SCOR Foundation Online Webinar
November 27, 2024

# Green- or de-growth: Is green growth possible?

Philippe Aghion

# CREATIVE DESTRUCTION…

- Process whereby new innovations displace old technologies
  - Joseph Schumpeter in *Capitalism, Socialism et Democracy (1942)*

# Peter Howitt

# BASIC "SCHUMPETERIAN GROWTH" PARADIGM

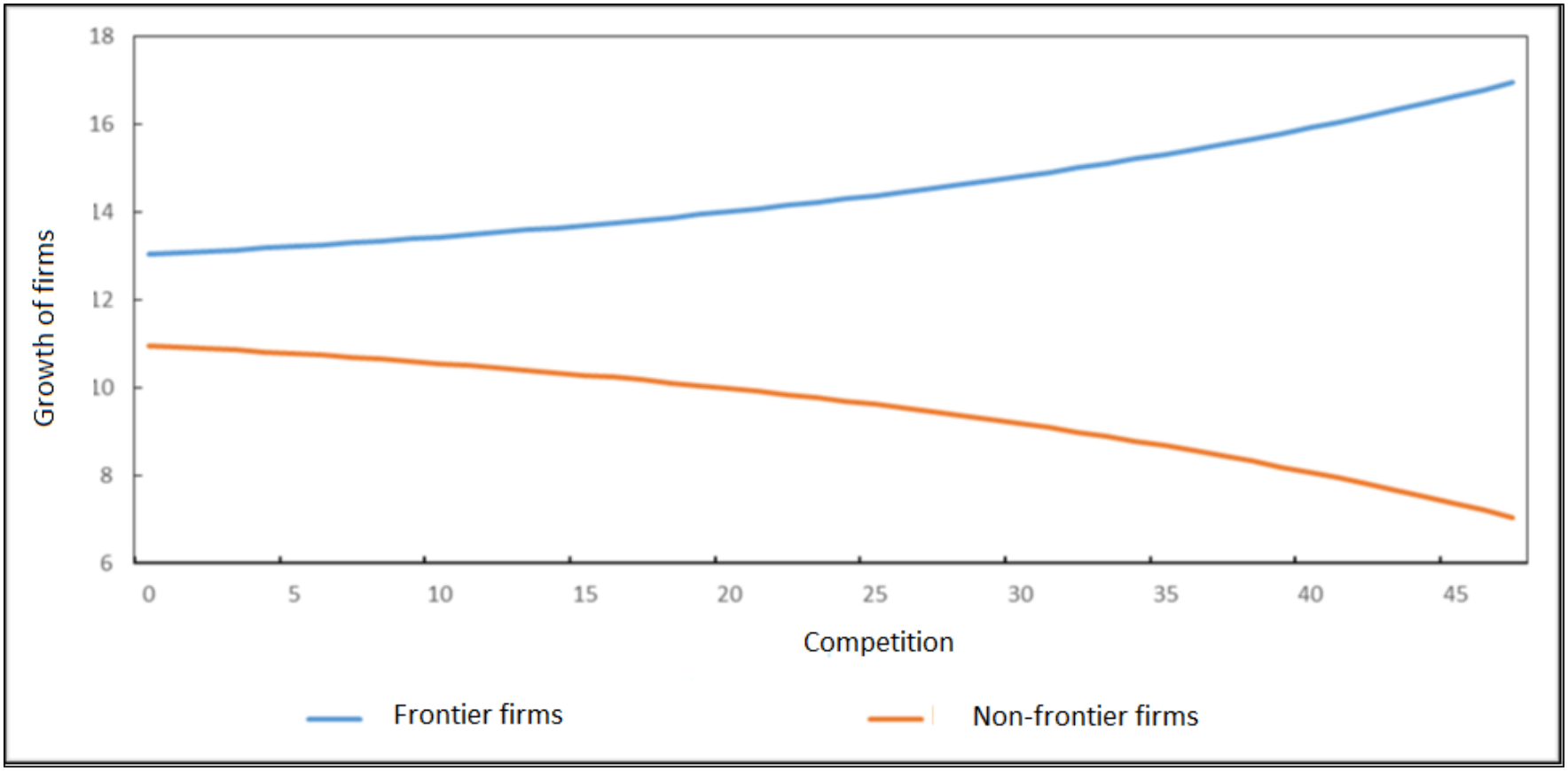
- Long-run growth driven by cumulative process of innovation
- Innovations result from entrepreneurial activities motivated by prospect of innovation rents
- Creative destruction: new innovations displace old technologies

# At the heart of the paradigm

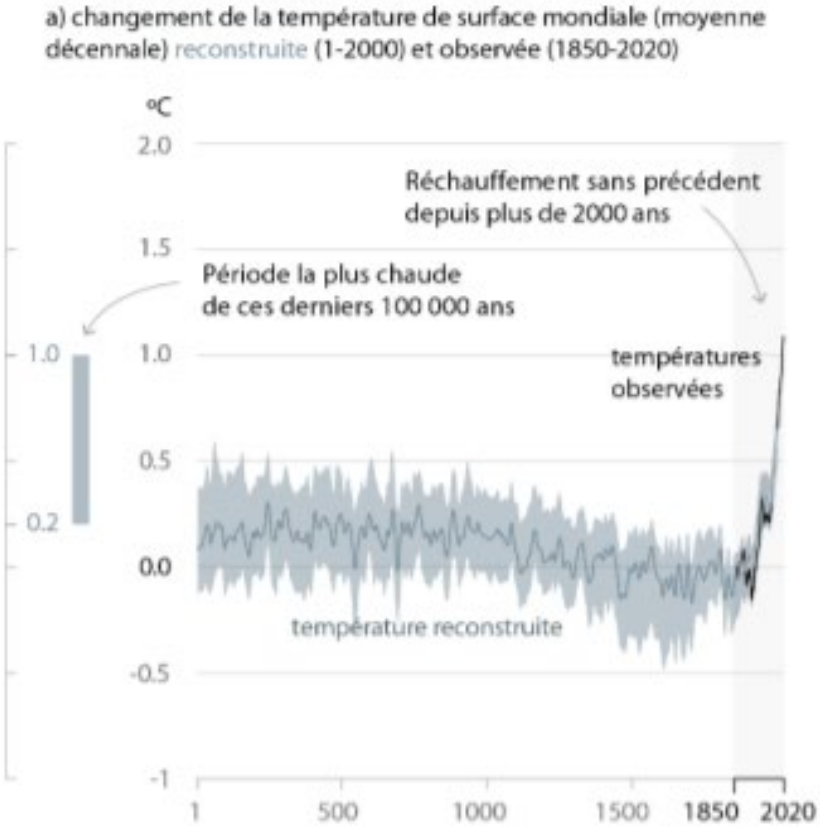
- Contradiction :
  - The innovator is motivated by prospect of monopoly rents
  - But those rents can be used ex post to prevent future innovations and to block new entry

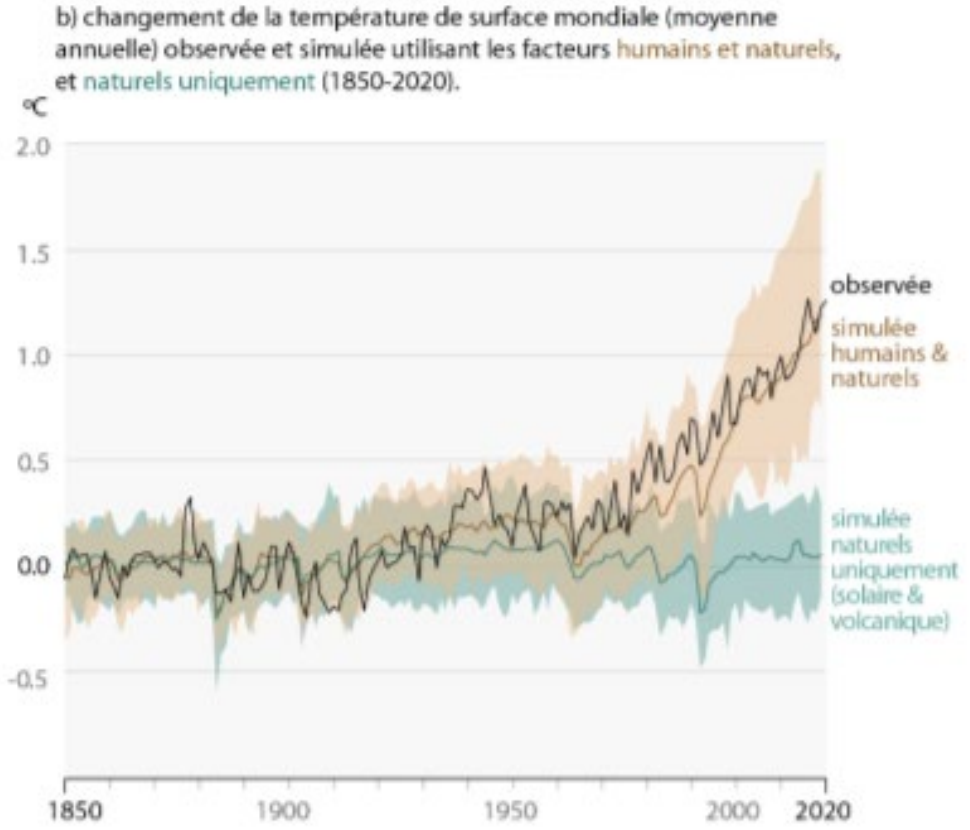
- Regulating capitalism is largely about how to manage this contradiction

# Competition, growth and distance to frontier

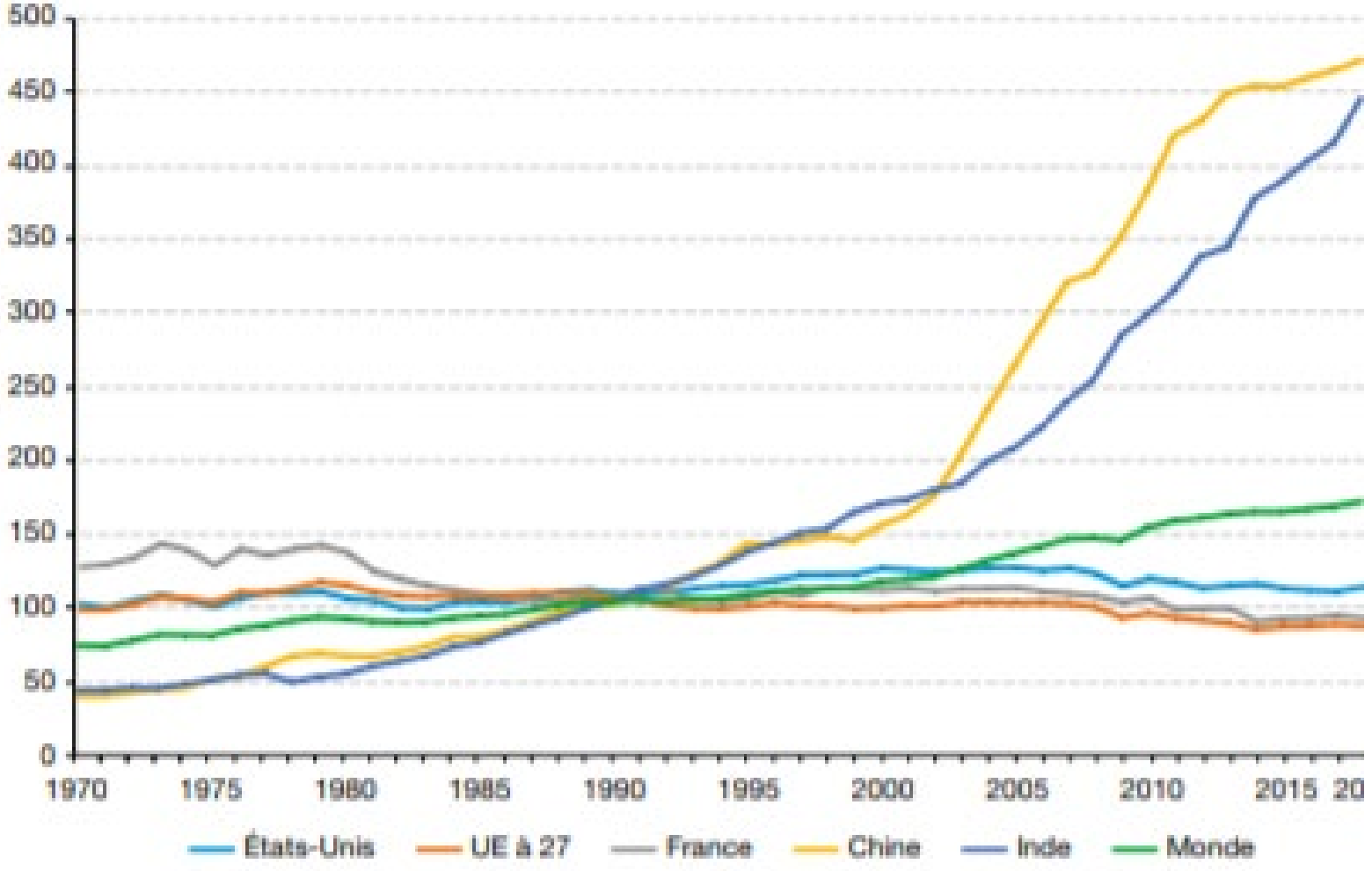


# Innovation, growth and climate


a) changement de la température de surface mondiale (moyenne décennale) reconstruite (1-2000) et observée (1850-2020)
°C
2.0
1.5
1.0
0.5
0.0
-0.5
-1
1.0
0.2
Réchauffement sans précédent depuis plus de 2000 ans
Période la plus chaude de ces derniers 100 000 ans
températures observées
température reconstruite
1
500
1000
1500
1850
2020


b) changement de la température de surface mondiale (moyenne annuelle) observée et simulée utilisant les facteurs humains et naturels, et naturels uniquement (1850-2020).
°C
2.0
1.5
1.0
0.5
0.0
-0.5
observée
simulée humains & naturels
simulée naturels uniquement (solaire & volcanique)
1850
1900
1950
2000
2020

# Evolution of CO2 emissions worldwide between 1970 and 2018 – Base 100 index in 1990




Source : EDGAR, 2019

# INTRODUCE INNOVATION IN THE CLIMATE DEBATE

- **Innovation versus de-growth**
- **Implications of introducing endogenous and directed innovation for the climate debate?**

# INTRODUCE INNOVATION IN THE CLIMATE DEBATE

- **Innovation versus de-growth**
- **Implications of introducing endogenous and directed innovation for the climate debate?**

# PATH-DEPENDENCE IN GREEN VERSUS DIRTY INNOVATION

# DATA

- World Patent Statistical Database (PATSTAT) at European Patent Office (EPO) over period 1978-2005
  - All triadic patents filed in 80 patent offices in world
- Extracted all patents pertaining to "clean" and "dirty" technologies in the automotive industry (following OECD IPC definition)
- Tracked applicants and extracted all their past patents.

# INTERNATIONAL PATENT CLASSES (IPC)

| Description | IPC code |
|---|---|
| **Electric vehicles** | |
| Electric propulsion with power supplied within the vehicle | B60L 11 |
| Electric devices on electrically-propelled vehicles for safety purposes; Monitoring operating variables, e.g. speed, deceleration, power consumption | B60L 3 |
| Methods, circuits, or devices for controlling the traction- motor speed of electrically-propelled vehicles | B60L 15 |
| Arrangement or mounting of electrical propulsion units | B60K 1 |
| Conjoint control of vehicle sub-units of different type or different function / including control of electric propulsion units, e.g. motors or generators / including control of energy storage means / for electrical energy, e.g. batteries or capacitors | B60W 10/08, 24, 26 |
| **Hybrid vehicles** | |
| Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines | B60K 6 |
| Control systems specially adapted for hybrid vehicles, i.e. vehicles having two or more prime movers of more than one type, e.g. electrical and internal combustion motors, all used for propulsion of the vehicle | B60W 20 |
| Regenerative braking | |
| Dynamic electric regenerative braking | B60L 7/1 |
| Braking by supplying regenerated power to the prime mover of vehicles comprising engine -driven generators | B60L 7/20 |
| **Fuel cells** | |
| Conjoint control of vehicle sub-units of different type or different function; including control of fuel cells | B60W 10/28 |
| Electric propulsion with power supplied within the vehicle - using power supplied from primary cells, secondary cells, or fuel cells | B60L 11/18 |
| Fuel cells; Manufacture thereof | H01M 8 |
| **Combustion engines** | |
| Combustion engines | F02 (excl. C/G/ K) |

"Clean"

"Dirty"

# ESTIMATION

Number of clean triadic patents by firm *i* in year *t*

Clean and dirty spillovers

$$PAT_{CLEAN,it} = \exp(\beta_{C,P} \ln FP_{it} + \beta_{C,1} \ln SPILL_{C,it} + \beta_{C,2} \ln SPILL_{D,it}$$

$$+ \beta_{C,3} \ln K_{C,it} + \beta_{C,4} \ln K_{D,it}$$

Lagged firm's own innovation stocks

$$+ \beta_{C,w} w_{it} + \ln \eta_{C,i} + T_{C,t}) + u_{C,it}$$

Other controls (GDP, GDP/capita, other policies)

Firm fixed effect

Time dummies

Random error

# TABLE 3: MAIN RESULTS

| | Clean | Dirty |
|---|---|---|
| **Fuel Price** | 0.886** | -0.644*** |
| ln(FP) | (0.362) | (0.143) |
| **Clean Spillover** | 0.266*** | -0.058 |
| $SPILL_C$ | (0.087) | (0.066) |
| **Dirty Spillover** | -0.160* | 0.114 |
| $SPILL_D$ | (0.097) | (0.081) |
| **Own Stock Clean** | 0.303*** | 0.016 |
| $K_C$ | (0.026) | (0.026) |
| **Own Stock Dirty** | 0.139*** | 0.542*** |
| $K_D$ | (0.017) | (0.020) |
| **#Observations** | 68,240 | 68,240 |
| **#Units (Firms and individuals)** | 3,412 | 3,412 |

**Notes: Estimation by Conditional fixed effects (CFX), all regressions include GDP, GDP per capita & time dummies. SEs clustered by unit.**

# THUS

- Bad news is that path-dependence implies that under laissez-faire the economy may get stuck with dirty technologies
- Good news is that government can avoid disaster by redirecting innovation towards clean technologies and early action now can become self-sustaining later due

# Further implications

# Creative destruction helps!!

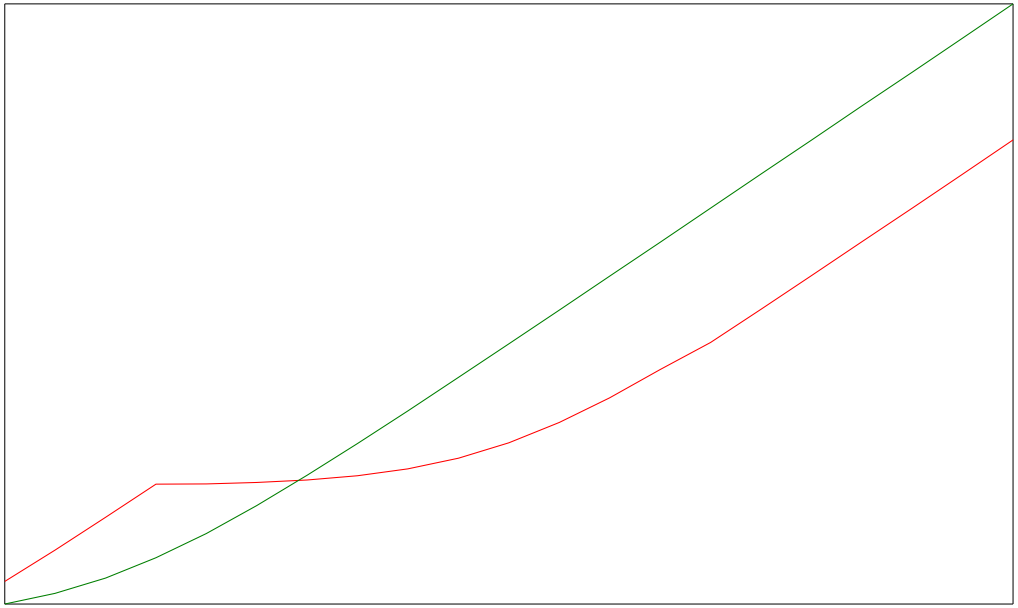
# Act now

- Without intervention, innovation is directed towards dirty inputs
- Thus the gap between clean and dirty technology widens
- Hence cost of intervention (reduced growth as long as clean technologies catch up with dirty technologies) increases

# Policy implications : act now

| Discount rate | 1% | 1.5% |
|---|---|---|
| Lost consumption, delay of 10 years | 5.99% | 2.31% |
| Lost consumption, delay of 20 years | 8.31% | 2.36% |

# Policy implications : act now



# Two instruments, not only carbon tax

- Two externalities:
  - Environmental externality
  - Knowledge externality (path-dependence)
- Thus need two instruments, not just carbon tax

# Two instruments

| Discount rate | 1% | 1.5% |
|---|---|---|
| Lost consumption | 1.33% | 1.55% |

$\longrightarrow$ using one instrument instead of two, when discount rate of 1 percent, leads to a consumption loss of 1.33 percent...

$\longrightarrow$ ....or to a carbon tax 15 times higher during first five years and 12 times higher during following five years.

# Reinforcing the case for green innovation subsidies

- Introduce an intermediate source of energy (e.g. shale gas)
- How should design the energy transition strategy?

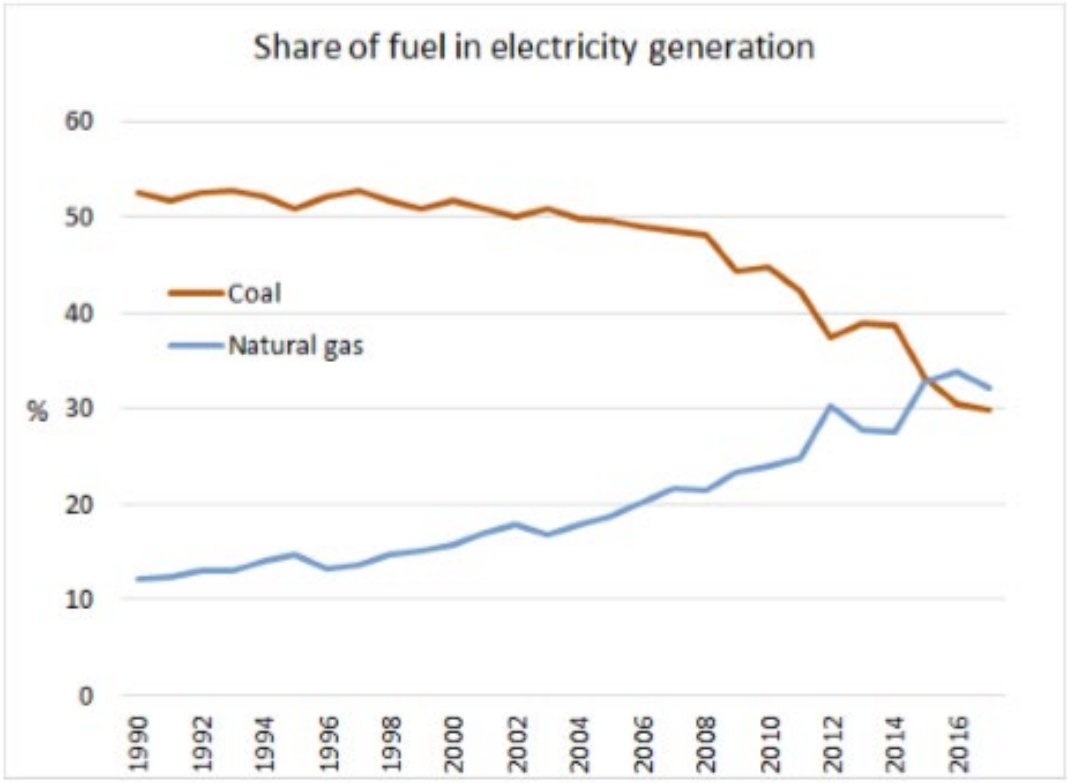
# Climate Change, Directed Innovation and Energy Transition: The Long-run Consequences of the Shale Gas Revolution

Daron Acemoglu (MIT), Philippe Aghion (Collège de France, LSE),
Lint Barrage (Brown) and David Hémous (University of Zurich)

SCOR Foundation Online Webinar - November 27, 2024

SCOR
FOUNDATION FOR SCIENCE

# Rise of gas


Share of fuel in electricity generation
60
50
40
% 30
20
10
0
Coal
Natural gas
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016

- Analyze effects of an exogenous improvement in extraction technology for gas (shale gas boom) on aggregate pollution in short run and long run

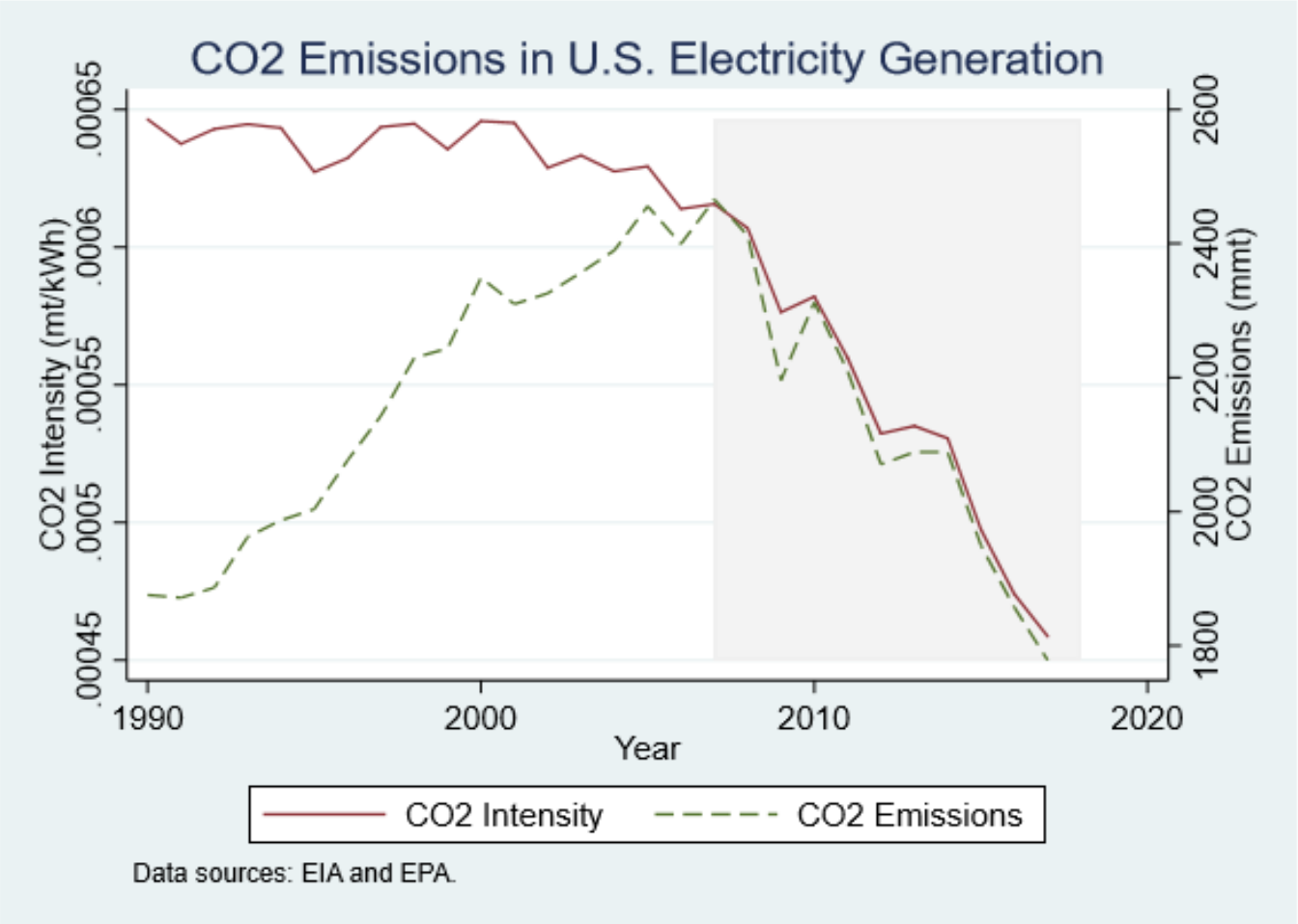
# Short-Run Effects

- Absent innovation (short-run), there are two opposite effects of shale gas boom:
  - Substitution effect
  - Scale effect
- Substitution effect dominates if gas sufficiently cleaner than coal

# Short-Run Impact Estimates

| **Total Effects of Improved Shale Extraction Technology $B_{s0}$** | | | |
|---|---|---|---|
| | $\%\Delta$Emiss. | $\%\Delta$Energy | $\%\Delta CO_2$ |
| | Intensity | Consumption | Emissions |
| Baseline Parameters | | | |
| $+10\%$ Increase in $B_{s0}$ | -16.7% | +5.5% | -12.1% |
| $+50\%$ Increase in $B_{s0}$ | -21.0% | +9.6% | -13.4% |

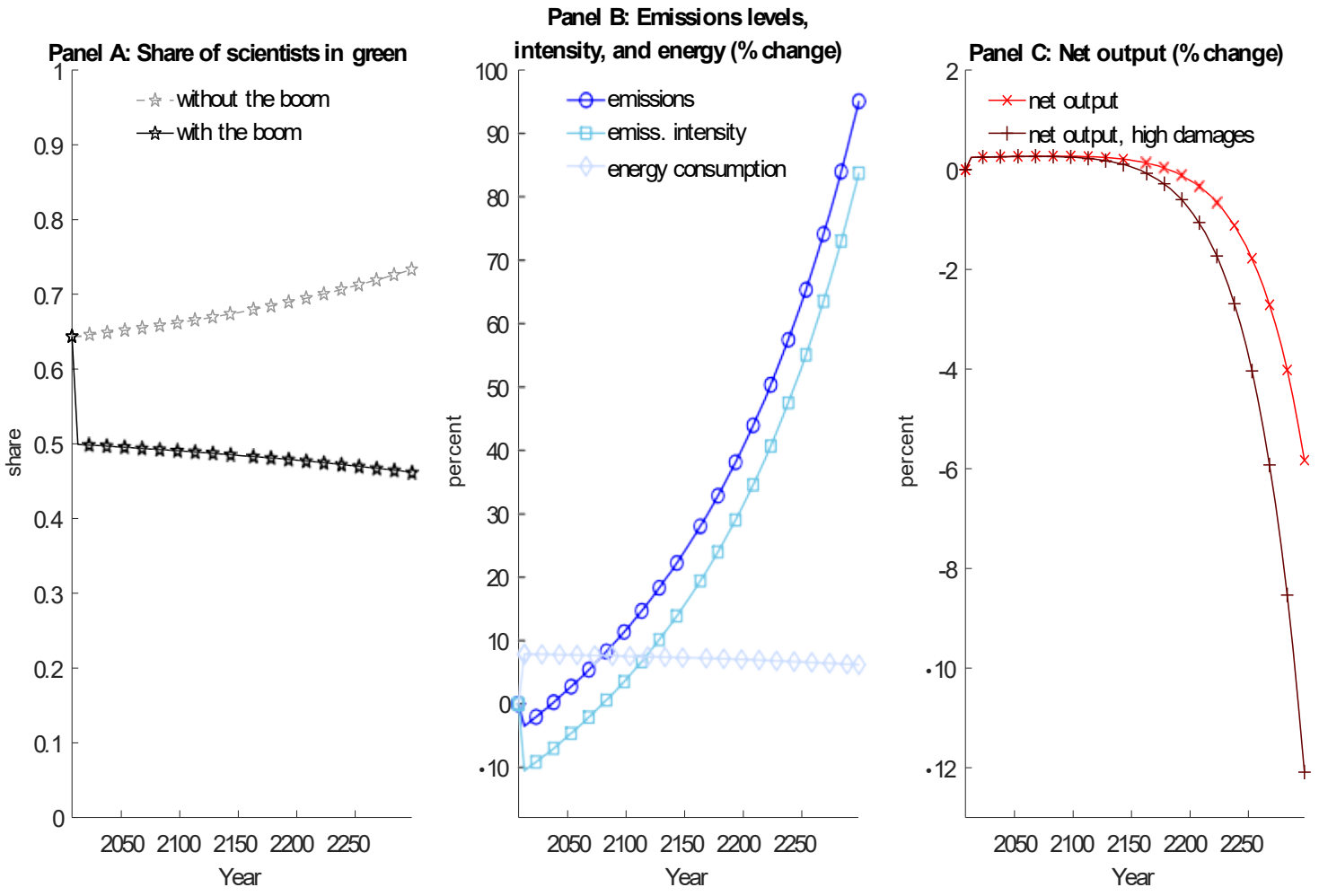
# Emissions and Emissions Intensity



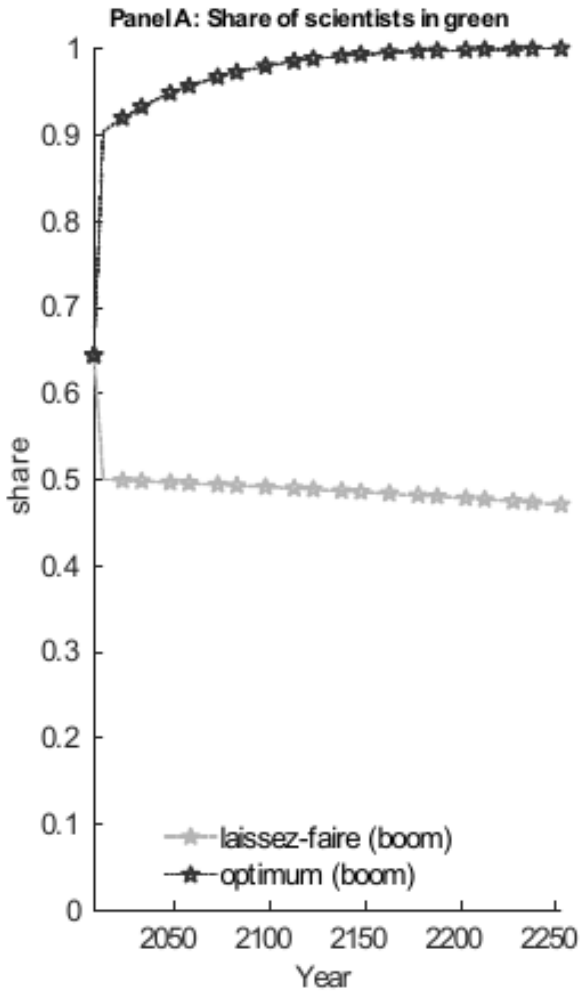
# Long-Run Effect

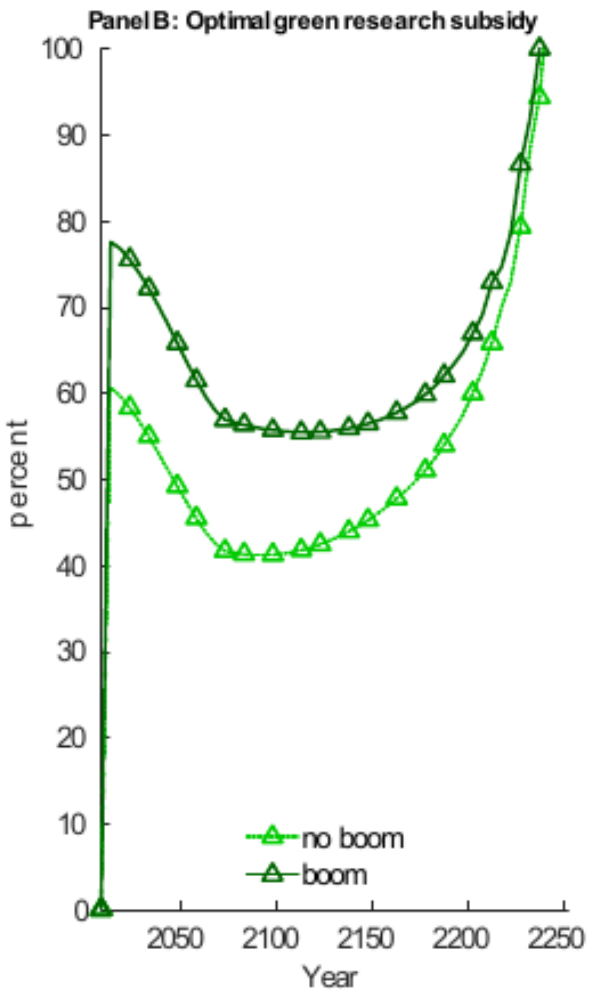
- Assume endogenous innovation on power plant technologies using the different sources of energy
- Shale gas boom directs innovation away from both, coal and clean production technologies into gas production technologies
- In the long-run, it may move the economy from a path with declining CO2 emissions to a path with increasing CO2 emissions

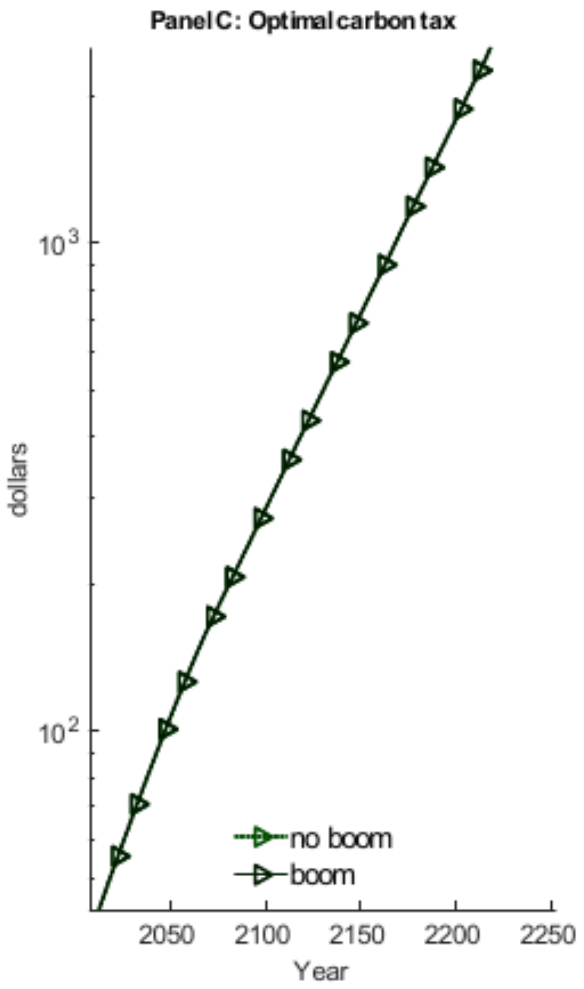
# Unmanaged boom



# Optimal Policy: effect of the boom



# THE ROLE OF CIVIL SOCIETY

- **Competition and Social Values**
  - Above analysis suggests a role for the State in directing firms' production and innovation
  - Question: Is there also a role for "Civil Society"?

# Environmental Values and Technological Choices: Is Market Competition Clean or Dirty?

Philippe Aghion [1] Roland Bénabou [2]
Ralf Martin [3] Alexandra Roulet [4]

[1]College de France [2]Princeton University

[3]Imperial College London [4]INSEAD

# Positive effect of consumers valuation of the environment

- Firms innovate green to cater to their consumers' demand for green

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Log (1+#clean)- Log (1+#dirty) | | | |
| Values | 0.170*** | 0.229*** | 0.233*** | 0.594*** |
| | (0.0397) | (0.0500) | (0.0524) | (0.144) |
| Competition | 0.189*** | 0.161*** | 0.325** | -0.0223 |
| | (0.0614) | (0.0605) | (0.139) | (0.0305) |
| ValuesXCompetition | 0.109*** | 0.0703*** | 0.0875*** | 0.0620** |
| | (0.0370) | (0.0234) | (0.0231) | (0.0243) |
| Log fuel price | 0.766*** | 0.601** | 0.151 | 0.856 |
| | (0.235) | (0.244) | (0.236) | (0.663) |
| Competition measure | OECD | OECD | World Bank | Lerner |
| Values measure | Higher tax | Index | Higher tax | Higher tax |
| Observations | 17,124 | 17,124 | 17,124 | 2,706 |
| R-squared | 0.121 | 0.122 | 0.121 | 0.199 |
| Number of xbvdid | 8,562 | 8,562 | 8,562 | 1,854 |

# Two opposite effects of competition

- **More competition:**
  - **Scale effect**: it increases output, thereby increasing emissions (« Chinese » effect)
  - **Innovation effect**: if consumers value the environment, then more competition induces more green innovation, thereby reducing emissions

| VARIABLES | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Log (1+#clean)- Log (1+#dirty) | | | |
| Values | 0.170*** | 0.229*** | 0.233*** | 0.594*** |
| | (0.0397) | (0.0500) | (0.0524) | (0.144) |
| Competition | 0.189*** | 0.161*** | 0.325** | -0.0223 |
| | (0.0614) | (0.0605) | (0.139) | (0.0305) |
| ValuesXCompetition | 0.109*** | 0.0703*** | 0.0875*** | 0.0620** |
| | (0.0370) | (0.0234) | (0.0231) | (0.0243) |
| Log fuel price | 0.766*** | 0.601** | 0.151 | 0.856 |
| | (0.235) | (0.244) | (0.236) | (0.663) |
| Competition measure | OECD | OECD | World Bank | Lerner |
| Values measure | Higher tax | Index | Higher tax | Higher tax |
| Observations | 17,124 | 17,124 | 17,124 | 2,706 |
| R-squared | 0.121 | 0.122 | 0.121 | 0.199 |
| Number of xbvdid | 8,562 | 8,562 | 8,562 | 1,854 |

# Conclusion

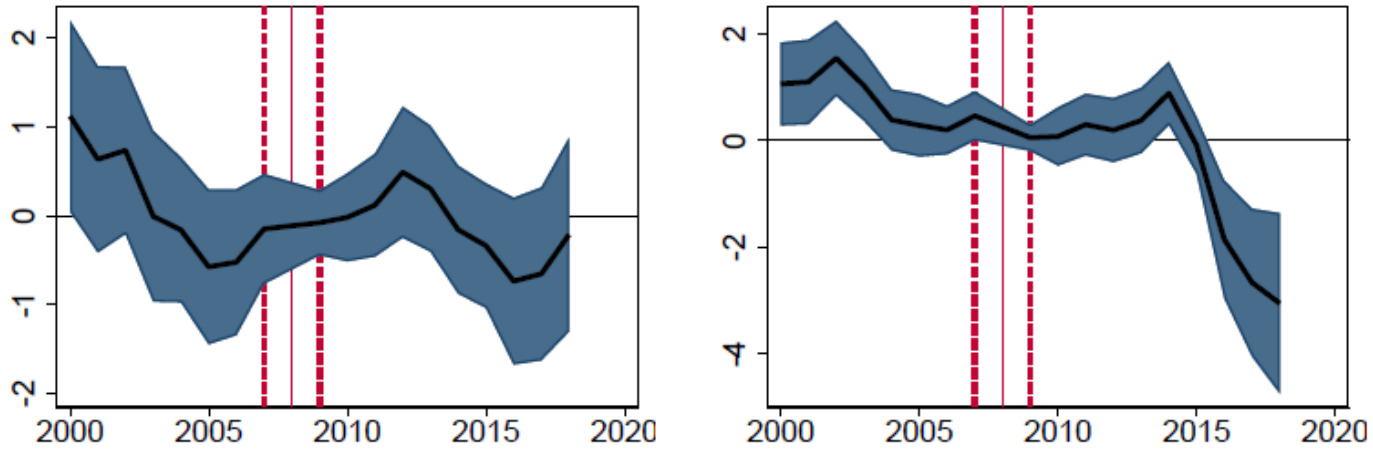
- Innovation-based climate models suggest that laissez-faire leads to disaster due to path-dependence in the direction of innovation
- One must act now and multiple instruments must be used, not just the carbon tax
- Triangle between firms, the State, and Civil Society

# Conclusion

- **The role of finance (Aghion, Bergeaud, De Ridder and Van Reenen)**

- Look at the effect of exposure to German banking crisis (2009) on green innovation

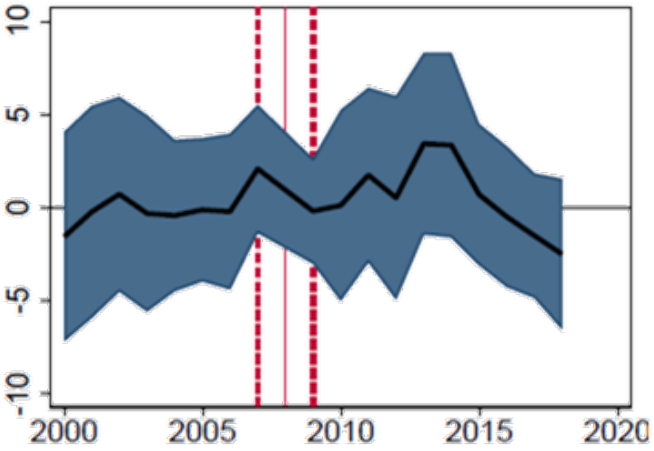
- Fraction of firm's bank relationships that involve Commerzbank: Commerzbank cut lending after losses to international trading portfolio



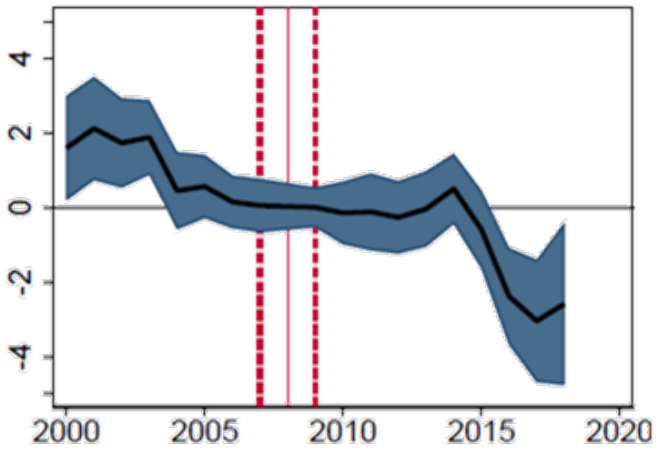

(a) Overall Patents

(b) Green Patents

The figure plots the effect of exposure to Commerzbank on patenting in the year on the horizontal axis. Estimates from PPML. Confidence bounds are at the 95% level using firm-clustered standard errors.




(e) Old Firms




(f) Young Firms

The figure plots the effect of exposure to Commerzbank on patenting in the year on the horizontal axis. Estimates from PPML. Confidence bounds are at the 95% level using firm-clustered standard errors.

# Conclusion

- **Rethink macro policy:**
  - Raising interest rates too much will slow down the transition to a low carbon economy
  - Arbitrage between current public debt and the environmental debt

# Conclusion

- **Development, structural change, and the perverse effects of protectionism**

# A Theory of Endogenous Degrowth and Environmental Sustainability

Philippe Aghion Timo Boppart Michael Peters
Matthew Schwartzman Fabrizio Zilibotti

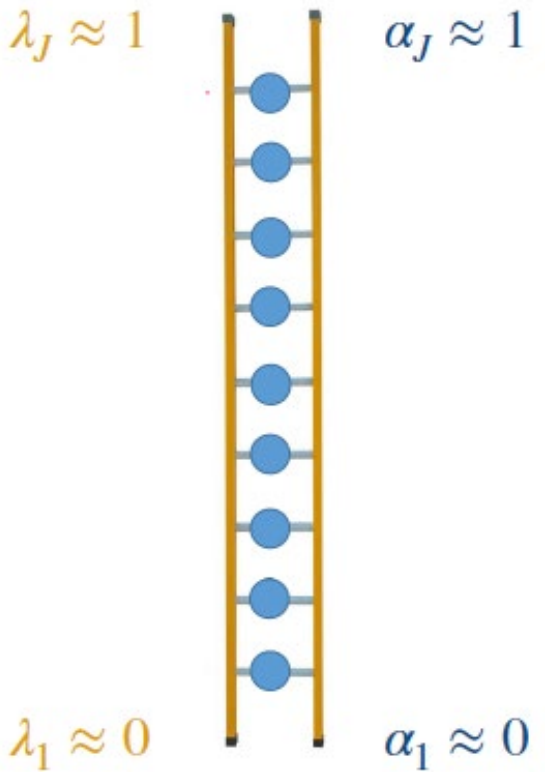
SCOR Foundation Online Webinar - November 27, 2024

SCOR FOUNDATION FOR SCIENCE

# Main idea

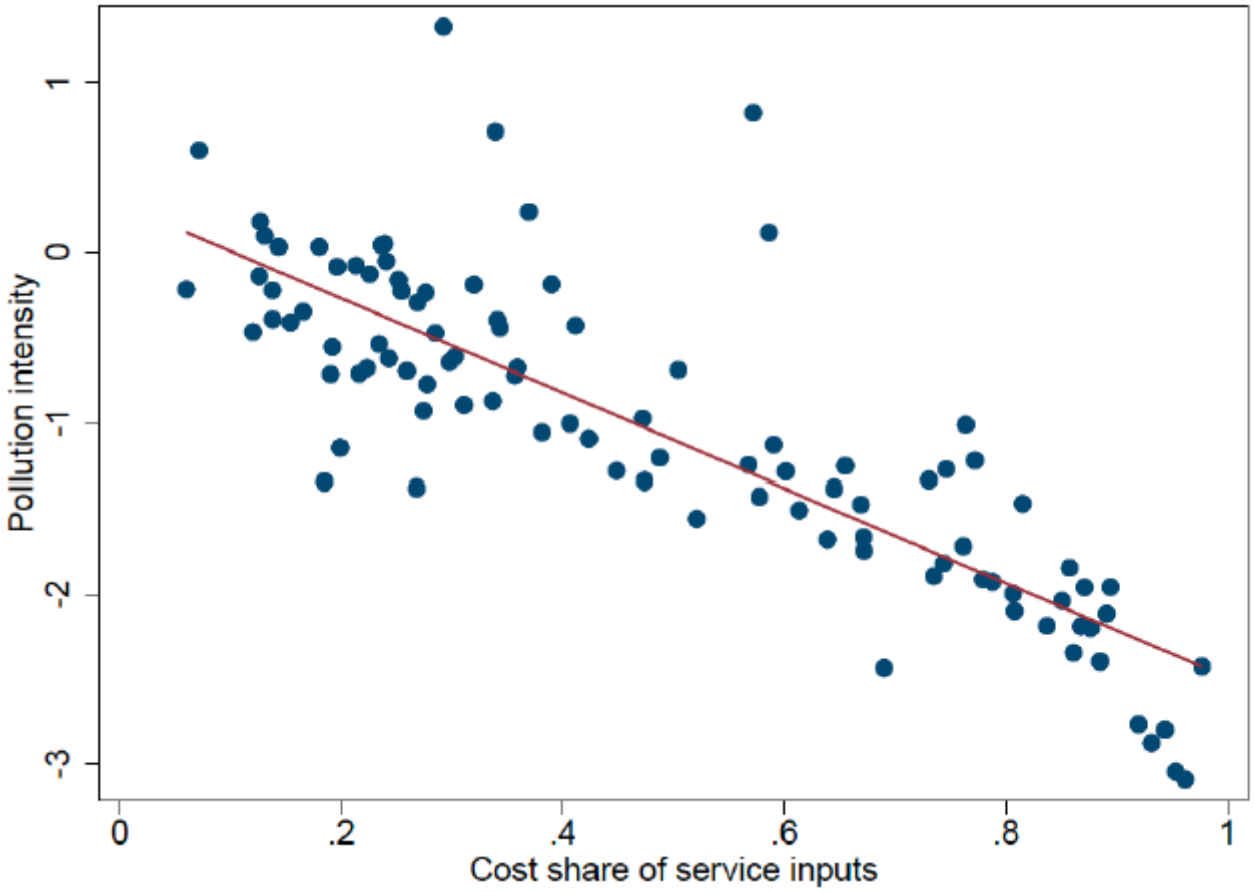
- Goods differ with respect to both:
  - Service intensity in their production
  - The premium to quality they carry
  - Goods with higher premium to quality tend to be more service intensive
  - Examples: cars, meals

# Quality, Services, and Income Effects

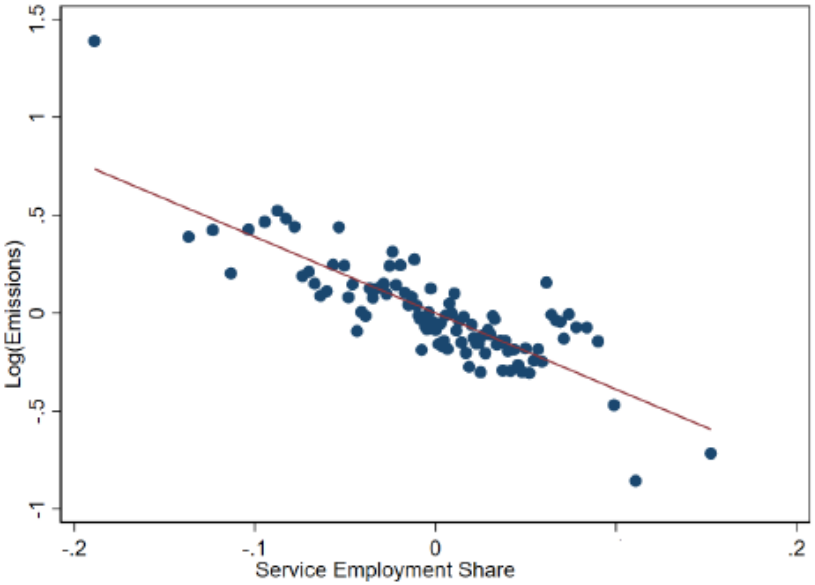


# Main idea

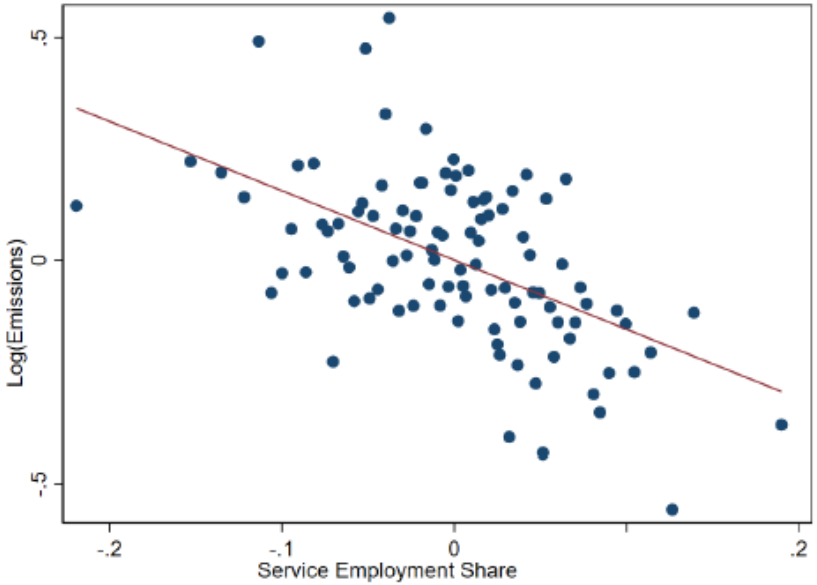
- More service-intensive goods have a lower carbon footprint
- Tertiarization reduces carbon footprint


Pollution intensity
1
0
-1
-2
-3
0
.2
.4
.6
.8
1
Cost share of service inputs

*Across countries*




*Across US counties*



# Main idea

- Non-homothetic preferences
  - As they become richer, consumers tilt their consumption more towards goods with higher premium to quality and higher service intensity
  - Hence proportionally they contribute less to aggregate pollution

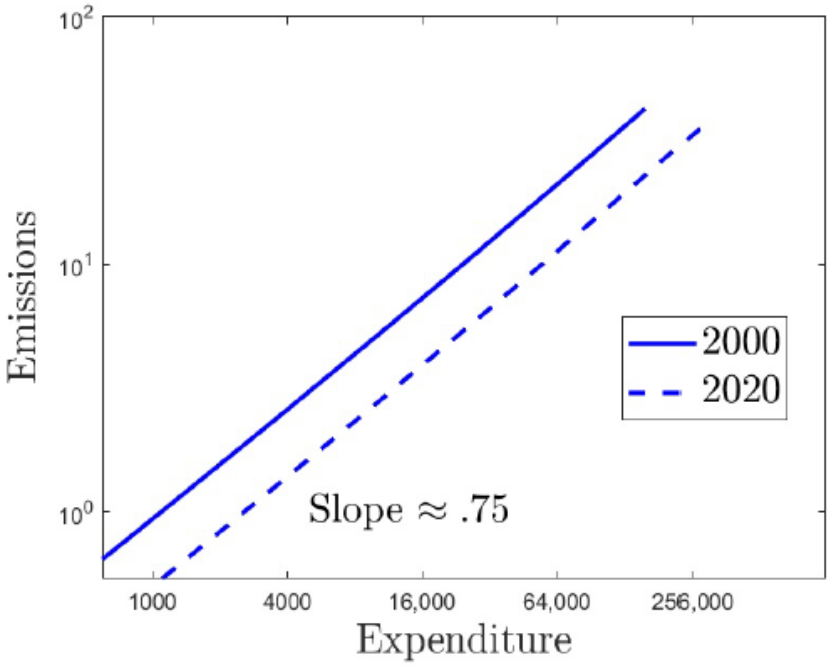
# Main idea

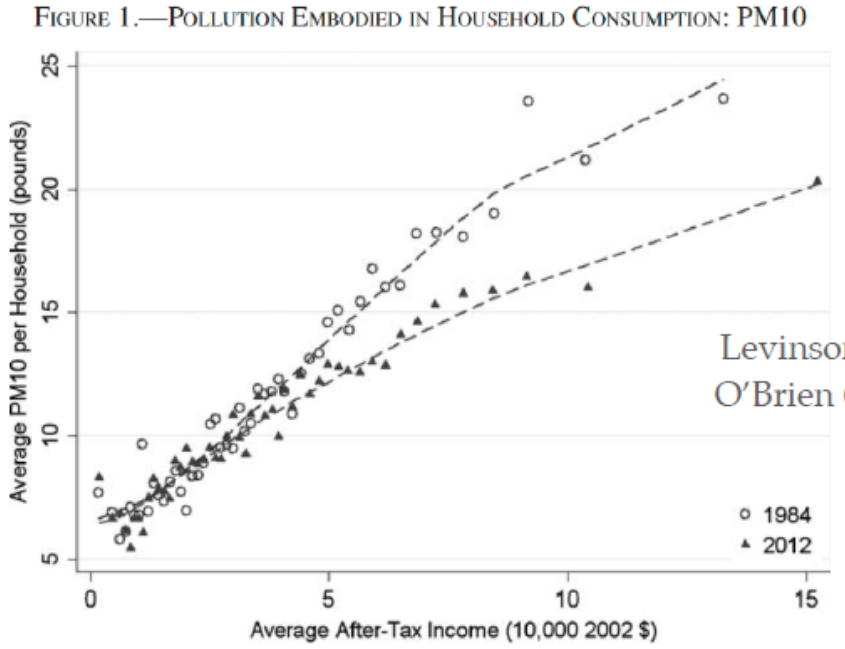
- Endogenous directed innovation
  - Researchers can direct effort to quantity (A) or to quality (Q) innovation
  - As the economy develops, innovation will shift toward quality innovation
  - Hence growth tilts towards becoming increasingly quality-driven, hence less well captured by measured GDP growth

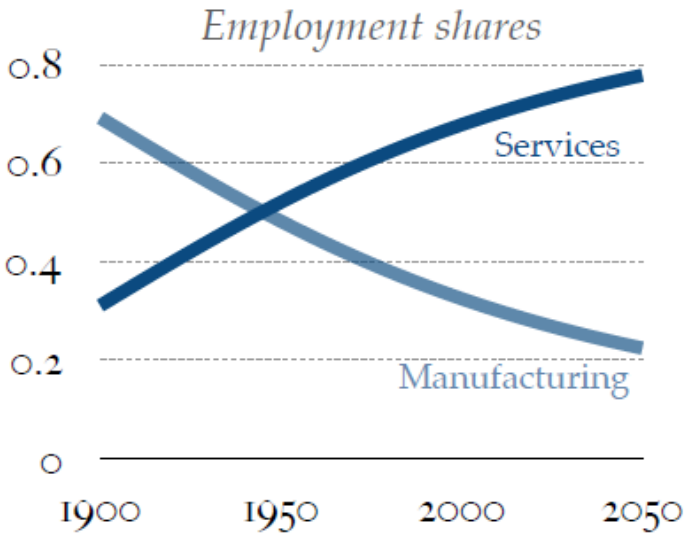
# Main idea

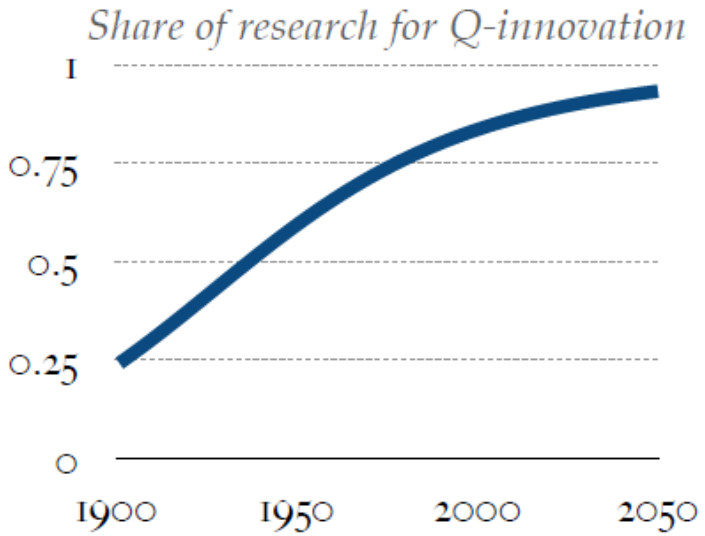
- Environmental Engel curves
- Structural change, degrowth and emissions

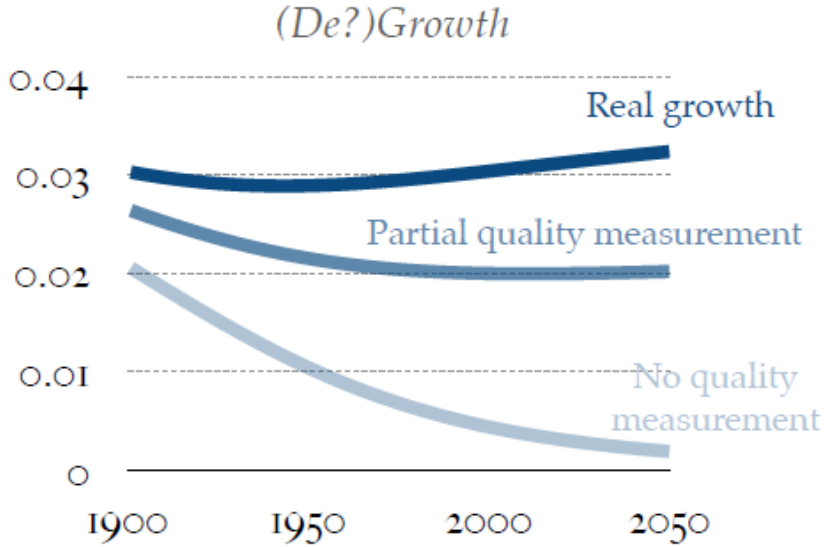
# Environmental Engel curves

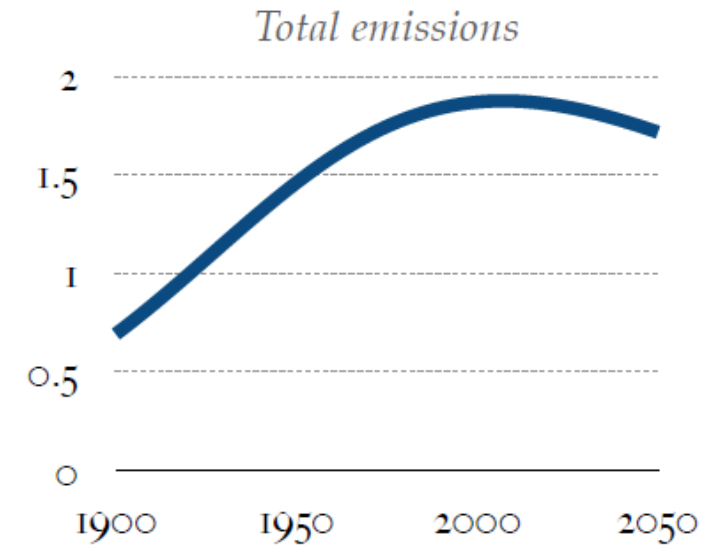



Employment shares
0.8
0.6
0.4
0.2
0
Services
Manufacturing
1900
1950
2000
2050


Share of research for Q-innovation
1
0.75
0.5
0.25
0
1900
1950
2000
2050


(De?)Growth
0.04
0.03
0.02
0.01
0
Real growth
Partial quality measurement
No quality measurement
1900
1950
2000
2050


Total emissions
2
1.5
1
0.5
0
1900
1950
2000
2050

# Conclusion

- Green innovation is key to fighting climate change
- Yet degrowth advocates were not totally wrong

# Conclusion

- **Financing the energy transition in Europe**
- Public-private partnership
  - EU borrowing based on revenues from ETS
  - Green development banking
  - Green European DARPA

# Conclusion

- **Reform European institutions**
  - Do not treat green innovation investment like other types of spending
  - Allow for green industrial policy which is competition-friendly
  - Allow for more EU borrowing