carbon capture and storage • Energy • Smart grids • Waste	• Predicting climate change impacts • Monitoring and preventive maintenance of renewables • Predicting and managing energy demand, reducing peak load on the grid
AI for greening the wider economy (TTT3)	• Buildings • Production • Transport	• Optimizing heating, cooling, and lighting, reducing energy consumption • Improving manufacturing processes to use fewer resources and produce less waste • Optimizing routes and maintenance for transport fleets, enhancing fuel efficiency

FIGURE 1: Digital green patents and share



Note: This graph includes all digital green patents without considering the national or regional jurisdictions in which they were issued, and thus differs from the rest of the analysis. Source: own elaboration based on PATSTAT.

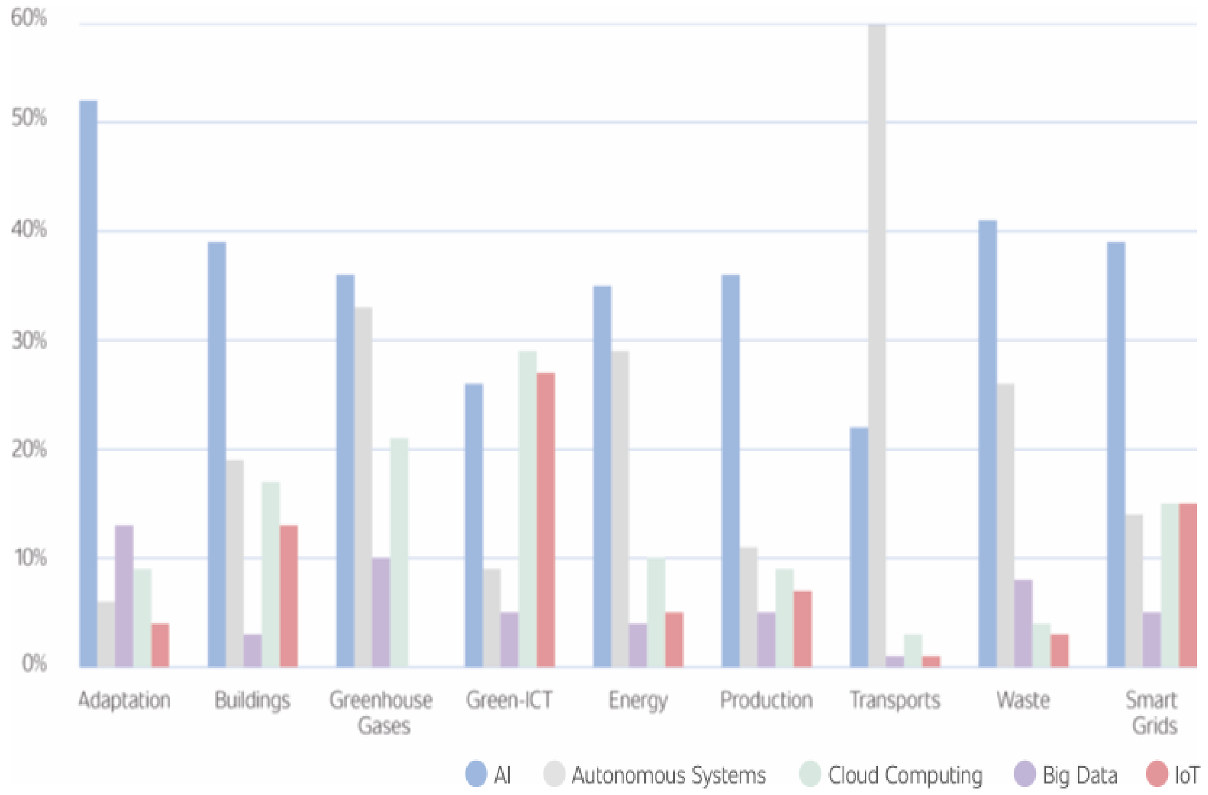
FIGURE 2: Cumulative evolution of digital green technologies by GPTs categories



Note: This graph includes patents applied for in the US, Japan or European Patent Office. Source: own elaboration based on WIPO.

- AI technologies are relevant in most of the classes of green technology;
- In green technologies related to ICTs, there is a more balanced integration with other technologies such as cloud computing and the IoT;
- In green transport-related technologies, autonomous systems are key.

FIGURE 3: Digital green technologies with Y02/Y04 tag by GPTs category (% applications)



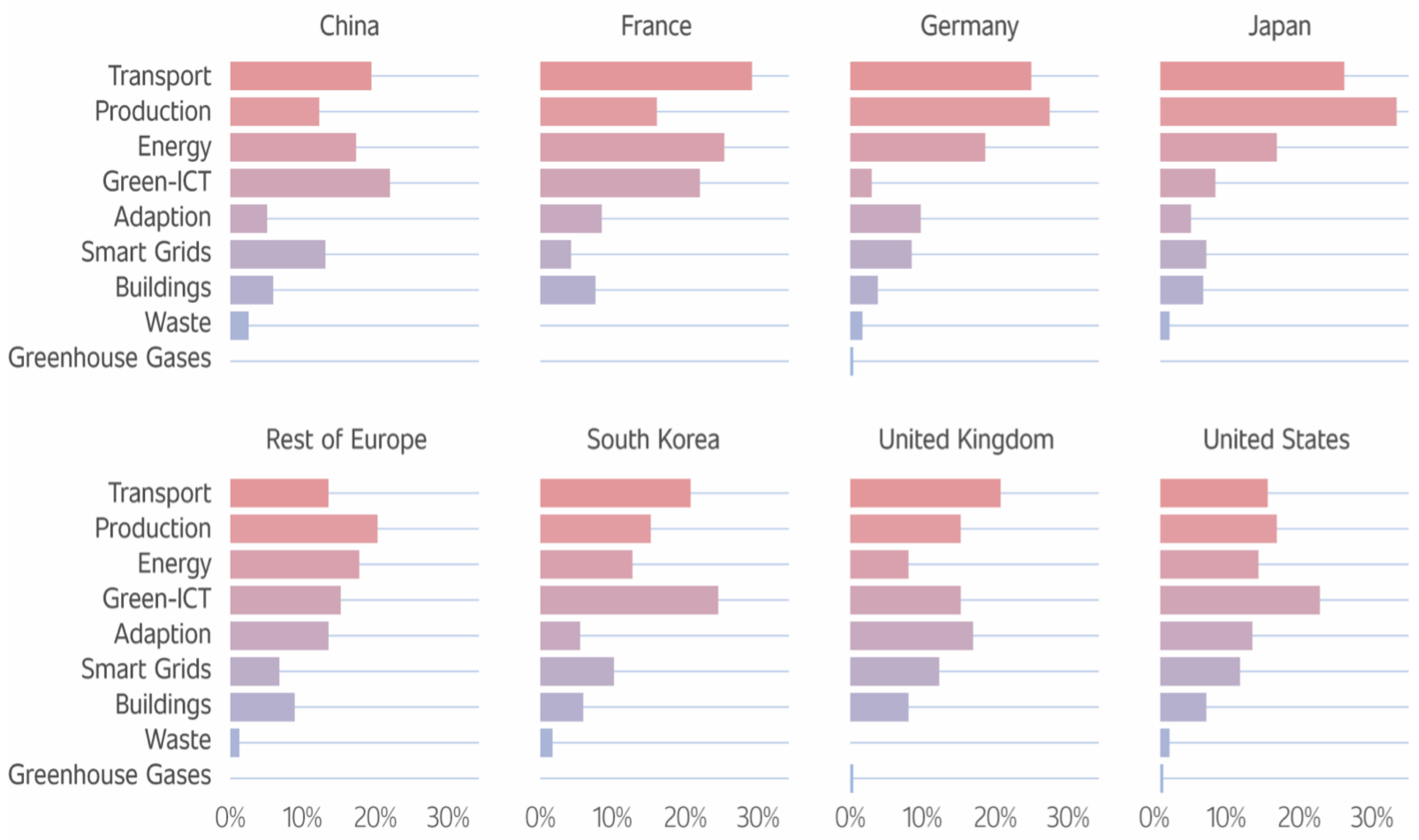
Source: own elaboration based on PATSTAT.

TABLE 2: Digital green patent applications by countries, 2000–2022

COUNTRY	NUMBER OF PATENTS	SHARE
United States	30,873	46.32%
Japan	11,859	17.79%
Europe	10,138	15.21%
• Germany	4,509	6.8%
• France	1,634	2.5%
• Netherlands	804	1.2%
• Italy	713	1.1%
• Sweden	702	1.1%
• Rest of Europe	1,777	2.67%
South Korea	3,714	5.57%
China	3,321	4.98%
United Kingdom	1,879	2.82%
Canada	1,228	1.84%
Switzerland	1,068	1.60%
Israel	796	1.19%
Australia	449	0.67%
Rest of the World	1,322	1.98%
Total	66,648	100%

Source: own elaboration based on WIPO.

FIGURE 4: Distribution of Y02 per applicant country



Source: own elaboration based on PATSTAT.

RTA (Revealed Technology Advantage): Relative technological specialization

TABLE 3: Positive RTAs: Green Technologies

Y02A	Adaptation	UK, USA
Y02B	Buildings	UK, EU
Y02C	GHG capture and storage	UK, EU, USA
Y02D	Green-ICT	China, USA
Y02E	Energy	China, EU, Japan
Y02P	Production	Japan
Y02T	Transport	China, UK, EU, Japan
Y02W	Waste	China, EU
Y04S	Smart Grids	UK, USA

TABLE 4: Positive RTAs: General Purpose Technologies

ARTIFICIAL INTELLIGENCE	USA
AUTONOMOUS SYSTEMS	EU, China, Japan
BIG DATA	EU, USA
CLOUD COMPUTING	USA
INTERNET OF THINGS	UK, China, USA
ROBOTICS	EU, UK, Japan

Source Table 3and 4: own elaboration based on WIPO

Patent quality: forward citations

- US patents are more cited in every technology.
- EU patents are more influential than Chinese ones.
- The digital green patents in which the EU is more influential are in autonomous systems. In these technologies, 22% of the most cited patents are produced in the EU.
- In AI, 17% of the EU patents fall into the top 10% in terms of citation distribution.
- In cloud computing, 17% of EU patents are among the most cited.
- In robotics, the EU share of top cited patents reaches 15%.

TABLE 5: Top 10% most cited digital green patents by GPTs, 2011–2020

GPTS	COUNTRY	# OF PATENTS	# OF MOST-CITED PATENTS	SHARE OF MOST-CITED PATENTS (%)
Artificial Intelligence	China	676	21	3.51
	EU	1076	100	16.72
	UK	185	4	0.67
	Japan	1234	58	9.70
	USA	5285	415	69.40
Autonomous Systems	China	478	31	10.76
	EU	967	64	22.22
	UK	138	2	0.69
	Japan	954	8	2.78
	USA	3001	183	63.54
Big Data	China	68	1	1.49
	EU	196	9	13.43
	USA	731	57	85.07
Cloud Computing	China	209	4	1.16
	EU	329	58	16.81
	Japan	270	12	3.48
	USA	2639	271	78.55
Internet of Things	China	211	6	1.97
	EU	223	36	11.80
	UK	96	2	0.66
	Japan	371	48	15.74
	USA	1814	213	69.84
Robotics	China	242	11	2.61
	EU	720	63	14.93
	UK	159	3	0.71
	Japan	920	45	10.66
	USA	2205	300	71.09

Note: this table only considers patents registered at USPTO. | Source: own elaboration based on WIPO

Summary of the key findings

- USA is the world leader in TTTs, largely reflecting its overall superiority in digital technology innovation.
- USA is followed by Japan and EU, although with a significant gap.
- China remains a relative 'latecomer' in the TTT field. Yet, China has relative technological specialization in:
  - **Green ICT** (TTT 1 - ICTs for ICT greening)
  - **Energy and waste management** (TTT 2 - 2 ICTs for improving the green economy)
  - **Transportation** (TTT 3 ICTs for greening the wider economy)
- The analysis of the quality of patents shows that China has less impactful digital green patents compared to USA, EU, and Japan.

Cooperation or decoupling?

- In the field of the twin transition technologies there is a delicate balance between cooperation on common challenges and competition to safeguard economic interests and values.
- Decoupling in digital green technologies, for example by means of export controls, seems both unrealistic and counterproductive because these are technologies aimed at tackling climate change and biodiversity loss, as well as enhancing resource efficiency and environmental sustainability with a clear global interest.
- In this field instead of decoupling, China and the EU (as well as the rest of the world) should increase public R&D investments and provide incentives to private investors to strengthen the existing areas of technological leadership at the same time deepening cooperation with relevant partners.
- Especially in non-competitive fields, such green digital technologies, competition needs to be combined with collaboration.
- It is essential to maintain a long-term perspective, which might offer a different set of opportunities in a rapidly changing global environment: cooperation at the technical level and exchanges in concrete domains should always remain possible.

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