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DISCUSSION PAPER

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Impacts of Ownership Changes on Emissions and Industrial Production: Evidence From Europe

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Impacts of ownership changes on emissions and industrial production: Evidence from Europe*

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Abstract

Firm ownership is a major determinant for the economic performance of firms, and emissions of pollutants are often by-products of industrial production. We investigate the impact of ownership on pollutant emissions of firms and their industrial facilities in Europe jointly with their output, productivity, and other key economic outcomes. To disentangle the influence of ownership from other firm characteristics, we analyse the effects of ownership changes in an event-study approach. We find that industrial facilities and firms decrease their emissions and industrial output after a change in ownership. Emissions intensity and productivity do not change suggesting that reductions in emissions follow proportional reductions in output rather than reflecting changes in pollution abatement technology. We find some evidence for positive spillover effects on productivity and profits of other facilities and firms owned by the acquiring parent company after a change in ownership.

Keywords: Ownership changes, pollution, productivity, event study
JEL Classification: D22, D23, Q53

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1 Introduction

Corporate ownership affects the economic performance of firms, such as productivity (e.g., Commander and Svejnar, 2011; Li, 2013) and innovation activity (e.g., Aghion et al., 2013; Clo et al., 2020). Ownership can affect knowledge transfer and management practices within firms (e.g., Burstein and Monge-Naranjo, 2009; Alcacer and Zhao, 2012; Bloom et al., 2013) as well as internal goal setting (e.g., Shleifer, 1998). Ownership changes, e.g., through mergers and acquisitions (M&A), often influence production and investment decisions. Furthermore, these changes reallocate funds across firms, thereby impacting even aggregate economic outcomes (David, 2021). However, against the background of climate change and pollution as two major societal challenges, it is unclear how these changes in firms' economic performance and overall economic outcomes translate to environmental impacts of firms, such as the emission of pollutants.

In this paper, we analyze the impact of ownership changes on emissions of industrial facilities and firms in Europe jointly with their output, productivity and other key economic outcomes.[1] In 2019, the industrial sectors had a share of about 16 percent of Europe's total employment (Eurostat, 2022a) and about 18 percent in its gross domestic product (GDP) (Eurostat, 2022b), but were also responsible for a substantial share in Europe's pollution: about 48 percent of total greenhouse gas emissions (EEA, 2022), 28 percent of nitrogen oxide emissions, and 81 percent of sulphur oxide emissions (EEA, 2021). These numbers underline the importance of the industrial sectors for economic but also environmental outcomes in Europe. Also in 2019, around 17 500 M&A deals (Thomson Reuters, 2019a) with a volume of € 991 billion were made in the European economy (Thomson Reuters, 2019b).

To shed light on the impact of ownership changes on emissions and economic performance, we use ZEW's ME-FINE dataset, which combines emission information of industrial facilities from the European Pollutant Release and Transfer Register (E-PRTR) and financial indicators of firms from Bureau van Dijk's Orbis database. Our

[1] Industrial refers to facilities and firms active in the manufacturing and energy supply sectors.

sample includes about 6,000 industrial facilities[2] associated to 4,600 firms[3] in the EU15[4] plus Hungary and Norway from 2007 to 2016.[5]

Since ownership changes and firm decisions, such as input and output choices, are likely endogenous, we use an event study design, exploiting variation in the timing of ownership changes among all units that experience a change in ownership during our observation period. In our sample, 47 percent of facilities and 43 percent of firms experience at least one ownership change between 2007 and 2016. Since ownership changes occur at different years across units, we address treatment effect heterogeneity by applying the estimator proposed by Sun and Abraham (2021) in addition to conventional two-way fixed effects models. We use only the within-variation in facilities' and firms' emissions and ownership status by including individual and a variety of year fixed effects.

In the context of large polluting industrial facilities in the European Union (EU), we investigate the effect of ownership changes on firms' and their industrial facilities' total emissions. On average, emissions decrease by about 46 percent at the facility and by about 55 percent at the firm level after an ownership change. However, emissions intensity of output and total factor productivity at the firm level are not affected by a change in ownership. Combined with a negative effect on output, these results suggest that changes in production volumes are a major driver of the observed emission reductions rather than changes in the underlying abatement technology.

The parent companies[6] acquiring the industrial facilities increase their total emissions from industrial facilities, while their emissions intensities remain unchanged. We

[2]Facility is the reporting unit in EPER/E-PRTR and describes "one or more installations on the same site that are operated by the same natural or legal person" (Regulation (EC) No 166/2006).

[3]A firm is the observational unit in Orbis defined by the Bureau van Dijk identifier. In our sample, the mean and median number of facilities per firm are 1.4 and 1, respectively.

[4]Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

[5]2007 is the first year of the emissions reporting in E-PRTR. ZEW's ME-FINE dataset also includes emissions data for 2001 and 2004 from the E-PRTR's predecessor, the European Pollutant Emissions Registry (EPER). We restrict the sample to the time period from 2007 to 2016 for a more comprehensive coverage and consistent definitions of pollutant emissions in those countries over time.

[6]The parent company in our paper is the global ultimate owner with a minimum 25 percent ownership stake, considering only owners that are industrial companies, insurance companies, financial companies and banks.

find that the newly acquired facilities employ relatively more capital and pay higher labor expenditures but are overall less productive compared to the industrial facilities that the parent company already owned. This negative impact on parent companies' factor productivity persists over time, consistent with a lack of evidence for productivity gains of newly acquired facilities. Furthermore, we observe an increase in intangible assets – both absolute and relative to the number of industrial facilities – of the parent company. Interestingly, for other industrial firms of the acquiring parent company, we find an increase in total factor productivity and profits after the parent company acquires a new industrial plant, potentially hinting at positive spillover effects across firms within the same parent company.

Our paper contributes to the large literature on the importance of corporate structure and ownership for firm performance and to the smaller literature on the effects of ownership on environmental performance. In a study closely related to ours, Jacqz (2021) finds that newly acquired facilities in the United States reduce their (toxic) emissions to the air, mainly driven by operational changes. Similar to our study, she uses an event study design. Two further US studies provide evidence that the ownership structure of facilities seems to matter for their emissions level: Grant and Jones (2003) compare emissions by subsidiaries and non-subsidiaries in the US and find that the former facilities pollute significantly more. Akey and Appel (2021) study how the degree of parent company liability affects pollution by subsidiaries in the US; they find that stronger liability protection for parents leads to increases in toxic pollutants emitted by subsidiaries. Several studies look at other outcomes than facility-level emissions related to pollution: Aden et al. (1999) study pollution abatement expenditures of foreign- and domestically-owned manufacturing plants in Korea. They find that domestically-owned plants spend more on abatement equipment than plants with some level of foreign ownership. Conversely, Albornoz et al. (2009) find that foreign direct investment (FDI) has a positive effect on the implementation of environmental management systems by Argentinean manufacturing firms. Ning and Wang (2018)

find that FDI reduces local pollution intensity via spillovers at the prefectural city level in China.

The effect of mergers and acquisitions, specifically FDI, on other outcomes of firm performance has been studied more extensively. Most studies find a positive effect of foreign ownership on firm productivity (Javorcik, 2004; Haskel et al., 2007; Arnold and Javorcik, 2009; Newman et al., 2015). However, Aitken and Harrison (1999) find negative productivity spillovers on domestically-owned firms so that the net productivity increase from FDI is small. Harris and Robinson (2002) find that foreign-owned companies purchase the most productive facilities but productivity declines after the acquisition. Wang and Wang (2015) find no additional gains from FDI; both foreign and domestic acquisitions increase productivity of the target facilities equally.

The effect of acquisitions on output and employment depends on the context. Siegel and Simons (2010) find that Swedish firms in the manufacturing sector reduce output and employment after acquisition, while Wang and Wang (2015) find that foreign, but not domestic, acquisitions increase the output and employment of Chinese target firms. Also Arnold and Javorcik (2009) find a positive effect of foreign acquisitions on employment in Indonesian manufacturing firms. Conversely, Li (2013) finds that employment drops in US facilities after acquisition. Chen (2011) compares the effect of foreign and domestic acquisitions on target firms' profits and finds FDI to increase profits more compared to domestic acquisitions.

We contribute to the literature being the first to provide evidence on the role of ownership changes for emissions of firms in Europe, jointly with the impact of ownership changes on a wide range of firms' economic performance indicators. We use a novel data set combining information from Orbis and the E-PRTR. This enables us, as compared to single-country studies, to extend our analysis to a major economic region with a wide range of countries, allowing us to draw broader conclusions less dependent on country-specific peculiarities. Furthermore, observing outcomes at different aggregation levels, such as at the facility, firm and parent company level, we can distinguish between those three levels of aggregation and shed light on potential

reallocation effects of production and emissions across facilities and firms within the parent company, and assess the impact on productivity and profits.

The remainder of this paper is structured as follows: The data is described in Section 2. Our empirical strategy for the analysis of ownership changes is outlined in Section 3. Section 4 presents our results and Section 5 concludes.

2 Data

Our main data source is ZEW's ME-FINE data set which combines emissions data from the EPER/E-PRTR and financial information from Orbis (Germeshausen et al., 2022). ME-FINE includes firms in the manufacturing and energy supply sectors (NACE Rev. 2: 10 - 35) in the EU-15 plus Norway and Hungary and covers about 70 percent of observations reported in EPER/E-PRTR in those sectors and countries. We use observations from the period 2007-2016[7], covering 6,097 facilities and 4,669 firms. For this period, ME-FINE covers about 87 percent of total E-PRTR observations in these sectors and countries. Furthermore, we add ownership links between firms and their parent company as reported in Orbis.

We divide the data set into three levels: facilities, firms and parent companies. At the facility level, facility-year observations contain information on reported emissions, on the associated firm and the parent company as well as the sector code (NACE Rev. 2). At the firm level, firm-year observations contain information on reported emissions (aggregated over all their E-PRTR facilities), financial indicators, the parent company, and the sector code. At the parent company level, parent company year observations contain information on reported emissions aggregated over all their E-PRTR facilities and financial indicators aggregated over all their firms with E-PRTR facilities. Reported emissions during our observation period stem from E-PRTR. Reporting emissions is mandatory for facilities in specific economic sectors that exceed capacity and pollutant-

[7]From 2007 on, the E-PRTR reports information on pollutant emissions annually. The EPER is the predecessor which reports pollutant emissions for the years 2001 and 2004.

specific thresholds. These thresholds are set such that about 90 percent of the emissions of each of the 91 pollutants in E-PRTR is covered.

Table 1 provides summary statistics on the outcome variables in our estimation sample at the facility, firm and parent company level. This sample includes only entities with one ownership change from 2007 to 2016. Total emissions is an aggregated measure which sums physical emission quantities over all pollutants reported to E-PRTR, whereby the quantity of each pollutant is divided by its pollutant-specific reporting threshold. Emissions intensity at the firm level scales total emissions by operating revenues in thousand euro (EUR). Operating revenues are deflated by two-digit sectoral (NACE Rev. 2) producer price indices from Eurostat. To obtain firm- and time-specific values for total factor productivity, we estimate a value added production function using firm investment as a proxy variable following Wooldridge (2009).[8]

[8]Total factor productivity estimates are highly correlated to estimates obtained by applying the methods by Olley and Pakes (1996) and Ackerberg et al. (2015). However, in the case of Ackerberg et al. (2015) the coefficient of capital input is negative. Therefore, we use the estimates obtained from following Wooldridge (2009) as reference.

Table 1: Summary statistics for final sample, 2007 - 2016

	N	Mean	St. Dev.	Min	P25	P75	Max
Variables at the facility level							
Total emissions	11,819	118.6	1,247.8	0.0	1.3	19.3	39,926.4
Variables at the firm level							
Total emissions	6,979	83.5	1,137.9	0.00	1.0	16.7	64,302.0
Operating revenues ('000 EUR)	6,210	838,806	9,204,588	0	20,411	227230	261,279,167
Emissions intensity	5,783	0.069	1.101	0.000	0.000	0.016	70.162
Total factor productivity	3,286	9.3	0.7	5.4	9.0	9.7	14.9
Number of employees	5,939	1,139	8,456	0	49	508	195,826
Tangible fixed assets ('000 EUR)	6,167	299,240	3,931,596	0	4,261	73,112	163,911,425
Labor expenditures ('000 EUR)	5,671	71,417	596,300	0	2,306	28,962	14,189,731
R&D expenditures ('000 EUR)	305	51,623	147,706	0	0	10,625	978,666
Intangible fixed assets ('000 EUR)	5,520	72,931	701,664	0	6	2,316	15,685,382
Variables at the parent company level							
Total emissions	2,612	202.7	1,408.2	0.0	2.9	59.7	35,201.3
Operating revenues ('000 EUR)	2,584	965,397	3,289,382	0	23,731	628,181	54,484,828
Emissions intensity	2,136	0.080	0.767	0.0	0.001	0.026	21.390
Total factor productivity	1,514	7.3	0.7	2.0	7.0	7.6	10.2
Number of employees	2,584	2,175	9,671	0	49	1,132	198,980
Tangible fixed assets ('000 EUR)	2,584	38,6025	1,561,469	0	5,225	220,251	25,848,393
Labor expenditures ('000 EUR)	2,583	125,575	658,641	0	1,704	56,949	12,188,843
R&D expenditures ('000 EUR)	2,584	13,818	170,347	0	0	0	453,9012
Intangible fixed assets ('000 EUR)	2,584	117,280	1,138,166	0	0	6,606	33,422,925

Notes: Total emissions is the sum over the quantities of all pollutants each divided by its reporting threshold. Emissions intensity refers to total emissions divided by deflated operating revenues at the firm level, and to total emissions divided by deflated operating revenues multiplied by 100,000 at the parent company level.

We define a change in ownership for both firms and facilities as a change in their parent company from one year to the next.[9] In total, we observe 2,621 changes of firm ownership in the sample. This corresponds to 1.3% of all M&A events recorded in the Zephyr Database for the EU15 plus Hungary and Norway for the period 2008-2016 (Zephyr Database, 2023). 978 firms experience one change, while in total 655 firms experience multiple ownership changes. 2,697 facilities experience at least one change in ownership, of which 1,525 change only once.[10] In our analysis, we only consider firms and facilities with one ownership change event.

[9]That means that we do not observe ownership changes according to our definition that happened in 2007, the first year in our sample, since we do not observe ownership in 2006.

[10]For facilities, we count changes in the global ultimate owner as indicated by Orbis. If the global ultimate owner is unknown, we assign the associated firm as the global ultimate owner.

There is considerable heterogeneity in the distribution of ownership change events over sectors and countries. In absolute terms, we observe most ownership changes in German, French and Spanish firms. Scaling the number of observed changes by the absolute number of observations for each country in our sample, heterogeneity is much less pronounced and, in relative terms, we observe most changes in Greek, Portuguese, German and Luxembourgian firms (see figure A1 in the Appendix). The absolute number of ownership changes is highest in sectors 20, 23 and 24.[11] In relative terms, the share of ownership changes is highest in sectors 27 and 33 (see figure A2 in the Appendix).[12] The distribution of ownership change events over the years is more uniform. Both the absolute number and the percentage of changes is higher in 2008, but remains almost stable thereafter (see figure A3 in the Appendix).

Total emission reports are unbalanced in our sample. We define facilities as active in years in which they report a positive amount of emissions. In years for which facilities do not report any emissions, facilities could either have closed down or they could have emitted pollutants below the reporting thresholds.[13] We consider facilities with missing emission reports for a facility-year observation as active as long as the facilities report again in a later year in the sample. If facilities do not report again until the last year in our sample we assume they have closed down. To proxy their exit in the data, inactive facilities remain as zero-values in the sample for up to four years (at the latest until 2016) after their last reporting year, similar to the approach used by Jacqz (2021).[14] At the firm level, we apply the same procedure. Since firms' emissions are aggregated over all their facilities, we consider a firm to have exited only if none of its facilities reports again in a later year during the sample period. The largest share of facilities

[11]The NACE codes 20, 23 and 24 correspond to sectors "Manufacture of chemicals and chemical products", "Manufacture of other non-metallic mineral products" and "Manufacture of basic metals".

[12]The NACE codes 27 and 33 correspond to sectors "Manufacture of electrical equipment" and "Repair and installation of machinery and equipment".

[13]Since reporting positive emission amounts is censored below the threshold (there are no reported emissions below the pollutant-specific threshold), we investigate the impact of this censoring by considering two different imputation strategies, i.e., either imputing missing values by zero or by the threshold value, as robustness checks.

[14]Results are qualitatively similar if we replace zero-values with the pollutant-specific threshold at the facility level since facilities could still emit up to this amount without reporting obligation. Using both approaches provides us with an upper and lower bound of emissions.

reports from 2007 on, only a small share of facilities enters the sample in later years. Later entries are relatively evenly distributed across years. The largest share of facilities reports until 2016, and similarly earlier exits are rather uniformly distributed.[15] At the firm level, most entries are recorded in the first two years and least entries in the later years. The majority of firms in our sample survive until the end of our observation period. The number of firm exits varies over time.[16]

Our sample consists of the overlap of E-PRTR and Orbis. Given the emissions reporting threshold in E-PRTR, we observe emission reports from rather large firms. With respect to Orbis, its coverage differs across the globe due to different national reporting requirements and firm structures. Bajgar et al. (2020) find that firms in Orbis are rather large, old and productive. While these characteristics of E-PRTR and Orbis facilitate the assignment of E-PRTR facilities to Orbis firms in the ME-FINE data set, it has to be considered in the interpretation of our results. Our final estimation sample is not necessarily representative of the overall economy but focuses on rather large industrial facilities and firms.

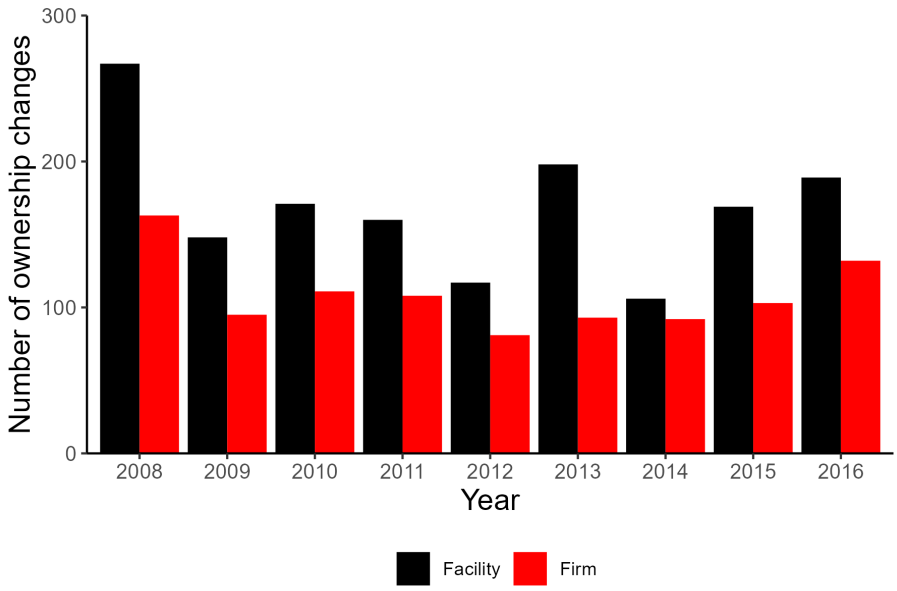
3 Empirical Strategy

We aim to identify the effect of a change in ownership (parent company change) on pollutant emissions and economic outcomes of firms and their facilities. In our sample, we observe 978 firms and 1,525 facilities whose parent company changes once during the period 2007-2016. Our empirical strategy relies on fixed unit characteristics at the facility and firm level which allows us to use only within-unit variation to identify the effect of ownership changes. The events are distributed over 9 years so that treatment adoption – change in ownership in our case – is "staggered". Our method is closely related to Jacqz (2021) who investigates a similar question in the US context.[17]

[15] See figure A4 in the Appendix.
[16] See figure A5 in the Appendix.
[17] Jacqz (2021) uses plant-level data from the EPA's Toxic Release Inventory for the period 2001-2019 to investigate the effect of corporate acquisition on facility-level air pollution and its firm level distribution.

For our event study of ownership changes, we use the Sun and Abraham interaction-weighted estimator that is robust to treatment effects heterogeneity (Sun and Abraham, 2021). The estimator interacts treatment group and relative time dummies which are then aggregated to obtain the average treatment effect for the treated for each period. In our setting, we have nine treated groups of units (firms and facilities) whose parent company changed in the respective year 2008 to 2016. Figure 1 shows how the ownership change events are distributed over the sample period for facilities and firms. Each treatment group has observations in up to 10 periods relative to the treatment period.

Figure 1: Distribution of ownership changes over time at facility and firm level



Notes: This figure shows number of ownership changes at the facility and firm level in each year for facilities and firms with only one ownership change during our observation period.

Based on Sun and Abraham (2021) the regression for our event study is:

$$Y_{it} = \alpha_i + \lambda_{ct} + \mu_{st} + \sum_{e \notin C} \sum_{l \neq -1} \delta_{el}(1\{E_i = e\} * D_{it}^l) + \varepsilon_{it},$$

where the outcome Y_{it} is aggregated emissions or economic outcomes of unit i in year t. D_{it}^l indicates the relative period of the observation, unit i being l periods away

from year of treatment E in year t, and $1\{E_i = e\}$ indicates the treatment group that unit i belongs to. The specification interacts these indicators, but omits interactions with the last group of units with ownership change in 2016 because these units do not have a not-yet-treated control group, and with the reference period $l = -1$ to avoid issues of multicollinearity. δ_{el} represents the group-specific average treatment effect on the treated. α_i, λ_{ct}, and μ_{st} capture unit-specific, country-year and sector-year fixed effects, respectively.

To form the interaction-weighted estimator, δ_{el} is weighted with sample shares of each group in each period $Pr\{E_i = e|E_i \in [-l, T-l]$. The resulting weighted average estimate normalized for the number of periods after treatment g is then:

$$\hat{v}_g = \frac{1}{|g|} \sum_{l \in g} \sum_{e} \delta_{el} \hat{Pr}\{E_i = e|E_i \in [-l, T-l].$$

We employ the Sun and Abraham estimator to identify the effect of an ownership change event on total emissions, emissions intensity and economic outcomes of firms and on total emissions of facilities. We apply the inverse hyperbole sine transformation to the outcome so that we can interpret the effects in percentage changes.[18] Our preferred specification estimates the ownership change effect using 4 leads and lags around the treatment year.[19] We include only treated firms or facilities so that the later treated units act as controls for the earlier treated units. Firms or facilities with more than one ownership change event during the period 2007-2016 are excluded. We cluster the standard errors at the respective unit level.

The main empirical challenge in identifying the ownership change effect in our setting is to find a reasonable counterfactual. Firms and facilities with an ownership change event may systematically differ from firms and facilities that keep their parent company over the entire period. Moreover, firms and facilities with more than one event may also be systematically different. We check empirically whether the groups

[18] We use the hyperbole sine transformation instead of the natural logarithm to deal with zero values when facilities do not report emissions or economic indicator values are equal to zero.

[19] We bin the first and the last lag following Schmidheiny and Siegloch (2020). Hence, we assume that effects remain constant before and after these years, respectively.

of firms differ systematically in observable characteristics. We find small differences in capital, long-term debt, total emissions, employment and intangible fixed assets (see figure A6 in the Appendix).

We deal with this issue by omitting firms and facilities with no ownership change and firms and facilities with multiple ownership changes over the sample period. Firms and facilities with an earlier change in ownership could also differ from firms with later changes if the reasons for ownership changes differ over time, e.g. via the financial crisis which had its strongest impact at the beginning of the sample period. Similarly, merger waves could be sector-specific and their timing could differ across industries. We address this issue by including sector-year and country-year fixed effects.

Anticipation effects are another threat to identification if the prospect of a change in ownership affects reported emissions and economic outcomes of firms or facilities before an acquisition. If the effect of a change in ownership manifests through a change in management practice or a technology transfer, the effect is implausible to affect emissions before an acquisition. It could however be advantageous for firms in a merger process to play down their emissions in the negotiations and report lower emissions. On the other hand, firms could ramp up production and increase output to appear more profitable for potential investors. Such anticipation effects would be visible in the pre-treatment coefficients close to treatment. We do not find evidence for an anticipation effect. We find however significant pre-treatment coefficients for some of the outcomes at the firm level three to two years before an ownership change event. In these cases, we must be cautious to interpret the coefficient as an isolated effect of the ownership change since the coefficient may reflect also other differential trends.

Shocks that affect both emissions and the propensity for an ownership event of firms and facilities can also bias the estimate. If a positive demand shock leads parent companies to buy up promising firms that will expand in the coming years, the estimate of emission reductions will be biased downward. If a negative demand shock leads parent companies to sell low-performing firms which would otherwise have closed down, the change in ownership delays the closure so that the estimate will be biased

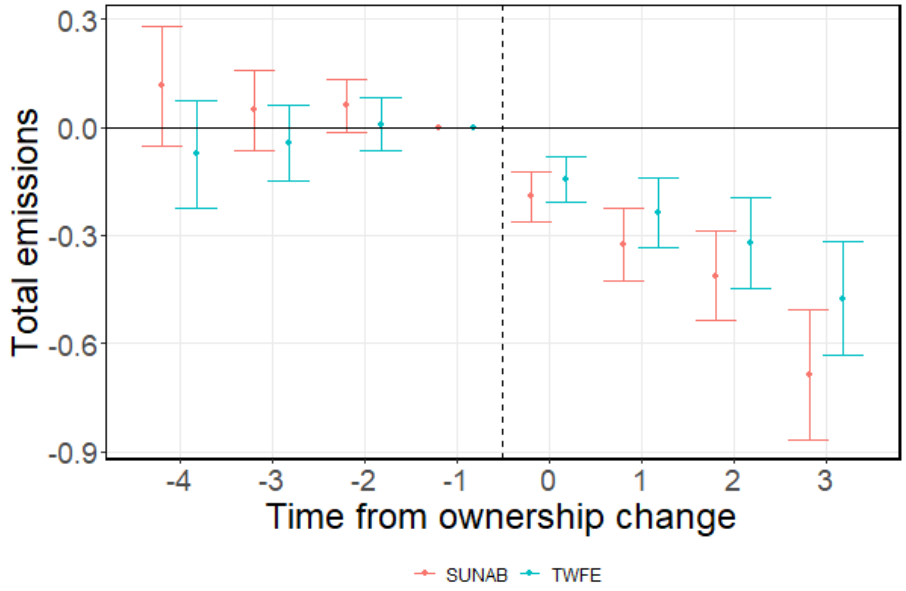
upward. Arnold (2019) and Jacqz (2021) counter this source of bias by focusing on ownership changes of larger firms which are less affected by local demand shocks. Our sample mainly consists of large firms as well.

4 Results

4.1 Effects on facilities experiencing an ownership change

Total emissions of facilities decrease steadily after an ownership change. In the third year after a change, their emissions decreased by about 40 to 68 percent (see figure 2). The point estimates of the average effect of an ownership change on total emissions at the facility level are at negative 25 to 46 percent. The estimates using the Sun and Abraham (2021) approach are larger in absolute terms as compared to the two-way fixed effects estimates (see table 2). Results are similar when we impute missing emission values at the facility level with either zero or the pollutant-specific thresholds (see table A1 in the Appendix). Since the E-PRTR data does not provide information on output of industrial facilities, we cannot investigate the impact of ownership changes on output.

Figure 2: Effect on total emissions at the facility level



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions. The inverse hyperbolic sine transformation is applied to the independent variable.

Up to this point, we assume that every ownership change has a similar impact, neglecting differences across types of ownership changes and across new owner characteristics. There is a large literature highlighting the role of foreign direct investments for firm performance. With respect to domestic and foreign ownership changes, we find similar effects to the average effects presented above and confidence intervals overlap for all ownership type groups. These results suggest no large differences across different owner types (see figure A7 and the more detailed explanation in the Appendix). Furthermore, we only find limited effect heterogeneity across sectors, with the exception of the sector manufacture of motor vehicles which experiences a larger reduction in total emissions compared to other sectors (see figure A8 in the Appendix).

Table 2: Aggregate effects on facilities

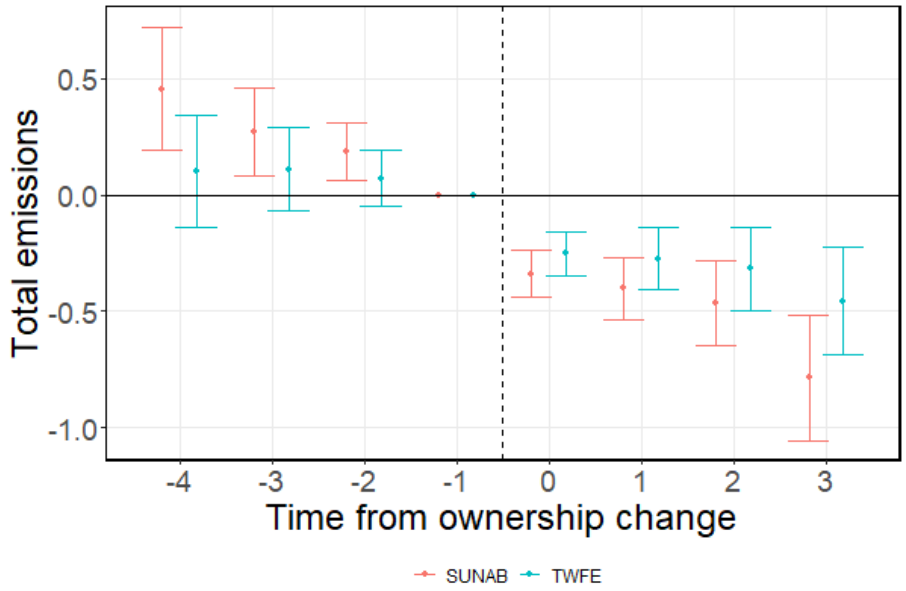
Dependent variables	ATT estimate	Std. Error	N
Total emissions	−0.4547***	(0.0579)	10,624

Notes: The first column denotes the dependent variables with an inverse hyperbolic sine transformation. The second and third columns show the point estimates and standard errors of the aggregated effect of the event study following Sun and Abraham (2021). The fourth column contains the number of observations. Standard errors clustered at the firm level are in parenthesis. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

4.2 Effects on firms experiencing an ownership change

Facilities that reduce their emissions after a change in ownership are often part of a larger firm which potentially owns many industrial facilities. So, investigating firms rather than facilities allows us to capture firm-wide adjustments in the course of the ownership change, e.g., reallocation of production among facilities within a firm. Furthermore, at the firm level, there is an abundance of financial and economic performance indicators to investigate, while this data is not available at the facility level.

Figure 3: Effect on total emissions at the firm level



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions. The inverse hyperbolic sine transformation is applied to the independent variable.

Firms reduce their total emissions on average by about 20 to 55 percent which is in the range of the effect at the facility level (see figure 3 and table 3). The decline in emissions starts in the year of the ownership change and decreases steadily for the basic two-way fixed effects specification, while there is a continuous downward trend for the ex-ante and ex-post period for the Sun and Abraham (2021) estimator which may point to additional underlying trends not driven by the ownership change. After the third year, emissions decrease by about 25 to 78 percent.[20] As in the case of facilities, we do not find differential effects based on the type of ownership change, i.e., from domestic to domestic, domestic to foreign, foreign to domestic or foreign to foreign owner, or across sectors (see figure A10 and figure A11 in the Appendix).[21]

Table 3: Aggregate effects on firms

Dependent variables	ATT estimate	Std. Error	N
Total emissions	−0.5485***	(0.0851)	6,272
Output	−1.4841***	(0.3002)	5,547
Emissions intensity	−0.0295	(0.0221)	5,175
Total factor productivity	0.0037	(0.0052)	2,945
Operating profits	−0.7512*	(0.3856)	4,191
Labor input	−0.4737***	(0.0986)	5,264
Capital input	−1.2169***	(0.2918)	5,500
Labor expenditures	−1.1523***	(0.3014)	5,057
Intangible fixed assets	−0.1481	(0.3917)	5,004

Notes: The first column denotes the respective dependent variables each with an inverse hyperbolic sine transformation. Each line represents a separate event study regression. Output refers to deflated operating revenues, emissions intensity to total emissions divided by output, labor input to number of employees, capital input to deflated tangible fixed assets, respectively. The second and third columns show the point estimates and standard errors of the aggregated effect of the event study following Sun and Abraham (2021). The fourth column contains the number of observations. Standard errors clustered at the firm level are in parenthesis. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

We investigate several potential drivers of these emission reductions and other economic performance indicators (see table 3). Firms' emissions intensity seems unaffected by ownership changes. The average effect is close to zero and none of the event-study coefficients is significant (see figure A9 in the Appendix). To further in-

[20] The effect is robust to imputation of missing values with both zero-values and threshold-values (see table A2).

[21] Furthermore, we explore whether effects differ for firms with one vs. many facilities and with above vs. below median parent company emissions. We do not observe any differential effects for these groups. Results are available upon request from the authors.

vestigate how the decrease in emissions is related to output, we additionally estimate the impact of an ownership change on (deflated) operating revenues as a measure of output. We find that an ownership change leads to a significant reduction in output. The point estimates decrease steadily after the first year and are statistically significant (see figure A13 in the Appendix). Thus, the decrease in total emissions mirrors the reduction in output.

For the subset of firms, for which all necessary variables are available, we analyze the impact of an ownership change event on total factor productivity. We use our estimated values as an outcome variable in the event study regressions and find that a change in ownership does not lead to a statistically significant change in total factor productivity of affected firms (see figure A18 in the Appendix). Consistent with the observed reduction in output and the constant total factor productivity, the effects on capital and labor input are negative (see figure A16 and figure A15 in the Appendix). There is also some evidence of a negative impact on operating profits of the firm after a change in ownership (see figure A14 in the Appendix). Some of the pre-treatment coefficients for labour and capital input, operating profits as well as output are significant, which cautions us to interpret the post-treatment coefficients as an isolated effect of the ownership change.

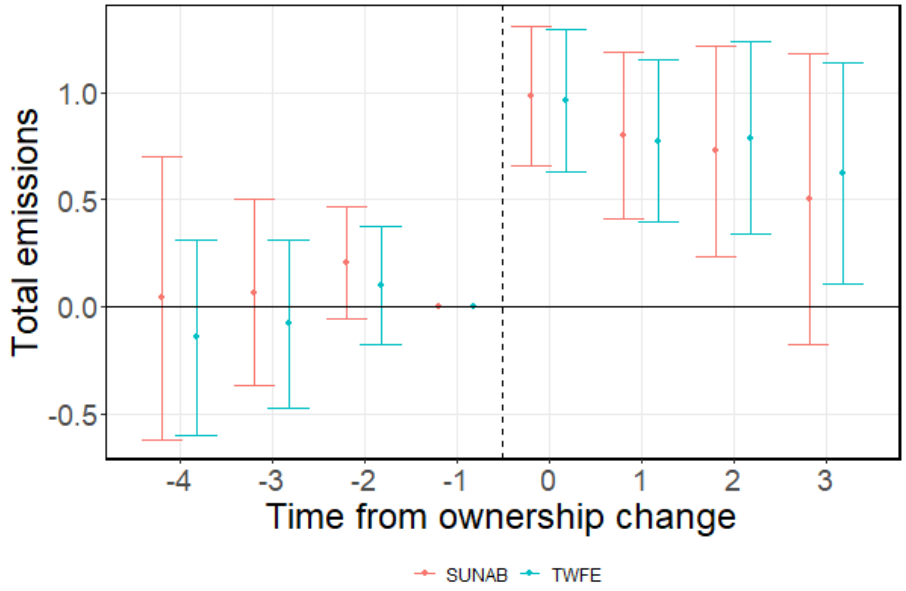
4.3 Effects on ownership groups acquiring a facility

After a change in ownership, facilities and firms appear to reduce their emissions mainly through a decrease in their production, as seen by changes in output and inputs. But how does the integration of industrial facilities and firms affect the overall environmental and economic performance of the new parent company?

To shed light on this question, we aggregate all firms with industrial plants reporting to the E-PRTR at the parent company level for each year. Then, we re-run the event

studies for the subset of parent companies that have already owned industrial plants before they acquired a new one and acquired new industrial facilities only once.[22]

Figure 4: Effect on total emissions at the parent company level



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

On average, total emissions of parent companies increase after acquiring a new industrial facility, while emissions intensity remains rather unchanged (see table 4 for a summary of the results).[23] Furthermore, there is a downward trend in emissions over time after the change in ownership (see figure 4), mirroring the results at the facility and the firm level. Total factor productivity of the parent company is rather unaffected (see figure A23 in the Appendix), but capital and labor inputs increase (see figure A21 and figure A20 in the Appendix). Furthermore, there is some evidence that intangible fixed assets, including e.g., patents, copyrights, trademarks and goodwill, increase after the acquisition (see figure A24 in the Appendix).

[22]The ownership change event starts in the year in which the parent company acquires a new facility. In the event studies on the parent company level, we only include parent company and year fixed effects since we cannot unambiguously assign countries and sectors to the parent company.

[23]The point estimates for output after acquisition are positive and potentially sizeable but the precision is rather low, preventing statistical significance at conventional levels.

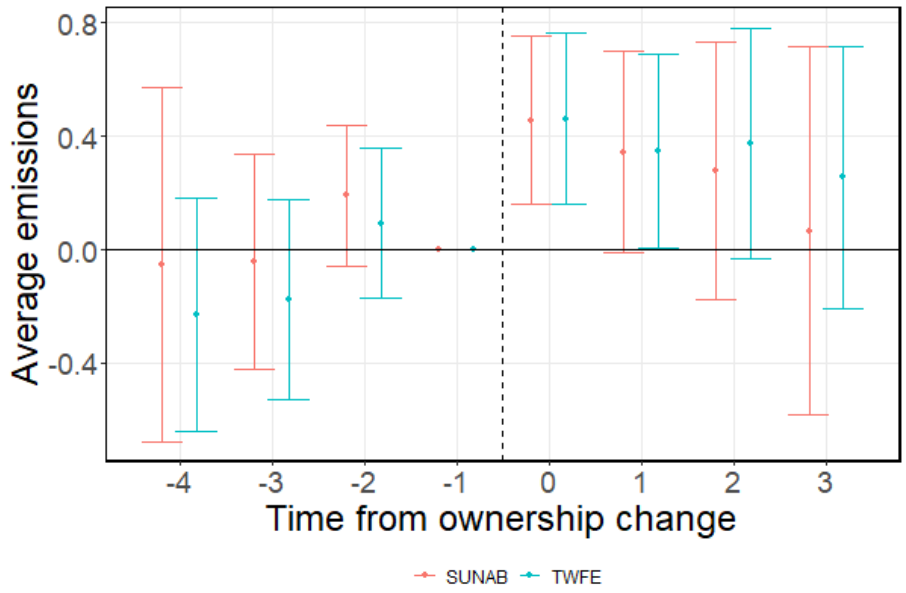
Table 4: Aggregate effects on acquiring parent companies

Dependent variables	ATT estimate	Std. Error	N
Total emissions	0.7421***	(0.2167)	2,274
Output	0.5921	(1.1858)	2,248
Emissions intensity	0.0200	(0.0276)	1,858
Total factor productivity	−0.0069	(0.0172)	1,305
Operating profits	0.8876	(2.1244)	2,248
Labor input	0.8339***	(0.2859)	2,248
Capital input	2.7013***	(0.7741)	2,248
Labor expenditures	2.2695***	(0.6701)	2,248
Intangible fixed assets	1.4771**	(0.6006)	2,248
Total emissions per industrial facility	0.2733	(0.2036)	2,274
Output per industrial facility	0.2562	(1.1193)	2,248
Emissions intensity per industrial facility	0.0162	(0.0210)	1,858
Total factor productivity per industrial facility	−0.4354***	(0.0755)	1,305
Operating profits per industrial facility	0.5474	(2.0359)	2,248
Labor input per industrial facility	0.4259	(0.2602)	2,248
Capital input per industrial facility	2.2521***	(0.7501)	2,248
Labor expenditures per industrial facility	1.8644***	(0.6430)	2,248
Intangible fixed assets per industrial facility	1.1121*	(0.5775)	2,248

Notes: The first column denotes the respective dependent variables each with an inverse hyperbolic sine transformation. Each line represents a separate event study regression. Output refers to deflated operating revenues, emissions intensity to total emissions divided by output multiplied to 100,000, labor input to number of employees, capital input to tangible fixed assets, respectively. The second and third columns show the point estimates and standard errors of the aggregated effect of the event study following Sun and Abraham (2021). The fourth column contains the number of observations. Standard errors clustered at the firm level are in parenthesis. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Average labor expenses, capital input and emissions (all relative to the number of industrial facilities) increase after the acquisition. Thus, compared to the already existing industrial plants of the parent company, newly acquired facilities are likely to employ above-average labor expenses, capital input, and – at least initially – emissions (see figures A27 and A26 in the Appendix as well as figure 5). Furthermore, those facilities are on average less productive and those differences persist over time (see figure A23 in the Appendix for more details). But again we see that the average intangible fixed assets per industrial facility increase immediately after acquisition (as can be seen in figure A28 in the Appendix), suggesting that new facilities bring in more intangibles.

Figure 5: Effect on average normal emissions per industrial facility at the parent company level



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions per industrial facility at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

We further investigate how other firms with industrial facilities of the same parent company react after the new industrial firm is acquired. There is some evidence that effects on total emissions, output, and emissions intensity are rather negligible. However, the other firms of the parent company experience a rather gradual increase in total factor productivity, profits and intangible assets over time after acquisition (see figures A29, A30, and A31 in the Appendix for more details).

Table 5: Aggregate effects on other industrial firms of acquiring parent companies

Dependent variables	ATT estimate	Std. Error	N
Total emissions	0.0323	(0.1528)	1,864
Output	−0.0875	(0.7153)	1,691
Emissions intensity	0.0062	(0.0194)	1,474
Total factor productivity	0.0136*	(0.0070)	972
Operating profits	3.6248**	(1.4794)	1,665
Labor input	−0.2748	(0.1840)	1,578
Capital input	−0.1091	(0.6392)	1,658
Labor expenditures	−0.1012	(0.5746)	1,534
Intangible fixed assets	0.9949*	(0.5221)	1,551

Notes: The first column denotes the respective dependent variables each with an inverse hyperbolic sine transformation. Each line represents a separate event study regression. Output refers to deflated operating revenues, emissions intensity to total emissions divided by output multiplied to 100,000, labor input to number of employees, capital input to tangible fixed assets, respectively. The second and third columns show the point estimates and standard errors of the aggregated effect of the event study following Sun and Abraham (2021). The fourth column contains the number of observations. Standard errors clustered at the firm level are in parenthesis. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

4.4 Discussion

We observe that emissions and output significantly decrease in the acquired firms and their facilities, while aggregated emissions of the parent companies increase significantly. The reduction is not uniform across all acquired firms and their facilities; the strong reduction rather originates from the shutdown of a substantial share of firms and facilities while the rest does not significantly change production and emissions. Labor and capital input as well as labor expenditures also decrease significantly on average in the acquired firms, while these figures increase significantly in the acquiring parent company. The increase in emissions, output and labor input per industrial facility in the parent company is not statistically significant, but capital input and labor expenditures rise significantly as the acquired firms and their facilities employ more inputs compared to the other facilities. However, the acquisition does not significantly affect emissions, output and inputs in the other firms within the parent company.

The transfer of technologies between the acquiring and the acquired firm is often discussed and studied as rationale for mergers and acquisitions in the literature. Our

results do not provide strong evidence for a transfer of production or environmental technologies from the acquired facilities to the acquiring parent company and neither inversely. The emissions intensity of production remains constant in the acquired firms and their facilities as well as in the aggregate, on average per industrial facility and in the other firms within the acquiring parent company. Likewise, the total factor productivity remains constant in the acquired firms and on aggregate in the parent company. Total factor productivity actually significantly decreases on average per industrial facility as the newly acquired firms are on average less productive, but potentially small enough to not significantly drag down aggregate productivity in the parent company. Other firms within the acquiring parent company experience a statistically significant but small increase in productivity which can be taken as evidence of limited positive spillovers on economic performance. Our results for European industrial firms and facilities differ from the findings by Jacqz (2021) that US-American facilities that continue operating after an M&A event reduce emissions of toxic chemicals hinting at operational changes and technology transfers as reasons for the observed reductions.

Another rationale for acquiring mother firms to close down the acquired firms could be to reduce output in sectors where there are oligopoly rents to harvest. We investigate this potential explanation by looking at the effect of an ownership change on output by sector. We would expect to see the large average output effect being driven by a few sectors that strongly reduce output while output reduction in the other sectors is negligible. However, we find that the output reduction is relatively uniform over the sectors and conclude that there is no evidence for strategic close downs in our sample (see Figure A12 in the Appendix).

An alternative explanation for the rationale of acquisitions provided by our analysis is a transfer of intangible fixed assets from the acquired firms to the acquiring parent company. Intangible fixed assets are assets of non-physical nature, such as intellectual property, licenses, trademarks or patents. While the stock of intangibles decreases, albeit insignificantly, for the acquired firms, intangibles significantly increase on ag-

gregate, per industrial facility and for the other firms within the parent company.[24] A descriptive comparison of intangible fixed assets between firms with and without ownership change events in the sample shows that firms that change ownership during the observation period have a higher stock of intangibles, the difference is however rather small (see figure A6 in the Appendix).

The significant decrease in operating profits for acquired firms is in line with the observed reduction in output. While profits increase on aggregate and per facility in the acquiring parent companies, these increases are not significant. However, positive spillovers appear to operate towards the other firms within the parent company as they experience a strong significant increase in operating profits. The increase could potentially origin from the transfer of intangible assets and their effect on productivity and profits.[25] Another potential channel could be that the acquisition of the firm results in a change in the market structure of the sector in which the company is operating. The buyout of a competitor can increase market power of the acquiring firm which in turn is able to set higher markups.[26]

We do not observe other benefits for the parent companies from their acquisitions than a transfer of intangible fixed assets. Potentially for this reason, they close down a significant share of their acquisitions in the first years after the purchase. The acquired firms, however, do not all exit in the acquisition year. As can be deduced from the stepwise reductions in output and emissions over the four years since the acquisition, a substantial share of acquired firms and their facilities only exit after two or three years. Potential reasons for the grace period that the parent companies grant their newly

[24] Evidence on the effect of acquisitions on intangibles is not conclusive. Lerner et al. (2011) study the effect of leveraged buyouts on innovation activities measured by patenting activity and find a positive impact. Amess et al. (2016) look at the effect of private equity-backed leveraged buyouts on the patent stock and find it to increase as a result of the acquisition. Conversely, Cumming et al. (2020) find a negative effect of public-to-private buyouts on patents and patent citations. Haucap et al. (2019) find a negative effect of horizontal mergers in the pharmaceutical market in Europe on patenting of the merged entity.

[25] Literature suggests however that the main rationale for the transfer of intangible assets across national borders is often to exploit differences in tax rates while it does not necessarily affect production (e.g., Juranek et al., 2018a,b). We look at profits before taxes so that a potential effect on taxes paid is not observable.

[26] Stiebale and Vencappa (2018) show for Indian manufacturing firms that acquired firms raise their markups substantially after acquisition, but the effect is driven by increased quality rather than a change in the market structure.

acquired firms could be rigid labour markets in the form of strong labour protection laws in some of the sample countries that do not allow for a quicker shutdown of large entities as they are present in our sample.[27]

5 Conclusion

We estimate the impact of ownership changes on pollutant emissions and economic performance indicators of industrial firms in Europe. We find a robust decrease in total emissions of newly acquired facilities and firms, which most likely originates from a proportional reduction in output rather than changes in abatement technology. Acquired firms emit a larger amount of pollutants compared to other firms in the same parent company. Thus, if the acquired firms reduce output and emissions but leave overall parent company output rather unchanged, this suggests that ownership changes in our setting may be overall beneficial for the environment.

However, even though we use a comprehensive data set and cover a major industrial continent with different countries, more research is needed to investigate these effects in other settings. Similarly, future research should try to disentangle even more deeply the mechanisms of the effects on emissions and economic performance indicators and assess their consequences on the firm distribution.

Finally, our research highlights that – absent comprehensive pollution regulation – environmental components could deserve more attention when discussing the costs and benefits of ownership changes as well as potentially play a more prominent role in M&A regulation.

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[27] McGuckin and Nguyen (1995) observe for acquisitions in the US food manufacturing sector that larger facilities are more likely to be purchased than closed when they are performing poorly.

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A Appendix

A.1 Additional tables

Table A1: Event study estimates for total emissions at the facility level

	Main (1)	Imp (0) (2)	Imp (threshold) (3)
time_to_treat = -4	0.1143	0.1510	0.1260
	(0.0851)	(0.0931)	(0.0817)
time_to_treat = -3	0.0469	0.0149	0.0225
	(0.0563)	(0.0635)	(0.0546)
time_to_treat = -2	0.0598	0.0209	0.0197
	(0.0371)	(0.0414)	(0.0358)
time_to_treat = 0	-0.1927***	-0.1705***	-0.1937***
	(0.0350)	(0.0395)	(0.0341)
time_to_treat = 1	-0.3256***	-0.2831***	-0.3244***
	(0.0507)	(0.0549)	(0.0496)
time_to_treat = 2	-0.4134***	-0.3793***	-0.4107***
	(0.0632)	(0.0671)	(0.0610)
time_to_treat = 3	-0.6856***	-0.6322***	-0.6775***
	(0.0916)	(0.0954)	(0.0880)
Adjusted R^2	0.77745	0.74034	0.76831
Observations	10,624	11,479	11,479
Country-Year fixed effects	✓	✓	✓
Sector-Year fixed effects	✓	✓	✓
FacilityID fixed effects	✓	✓	✓

Notes: The first column shows the point estimates and standard errors of the main specification. The second and third column present the results using the data set in which gaps in emission reports are imputed with zero and the pollutant specific threshold, respectively. The fourth column shows results on total emissions scaled by CO2 emissions for the data set without imputation. All results refer to the Sun and Abraham (2021) specification. Standard errors clustered at the facility level are in parenthesis. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

Table A2: Event study estimates for total emissions at the firm level

	Main (1)	Imp (0) (2)	Imp (threshold) (3)	Intensity (4)
time_to_treat = -4	0.4570***	0.4282***	0.4475***	0.0026
	(0.1360)	(0.1357)	(0.1294)	(0.0312)
time_to_treat = -3	0.2696***	0.1841*	0.2318***	0.0162
	(0.0970)	(0.0961)	(0.0897)	(0.0175)
time_to_treat = -2	0.1863***	0.1254*	0.1505**	-0.0054
	(0.0642)	(0.0652)	(0.0599)	(0.0124)
time_to_treat = 0	-0.3389***	-0.3683***	-0.3518***	-0.0201**
	(0.0509)	(0.0530)	(0.0484)	(0.0090)
time_to_treat = 1	-0.4028***	-0.4244***	-0.4373***	-0.0186
	(0.0690)	(0.0697)	(0.0661)	(0.0148)
time_to_treat = 2	-0.4638***	-0.4282***	-0.4504***	-0.0226
	(0.0924)	(0.0919)	(0.0881)	(0.0215)
time_to_treat = 3	-0.7854***	-0.7389***	-0.7700***	-0.0435
	(0.1373)	(0.1317)	(0.1306)	(0.0372)
Adjusted R^2	0.71605	0.69154	0.71246	0.41212
Observations	6,272	6,737	6,737	5,175
Country-Year fixed effects	✓	✓	✓	✓
Sector-Year fixed effects	✓	✓	✓	✓
BVDID fixed effects	✓	✓	✓	✓

Notes: The first column shows the point estimates and standard errors of the main specification. The second and third column present the results using the data set in which gaps in emission reports are imputed with zero and the pollutant specific threshold, respectively. All results refer to the Sun and Abraham (2021) specification. Standard errors clustered at the firm level are in parenthesis. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

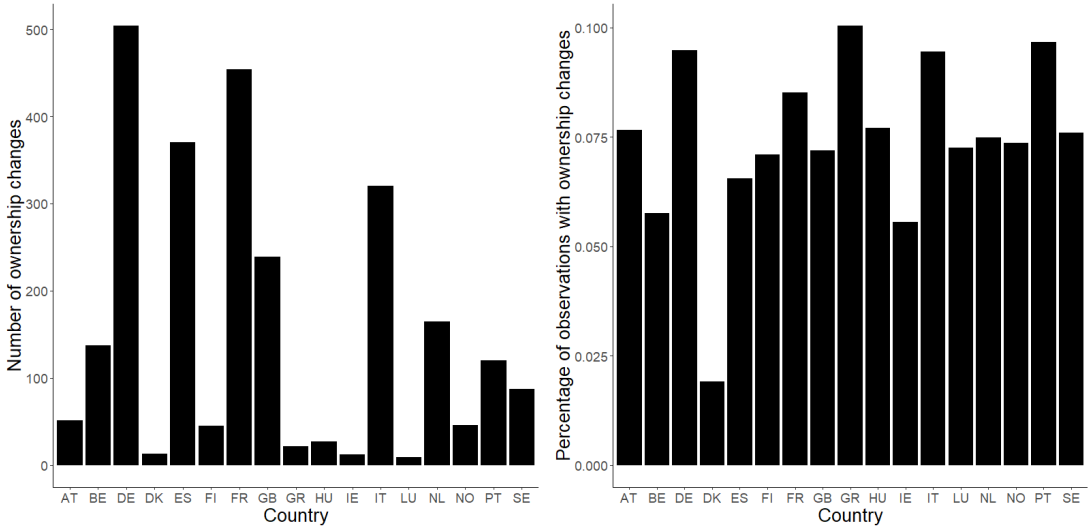
Table A3: Event study estimates for total emissions at the parent company level

	Main (1)	Imp (0) (2)	Imp (threshold) (3)	Intensity (4)
time_to_treat = -4	0.0396	0.0396	0.0753	0.0214
	(0.3364)	(0.3364)	(0.3312)	(0.0335)
time_to_treat = -3	0.0649	0.0649	0.0859	-0.0028
	(0.2217)	(0.2217)	(0.2212)	(0.0172)
time_to_treat = -2	0.2039	0.2039	0.1870	0.0155
	(0.1334)	(0.1334)	(0.1305)	(0.0153)
time_to_treat = 0	0.9832***	0.9832***	0.9847***	0.0398
	(0.1670)	(0.1670)	(0.1629)	(0.0372)
time_to_treat = 1	0.8008***	0.8008***	0.8426***	0.0368
	(0.1989)	(0.1989)	(0.1944)	(0.0399)
time_to_treat = 2	0.7257***	0.7257***	0.7548***	0.0335
	(0.2499)	(0.2499)	(0.2432)	(0.0405)
time_to_treat = 3	0.4986	0.4986	0.5113	-0.0128
	(0.3463)	(0.3463)	(0.3362)	(0.0196)
Adjusted R^2	0.74651	0.74651	0.75650	0.45075
Observations	2,274	2,274	2,274	1,858
Year fixed effects	✓	✓	✓	✓
ParentCompany fixed effects	✓	✓	✓	✓

Notes: The first column shows the point estimates and standard errors of the main specification. The second and third column present the results using the data set in which gaps in emission reports are imputed with zero and the pollutant specific threshold, respectively. Note that the first and second columns are the same since gaps in individual facilities or firms do not contribute to overall emissions of the parent company as in the case in which gaps are imputed by zero. All results refer to the Sun and Abraham (2021) specification. Standard errors clustered at the firm level are in parenthesis. $^{***}p < 1\%$, $^{**}p < 5\%$, $^{*}p < 10\%$.

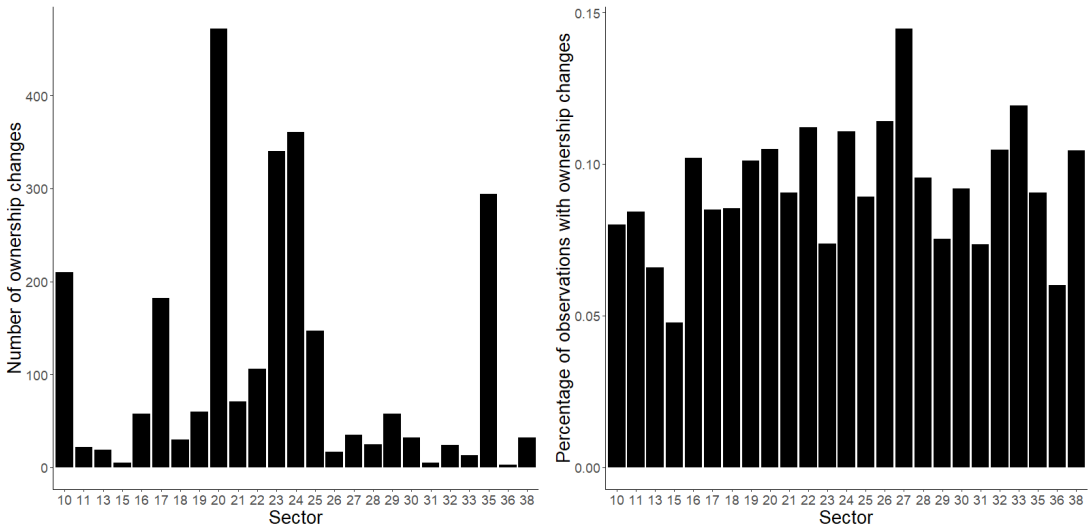
A.2 Additional figures

Figure A1: Distribution of ownership changes over countries



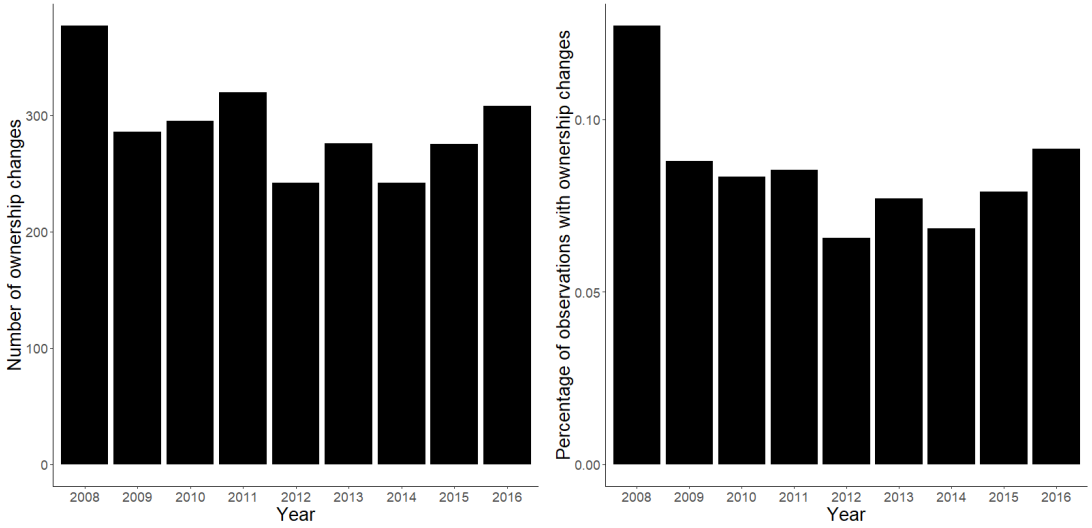
Notes: This figure shows the distribution of ownership changes over countries. The left panel shows the absolute number of changes and the right panel shows the relative share of changes out of all observations for the respective country.

Figure A2: Distribution of ownership changes over sectors



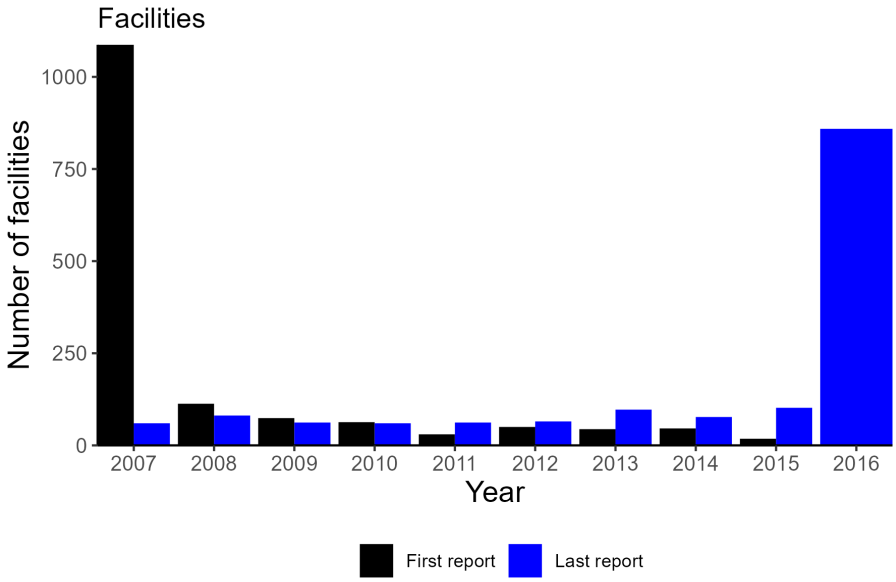
Notes: This figure shows the distribution of ownership changes over the sectors. The left panel shows the absolute number of changes and the right panel shows the relative share of changes out of all observations for the respective sector.

Figure A3: Distribution of ownership changes over years



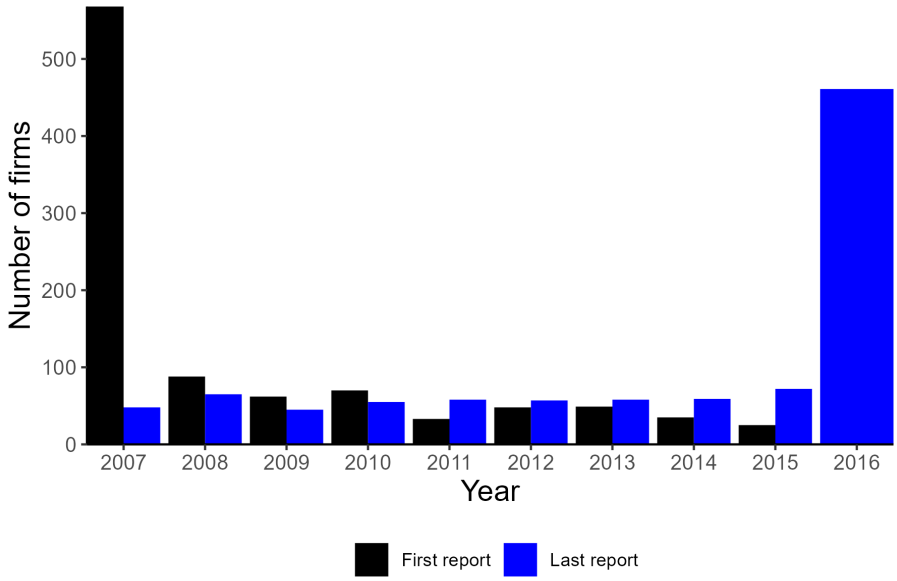
Notes: This figure shows the distribution of ownership changes over the years. The left panel shows the absolute number of changes and the right panel shows the relative share of changes out of all observations for the respective year.

Figure A4: First and last reporting year of facilities



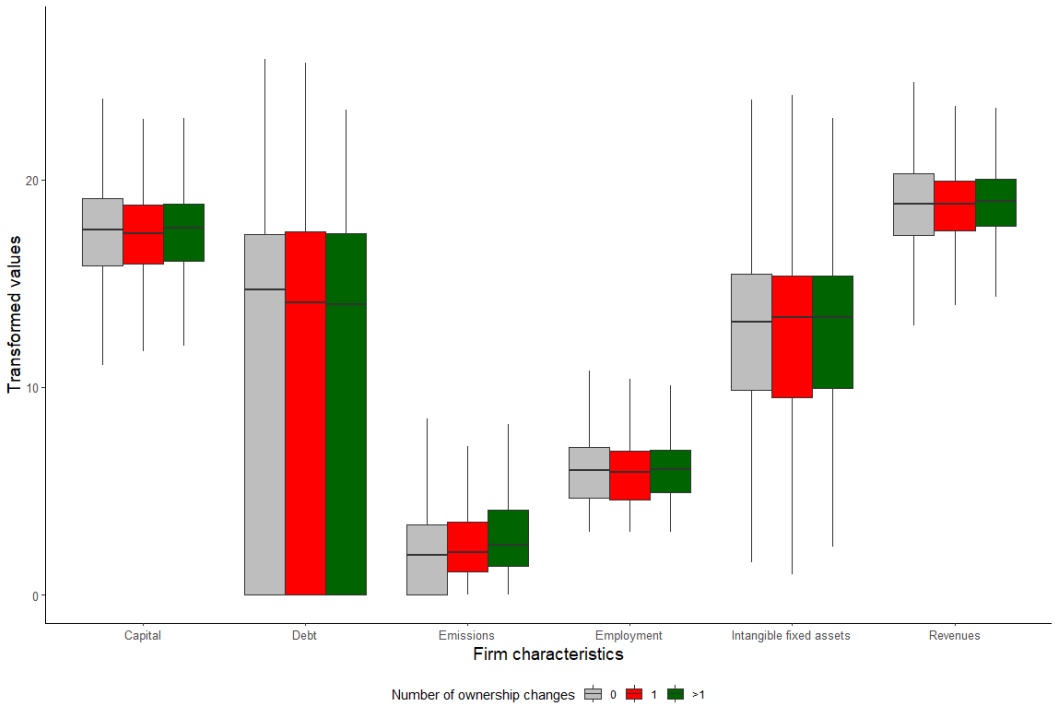
Notes: This figure shows the number of facilities that have their first reporting year and last reporting year, respectively, in the particular year. The sample is restricted to facilities that experience only one change in ownership.

Figure A5: First and last reporting year of firms



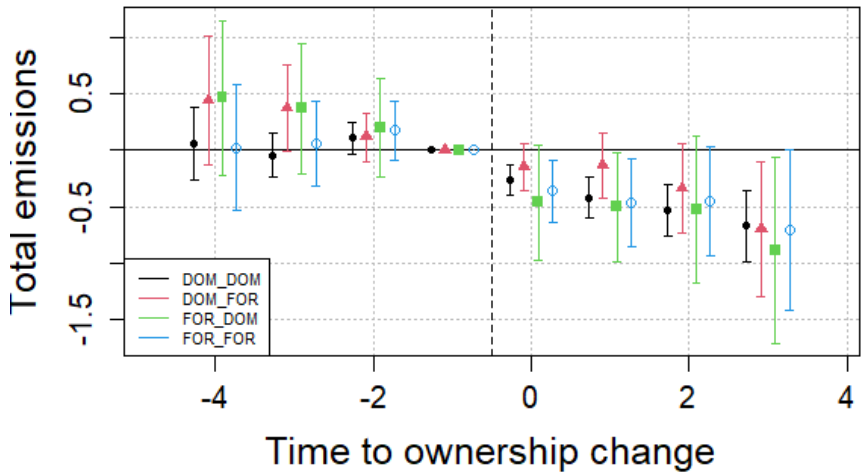
Notes: This figure shows the number of firms that have their first reporting year and last reporting year, respectively, in the particular year. The sample is restricted to firms that experience only one change in ownership.

Figure A6: Differences in firm characteristics for firms with and without ownership change



Notes: This figure shows a comparison of several firm characteristics for groups of firms with no, one and more than one ownership change event during our sample period. The values for capital, long-term debt, total emissions, employment, intangible fixed assets and operating revenues are inverse hyperbolic sine transformed to facilitate the comparison.

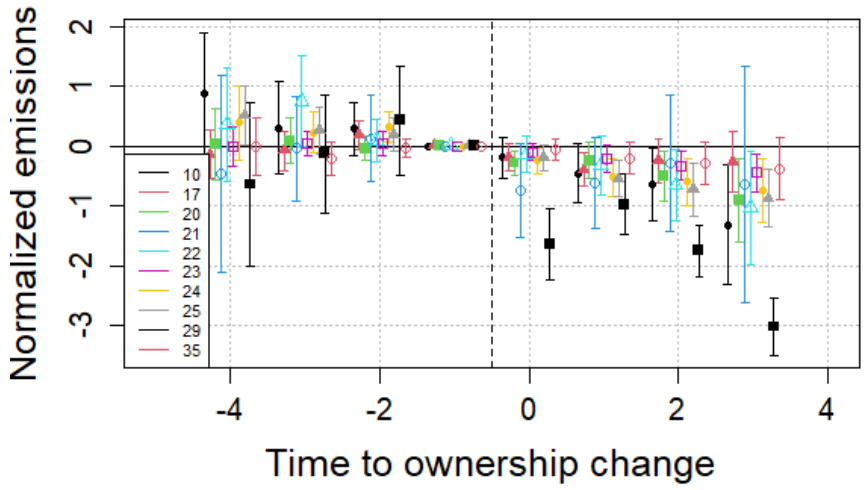
Figure A7: Effect on total emissions by type of ownership change at the facility level



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions for different subsamples of ownership change types for the Sun and Abraham (2021) estimator. The inverse hyperbolic sine transformation is applied to the independent variable. "DOM_DOM", "DOM_FOR", "FOR_DOM", and "FOR_FOR" are the changes from a domestic to a domestic owner, from a domestic to a foreign owner, from a foreign to a domestic owner, and from a foreign to a foreign owner, respectively.

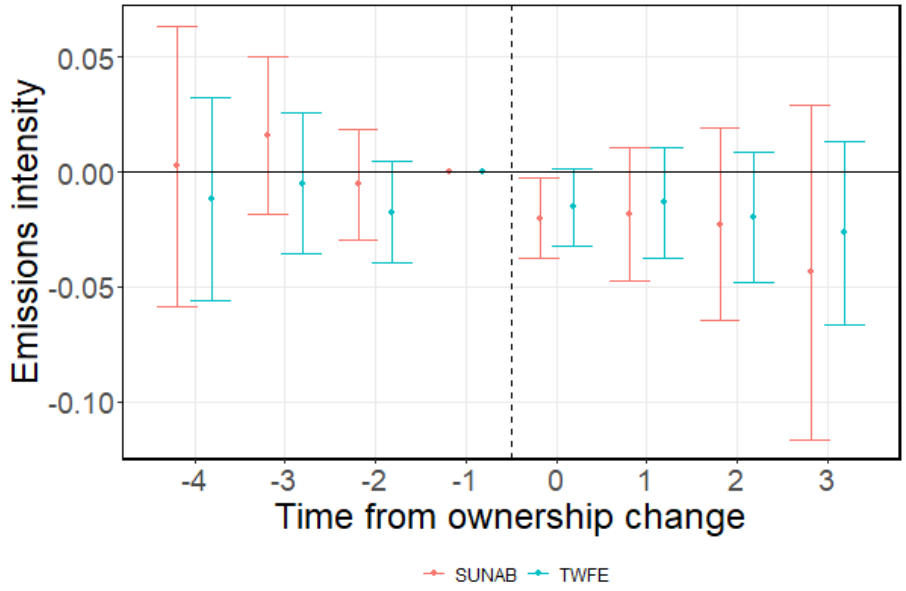
We investigate differences in the effects of ownership changes among foreign or domestic parent companies. We define a foreign (domestic) parent company when the global ultimate owner is based in a different (the same) country as facility or firm. Based on this definition, we distinguish four different cases of ownership changes: first, from a domestic to another domestic owner; second, from a domestic to a foreign owner; third, from a foreign to a domestic owner; fourth, from a foreign to a foreign owner. Dividing samples by these four different categories, we estimate the event study regression for each of the samples. The effects are similar to the overall sample and confidence intervals for all point estimates overlap for all groups, suggesting no large differences across different owner types.

Figure A8: Effect on total emissions by sector at the facility level



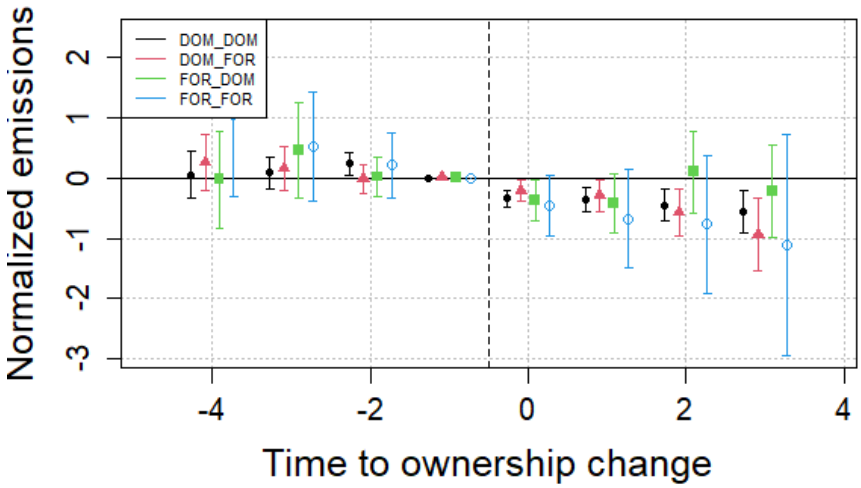
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions for different subsamples based on the facility's main sector for the Sun and Abraham (2021) estimator. The inverse hyperbolic sine transformation is applied to the independent variable. We include only sectors with a minimum of 1,000 observations. Sector 10 refers to manufacture of food products, sector 17 to manufacture of paper and paper products, sector 20 to manufacture of chemicals and chemical products, sector 21 to manufacture of basic pharmaceutical products and pharmaceutical preparations, sector 22 to manufacture of rubber and plastic products, sector 23 to manufacture of other non-metallic mineral products, sector 24 to manufacture of basic metals, sector 25 to manufacture of fabricated metal products, except machinery and equipment, sector 29 to manufacture of motor vehicles, trailers and semi-trailers, and sector 35 to electricity, gas, steam and air conditioning supply.

Figure A9: Effect of ownership change on emissions intensity at the firm level



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on the emissions intensity, i.e., total emissions scaled by deflated operating revenues. The inverse hyperbolic sine transformation is applied to the independent variable.

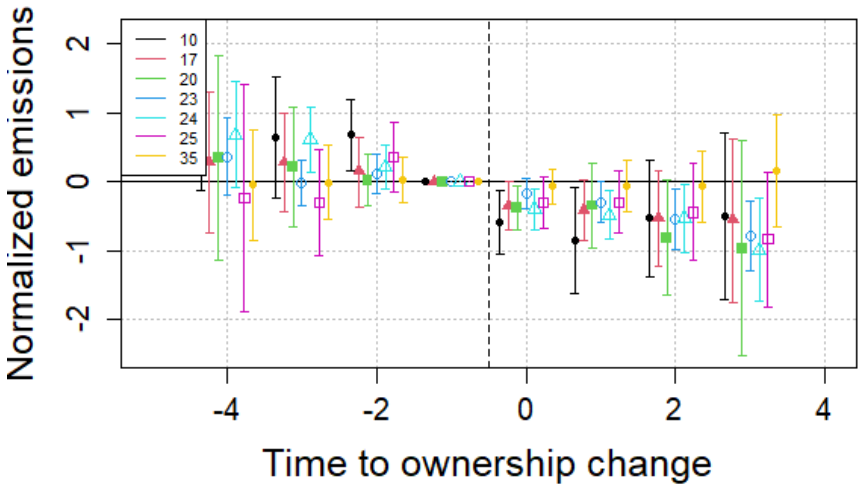
Figure A10: Effect on total emissions by type of ownership change at the firm level



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions for different subsamples of ownership change types for the Sun and Abraham (2021) estimator. The inverse hyperbolic sine transformation is applied to the independent variable. "DOM_DOM", "DOM_FOR", "FOR_DOM", and "FOR_FOR" are the changes from a domestic to a domestic owner, from a domestic to a foreign owner, from a foreign to a domestic owner, and from a foreign to a foreign owner, respectively.

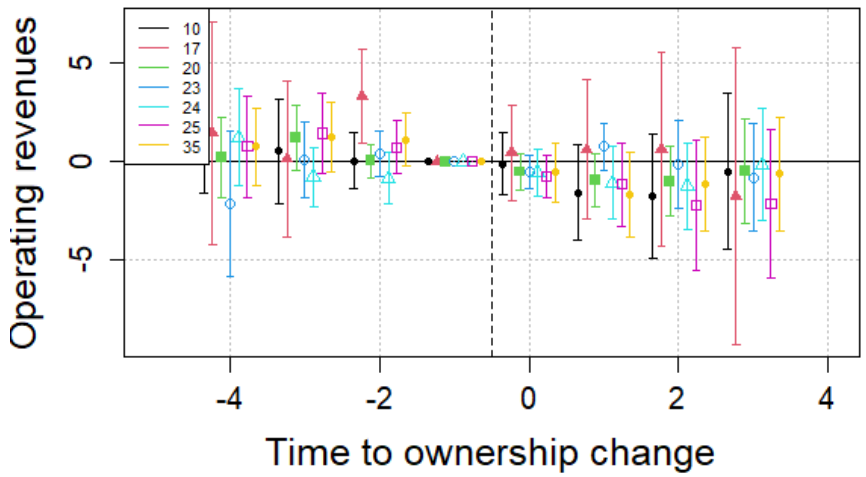
We investigate differences in the effects of ownership changes among foreign or domestic parent companies. We define a foreign (domestic) parent company when the global ultimate owner is based in a different (the same) country as facility or firm. Based on this definition, we distinguish four different cases of ownership changes: first, from a domestic to another domestic owner; second, from a domestic to a foreign owner; third, from a foreign to a domestic owner; fourth, from a foreign to a foreign owner. Dividing samples by these four different categories, we estimate the event study regression for each of the samples. The effects are similar to the overall sample and confidence intervals for all point estimates overlap for all groups, suggesting no large differences across different owner types.

Figure A11: Effect on total emissions by sector at the firm level



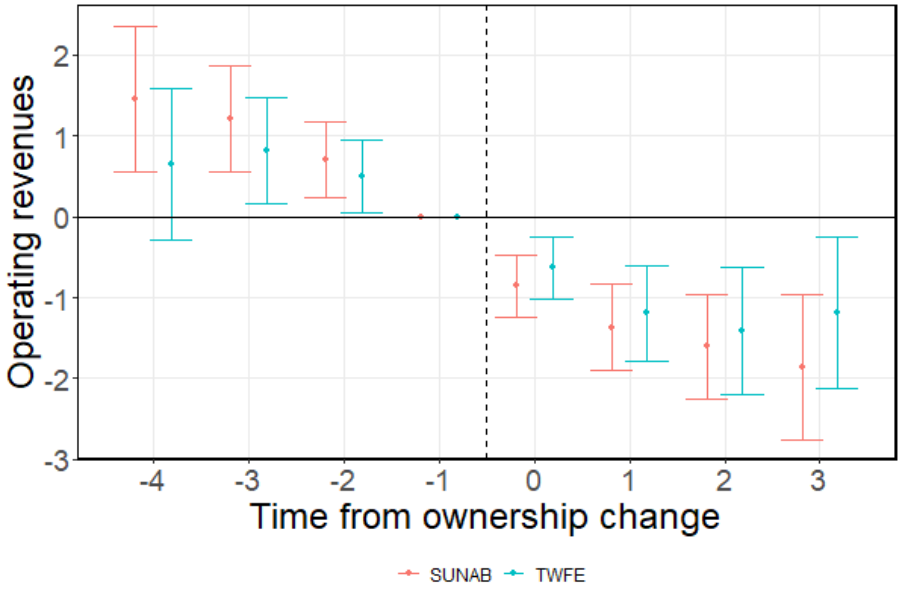
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total emissions for different subsamples based on the firm's main sector for the Sun and Abraham (2021) estimator. The inverse hyperbolic sine transformation is applied to the independent variable. We include only sectors with a minimum of 1,000 observations. Sector 10 refers to manufacture of food products, sector 17 to manufacture of paper and paper products, sector 20 to manufacture of chemicals and chemical products, sector 23 to manufacture of other non-metallic mineral products, sector 24 to manufacture of basic metals, sector 25 to manufacture of fabricated metal products, except machinery and equipment, and sector 35 to electricity, gas, steam and air conditioning supply.

Figure A12: Effect on output by sector at the firm level



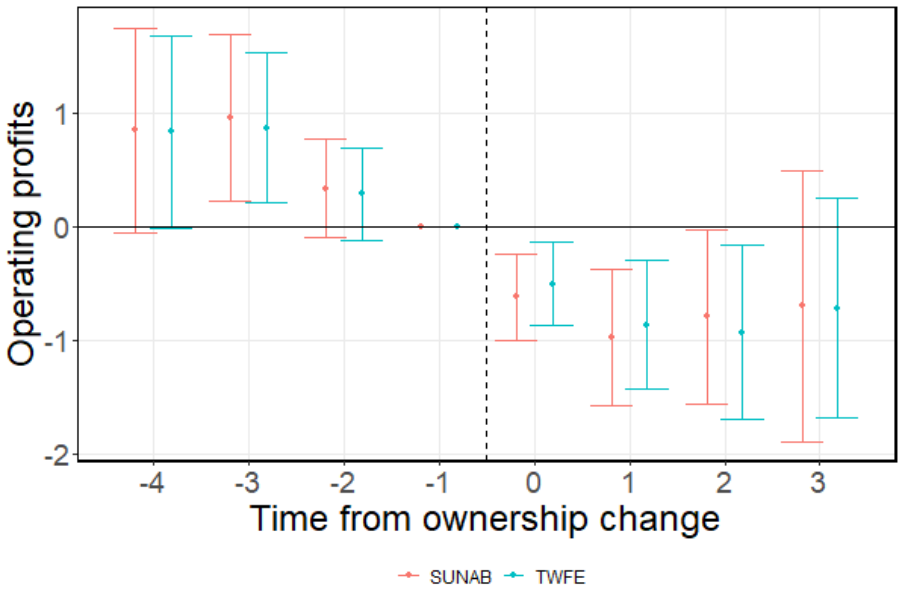
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on operating revenues for different subsamples based on the firm's main sector for the Sun and Abraham (2021) estimator. The inverse hyperbolic sine transformation is applied to the independent variable. We include only sectors with a minimum of 1,000 observations. Sector 10 refers to manufacture of food products, sector 17 to manufacture of paper and paper products, sector 20 to manufacture of chemicals and chemical products, sector 23 to manufacture of other non-metallic mineral products, sector 24 to manufacture of basic metals, sector 25 to manufacture of fabricated metal products, except machinery and equipment, and sector 35 to electricity, gas, steam and air conditioning supply.

Figure A13: Effect on output at the firm level



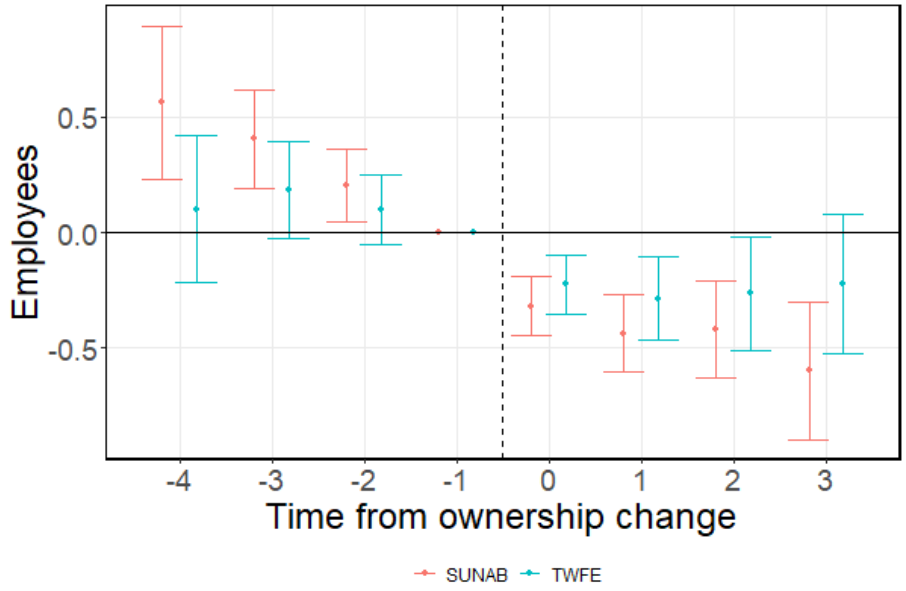
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated operating revenues. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A14: Effect on operating profits at the firm level



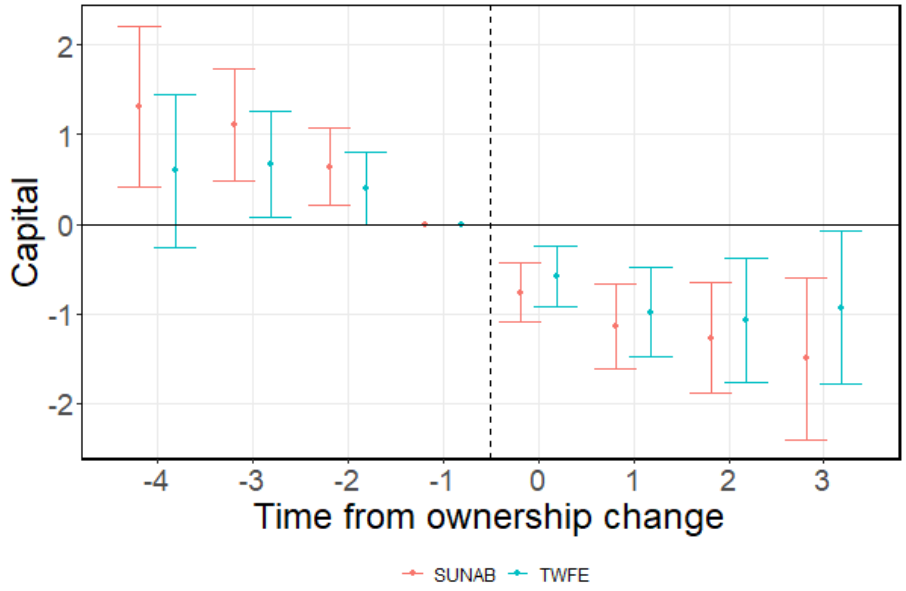
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated operating profits. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A15: Effect on labor input at the firm level



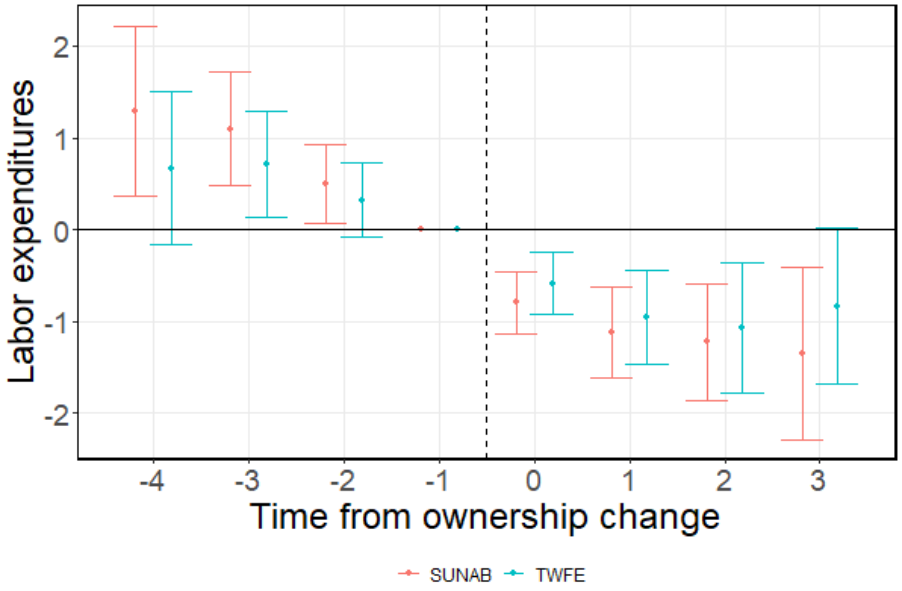
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on the number of employees. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A16: Effect on capital input at the firm level



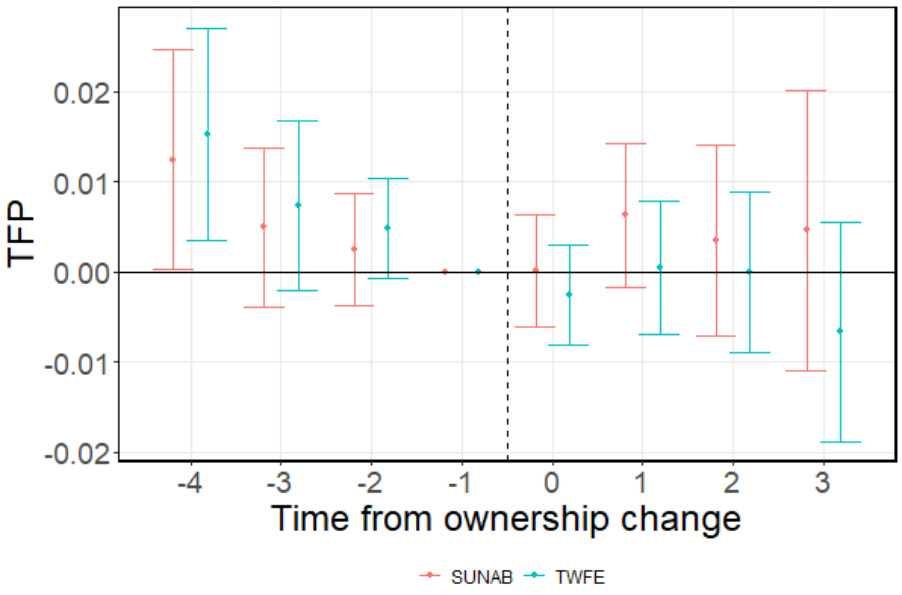
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated tangible fixed assets. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A17: Effect on labor expenditures at the firm level



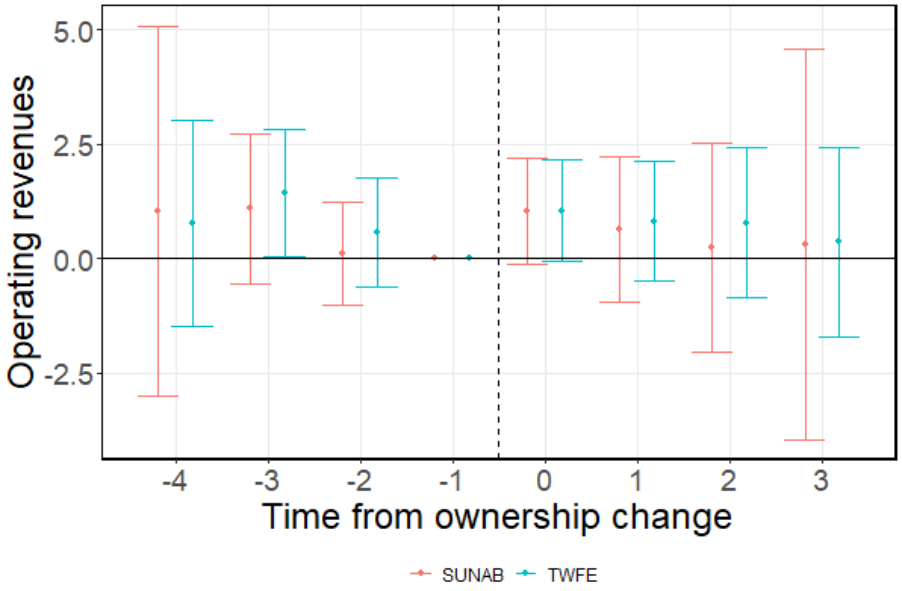
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated labor expenditures. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A18: Effect on total factor productivity (TFP) at the firm level



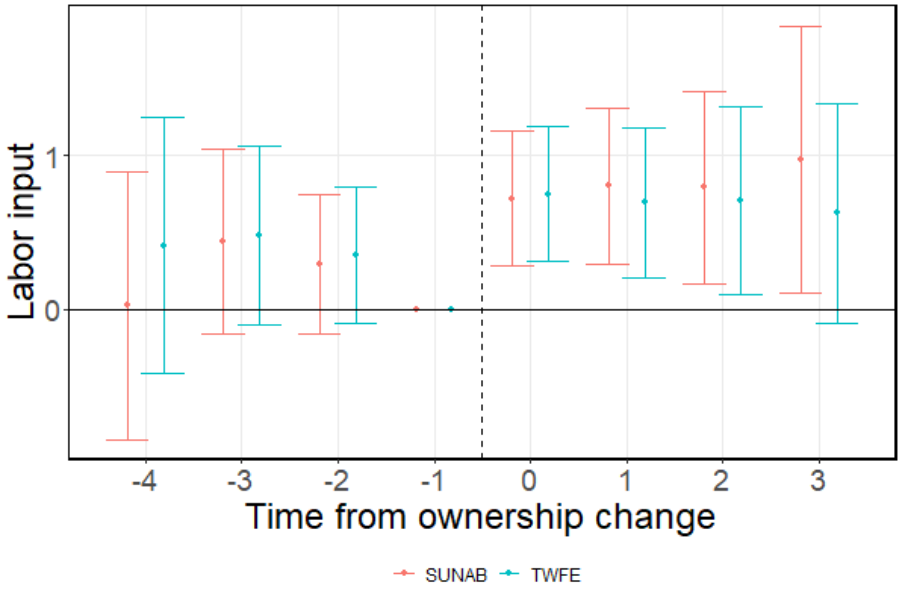
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total factor productivity. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A19: Effect on output at the parent company level



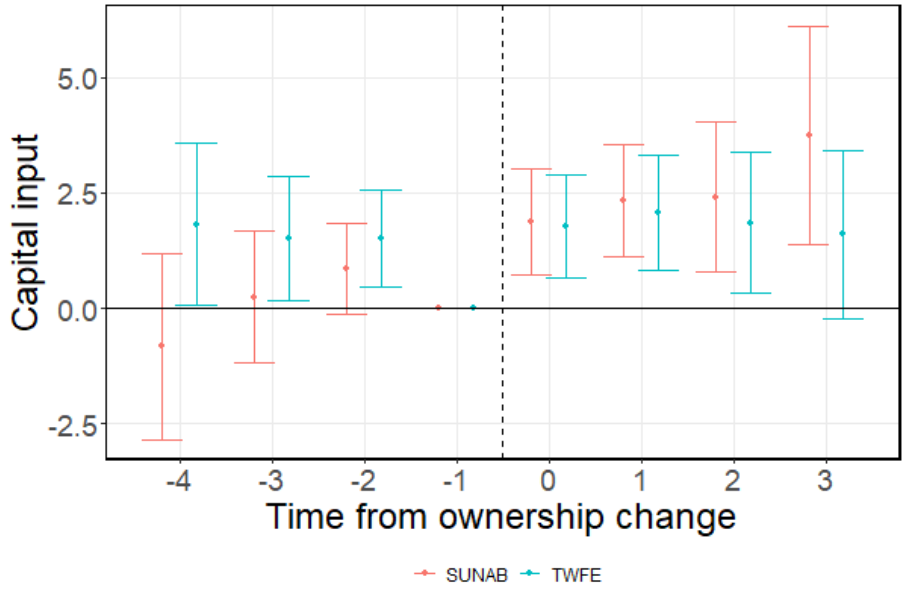
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated operating revenues at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A20: Effect on labor input at the parent company level



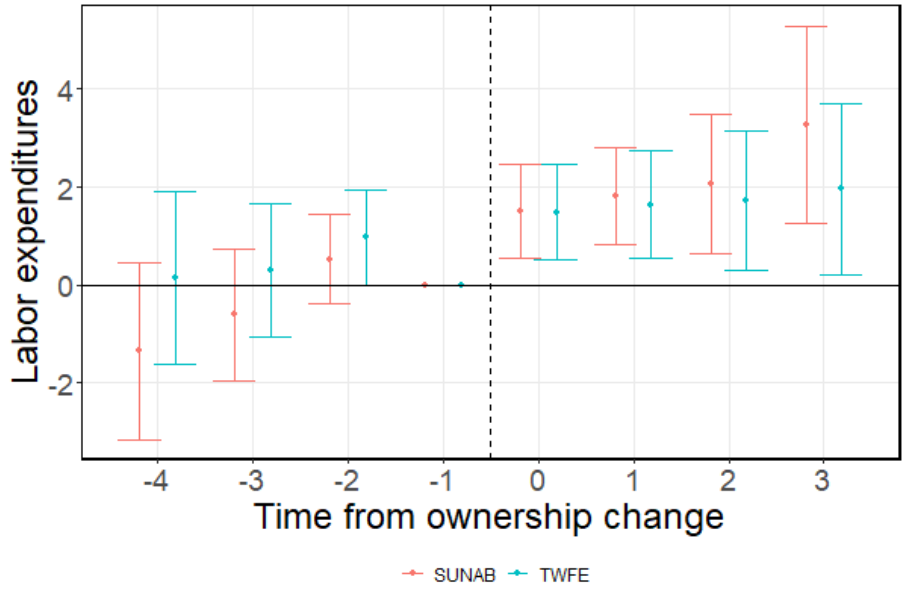
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on number of employees at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A21: Effect on capital input at the parent company level



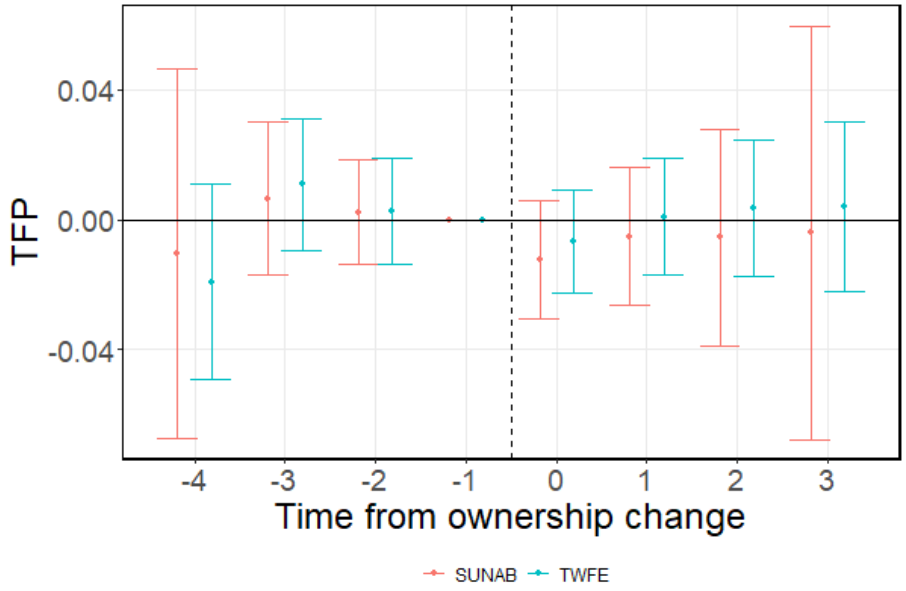
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated tangible fixed assets at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A22: Effect on labor expenditures at the parent company level



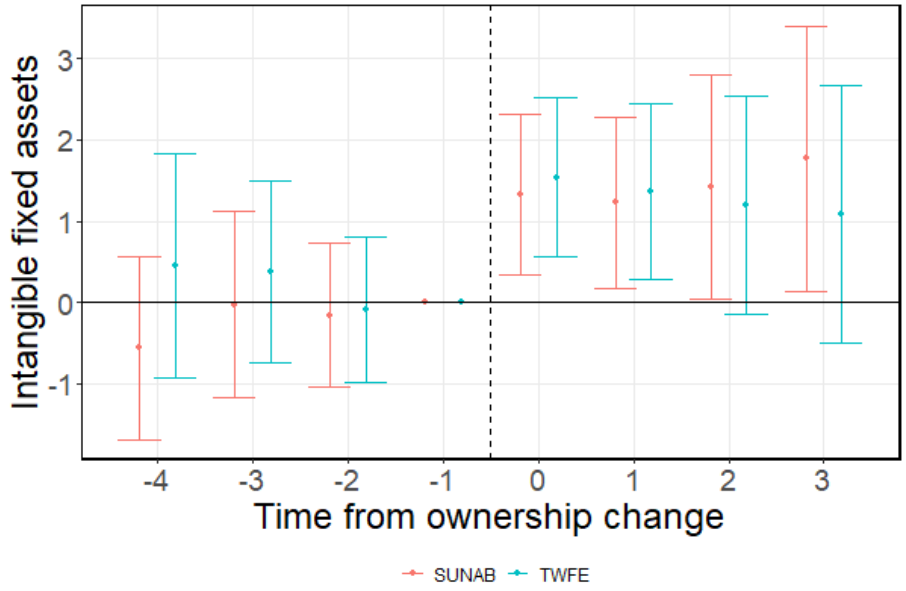
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated labor expenditures at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A23: Effect on total factor productivity (TFP) at the parent company level



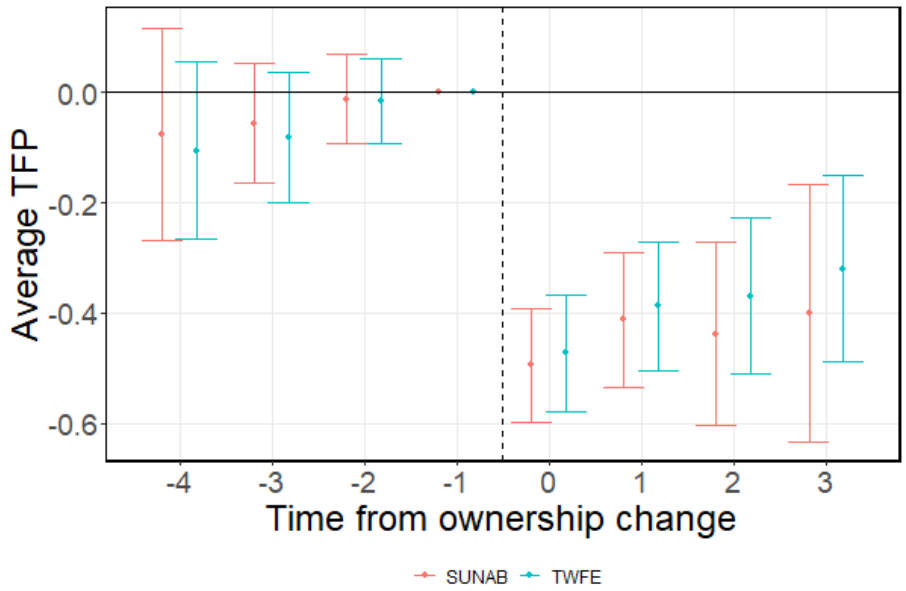
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total factor productivity at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A24: Effect on intangible fixed assets at the parent company level



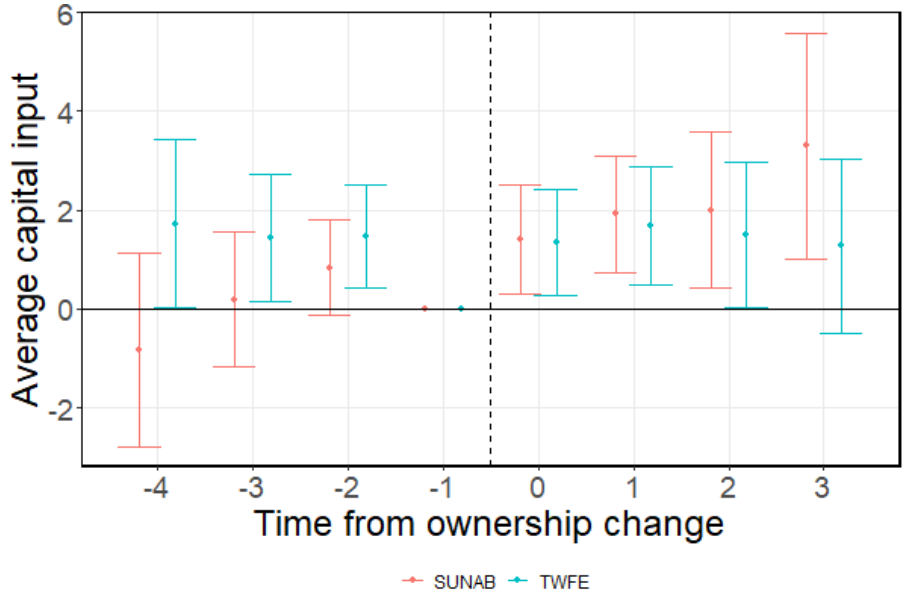
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated intangible fixed assets at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A25: Effect on average total factor productivity (TFP) per industrial facility at the parent company level



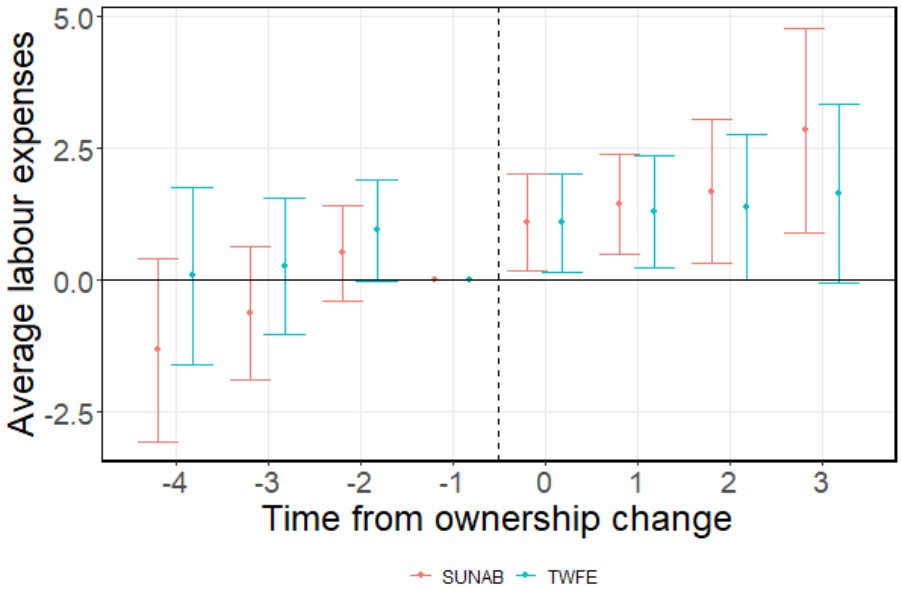
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total factor productivity per industrial facility at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A26: Effect on average capital input per industrial facility at the parent company level



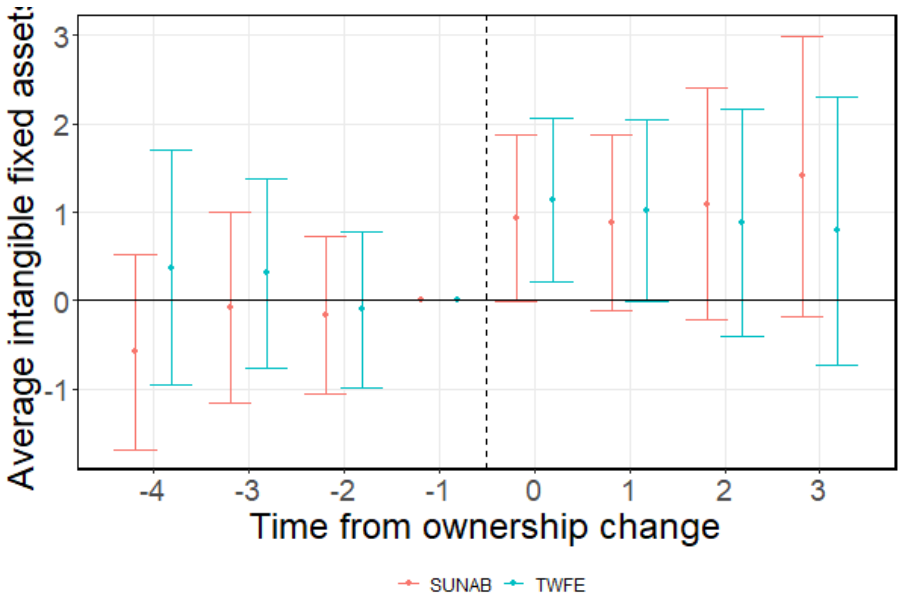
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated total fixed assets per industrial facility at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A27: Effect on average labour expenditures per industrial facility at the parent company level



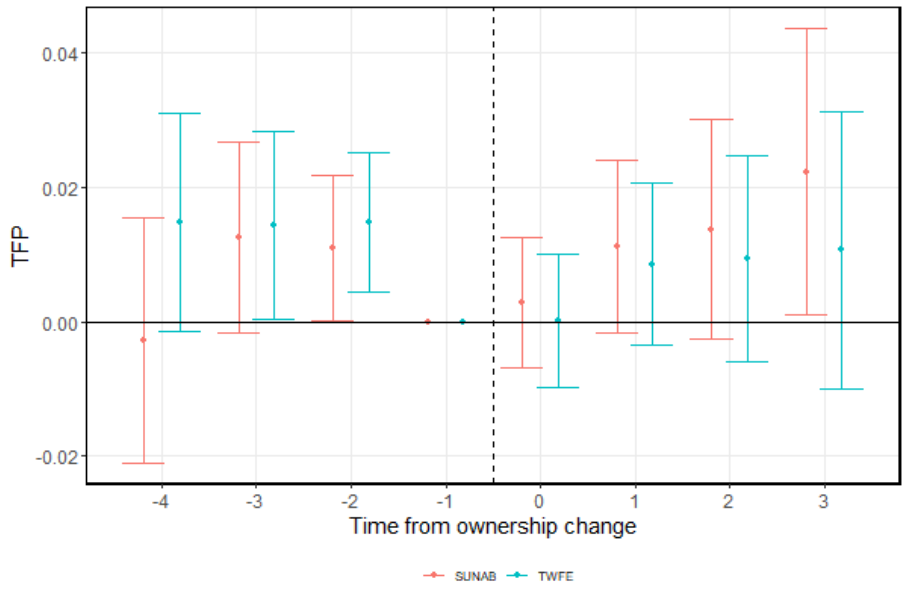
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on labor expenditures per industrial facility at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A28: Effect on average intangible fixed assets per industrial facility at the parent company level



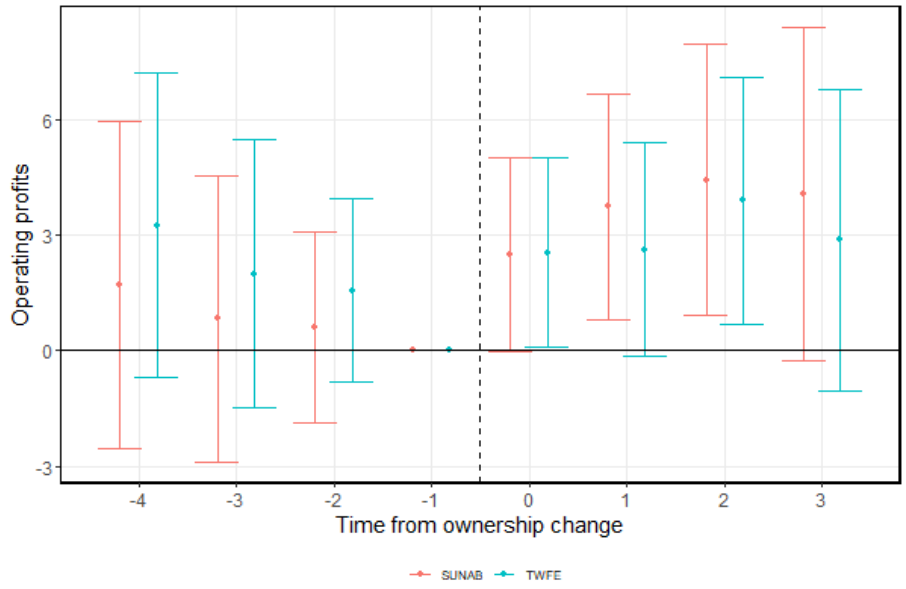
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on deflated intangible fixed assets per industrial facility at the parent company level. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A29: Effect on total factor productivity (TFP) for the other firms of the parent company acquiring a new facility



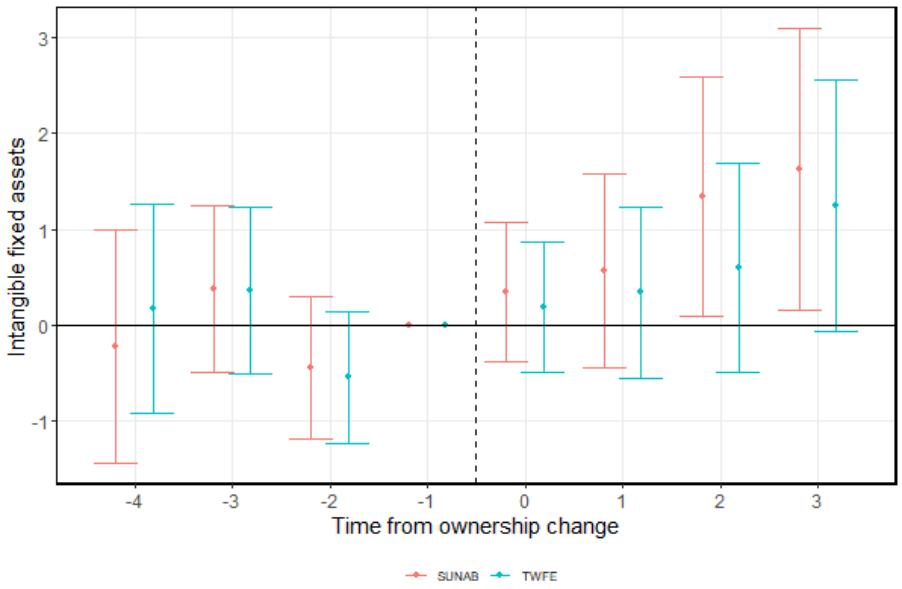
Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on total factor productivity for the other firms of the parent company acquiring a new facility. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A30: Effect on operating profits for the other firms of the parent company acquiring a new facility



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on operating profits for the other firms of the parent company acquiring a new facility. The inverse hyperbolic sine transformation is applied to the independent variable.

Figure A31: Effect on intangible fixed assets for the other firms of the parent company acquiring a new facility



Notes: This figure shows the estimates and 95% confidence intervals for the event study coefficients for the effect of an ownership change on intangible fixed assets for the other firms of the parent company acquiring a new facility. The inverse hyperbolic sine transformation is applied to the independent variable.

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