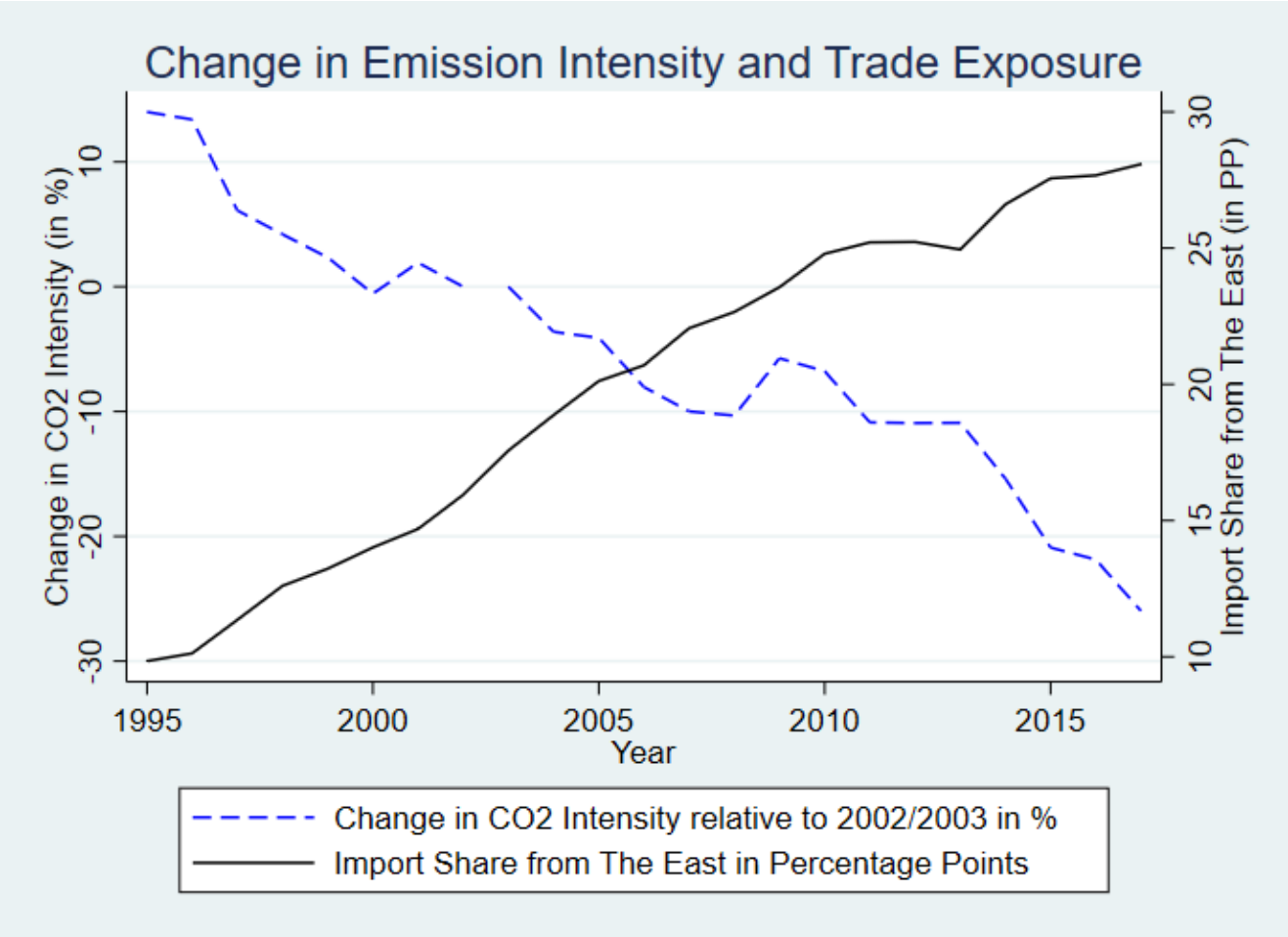
Import Competition and Carbon Intensity in the German Industry

Jakob Lehr

IfW

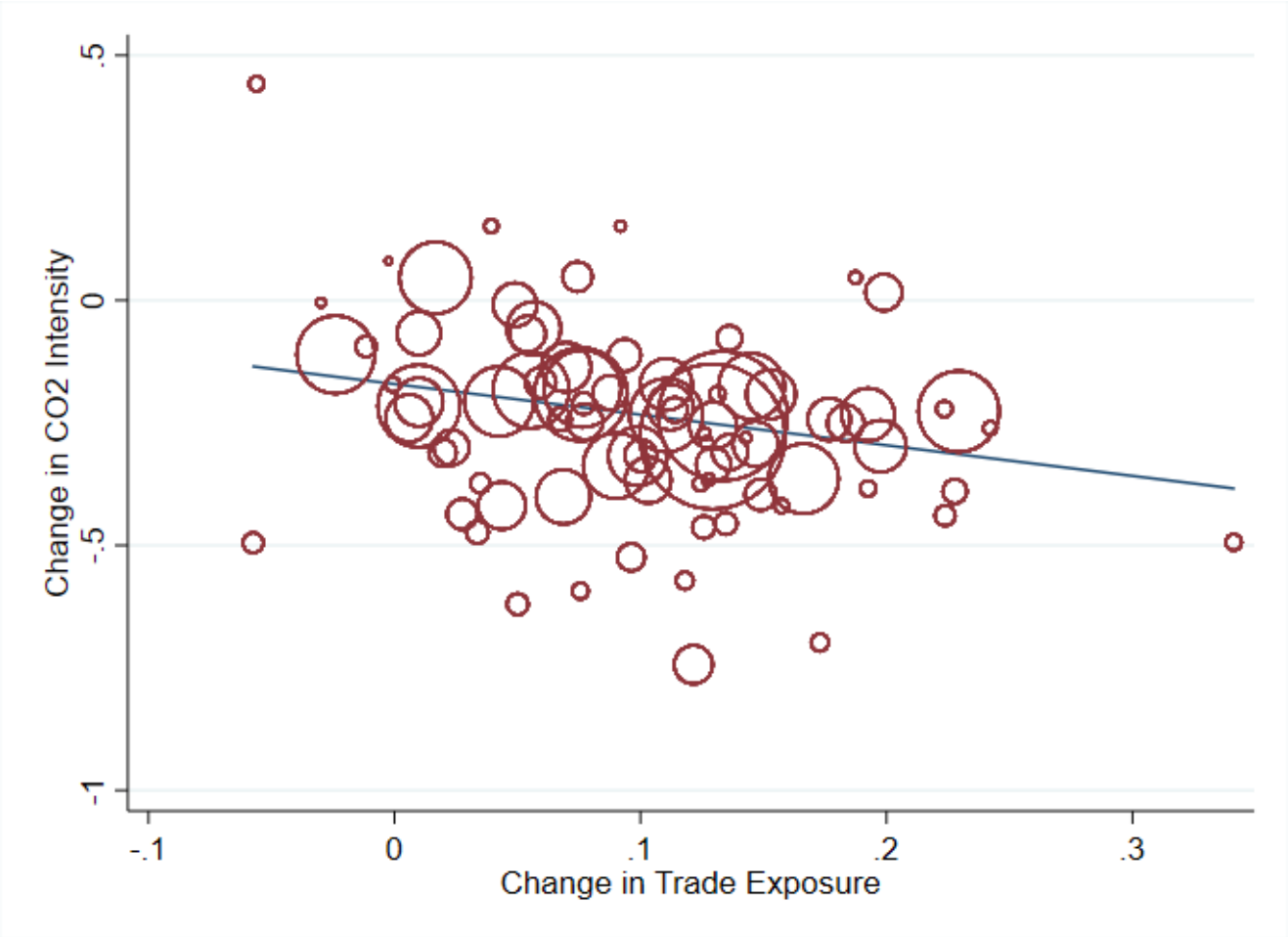
August 24, 2022

Motivation



Notes: The Figure shows the evolution of total emission intensity (i.e. CO_2 emissions per unit of sales) relative to 2002/2003 and the change in the share of imports from China and eastern Europe (i.e. imports from "The East" divided by total imports) Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel and BAKI trade data, 1995-2017.

Motivation



Notes: The Figure plots the change in sectoral trade exposure from China and eastern Europe against the change in emission intensity (i.e. CO_2 emissions per unit of sales) between 2003 and 2017 Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel and BAKI trade data, 1995-2017.

Motivation

1. Positive link between import competition and firm-level productivity in Europe (Schmidt, 1997; Bloom et al., 2015; Chen and Steinwender, 2021)
2. "Energy efficiency paradox": firms use energy inefficiently (DeCanio, 1993; Jaffe and Stavins, 1994; Gerarden et al., 2017)

Motivation

1. Positive link between import competition and firm-level productivity in Europe (Schmidt, 1997; Bloom et al., 2015; Chen and Steinwender, 2021)
2. "Energy efficiency paradox": firms use energy inefficiently (DeCanio, 1993; Jaffe and Stavins, 1994; Gerarden et al., 2017)

$\rightarrow$ Did the increasing import competition from China and eastern Europe ("The East") contribute to the decrease in CO_2 Emission intensity in the German manufacturing industry?

Related literature

- Trade, globalization and the environment:
  - Brucal et al. (2019) effect of FDI on CO_2 intensity among Indonesian manufactures
  - Environmental effects of exporting, e.g. Richter and Schiersch (2017), Forslid et al. (2018) and Barrows and Ollivier (2018)
  - Effect of import competition, e.g. Gutiérrez and Teshima (2018) and Cherniwchan (2017) who look at local pollutants
- Import competition and innovation at the firm level (cf. Shu and Steinwender (2019))
- China Shock literature e.g. Autor et al. (2013), Acemoglu et al. (2016) and Dauth et al. (2014) (focus on labor markets)

Data

- Administrative data on German manufacturing plants (AFiD)
  - Includes the universe of manufacturing plants with more than 20 employees ($>$ 40.000 plants per year)
  - CO_2 emissions can be calculated based on information about plant specific energy use
  - I aggregate plant level data to the firm level
  - Covers the period 1995 - 2017
- BAKI Trade Data (CEPII)
  - Bilateral trade flows at the product level (HS - 6 digits)
  - Trade data is mapped into 3-digit economic sectors (classification from 1993)

Empirical Approach

- Firm level regression in long (4 years) differences (e.g. Bloom et al., 2015):

$$\Delta y_{itz} = \beta_0 + \alpha \Delta IPR_{zt}^{East} + \Delta X_{itz} + \Delta \epsilon_{itz}$$

- Import penetration ratio

$$IPR_{zt}^{East} \equiv \frac{Imp_{zt}^{East}}{Y_{z,1995} + Imp_{z,1995} - Exp_{z,1995}}$$

- Instrument endogenous trade flows with flows to other countries $\rightarrow$ isolate variation from supply side

$$IPR_{zt}^{Other \leftarrow East} \equiv \frac{Imp_{zt}^{Other \leftarrow East}}{Y_{z,1995} + Imp_{z,1995} - Exp_{z,1995}}$$

Countries in Instrument Group (Dauth et al. (2014))

Descriptive Statistics

Table 1: Descriptive Statistics - Firm Level Information

Variable	Mean	Std. Dev	p10	p50 (Median)	p90	N
Number of Employees	99	117.6	25	54	226	752197
Gross Output	17111.71	28799.70	1859.68	6553.98	43284.27	752197
Export Share	0.18	0.24	0	.07	0.56	752197
Total Energy (in MWh)	4575.96	22549.41	161.24	892.706	90110.92	752197
Total CO2 Emissions (in t)	1639.049	4966.97	66.64	418.04	3599.66	752197
Total electricity (in Mwh)	1872.07	5715.37	64.07	410.91	4219.11	752197

Notes: The table shows the average of respective variables from the period 1995-2017. Delflated Sales is in 1000 Euro, energy use (total and electricity) is in MwH and CO_2 emissions in tons. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel Industriebetriebe, 1995-2017, own calculations.

Decomposition of sector-level emission intensity

Main Results - Firm Level Analysis

Table 2: Baseline results

	IV		OLS	
	(1)	(2)	(3)	(4)
Panel A. Log of CO_2 emission intensity				
Coefficient	-0.0041***	-0.0024***	-0.0036***	-0.0003
Standard Error	0.0008	0.0009	0.0006	0.0005
Panel B. Log of CO_2 Emissions				
Coefficient	-0.0079***	-0.0029***	-0.0015***	-0.0003
Standard Error	0.0012	0.0009	0.0006	0.0005
Panel C. Log of Sales				
Coefficient	-0.0038***	-0.0005	0.0021***	0.0018***
Standard Error	0.0012	0.0011	0.0006	0.0007
First-stage coefficient	0.359	0.341		
Standard Error	0.0275	0.0301		
Kleibergen-Paap F-statistic	170.5	128.2		
CO_2 intensity-decile-year-dummy	Yes	Yes	Yes	Yes
Sales-decile-year-dummy	Yes	Yes	Yes	Yes
Export share-decile-year-dummy	Yes	Yes	Yes	Yes
Sector-dummy	No	Yes	No	Yes
Observations	365745	365745	365745	365745

Notes: *** denotes 1% significance; ** denotes 5% significance; and * denotes 10% significance. Column (1) and (2) show results from 2SLS estimations and column (3) and (4) from a OLS estimation. The dependent variable is the four-year change in log of firms' CO_2 emissions scaled with firms' sales (emission intensity) (Panel A.), the log of firms' CO_2 emissions and the log of firms' sales (Panel C.). Standard errors were clustered both, at the firm and at the three-digit-industry-year level. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel Industriebetriebe, 1995-2017, own calculations.

Robustness

- Alternative specifications Results Robustness:
  - Full sample
  - Single plant firms
  - Non-overlapping intervals
  - Standard errors clustered at 3-digit sector level
  - Alternative instrument group
- Leakage emissions per value added
  - Similar effect on value added
  - No change in the share of value added (VA/Sales)

Effect Heterogeneity

- Interact trade shock with dummy for above median:
  - CO_2 intensity $\rightarrow$ Effect stronger among firms with high CO_2 intensity
  - Export intensity $\rightarrow$ Effect driven by firms that are less active in export markets
  - Number of employees $\rightarrow$ No differences in response to trade shock depending on firm size (measured by number of employees)
  - Import share in 1995 $\rightarrow$ Response to trade shock stronger among firms with lower initial trade exposure

Heterogeneities

Conclusion

- Firm level analysis points to a negative effect of import competition on emission intensity
  - Effect stronger among firms with high emissions relative to sales and lower export shares
  - Effect comes from reduction in emissions, not because of higher sales
- Back of the envelope:
  - IPR from the East $\uparrow$ 20pp
  - Emission intensity $\downarrow$ by 0.4% for import share $\uparrow$ 1pp
  - Emission intensity fell by $\approx$40% btw. 1995 and 2017

References I

Acemoglu, Daron et al. (2016). "Import Competition and the Great US Employment Sag of the 2000s". In: *Journal of Labor Economics* 34.S1, S141–S198. DOI: 10.1086/682384. eprint: https://doi.org/10.1086/682384.

Autor, David H. et al. (Oct. 2013). "The China Syndrome: Local Labor Market Effects of Import Competition in the United States". In: *American Economic Review* 103.6, pp. 2121–68. DOI: 10.1257/aer.103.6.2121.

Barrows, Geoffrey and Hélène Ollivier (2018). "Cleaner firms or cleaner products? How product mix shapes emission intensity from manufacturing". In: *Journal of Environmental Economics and Management* 88.C, pp. 134–158.

References II

Bloom, Nicholas et al. (Sept. 2015). "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity". In: *The Review of Economic Studies* 83.1, pp. 87–117. DOI: 10.1093/restud/rdv039. eprint: https://academic.oup.com/restud/article-pdf/83/1/87/17417082/rdv039.pdf.

Brucal, Arlan et al. (2019). "Good for the environment, good for business: Foreign acquisitions and energy intensity". In: *Journal of International Economics* 121, p. 103247. DOI: https://doi.org/10.1016/j.jinteco.2019.07.002.

Chen, Cheng and Claudia Steinwender (2021). "Import competition, heterogeneous preferences of managers, and productivity". In: *Journal of International Economics* 133, p. 103533. DOI: https://doi.org/10.1016/j.jinteco.2021.103533.

References III

Cherniwchan, Jevan (2017). "Trade liberalization and the environment: Evidence from NAFTA and U.S. manufacturing". In: *Journal of International Economics* 105, pp. 130–149. DOI: https://doi.org/10.1016/j.jinteco.2017.01.005.

Dauth, Wolfgang et al. (2014). "THE RISE OF THE EAST AND THE FAR EAST: GERMAN LABOR MARKETS AND TRADE INTEGRATION". In: *Journal of the European Economic Association* 12.6, pp. 1643–1675. DOI: https://doi.org/10.1111/jeea.12092. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/jeea.12092.

DeCanio, Stephen J. (1993). "Barriers within firms to energy-efficient investments". In: *Energy Policy* 21.9, pp. 906–914. DOI: https://doi.org/10.1016/0301-4215(93)90178-I.

References IV

Forslid, Rikard et al. (2018). "Why are firms that export cleaner? International trade, abatement and environmental emissions". In: *Journal of Environmental Economics and Management* 91, pp. 166–183. DOI: https://doi.org/10.1016/j.jeem.2018.07.006.

Gerarden, Todd D. et al. (Dec. 2017). "Assessing the Energy-Efficiency Gap". In: *Journal of Economic Literature* 55.4, pp. 1486–1525. DOI: 10.1257/jel.20161360.

Gutiérrez, Emilio and Kensuke Teshima (2018). "Abatement expenditures, technology choice, and environmental performance: Evidence from firm responses to import competition in Mexico". In: *Journal of Development Economics* 133, pp. 264–274. DOI: https://doi.org/10.1016/j.jdeveco.2017.11.004.

References V

- Jaffe, Adam B. and Robert N. Stavins (1994). "The energy paradox and the diffusion of conservation technology". In: *Resource and Energy Economics* 16.2, pp. 91–122. DOI: https://doi.org/10.1016/0928-7655(94)90001-9.
- Olley, G. Steven and Ariel Pakes (1996). "The Dynamics of Productivity in the Telecommunications Equipment Industry". In: *Econometrica* 64.6, pp. 1263–1297.
- Richter, Philipp M. and Alexander Schiersch (2017). "CO2 emission intensity and exporting: Evidence from firm-level data". In: *European Economic Review* 98, pp. 373–391. DOI: https://doi.org/10.1016/j.euroecorev.2017.07.011.
- Schmidt, Klaus M. (1997). "Managerial Incentives and Product Market Competition". In: *The Review of Economic Studies* 64.2, pp. 191–213.

References VI

Shu, Pian and Claudia Steinwender (2019). "The Impact of Trade Liberalization on Firm Productivity and Innovation". In: *Innovation Policy and the Economy* 19, pp. 39–68. DOI: 10.1086/699932. eprint: https://doi.org/10.1086/699932.

Instrument Group

- Eastern Europe comprises the following countries: Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, Russian Federation, Belarus, Estonia, Latvia, Lithuania, Moldova, Ukraine, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.
- To instrument trade flows from China and Eastern Europe to Germany I use trade flows from China and Eastern Europe to the following countries:
  - Australia, Canada, Japan, Norway, New Zealand, Sweden, Singapore, and the United Kingdom (compare Dauth et al., 2014)

Back to Slides

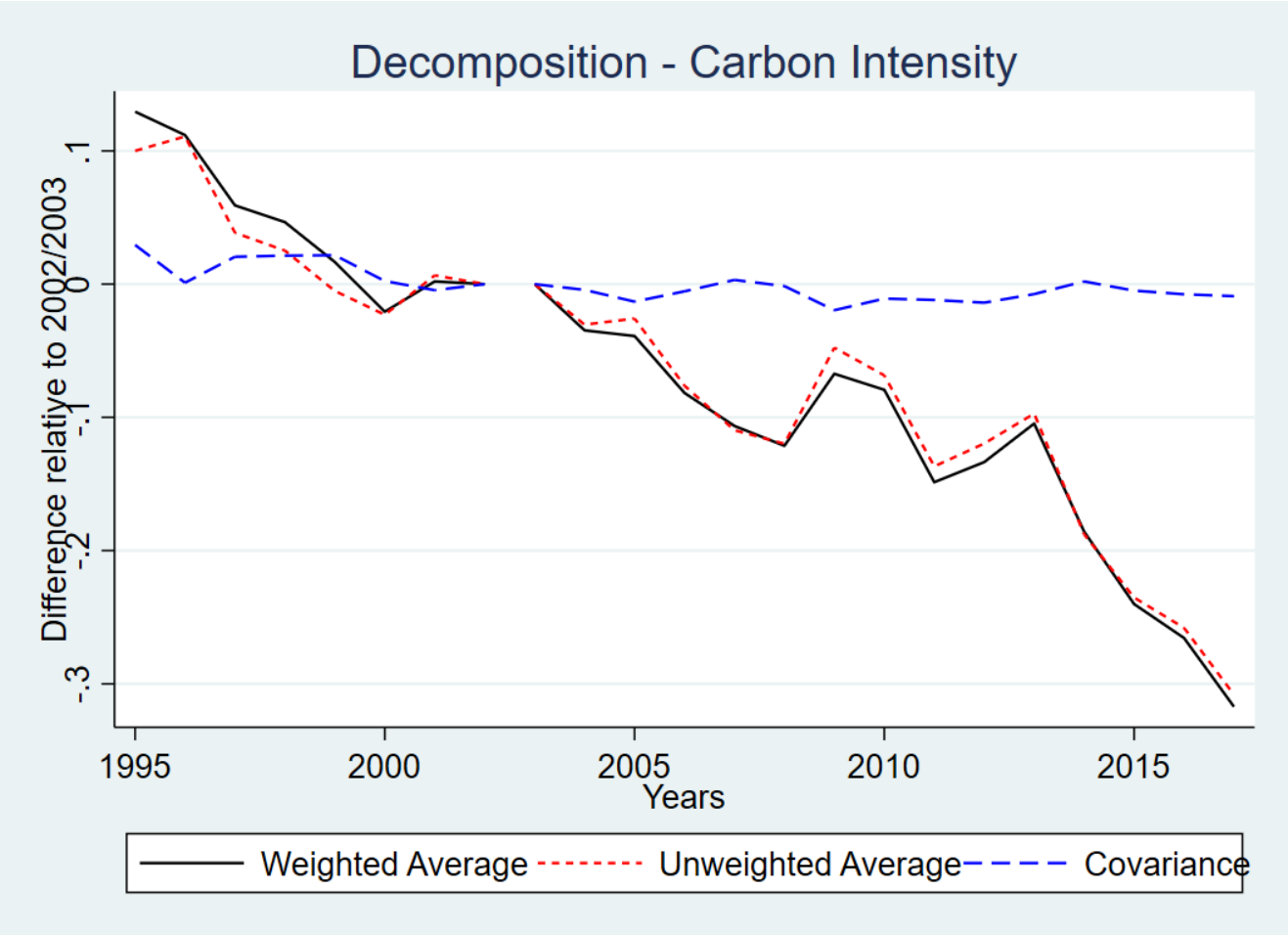
Decomposition - Sector Level Results

- Decompose aggregate emission intensity at the sector level in the unweighted mean and the covariance between firms' emission intensity and their market share (s_{it} is share of sales from firm i in total sales in sector z)(e.g.Olley and Pakes (1996), Brucal et al. (2019))

$$\underbrace{W_{zt} = \sum_{i \in Z} s_{it} lnE_{it}}_{\text{Weighted } CO_2 \text{ Intensity in Sector Z}} = \underbrace{\overline{lnE_{zt}}}_{\text{Unweighted avg. Intensity}} + \underbrace{\sum_{i \in Z} (s_{it} - \overline{s_t})(lnE_{it} - \overline{lnE_t})}_{Covariance}$$

- Change in the unweighted mean capture within firm changes
- Changes in the covariance capture reallocation of market shares

Decomposition



Notes: The figure shows the average across three digit sectors from a decomposition of total emissions (weighted average) in the unweighted average and and the covariance between market share and CO_2 intensity. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel and BAKI trade data, 1995-2017.

Results - Decomposition

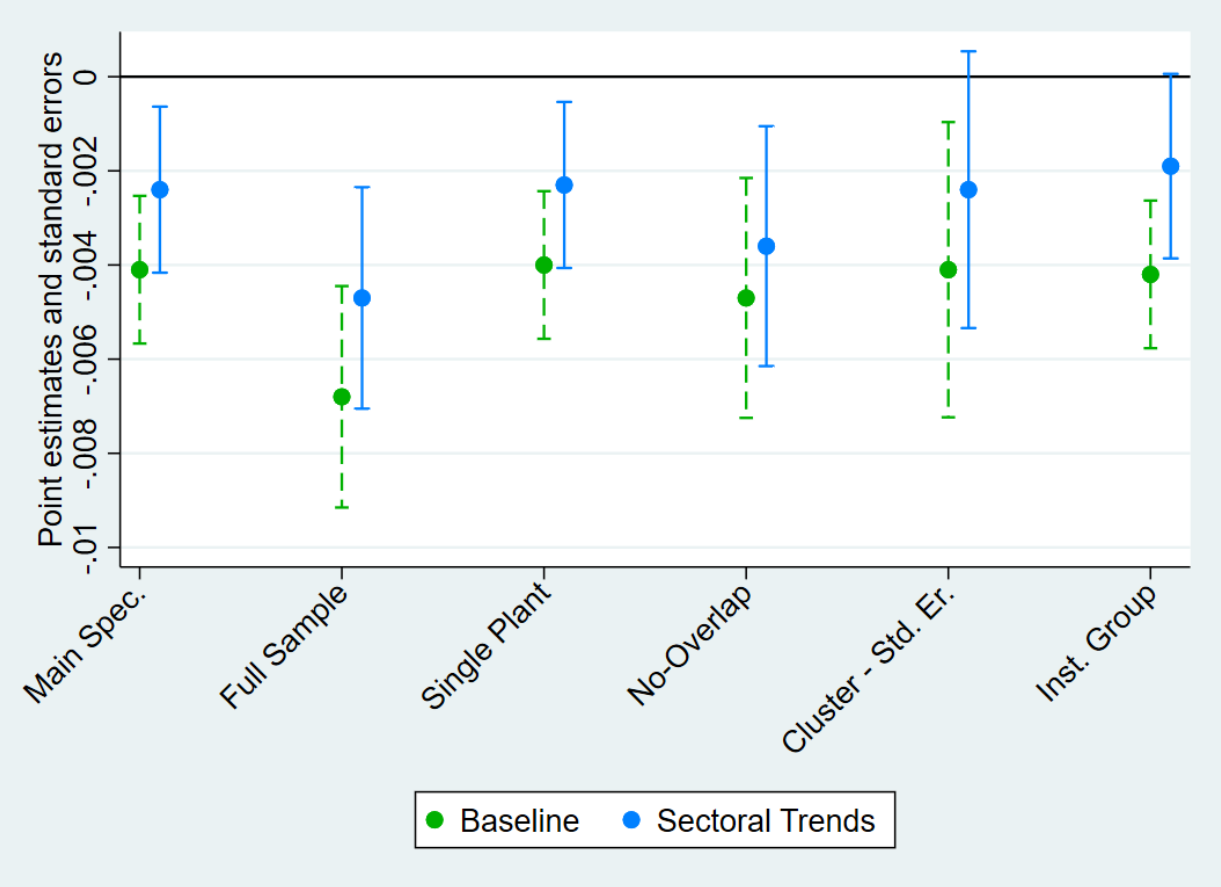
Table 3: Import Competition from the East and CO_2 Intensity - Sectoral Effects

	Weighted Mean		Unweighted Mean		Covariance	
	IV	OLS	IV	OLS	IV	OLS
Import Share	-0.003	-0.002	-0.003**	-0.002*	-0.000	-0.000
	0.002	0.001	0.001	0.001	0.002	0.001
Observations	1909	1909	1909	1909	1909	1909
F-Stat	112.4		112.4		112.4	
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** denotes 1% significance; ** denotes 5% significance; and * denotes 10% significance. The table shows IV and OLS regressions results for three different dependent variables (given at the top of the table). "Weighted mean" is total emissions divided by total sales in sector z. "Unweighted Mean" is the average firm's CO_2 intensity in sector z. "Covariance" is the covariance between a firm's market shares and firm's CO_2 intensity. Regressions include different sector level fixed effects before and after the change in the reporting of energy variables (before and after 2003). Standard errors are clustered at the sector level and given in parentheses. Regressions are weighted with the number of firms in the respective sector. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel Industriebetriebe, 1995-2017, own calculations.

Back to Slides

Robustness



Notes: The figure shows IV estimates from the baseline specification and from the specification accounting for sectoral trends. Specification from right to left: main specification, the whole panel, i.e. including the NACE1 sectors 30 and 32, subsample of single plant firms, only non-overlapping intervals, standard errors clustered at the sector level and alternative set of countries in the instrument group. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel and BAKI trade data, 1995-2017.

Back to Slides

Emission per value added

Table 4: Emission per value added

	IV		OLS	
	(1)	(2)	(3)	(4)
Panel A. Emission Intensity of Value Added				
Coefficient	-0.0038***	-0.0015*	-0.0037***	-0.0009
Standard Error	0.0008	0.0009	0.0006	0.0007
Observations	70635	70635	70635	70635
Kleibergen-Paap F-statistic	181.7	141.3		
Panel B. Share of Value Added				
Coefficient	0.0007*	0.0006	0.0002	0.0000
Standard Error	0.0003	0.0004	0.0003	0.0003
Observations	70783	70783	70783	70783
Kleibergen-Paap F-statistic	180.2	140.8		
CO_2 intensity-decile-year-dummy	Yes	Yes	Yes	Yes
Sales-decile-year-dummy	Yes	Yes	Yes	Yes
Export share-decile-year-dummy	Yes	Yes	Yes	Yes
Sectoral Trends	No	Yes	No	Yes

Notes: *** denotes 1% significance; ** denotes 5% significance; and * denotes 10% significance. Column (1) and (2) show results from 2SLS estimations and column (3) and (4) from a OLS estimation. The dependent variable in Panel (A) is the four-year-change in the share of value added (i.e. value added divided by sales), in Panel (B) CO_2 emissions per unit of value added. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel Industriebetriebe, 1995-2017, own calculations.

Back to Slides

Baseline Results by Country

Table 5: East and China Separately

	IV		OLS	
	(1)	(2)	(3)	(4)
Panel A. China				
Coefficient	-0.0053***	-0.0026**	-0.0021***	0.0006
Standard Error	0.0012	0.0012	0.0008	0.0006
Observations	365745	365745	365745	365745
Kleibergen-Paap F-statistic	198.6	170.4		
Panel B. Easter Europe				
Coefficient	-0.0089***	-0.0087**	-0.0063***	-0.0015*
Standard Error	0.0023	0.0037	0.0009	0.0008
Observations	365745	365745	365745	365745
Kleibergen-Paap F-statistic	6.391	4.948		
CO_2 intensity-decile-year-dummy	Yes	Yes	Yes	Yes
Sales-decile-year-dummy	Yes	Yes	Yes	Yes
Export share-decile-year-dummy	Yes	Yes	Yes	Yes
Sectoral Trends	No	Yes	No	Yes

Notes: *** denotes 1% significance; ** denotes 5% significance; and * denotes 10% significance. Column (1) and (2) show results from 2SLS estimations and column (3) and (4) from a OLS estimation. The dependent variable is the four-year change in log of firms' CO_2 emissions per value added. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel Industriebetriebe, 1995-2017, own calculations.

Back to Slides

Effect Heterogeneity: Interaction effects

Table 6: Effect Heterogeneity - CO_2 Intensity

	(1)	(2)	(3)	
Main effect	0.0008	-0.0056***	-0.0037***	-0.0051***
	(0.0007)	(0.0011)	(0.0009)	(0.0012)
Interaction - CO2 intensity	-0.0035***			
	(0.0009)			
Interaction - Export intensity		0.0027**		
		(0.0012)		
Interaction - Size			0.0007	
			(0.0008)	
Interaction - High Imp. Sh.				0.0033**
				(0.0015)
Kleibergen-Paap F-statistic	53.87	69.19	128	75.09
CO_2 intensity-decile-year-dummy	No	Yes	Yes	Yes
Sales-decile-year-dummy	Yes	Yes	No	Yes
Export share-decile-year-dummy	Yes	No	Yes	Yes
Observations	363574	364004	363667	365745

Notes: *** denotes 1% significance; ** denotes 5% significance; and * denotes 10% significance. The table reports main and interaction effects. The set of fixed effects differs depending on the interaction variable. All fixed effects were also interacted with the "above-median dummy". The regression in column 1 further includes start-off period values of the dependent variable. The dependent variable is the four-year change in log of firms' CO_2 emissions per sales. Source: Research Data Centres of the Federal Statistical Office and the Statistical Offices of the Länder: AFiD-Panel Industriebetriebe, 1995-2017, own calculations.

Back to Slides