Can omitted carbon abatement explain productivity stagnation?

Timo Kuosmanen

Turku School of Economics
University of Turku

28th of August 2024

Stagnation in Western countries: Many explanations suggested in the literature

- Decline in business dynamism (new firms, job turnover, etc.)
  - Decker et al. (2016) AER, Grossman et al. (2017) NBER
- Growth of markups and market power
  - De Loecker et al. (2020) QJE
- Misallocation of resources
  - Hsieh & Klenow (2009) QJE, Restuccia & Rogerson (2017) J. Econ. Persp.
- New ideas getting harder to find
  - Gordon (2012) NBER, Bloom et al. (2020) AER
- Measurement problems (digital services, free goods)
  - Brynjolfsson et al. (2021)
- Other: ageing society, zero interest rates, etc.

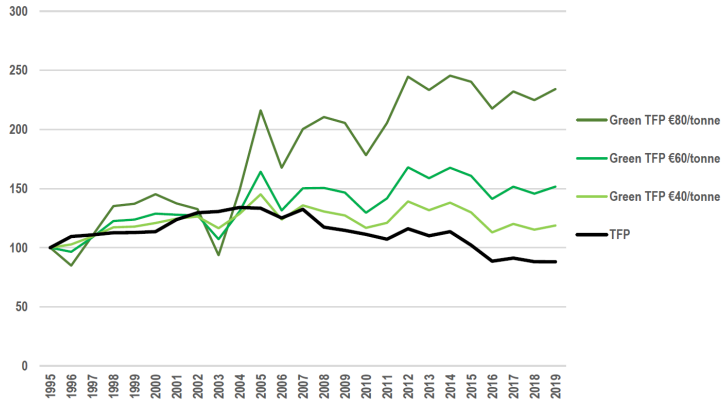
Are we forgetting the Kyoto Protocol?

- Temporary association: First commitment period 2008–2012, Doha Amendment 2012–2020
  - Note: EU implemented, USA never ratified
- In the late 1990s, Kyoto Protocol was considered highly cost-ineffective
  - Nordhaus and Boyer (1999): the net present value of total cost is $716 billion US dollars (prices of 1990), which is 7 times higher than the benefit
  - Murkowski (2000): average cost for a US household could be as high as $2728 per year, leading to eradication of 2.4 million jobs

Mismeasurement of the productivity impacts of the green transition

- Mechanism:
  - Massive R&D and capital investments on the abatement of greenhouse gas (GHG) emissions
  - Conventional productivity measures (labor productivity, total factor productivity TFP) include labor and capital resources targeted to GHG abatement, but do not include reduction of GHG or the associated benefits
- Alternative Green TFP measures try to adjust the TFP for the changes in GHG emissions

Green TFP in the Finnish energy industry (D) if the price of CO_2 is set at 0, 40, 60, 80 €/tonne, index 1995=100



This paper: shadow-price Fisher index

- In the index theory, Fishers ideal index has many desirable properties
- Fisher TFP index is a quantity index that uses prices as index weights
- If price information is incomplete (e.g., CO_2 emissions), Kuosmanen et al. (2004) propose to use shadow-prices

$$F_s(\boldsymbol{\rho}^{0,1}, \boldsymbol{\omega}^{0,1}, \boldsymbol{y}^{0,1}, \boldsymbol{x}^{0,1}) \equiv \left[\frac{\boldsymbol{\rho}^0\boldsymbol{y}^1}{\boldsymbol{\rho}^0\boldsymbol{y}^0} \times \frac{\boldsymbol{\rho}^1\boldsymbol{y}^1}{\boldsymbol{\rho}^1\boldsymbol{y}^0}\right]^{1/2} \Big/ \left[\frac{\boldsymbol{\omega}^0\boldsymbol{x}^1}{\boldsymbol{\omega}^0\boldsymbol{x}^0} \times \frac{\boldsymbol{\omega}^1\boldsymbol{x}^1}{\boldsymbol{\omega}^1\boldsymbol{x}^0}\right]^{1/2}$$

- The shadow-price Fisher index is closely related to the Malmquist productivity indicator that similarly uses shadow prices, but retains the properties of the Fisher ideal index

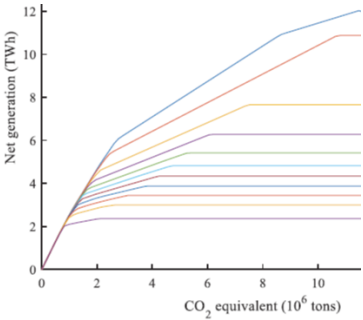
Shadow-price Fisher index of GTFP

- Including bad outputs b (such as GHG), we have the shadow price Fisher index of GTFP

$$F_s^b(\tilde{\rho}^{0,1}, \tilde{\delta}^{0,1}, \tilde{\omega}^{0,1}, y^{0,1}, x^{0,1}, b^{0,1}) \equiv \left[\frac{\tilde{\rho}^0 y^1 - \tilde{\delta}^0 b^1}{\tilde{\rho}^0 y^0 - \tilde{\delta}^0 b^0} \times \frac{\tilde{\rho}^1 y^1 - \tilde{\delta}^1 b^1}{\tilde{\rho}^1 y^0 - \tilde{\delta}^1 b^0}\right]^{1/2} \Big/ \left[\frac{\tilde{\omega}^0 x^1}{\tilde{\omega}^0 x^0} \times \frac{\tilde{\omega}^1 x^1}{\tilde{\omega}^1 x^0}\right]^{1/2}$$

How do we estimate the shadow-prices?

- Kuosmanen & Zhou (2021) propose a convex quantile regression approach for the estimation of shadow prices
- Key advantages:
  - Data-driven, fully nonparametric approach
  - Imposes axioms such as monotonicity, convexity
  - Adjusts for technical inefficiency
  - Robust to noise and heteroskedasticity
  - Can avoid quantile crossing problem
- Python package pystoned:
  - Dai et al. (2024), *J. Stat. Software*

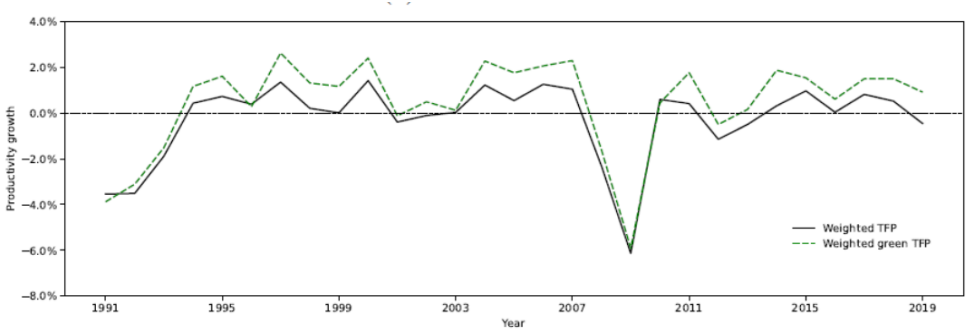


Application to OECD countries

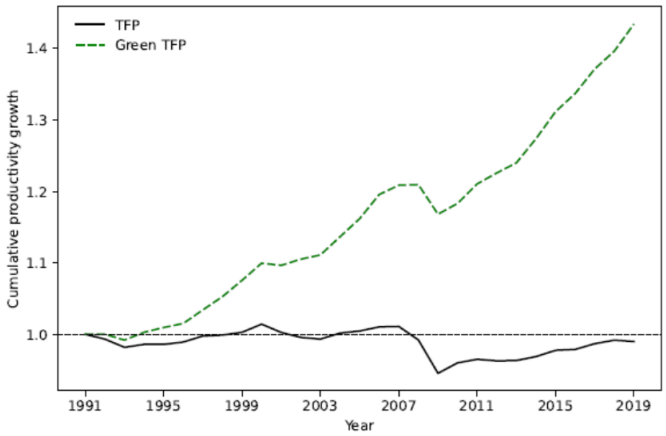
- 38 OECD countries in 1990–2019 (Penn World Tables)
- Outputs: GDP and GHG
- Inputs: labor and capital stock
  - Alternative input measures: capital services and human capital

Variable	Unit	Mean	Std. Dev.
Labor	million	15	25
Capital stocks	million 2017US$	5174738	9683973
GDP	million 2017US$	1193039	2581171
GHG	million tonnes	399	1016
Capital services	million 2017US$	479156	1017760
Human capital	years	11	2

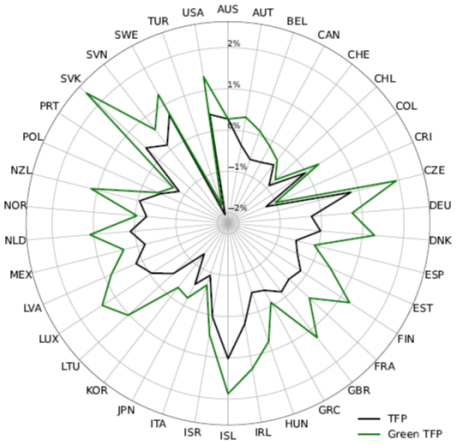
Yearly growth of TFP and GTFP in the OECD countries



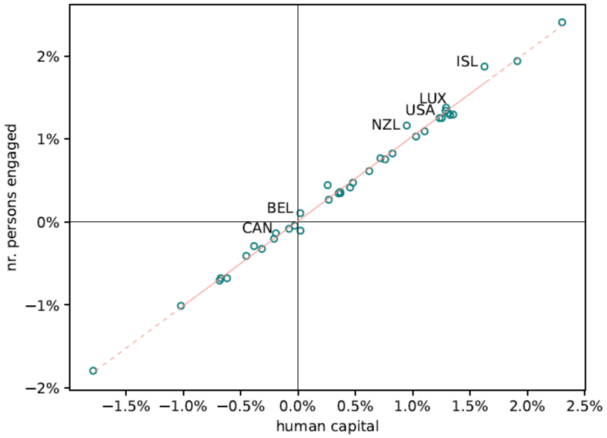
Cumulative TFP and GTFP of the OECD countries



Average TFP and GTFP growth by country



A robustness check: GTFP estimated using the number of persons vs human capital as the labor input



Conclusions

- We empirically show that GTFP of the OECD countries exhibits major growth while the conventional TFP has stagnated
- To put the present stagnation into a perspective, it would be helpful to recognize that there can be economic progress, which GDP does not capture
  - Instead of falling in pessimism, perhaps we should appreciate that our living standards did not collapse despite the cost-ineffective implementation of the Kyoto Protocol
- Achieving net zero targets will require further investment and innovation over the next decades
  - Long-term perspective: like any transition, the energy transition is temporary and will come to an end one day

Thank You