Introduction
ooooo

Methods and Data
ooooo

Results
oo

Conclusions
oo

The role of firm dynamics in the green transition
Carbon productivity decomposition in Finnish manufacturing

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Introduction
○○○○○

Methods and Data
○○○○○

Results
○○

Conclusions
○○

Highlights

We break down carbon productivity growth of the Finnish manufacturing sector using a structural change decomposition. Our main findings are:

- Continuing firms are the main driver of carbon productivity growth.
- The contribution of firm entry and exit is negative.
- Allocation of emission rights across firms is not efficient.

Introduction

- Improving carbon productivity is crucial for addressing climate change (He and Su 2011, Li and Wang 2019).

- Carbon productivity measures how efficiently economies and firms use emissions.

- Previous studies mostly relied on macro-level data to decompose carbon productivity changes into components such as efficiency and technological change (Hu and Liu 2016, Wang et al. 2018, Bai et al. 2019).

- Our focus is on the role of firm dynamics in carbon productivity growth.

Introduction
○○●○○

Methods and Data
○○○○○

Results
○○

Conclusions
○○

Carbon Productivity of the Finnish Manufacturing Sector, 2000–2019

Carbon productivity, Euros per tonne of GHG (CO2 eq.)

Introduction
○○○●○

Methods and Data
○○○○○

Results
○○

Conclusions
○○
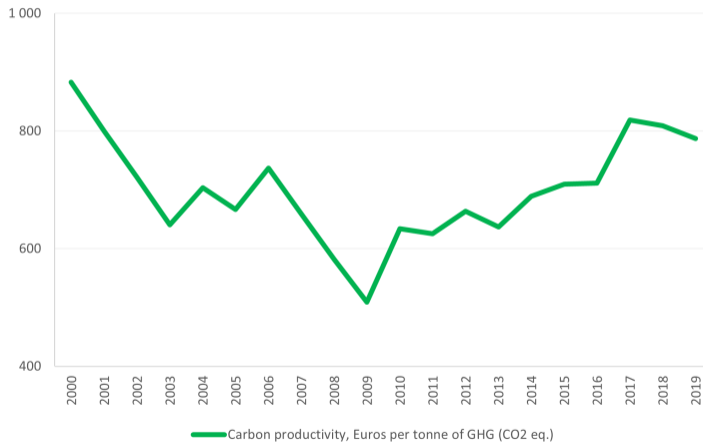
Motivation

Average carbon productivity decreased by -4.7% per year in 2000–2009 and increased by 5.5% in 2009–2019

- What are the factors behind those changes?
- Are the continuing firms driving the growth?
- Is there an entry and exit effect?
- Is the allocation of emissions between firms improving?

Introduction
○○○○●

Methods and Data
○○○○○

Results
○○

Conclusions
○○

Previous Contributions

Previous **structural change decompositions** of TFP and labor productivity include:

- Entry and exit of firms (Baily et al. 1992, Griliches & Regev 1995, Foster et al. 2001)
- Re-allocation of resources across firms (Olley & Pakes 1996)
- Re-allocation + entry and exit (Melitz & Polanec 2015, Maliranta & Määttänen 2015)
- Re-allocation + entry and exit + industry switching (Kuosmanen & Kuosmanen 2021)

Introduction
○○○○○

Methods and Data
●○○○○

Results
○○

Conclusions
○○

Introduction
00000

Methods and Data
0●000

Results
00

Conclusions
00

Structural Change Decomposition of Carbon Productivity - Level

$$C_t = \bar{c}_{Sn,t} + (\bar{c}_{S,t} - \bar{c}_{Sn,t}) + (\bar{c}_t - \bar{c}_{S,t}) + (C_t - \bar{c}_t)$$

- $\bar{c}_{Sn,t}$ is the average carbon productivity of non-switching continuing firms.
- $(\bar{c}_{S,t} - \bar{c}_{Sn,t})$ captures the impact of industry switching.
- $(\bar{c}_t - \bar{c}_{S,t})$ accounts for firms' entry and exit.
- $(C_t - \bar{c}_t)$ reflects the allocation of emissions across all firms.

Introduction
○○○○○

Methods and Data
○○●○○

Results
○○

Conclusions
○○

Structural Change Decomposition of Carbon Productivity - Change

$$\frac{C_t}{C_{t-1}} = \frac{\bar{c}_{Sn,t}}{\bar{c}_{Sn,t-1}} + \left[\frac{\bar{c}_{S,t}}{\bar{c}_{S,t-1}} - \frac{\bar{c}_{Sn,t}}{\bar{c}_{Sn,t-1}} \right] + \left[\frac{\bar{c}_t}{\bar{c}_{t-1}} - \frac{\bar{c}_{S,t}}{\bar{c}_{S,t-1}} \right] + \left[\frac{C_t}{C_{t-1}} - \frac{\bar{c}_t}{\bar{c}_{t-1}} \right]$$

- First term: Carbon productivity change of non-switching firms.
- Second term: Contribution of industry-switching firms.
- Third term: Impact of firms entry and exit on carbon productivity.
- Fourth term: Allocation of emissions among firms.

Introduction
○○○○○

Methods and Data
○○○●○

Results
○○

Conclusions
○○

Data

- Firm-level register data of GHG emissions (in CO_2 eq.) from Statistics Finland's Greenhouse Gas Inventory, merged with Financial Statement Data.

- Focus on the Finnish manufacturing sector: 602 firms operating between 2000–2019, 5,269 observations in total.

- Notably, our GHG data are representative of the entire manufacturing sector.

- Calculation of carbon productivity relies on two key variables:
  - **Output (y)**: Value added (prices of 2015).
  - **Emissions (c)**: GHG emissions (in tonnes of CO_2 eq.).

Introduction
○○○○○

Methods and Data
○○○○●

Results
○○

Conclusions
○○

Average Carbon Productivity Across Firm Sub-groups, 1,000 /t

Year	Non-switching firms	Switching firms	Exiting	Entering
2000	19.8	32.1	43.0	–
2006	29.1	42.8	–	44.5
2007	39.8	40.8	49.8	–
2012	64.1	28.4	–	23.7
2013	45.3	32.9	131.7	–
2019	111.8	86.1	–	124.7

Introduction
00000

Methods and Data
00000

Results
●0

Conclusions
00

Structural Change Decomposition of Average Yearly Change in Carbon Productivity in Finnish Manufacturing Sector (% per year)

	2000–2006	2007–2012	2013–2019
Carbon productivity of continuing non-switching firms	7.81	12.17	24.43
+ Effect of industry switching	-0.16	-1.12	0.14
+ effect of entry and exit	-2.88	-3.14	-8.59
+ effect of GHG reallocation	-7.60	-6.92	-12.18
= Carbon productivity of the sector	-2.82	0.99	3.81

Note: The results remain robust in the decomposition of carbon productivity levels.

Introduction
00000

Methods and Data
00000

Results
00

Conclusions
●○

Conclusions

- Carbon productivity of the Finnish manufacturing sector improved since 2009.
- Continuing non-switching firms drive carbon productivity growth.
- The contribution of entry and exit was found to be negative $=>$ carbon productivity of exiting firms was higher than that of entering firms.
- Allocation of GHG emissions across firms had a systematic negative contribution $=>$ emission rights are not efficiently allocated to the most productive use.