

# The Past, Present and Future of European Productivity

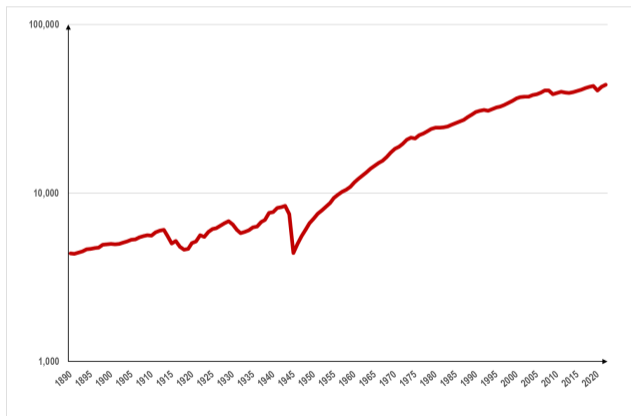
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HEC Paris

NBB Conference: Deglobalisation, Decarbonisation, and Digitalisation  
October 2024

# Growth, the very long run

Figure: GDP per capita in the euro area since 1890.

Source: [www.longtermproductivity.com](http://www.longtermproductivity.com)



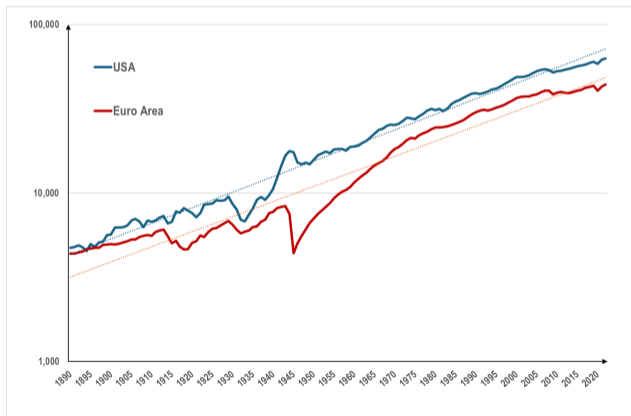
- GDP per capita in the EA: **2.1%** per year on average since 1890
- Most gains from 1950 to 1980:
  - Consumption per capita  $\times 3$
  - Working time  $-400$  hours
- Since 1995: 1.1% on average per year
  - Since 2004: 0.7%

# Euro area and the US

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Figure: GDP per capita in the US area since 1890.

Source: [www.longtermproductivity.com](http://www.longtermproductivity.com)

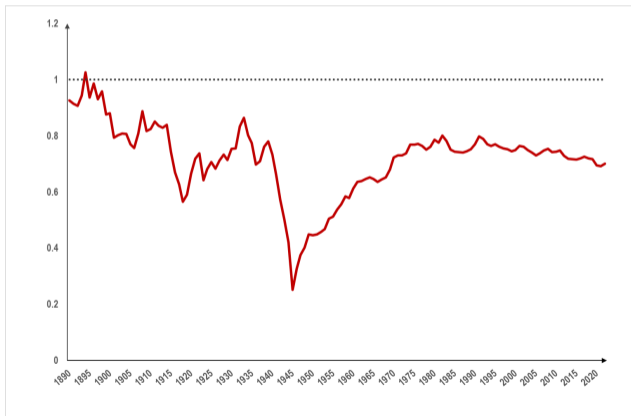


# Euro area and the US

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Figure: GDP per capita in the euro area since 1890.  
US = 1. Source: [www.longtermproductivity.com](http://www.longtermproductivity.com)

- Different dynamics in the US
  - Remarkable constant 2% growth rate
- Europe **caught-up** after WW2 but **diverges** since 1995
- **In 2022 same relative gap as in... 1970**



# The past, present and future of European productivity

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- A simple decomposition

$$\frac{GDP}{Pop} = \underbrace{\frac{GDP}{Labour}}_{\text{Labour Productivity}} \times \underbrace{\frac{Labour}{Pop}}_{\text{Labour Utilization}}$$

- Since 1890: labour productivity  $\approx \times 20$
  - GDP per capita:  $\approx \times 10$
  - Working time divided by 2
- 
- To understand the dynamics of GDP per capita
    - Productivity gains
    - Choice regarding how to use these gains (Consumption / Leisure)

# The past, present and future of European productivity

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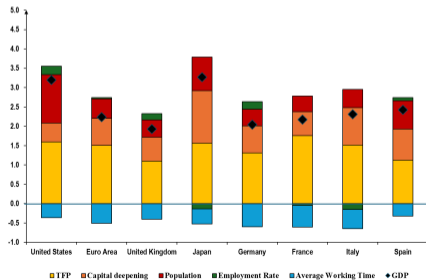
- In this paper we look at the drivers of GDP per capita in Europe over the 20<sup>th</sup> century
  - In particular what explains the 1950-1980 exceptional period
- We focus on the reasons behind the slowdown since 1995 and the post-pandemics trends
- And we discuss what the future of European productivity can be
  - Artificial Intelligence
  - Environmental transition

# The past (1890-1995)

# Another decomposition

$$\frac{GDP}{Pop} = \frac{TFP \cdot K^\alpha \cdot H^{1-\alpha}}{Pop} = \underbrace{TFP \times \left(\frac{K}{H}\right)^\alpha}_{\text{Labour Productivity}} \times \frac{Emp}{Pop} \times \frac{H}{Emp}$$

Figure: Growth Accounting

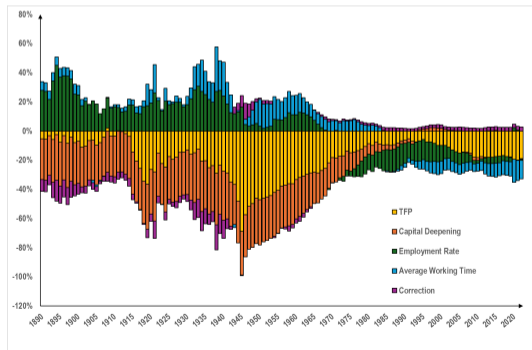




# Growth accounting

- Total factor productivity (TFP) main driver of GDP per capita over the long run
  - Catch-up of Europe is essentially due to resorbing TFP differences with US
- After 1975
  - Negative relative contribution of **employment rate**
  - **Since 1995**: working time declined faster than in the US
  - No more relative TFP gains
- European preference for more leisure
  - With less TFP **this implies less growth**

Figure: Growth Accounting: EA vs the US



# What made the catch-up possible?

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- After WW2, Europe developed institutions that favoured investment to replace old capital  
⇒ Capital Deepening
- Europe also increased its total factor productivity
  - Relied on a relatively educated population
  - Relative success in **country-specific** industrial policies (especially in Germany)
- Overestimated?
  - Massively adopted US technologies → US firms share of French/German patents increased from 10 to 25% (IBM, GE, Kodak...)
  - Europe also relied on (almost) unlimited supply of energy (oil)

# What made this possible?

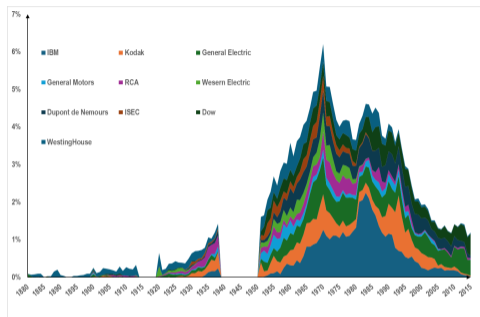


Figure: Top patenting firms in France and Germany

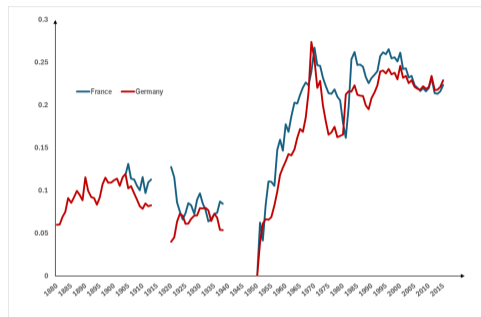


Figure: Share of US firms in France and Germany

*“The third largest industrial power in the world, after the United States and the U.S.S.R., could well be in fifteen years, not Europe but American industry in Europe” Servan-Schreiber (1967)*

# What made this possible?

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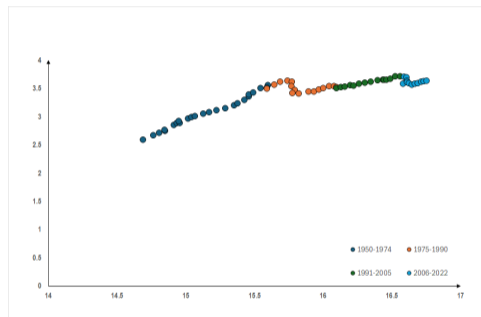
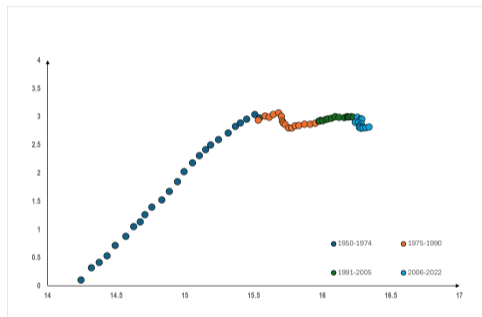


Figure: Oil consumption and GDP per capita for the Euro area (left) and the USA (right).  
Source: [Bergeaud and Lepetit \(2020\)](#)

# But...

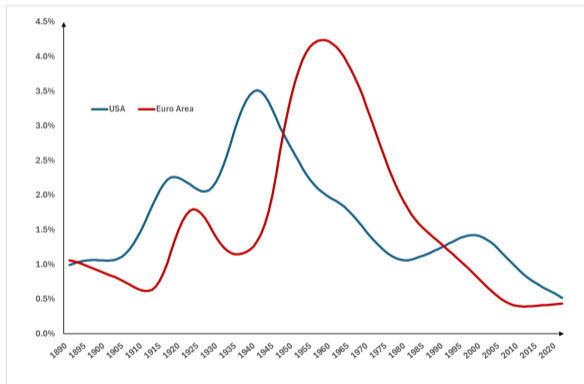
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- Public investment into R&D **not coordinated enough** and not **mission-oriented** as in the US
  - Federal R&D expenditure in the US: almost 2% of GDP in 1960s (Dyèvre, 2024)
  - 40b USD for the sole NASA in 1970
  - **Spillovers to electronic and computer technologies, and also pharma** (Gross and Sampat, 2024)
- Europe's innovation policy relied on the **development of national champions**
  - Smaller markets
  - Costly failures
  - Limit entry of firms
  - Competition of US (then Japanese) firms
- **As a result: Europe as a whole missed the IT revolution**

# Big waves of productivity

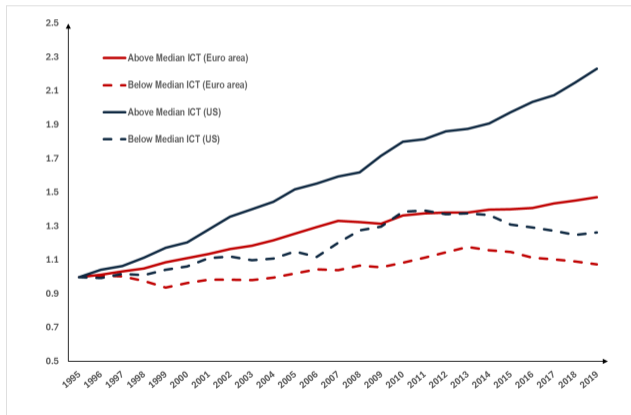
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Figure: Filtered TFP growth. Source: [Bergeaud, Cette and Lecat \(2016\)](#)



# The missed IT revolution

Figure: ICT and Growth



- ICT is the main drivers of TFP in the US after 1995 (Jorgenson, 2001)
- ICT intensive sectors experienced huge productivity gains, but not in Europe
- Confirmed by a country-sector panel regression [See model](#)
- Explains 20% of the productivity growth rate gap between the US and Europe during the period 1995-2005 (Gordon and Sayed, 2020)

# Country-sector panel regression

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Table: Dependent variable: log of labour productivity

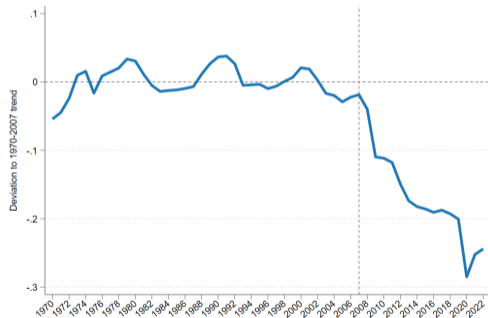
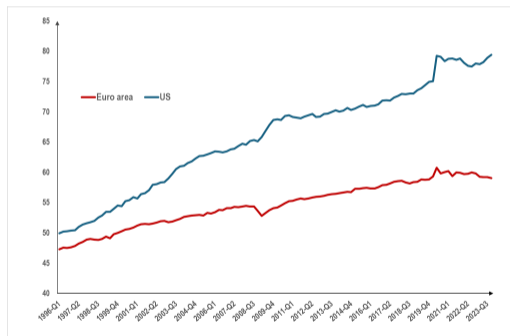
	OLS and IV Estimates			
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	IV
IT capital stock over total capital stock	2.774 (0.959)	1.690 (0.777)	1.658 (0.549)	6.608 (3.136)
Observations	12,948	12,948	12,948	12,380
Fixed effects				
Sector - country	Yes	Yes	Yes	Yes
Year	Yes			
Sector-year	No	Yes	Yes	Yes
Country-year	No	No	Yes	Yes



# The present (1995-2023)

# Relative US / EA since 1995

Figure: Labour productivity EA and US and deviation to trend



2011-2020

# Why?

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## Short term causes

- Shocks such as pandemics and Russian's invasion of Ukraine  $\implies$  labour reacted less than output Show regression
  - Why? Hiring difficulties: firms reluctant to let go their workforce
- Geopolitical risk / Disruption of Global Value Chains  $\implies$  stronger impact on more productive firms
- Zombification of the economy due to policies conducted during Covid

# Why?

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## Structural causes

- Structural reduction of working time  $\rightarrow$  change in preferences? Time series
- Misallocation of R&D
- Lack of innovation in high tech

# Misallocation of R&D

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- R&D expenditures in Euro area: 2.3% of GDP (3.4% in the US) Time series
- Public R&D expenditures are similar → **Not a problem of public spendings**
  - Main question is its allocation
  - Innovation and industrial policies in Europe has led to a **middle technology trap** (Fuest et al., 2024)
- Top patenting firms in 2005
  - **USA:** Procter & Gamble, 3M, General Electric, DuPont, Qualcomm
  - **EA:** Siemens, Bosch, Ericsson, Philips, BASF
- Top patenting firms in 2023
  - **USA:** Qualcomm, Microsoft, Apple, Google, IBM
  - **EA:**

# Misallocation of R&D

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# Middle technological trap

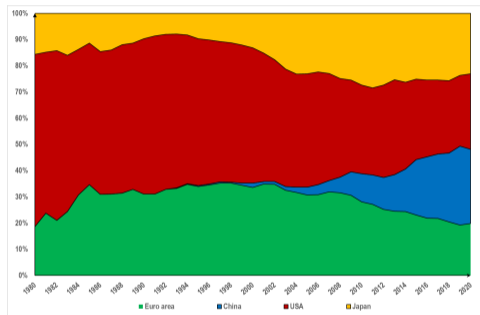


Figure: Patents filed under the PCT  
(OECD)

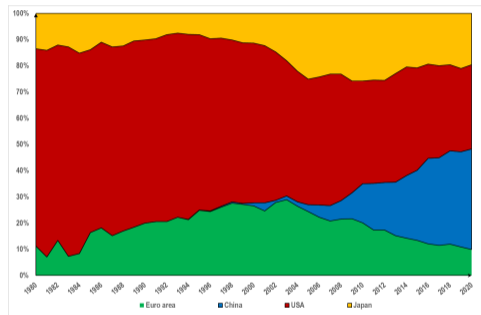
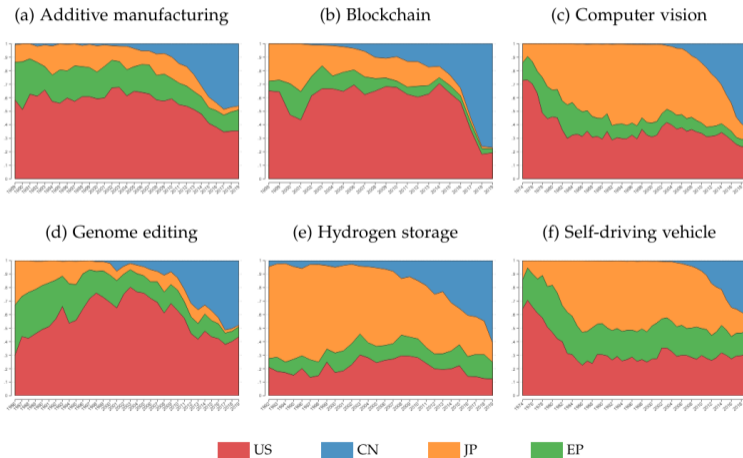


Figure: High technologies patents filed  
under the PCT

# High tech in Europe

Figure: Patenting in selected technologies. Source: [Bergeaud and Verluise \(2023\)](#)





# Why?

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- European innovation policies are **unsufficiently coordinated**
  - Benefit of **large market** not exploited enough
  - Capital market is **unsufficiently integrated** (Letta, 2024)
  - Organization of research agencies does not sufficiently rewards **long-term risk** (Draghi, 2024)
  
- R&D subsidies cannot be the only instrument
  - Very hard to **direct to the right firms**
  - Moral hazard and misreporting
  
- Innovation policies do **not sufficiently rely on public research**
  - Spillovers from public to private research can be sizable
  - A way to direct public R&D support to the firms with the best capabilities
  - Important effects historically in the US (Gross and Sampat, 2023) and succesful examples in Europe (Bergeaud et al., 2023)

# Europe has the potential

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Table: Origin of the basic knowledge used in patents in specific technologies

	<b>USA</b>	<b>Japan</b>	<b>China</b>	<b>Europe</b>
<b>Additive Manufacturing</b>	51%	6%	3%	28%
<b>Blockchain</b>	54%	5%	4%	23%
<b>Computer Vision</b>	54%	5%	3%	27%
<b>Genome Editing</b>	57%	5%	1%	29%
<b>Hydrogen Storage</b>	35%	12%	6%	29%
<b>Self-Driving Vehicle</b>	49%	6%	2%	28%

# The future

# AI: what can we expect

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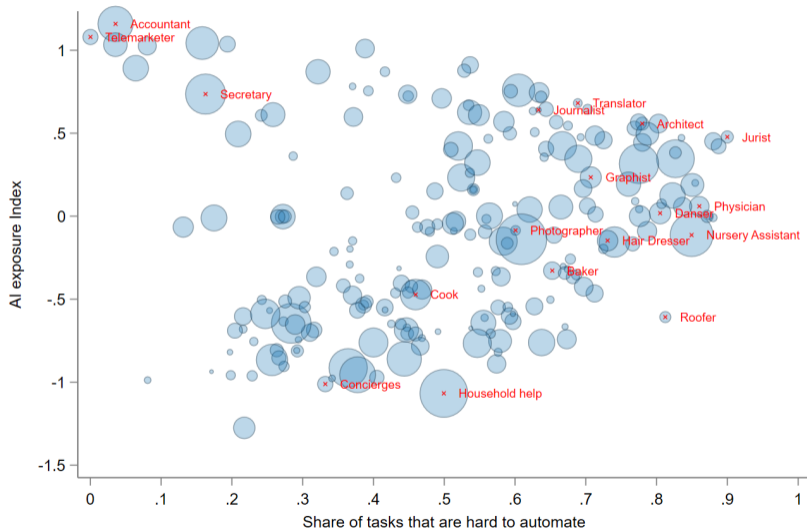
- AI can impact growth through many channels
  - Automate some tasks and free up time for creative and more valuable activities (**Automation channel**)
  - Enhance workers' efficiency by complementing workers in core tasks (**Automation channel**)
  - Automate the production of ideas and improve R&D productivity (**R&D and TFP**)
  - Substitute labour with capital (**Capital Deepening**)
- Can the global effect match what we experienced with other **General Purpose Technologies**?

# The Automation Channel

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- [Acemoglu \(2024\)](#) offers a simple way to estimate the **automation channel**. Product of 4 components
  - ① Share of GDP accounted for by exposed tasks
  - ② Share of these tasks for which it is cost-effective to use AI
  - ③ Average saving cost from AI adoption
  - ④ The labour share

# The Automation Channel



# The Automation Channel

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- What is the average efficiency gains from AI adoption in impacted tasks?
- Some evidence from the literature from GenAI based on RCT. Workers using GenAI are
  - **Faster** → 40% increase for analysts (Noy and Zhang, 2023)
  - **More precise** → 23% increase in prediction accuracy in a forecasting (Schoenegger et al., 2024)
  - **More creative** → better rated stories (Doshi et al., 2023)
- But workers may trust AI too much in areas where AI does not have a comparative advantage

# AI: what can we expect

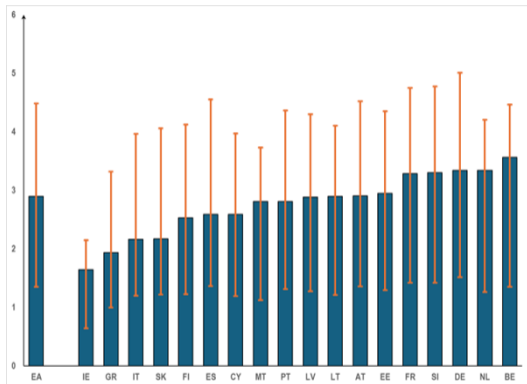
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- Acemoglu (2024) offers a simple way to estimate the automation channel. Product of 4 components
  - ① Share of GDP accounted for by exposed tasks  $\approx 45\%$
  - ② Share of these tasks for which it is cost-effective to use AI  $\approx 40\%$
  - ③ Average saving cost from AI adoption  $\approx 35\%$
  - ④ The labour share  $\approx 60\%$



# AI: what can we expect

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- Gains from adopting AI likely to be important **but not substantial**
- Most of the gains will come from **producing AI** to create new ideas
- This requires to be at the **technological frontier** and to be able to produce new models and tools

Figure: Estimated TFP gains from AI adoption through automation in next 10 years. Adapted from [Acemoglu \(2024\)](#)

# AI: where are we in Europe

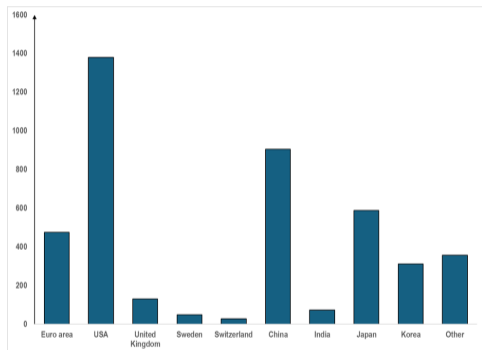


Figure: AI patents per region

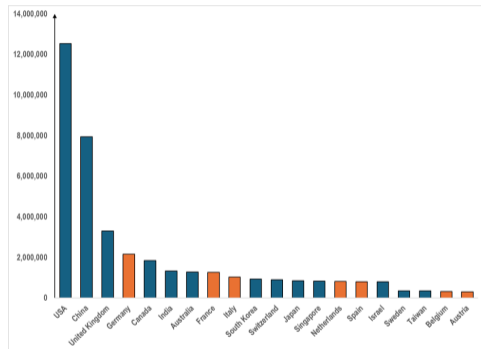


Figure: AI articles in Europe and in other regions (11m in total)

# Green transition

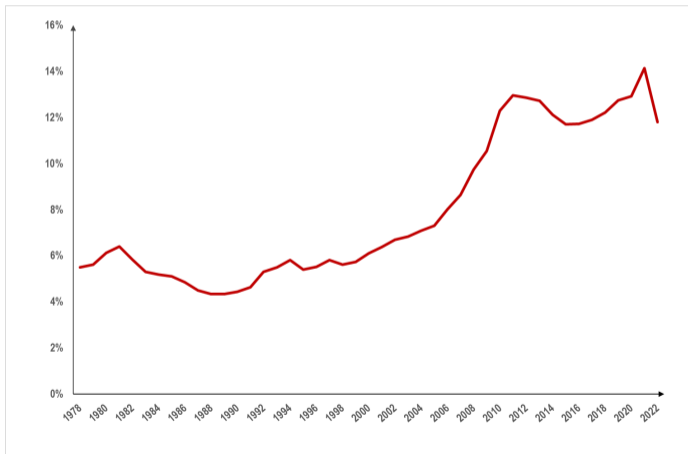
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- **Energy and environmental transition** requires a complex mix of policies, regulations and innovations
  - But green innovation is necessary to reduce our footprint while limiting the economic impact
- Europe is a clear leader in producing green technologies [See](#)
- Green innovation also generates important spillovers to other sector [See](#)
- But the green innovation is particularly sensitive to the ability of **young firms to innovate**
  - Important question of how to finance these firms

# Green transition

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Figure: Share of Green patent worldwide ([Aghion et al., 2024](#))



# Conclusion: European productivity on the long-run

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- The Past

- Catch-up: adoption, low energy price, investment
- Missed IT revolution

- The Present

- Recent slowdown partly cyclical but structural factors are still active
- Europe is a second-mover in most high-tech
- Structural changes in innovation policies and capital markets needed
- Capitalize on European strengths: research, market size, environment

- The Future

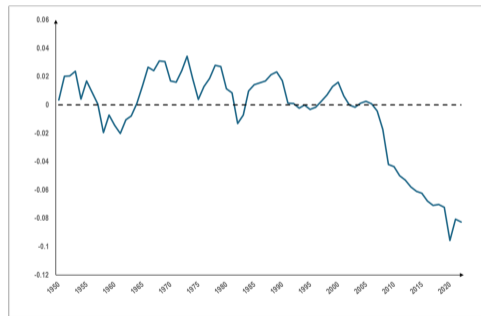
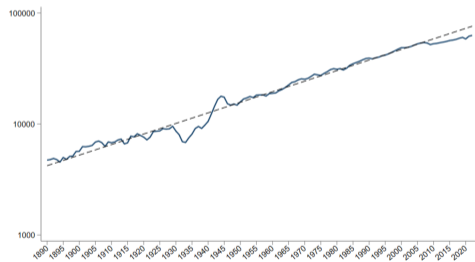
- Gains from AI will not be substantial unless AI revolutionizes the creation of ideas
- Potential gains from green innovation if young firms find external finance

# Appendix

# Deviation from trend in the US

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Figure: Comparison of GDP per capita trends in the US



# Econometric model

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$$\log(lp_{i,c,t}) = \alpha_{i,c} + \gamma X_{i,c,t-1} + \phi_{c,t} + \psi_{i,t} + \epsilon_{i,c,t} \quad (1)$$

- **Indices:**

- $i$ : Industry (32 industries)
- $c$ : Country (21 countries)
- $t$ : Year (1995-2019)

- **Dependent Variable:**  $\log(lp)$

- Level of value added in volume divided by total working time, taken in logarithm.

- **Main Regressor:**  $X$

- Ratio of IT capital over total capital stock in volume.

- **Fixed Effects:**

- $\alpha_{i,c}$ : Industry-country fixed effects
- $\phi_{c,t}$ : Country-year fixed effects
- $\psi_{i,t}$ : Sector-year fixed effects

- **Coefficient of Interest:**  $\gamma$

- Captures the effect of an increase in the share of IT capital on labour productivity.



## Results Summary:

- Excluding  $\phi_{c,t}$  and  $\psi_{i,t}$ , using year fixed effect (Column 1)
- Adding  $\phi_{c,t}$  (Column 2)
- Fully saturated model with  $\psi_{i,t}$  (Column 3)
- IV approach with instrument  $Z$  (Column 4)

## Instrument $Z$ :

- $Z = Z_t \cdot Z_i \cdot Z_c$
- $Z_t$ : Time-specific factor - US production price of computer sector divided by value added price.
- $Z_i$ : Sector-specific factor - US sector-specific ICT intensity in 1995.
- $Z_c$ : Country-specific factor - Share of patents at EPO before 1995 citing US patents in technology H.

# Econometric model

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$$\log(\text{PROD}_{i,c,t}) = \alpha_{i,c} + \gamma X_{i,c} \times T_t + \phi_{c,t} + \psi_{i,t} + \epsilon_{i,c,t} \quad (2)$$

- **Indices:**
  - $i$ : Sector (27 manufacturing sectors)
  - $c$ : Country (18 countries)
  - $t$ : Quarter (excluding year 2020)
- **Dependent Variable:**  $\text{PROD}_{i,c,t}$ 
  - Measures production of sector  $i$  in country  $c$  during quarter  $t$ .
- **Main Regressor:**  $X_{i,c}$ 
  - Share of import from BRIICS defined in 2019 for a given sector-country pair.
- **Dummy Variable:**  $T_t$ 
  - Equals 1 after 2020q1.
- **Fixed Effects:**
  - $\alpha_{i,c}$ : Sector-country fixed effects
  - $\phi_{c,t}$ : Country-time fixed effects
  - $\psi_{i,t}$ : Sector-time fixed effects

# Econometric model

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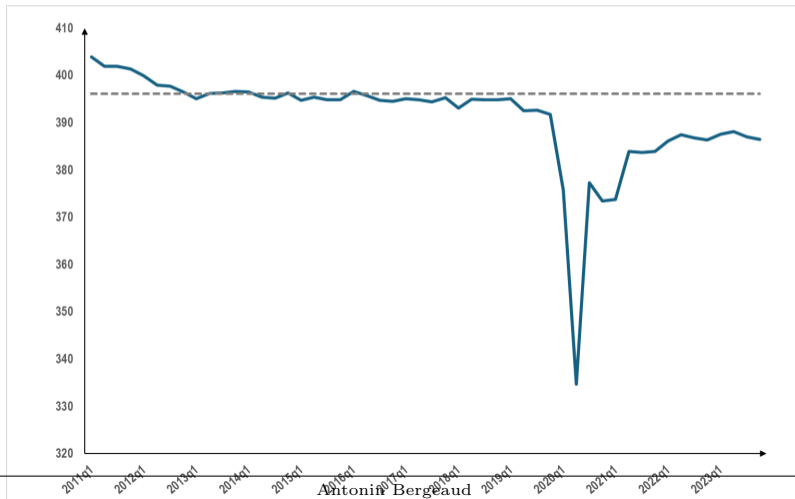
Table: Production, Hours Worked, and Employment

	<b>Exposure to BRIICS</b>			<b>Exposure to Russian</b>		
	<b>(1)</b>	<b>(2)</b>	<b>(3)</b>	<b>(4)</b>	<b>(5)</b>	<b>(6)</b>
$\gamma$	-1.406 (0.499)	-0.968 (0.446)	-0.817 (0.313)	-1.129 (0.508)	-0.804 (0.490)	-0.731 (0.306)
Obs.	36,749	34,579	35,588	36,749	34,579	35,588
Adjusted R <sup>2</sup>	0.816	0.790	0.771	0.816	0.790	0.771

# Working time in Euro area

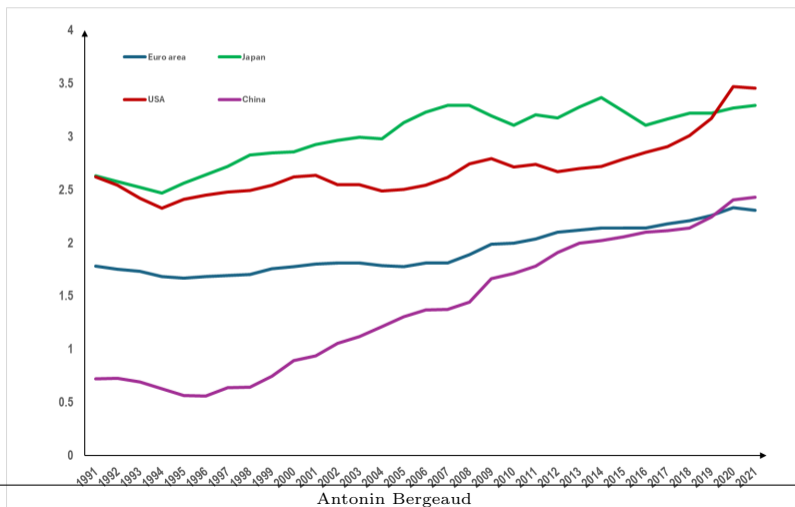
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Figure: Average working time in the euro area



# Time series

Figure: R&D expenditures in main regions



# Europe leads in green tech

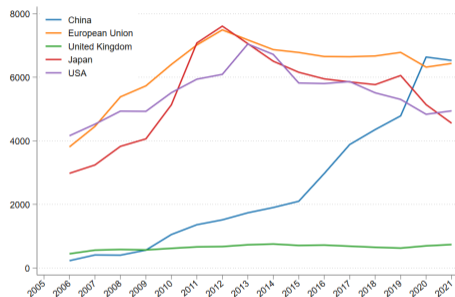


Figure: Number of green patents filed under PCT by region. Source: OECD

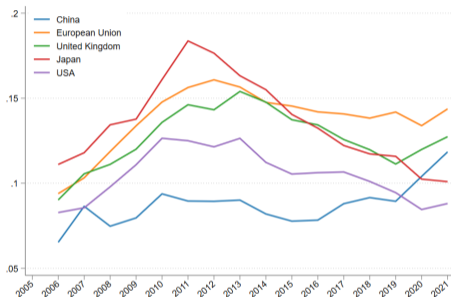


Figure: Share of green patents filed under PCT by region. Source: OECD

# Green tech generates spillovers

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	<b>Fwd Citations</b>	<b>Quality Indicator</b>	<b>Generality</b>	<b>Originality</b>
<b>Green patent</b>	0.353 (0.0408)	0.016 (0.0014)	0.039 (0.0144)	0.044 (0.0131)
<b>Average value</b>	0.978	0.314	0.351	0.675
Obs.	2,249,577	2,249,577	2,249,577	2,249,577
Year-Tech Fixed effects	Yes	Yes	Yes	Yes

# Deviation from trend

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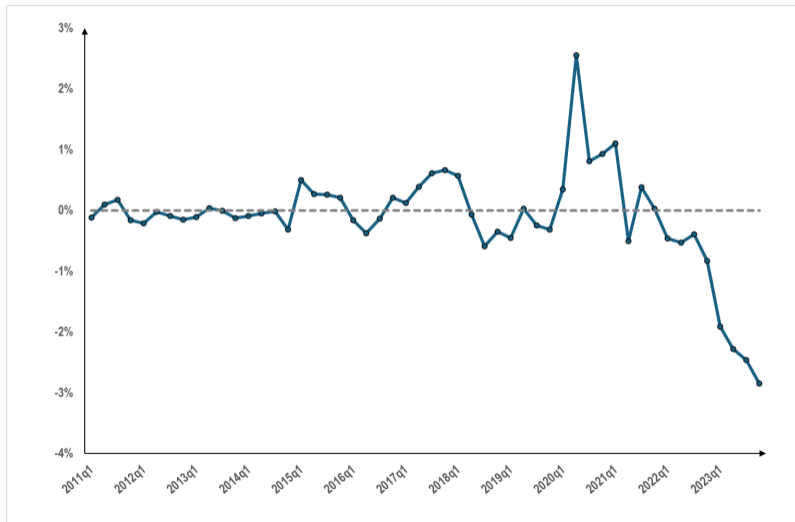


Figure: Labor productivity deviation from pre 2020q1 trend