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Abstract

This paper investigates the impact of a 2016 electricity tax reform on French manufacturing using micro-panel data spanning eight years. The reform introduced a tax reduction on electricity use contingent on gross electricity tax liability exceeding 0.5% of firm value-added. Firms that satisfy the threshold criteria are considered electro-intensive. This paper exploits a Differences-in-Differences (DiD) event study specification to estimate the effect of the tax cut relative to ineligible firms. On average, electro-intensive firms experienced a relative drop in in their average electricity costs ranging between 8.5% and 12.4% in the post-reform period. Findings also uncover heterogeneous effects across manufacturing sectors. Nevertheless, results do not indicate that the reform had a significant or robust impact on either energy use input choice or on economic performance.

Keywords: Electricity tax, Policy Evaluation, Manufacturing, France
JEL Codes: Q48, L5, L6

1 Introduction

Electricity accounts for three-fifths of total energy costs in French industry (Ministry of the Environment, 2022), rendering opportunities to benefit from preferential tax treatment potentially attractive to cost-conscious firms. In 2016 France introduced in its Tax Code an electro-intensity ratio with a cutoff above which firms are considered electro-intensive. More specifically, industry firms with a gross electricity tax liability exceeding 0.5% of their value-added can pay a substantially lower marginal tax rate on electricity use. Tax expenditures related to the tax cut reached almost €2 billion

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by 2019 (PLF, 2021). The purpose in introducing the tax relief in 2016 was twofold: to conform to the EU Energy Taxation Directive and to preserve firm competitiveness against a high energy tax burden.

Accordingly, the first purpose of this paper is to investigate the impact of the reform on the average cost of electricity paid. A back of the envelope calculation indicates that the statutory electricity tax rate, absent any preferential tax treatment, would have represented between 22% and 25% of the total price of electricity in 2019 among non-residential consumers, whereas the effective tax rate paid represented between 14% and 16% of the total price on average (Ministry of the Environment, 2023). As preferential tax treatment is not automatically granted in France, a relative drop in electricity costs, ceteris paribus, indicates electro-intensive firms requested to benefit from the tax cut upon proof of eligibility. A second purpose of this paper is to evaluate the impact of the reform on energy use input choices and economic performance, as electro-intensive firms that rely on energy for production would have benefited from a relatively lower electricity and energy tax burden. More broadly, this paper contributes to the scarce but growing empirical literature that investigates the effect of energy tax policy and regulation, specifically in the form of subsidies, on manufacturing performance.

Exploiting an event study Differences-in-Differences (DiD) specification and based on energy use microdata and corporate tax returns, electro-intensive firms experienced a drop ranging between 8.5% and 12.4% in their average electricity costs at the one percent level of significance and relative to firms that were ineligible to the tax cut. Moreover, findings reveal differential industry responses to the policy, where eligible firms in the more energy intensive industries experienced the more significant drops in costs. However, the analysis does not identify substantial or robust effects on energy input choices or economic performance. Findings cast doubt on the usefulness and necessity of the public policy vis-à-vis government revenues foregone.

The next section provides a summary of the relevant empirical literature on the impact of energy tax subsidies on corporate environmental, energy, and economic performance. Section (2) outlines the institutional background related to electricity taxation in France and details the calculation of the electro-intensity ratio. Section (3) describes the data sources, describes the construction of the treatment variable and the panel and summaries descriptive statistics. Section (4) explains the empirical strategy and Section (5) reports the empirical findings. The last section concludes.

1.1 Related empirical literature

This paper contributes to the scarce but growing empirical literature that investigates the effect of energy tax policy and regulation, specifically in the form of subsidies, on manufacturing performance. Tax subsidies are generally granted to businesses to mitigate any detrimental impact of increasing energy tax rates on competitiveness, to the extent that energy costs can represent a large share of total production costs in certain industries. Similar to the French context, these subsidies are typically granted based on set energy use thresholds. Overall, the ongoing empirical research does not uncover evidence that granting energy tax subsidies significantly influences economic indicators, although it does tend to find significant effects on energy input choices.

In the United Kingdom (UK), a Climate Change Levy (CCL) applies to energy consumed by professionals since 2001. Industry can benefit from a substantial rate reduction if they enter into a Climate Change Agreement (CAA) whereby plants voluntarily adopt a binding energy use or carbon emission reduction target. Exploiting an instrumental variable (IV) for eligibility to treatment and a DiD specification, Martin, de Preux, and Wagner (2014) find that plants that paid the full CCL rate experienced lower energy intensity relative to CCA plants, as well as a reduction in electricity use. Nevertheless, they do not uncover any significant impact on economic performance, including on plant exit.

In Finland, a 2012 energy tax reform not only substantially increased excise tax rates on energy, but also expanded a pre-existing energy tax reduction measure for large, energy-intensive firms. From January 2012 onward, Finnish firms with an energy tax liability exceeding 0.5% of value-added could benefit up to a 85% refund of their energy taxes, compared to 3.7% cutoff before the reform. Accordingly, Laukkanen, Ollikka, and Tamminen (2019) take a matching DiD approach to evaluate the causal impact of energy tax reductions on Finnish manufacturing from 2007 to 2016. They do not find any significant effect on neither economic outcomes nor energy use, with the exception of a negative effect on gross output and energy efficiency.

In Germany from 1999, manufacturing firms could benefit from reduced marginal tax rates on electricity use contingent on quantity consumed: from above 50 MWh in 1999 to above 25 MWh in 2003. Using a regression discontinuity design (RDD) and leveling firm micro-data from 1995 to 2005, Flues and Lutz (2015) also do not uncover any significant impact of reduced electricity tax rates on economic performance.

Additionally since 2000 in Germany, energy use is subject to a Renewable Energy Levy (REL), a surcharge on electricity prices to finance feed-in-tariffs (FiTs) payments. From 2003 to 2012, manufacturing plants that consumed over 10 GWh of electricity, along with a ratio of electricity cost to gross value-added exceeding 15%, could benefit from a drastically reduced REL rate on electricity use. Gerster and Lamp (2022) take a fuzzy RDD approach to estimate the impact of the reduced rate on German manufacturing energy use choice and economic performance, and based on a list of plants that benefited from the exemption. They also take a matched DiD approach to exploit a 2012 reform that altered eligibility criteria. They find that treated plants significantly increased their electricity use under both tax regimes and econometric approaches (by 3.1 GWh or 78% under the RDD and by 3% under the DiD). Nevertheless, they also do not uncover any significant impact of the tax reduction on competitiveness indicators.

This paper specifically adds to the related empirical literature by investigating the effect of a French 2016 electricity tax reform that introduced a new threshold above which firms can benefit from a substantial reduction on their marginal electricity tax rate. Echoing the energy tax system in other European countries, the cutoff at 0.5% is determined by the ratio of statutory tax liability over value-added: the same cutoff as in Laukkanen, Ollikka, and Tamminen (2019), but a substantially lower cutoff than detailed in Gerster and Lamp (2022).

2 Institutional context

2.1 Conforming to the EU Energy Taxation Directive

The taxation of electricity use in France conforms to the European Union (EU) framework for energy product taxation as defined by Council Directive 2003/96/EC that sets minimum tax rates on energy use.

Before the 2016 reform

All electricity consumers were subject to the CSPE (*Contribution au Service Public de l'Electricité*) from 2003 to 2015. CSPE rates were set by the CRE (*Commission de Régulation de l'Energie*), an independent administrative authority, to offset costs associated with public service charges borne by public electricity network suppliers (CRE, 2014). The CSPE rate steadily increased from €3 per megawatt-hour (MWh) to €19.5 per MWh by 2015. Under the CSPE regime, industry taxpayers could exploit three alternative and cumulative tax reduction measures. As a share of total tax revenue foregone from 2003 to 2015, the largest measure (69% of €6.8 billion) was a monetary cap on total CSPE tax owed equivalent to 0.5% of value-added for firms consuming over 7 gigawatt-hour (GWh) of electricity. Additionally, around 29% of foregone revenues were due to a plant-level cap on CSPE tax payments (European Commission, 2019). In 2012 and 2013, 1 085 firms and 400 plants requested a reimbursement of the CSPE based on these set caps, respectively (CRE, 2014)[1].

The 2016 electricity tax reform

On January 2016, both the CSPE and TICFE rates merged to form a single national-level excise duty on electricity consumption (henceforth TICFE_{2016}) at a fixed rate of €22.5 per MWh. The objective of the reform was to conform to EU law and to secure revenue flows (PLF, 2015). It introduced new tax rate reductions applicable to electro-intensive firms (defined below) to preserve competitiveness and to compensate for the loss in preferential tax treatment cap-related measures granted under the former CSPE regime. The TICFE_{2016} rate applies to all taxpayers, no matter their subscribed electricity power. In 2019, the effective TICFE_{2016} paid represented around 14% of the total electricity price on non-residential consumption below 150 gigawatt-hours (GWh) (Ministry of the Environment, 2023).

2.2 Electro-intensity status

According to the French Tax Code, electro-intensity is determined by the ratio of total gross TICFE_{2016} liability - abstracting from any preferential tax treatment - over value-added (French Customs, 2019a), as shown in Equation (1) and (2). The statutory TICFE_{2016} rate post-reform is fixed at €22.5 per MWh. Value-added is defined in Art. 1586 sexies of the Tax Code.

$$\text{Gross TICFE}_{2016}\text{ liability (€)} \equiv \text{Electricity use (MWh)} \times \text{€22.5 per MWh} \quad (1)$$

$$\text{Electro-intensity ratio} \equiv \frac{\text{Gross TICFE}_{2016}\text{ liability (€)}}{\text{Value added (€)}} \times 100 \begin{cases} \geq 0.5\%, \text{Electro-intensive} \\ < 0.5\%, \text{Not electro-intensive} \end{cases} \quad (2)$$

[1]From 2011, taxpayers with a subscribed power exceeding 250 kilovolt-ampere (kVA) were additionally subject to the TICFE (*Taxe intérieure sur la consommation finale d'électricité*), at a fixed rate of €0.5 per MWh[2]. The purpose in introducing the TICFE was to transpose the provisions of Directive 2003/96/EC into French domestic law (PLF, 2015).

A firm is characterized as electro-intensive if the ratio detailed in Equation (2) exceeds 0.5 percent. An electro-intensive firm can benefit from a rate reduction on their electricity use. At a minimum, it can benefit from a EUR 15 per MWh reduction on the statutory TICFE_{2016} rate: a rate drop from €22.5 per MWh to €7.5 per MWh applied to all electricity use. More specifically, the applied reduced TICFE_{2016} rate depends on the quantity of electricity consumed per euro of valued-added[3].

$$\text{Applicable reduced TICFE}_{2016}: \frac{\text{Electricity use (kWh)}}{\text{Value added (€)}} \begin{cases} > 3 \text{ kWh}, €2 \text{ per MWh} \\ \geq 1.5 \text{ kWh and} \leq 3 \text{ kWh}, €5 \text{ per MWh} \\ < 1.5 \text{ kWh}, €7.5 \text{ per MWh} \end{cases} \tag{3}$$

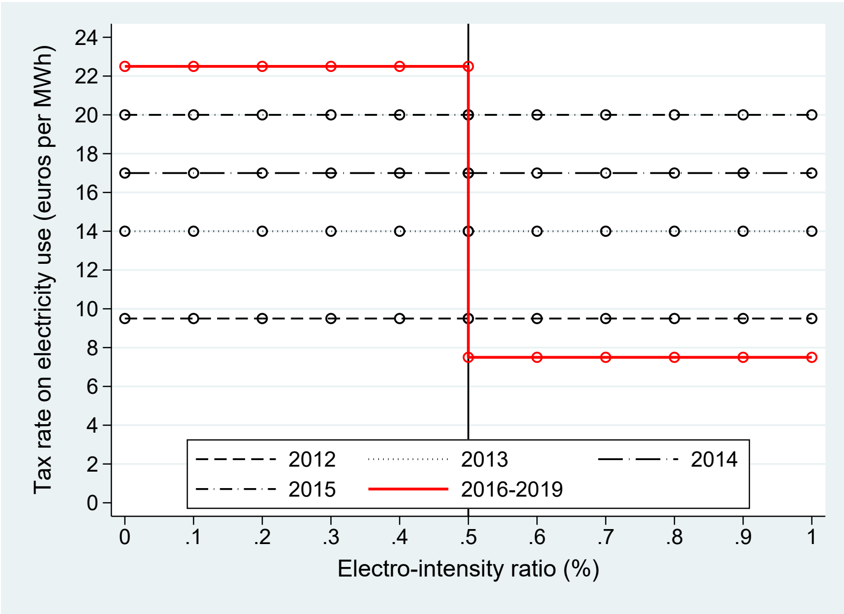
To benefit from the tax rate reduction on delivery, firms must send a certificate to their supplier and to Customs with a justification of their electro-intensity status. Absent any certificate, the consumer pays the full rate on electricity use. Firms can also request a reimbursement on electricity tax paid up to two years after payment with a justification of eligibility to reduced taxation. The reduction applies to all electricity consumption.

Figure (1) illustrates the applicable tax rates on electricity consumption around the electro-intensity ratio cutoff (0.5%) introduced from 2016 onward. Table (A1) reports estimates of foregone electricity tax revenues. In 2016, total expenditure amounted to €968 million and reached almost €2 billion by 2019. The majority of expenditures are from businesses that are neither at risk of carbon leakage, nor hyper-electro-intensive[4]. From 2016 to 2017 total expenditures increased by over a third, highlighting the fact that preferential tax treatment has to be requested by the firm upon proving its electro-intensity and is not automatically granted to eligible firms.

[3]Firms that consume over 6 kWh per euro of value-added (hyper-electro-intensive) or that are considered at risk of carbon leakage - as defined in European Commission, 2012 - can benefit from even lower TICFE rates reductions. Firms that estimate a negative value-added are also considered hyper-electro-intensive.

[4]see Footnote 3

Figure 1: Tax rates on electricity use based on the electro-intensity ratio, 2012-2019



Note: Figure (1) illustrates the preferential tax treatment granted to electro-intensive firms, as defined in Equation (2), from 2016 onward at the 0.5% cutoff. It shows estimated marginal tax rates (MRT) on electricity use applicable to firms with a subscribed power exceeding 250 kilovolt-ampere (kVA). The MRT for years 2012-2015 represent the sum of the CSPE and the TICFE. For years 2016-2019, the MRT are those applicable to firms consuming less than 1.5 kWh per euro of value-added (see Equation 3). Before 2016, firms were not granted any preferential tax treatment based on this ratio. From 2016, firms exceeding the cutoff benefit from a large drop in their applicable tax rate, relative to firms that fall short from the cutoff and pay the full statutory rate, abstracting from the application of any other preferential electricity tax treatment.

3 Data

3.1 Data sources and panel construction

The final balanced panel is composed of manufacturing firms located in metropolitan France, and spans years 2012 through 2019. It merges five different data-sets.

The Eacei (*Enquête sur les consommations d'énergie dans l'industrie*) database[5] provides plant-level survey data on energy consumption and expenditure by fuel and in aggregate. Eacei surveys only production plants. It surveys all plants with over 250 employees, as well as a stratified random sample of plants with at least 20 employees. The response rate was 90% in 2014. Each year, surveyed plants provide information on purchased quantities of electricity in megawatt-hours (MWh), as well as the monetary cost value of electricity purchase (excluding any deductible value-added tax), for the prior calendar year. The total cost of electricity includes the cost of transport and distribution. The average cost of electricity refers to the ratio of electricity purchased

[5] Marin and Vona (2018) provide an overview of the Eacei database and its applications.

(in MWh) over its total cost value (in €). The Eacei database helps construct the numerator in Equation (2).

The BIC-RN and CVAE databases provide administrative data from french corporate tax and value-added tax returns. The analysis also relies on the FARE data-sets that provide financial and economic business statistics that also largely come from corporate tax returns. Nevertheless, FARE does not provide all variables required to calculate an electro-intensity ratio, as detailed in Annex 4bis of French Customs (2019a) - French Customs (2019b). Hence while the denominator in Equation (2) is based on the administrative data, the rest of the analysis relies on corporate statistics. Finally, data on EU-ETS participation comes from the European Union Transaction Log (EUTL), and more specifically from Abrell (2021). The EUTL provides data on participating plants in the carbon market, including compliance status and verified emissions.

As noted above the energy use data is provided at the plant level, whereas the unit of observation in this paper is at the firm level since electro-intensity status can only be determined at that level. A plant is identified by its 14-digit plant identifier number, Siret, in France. The firm identifier, Siren, is the first nine digits of the Siret. Therefore Eacei variables are summed by Siren and by year. In the case of multi-plant firms, the panel should only include firms whose establishments are fully covered in Eacei. Echoing Dussaux (2020) and Dussaux, Vona, and Dechezleprêtre (2023), the sum of plant employees as reported in Eacei is compared to the sum of employees as reported in the corporate statistics. A very low ratio may suggest that the aggregated energy use and cost data may not adequately represent total firm level energy use and cost. A very high ratio (notably above 100%) may suggest measurement errors[6]. To minimize bias, the panel omits the bottom and top 10th percentile of the ratio across all years. Note that as a robustness check, this paper also presents results based on the sample without this omission. The final balanced panel includes 808 firms per year, or 6 464 firms across all years in total.

3.2 Construction of treatment variable

Equation (5) estimates for each firm i the pre-reform (2012-2015) average value of their electro-intensity ratio. Hence it estimates post-reform treatment status as under the TICFE_{2016} regime but based on pre-reform electricity use and value-added values.

$$\text{Gross TICFE}_{2016} \text{ liability } (€)_{i,<2016} \equiv \text{Electricity use (MWh)}_{i,<2016} \times €22.5 \text{ per MWh} \quad (4)$$

$$\text{Electro-intensity ratio}_{i,<2016} \equiv \left[\frac{\text{Gross TICFE}_{2016} \text{ liability } (€)}{\text{Value added } (€)} \times 100 \right]_{i,<2016} \quad (5)$$

Equation (6) is the treatment variable: it equals one if the average pre-reform electro-intensity ratio of firm i exceeds 0.5%, and zero otherwise. The use of the pre-reform average minimizes the risk of capturing unobserved confounders correlated with both the tax reform and the outcomes of interest.

[6] In Eacei, the number of employees is the average number of employees by the end of the year. Whereas in the corporate statistics, employment is measured as the number of full time equivalents (FTE).

$$\text{Electro-intensive}_{i,<2016} \begin{cases} 1, & \text{Electro-intensity ratio}_{i,<2016} \geq 0.5\% \\ 0, & \text{Electro-intensity ratio}_{i,<2016} < 0.5\% \end{cases} \tag{6}$$

3.3 Descriptive statistics

Summary statistics and industry composition

The final balanced panel includes 808 firms per year, including 591 firms identified as electro-intensive and 217 firms per year as non-electro-intensive based on Equation (6).

Table (A3) presents summary statistics by electro-intensity status in 2012, the first year of the panel. Across all firms, electricity represents on average over two-fifths of total energy costs and around half of total energy use. Firms mostly rely on electricity and fossil fuels (natural gas) as energy products for production. Nevertheless, electro-intensive firms from 2016 faced lower average electricity costs (€73 per MWh) compared to non-electro-intensive firms (€82 per MWh).

On average, electro-intensive firms consume considerably more energy and face considerably higher energy costs. On the other hand they tend to be smaller than their non-electro-intensive counterparts with regards to economic and financial characteristics. Industrial composition also slightly differs across both groups of firms. They only share the manufacturing of chemical products and fabricated metals as their six most frequently observed industries per group. Non-electro-intensive firms include more technology-oriented industries (notably in the manufacturing of different types of equipment), whereas the electro-intensive include more traditional manufacturing known to be energy and carbon-intensive.

Effective tax rate rates paid and policy take-up

Since 2017, Ministry of the Environment (2023) details a breakdown of the average effective electricity price by electricity use bracket and including the TICFE_{2016} rate paid. Figure (A1) indicates that the smallest consumers pay an electricity tax rate on average close to the statutory rate (€22.5 per MWh) compared to larger consumers that pay much lower rates. From 2017 to 2019 in the panel, 57% of all firms and three-fifths of all electro-intensive firms are located in consumption bracket ID, i.e., consume between 2 and 20 GWh of electricity. Based on the figure, on average firms in bracket ID experienced a 7.9 euro per MWh drop in the tax rate relative to the statutory rate across all three post-reform years. In the panel, full take-up suggests a relative drop of at least 15 euros per MWh among electro-intensity firms in the post-reform period.

While Figure (A1) includes all non-residential consumers and not specifically electro-intensive firms, these results echo observations regarding policy take-up by eligible firms in Gerster and Lamp (2022). They analyse the effects of similar threshold-based policies on German manufacturing and observe that around three-quarters of eligible plants claim their preferential tax treatment the first year it came into effect. They conclude businesses make a trade-off between the financial benefits of the preferential tax treatment and the compliance cost associated with its use.

4 Empirical strategy

Regression equations

The empirical strategy exploits a differences-in-differences (DiD) approach to investigate the effects of eligibility to the electro-intensity tax cuts relative to ineligible firms. Equation (7) is the event study specification. The main coefficient of interest, β_1 interacts the treatment variable (Equation (6)) with 8 dummy variables equalling one for each year in the panel, $\sum_{y=2012}^{2019}$. The main outcome of interest is the average cost of electricity use to attest to whether eligible firms request their tax cuts in the post-reform years. Other outcomes of interest include energy use and economic and financial indicators to gauge both input choice and economic performance under the new electricity tax regime.

$$\begin{aligned} y_{i,year} = \alpha_i + \sum_{y=2012}^{2019} \beta_1 (\text{Electro-Intensive}_{i,<2016,y} + \sum_{y=2012}^{2019} \Big[\gamma(\text{Industry}_{i,y}) \\ + \eta(\text{ETS}_{i,y}) + \zeta(\chi_{i,2012,y}) + \varepsilon_{i,y} \Big] \end{aligned} \tag{7}$$

The analysis also estimates the average effect of the policy on electro-intensive firms in the post-reform period ($t = 1$: 2016-2019) relative to pre-reform ($t = 0$: 2012-2015) on the outcome y of firm i in time t.

$$\begin{aligned} y_{i,t} = \alpha_i + \beta_1 (\text{Electro-Intensive}_{i,<2016,t}) + \gamma(\text{Industry}_{i,t}) \\ + \eta(\text{ETS}_{i,t}) + \zeta(\chi_{i,2012,t}) + \varepsilon_{i,t} \end{aligned} \tag{8}$$

To help account for omitted variable bias, firm dummies (α_i) control for time-invariant firm-specific characteristics. Coefficient γ captures industry shocks and trends at the NACE Rev.2 2-digit industry code level. Coefficient η accounts for any impact of the European cap-and-trade system. Finally, coefficient ζ captures size effects. Variable $\chi_{i,2012}$ includes (logged) total energy use, net operating income and the ratio of gross operating surplus over value-added set at their 2012 levels to minimize correlation with the policy in the post-reform years. Coefficient $\varepsilon_{i,y}$ is the error term.

Switcher firms

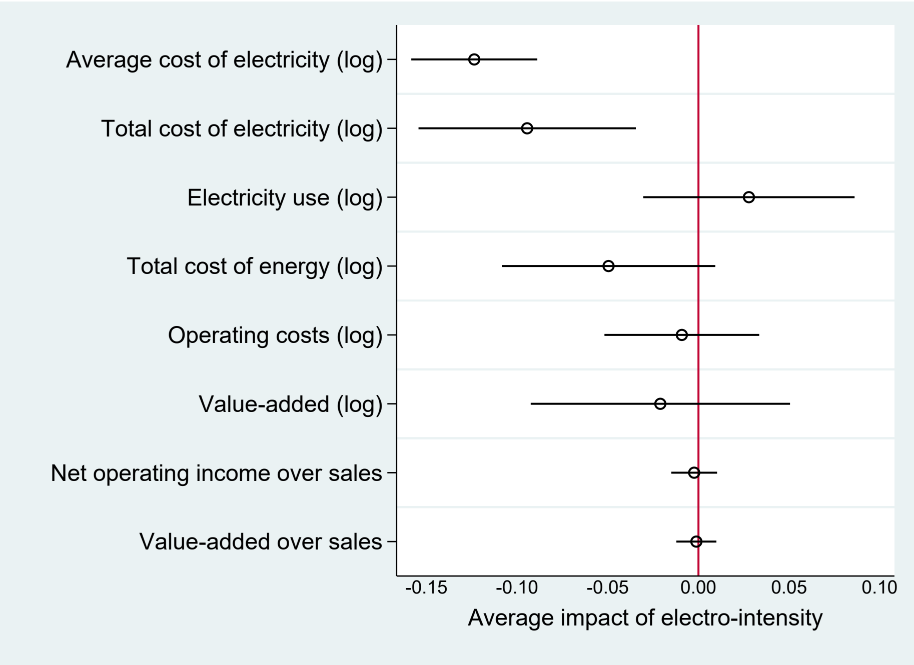
Since electro-intensity status is based on both a continuous ratio and a fixed cutoff, firms can switch across their eligibility status. Firm manipulation of their electro-intensity ratios threatens the identification of the reform (notably a strategic switch to the right of the cutoff or an increase in the electro-intensity ratio above 0.5%). Roughly 19% of firms switch across their electro-intensity status at least once across all years (whether it be to the right or to the left of the cutoff and whether it was before or after the policy implementation). On average, 'switcher' firms have an electro-intensity ratio of around 0.69% compared to 2.5% among non-switcher firms. Figure (A2) indicates that switcher firms tend to oscillate around the cutoff (0.5%), suggesting that the switching behavior is likely more random than strategic. Figure (A3) additionally indicates that switcher firms more frequently decrease their electro-intensity across the years. Finally, Table (A2) does not find evidence that firms precisely and strategically manipulating their electro-intensity ratios. Findings detailed in the next section are additionally based on a sample of firms that never change their electro-intensity status across all years ('non-switchers').

Common trends Identification in a DiD setting rests upon the assumption of common trends between the group of firms affected by the policy and the group that is not. Figure (A4) plots the year-by-year evolution of the average cost of electricity by electro-intensity eligibility status for the panel of firms that includes both switchers and non-switcher firms (Figure (A4a)) and the panel that omits switchers (Figure (A4b)). In both figures, electricity costs followed the same upwards trajectory across all firms pre-reform, with a considerable drop in costs among electro-intensive firms from 2016. Figure (A4b) suggests less noisy pre-trends with a more pronounced decrease in electricity costs than Figure (A4a) which includes switcher firms. Figures (A5) and (A6) similarly plot the data for electricity use, the electricity use share of total energy use, total energy costs, operating costs, value-added and the operating margin (net operating income over sales). In both figures the gap in total energy costs widen in the post-reform period with a decrease among electro-intensive firms and an increase among non-electro-intensive firms, reflecting the electricity tax cuts granted to the former. Other figures are less conclusive.

5 Results

On average, electro-intensive firms experienced a 8.5% (or €7 per MWh) drop in electricity costs compared to non-electro-firms in the post-reform period, as detailed in Table (B1). When only including firms that never change their electro-intensity status, the decrease is more pronounced and amounts to 12.4% on average (or around €11 per MWh). Moreover and reflecting the drop in average costs, total electricity costs exhibit a decrease ranging from 8.5% to 9.4% and the share of electricity cost over total energy costs a drop from 1.5 to 2.3 percentage points. On the other hand, total energy costs decrease by around 5% albeit the effect is only significant at the 10 percent level among non-switcher firms. All other outcomes are not statistically significant, including total operating costs or the operating margin (net operating income over sales). Figures (2) and (B2) illustrate select average DiD results from Table (B1) among non-switcher firms and in the baseline sample, respectively.

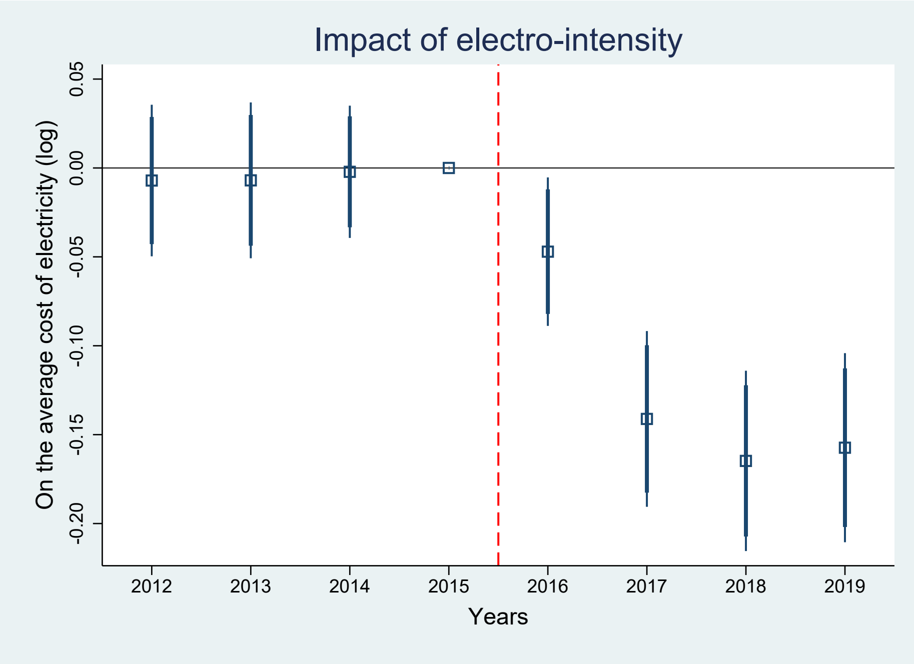
Figure 2: Average effects of electro-intensity among non-switcher firms on energy use and corporate performance indicators



Note: Figure (2) illustrates average effects of electro-intensity status on energy use and economic and financial performance indicators. It graphs results detailed in Table (B1) (columns II, ii). The sample includes firms that never change their electro-intensity status across all years (507 electro-intensive and 147 non-electro-intensive firms per year). For readability, it omits the outcomes that are in percentage form. Standard errors are clustered at the firm-level. Confidence intervals are set at the 5% level.

Figure (2) presents the event study DiD effect of electro-intensity on the average cost of electricity among non-switcher firms. The treatment effects in the pre-reform years show a flat trend and are not statistically different from zero, supporting the assumption of common trends. In the initial year of the implementation of tax cuts based on electro-intensity status, eligible firms exhibit a significant relative reduction in costs, followed by an even more substantial decrease that remains consistent from 2017 to 2019. Figure (B1) present the same graph with the non-logged outcome. Note that by 2019, the average relative decrease in cost reached around €15 per MWh, which is the minimum tax cut benefit an eligible firm can obtain. Figure (B2) presents the same event study based on the baseline sample. The results suggest that eligible firms actively sought to benefit from lower tax rates on electricity usage starting from the first year of the reform, an adjustment period, before they started to better capitalize on the incentives provided by the policy. Nevertheless and overall, findings also suggest that the beneficial tax treatment granted to electro-intensive firms did not translate into significantly lower total energy costs, and especially lower manufacturing operation costs.

Figure 3: Event study effect of electro-intensity among non-switcher firms on the average cost of electricity (log)



Note: Figure (3) illustrate the event study DiD results of the effect of electro-intensity on the average cost of electricity (log) based on Equation (7). The sample only includes firms that never switch their electro-intensity status across all years (507 electro-intensive and 147 non-electro-intensive firms per year). Standard errors are clustered at the firm-level. Confidence intervals are set at the 10% level (thick line) and at the 5% level (thin line).

Heterogeneous effects across sectors Figure (B4) additionally indicates differential industry responses to the policy. With varying degrees of noise, electro-intensive firms in the manufacturing of chemicals, basic pharmaceuticals, rubber and plastic, basic metals, fabricated metals and electrical equipment experience a statistically significant drop in electricity costs, while eligible firms in other sectors do not. In sum, certain industries appear to be more responsive or better positioned to benefit from the policy's incentives. It is also noteworthy that these reactive industries are also likely to be relatively more energy and carbon-intensive, and therefore would likely benefit the most from a tax cut on energy use.

5.1 Robustness checks

Restriction to firms around the cutoff The hypothesis of no difference in means listed in Table (B2) between electro-intensive and non-electro-intensive firms is rejected for most variables in the baseline panel (A). To account for any remaining omitted variable bias that could drive results, the sample is restricted to around the electro-intensity cutoff (0.5%), under the assumption that firms at a close distance from the cutoff are similar on both observable and un-observable characteristics. Specifications B-C detail the estimated t-test p-values as specifications become increasingly more restrictive.

Under specification C where firms have a pre-reform electro-intensity ratio ranging between 0.2% and 0.8%, eligible and non-eligible firms are on average not significantly different on a number of observable characteristics. Figure (B5) illustrates the average effects on electro-intensity. Results are noisier due to the smaller sample size and as well as likely due to the increase in the share of switchers in the sample (43%). Results are not statistically significant with the exception of the average cost of electricity.

Full balanced panel Treatment effects are estimated based on the full balanced panel, without the exclusions based on employment detailed in Section (3.1). The panel includes 1 608 firms per year, including 1 207 electro-intensive firms. Figures (B6) and (B7) present the average effects and Figures (B8) and (B9) the event study results. Overall findings conform to the main results, albeit value-added significantly decreases in the sample that omits switcher firms.

Pre-reform cap on electricity tax for consumers over 7 GWh As detailed in section (2.1), under the old electricity regime before 2016 firms consuming over 7 GWh of electricity could benefit from a cap on total electricity tax owed. To assess potential differences between firms that benefited from the pre-reform cap and those that did not, firms are identified as benefiting from the previous tax regime if their electricity use exceeds 7 GWh during any year in the pre-reform years. The coefficient of interest in Equation (4) interacts the treatment variable with the Above7GWh dummy. Figure (B10) presents average effects of electro-intensity for high electricity consumption firms that would have benefited from the old electricity tax regime. Findings are close to those found in Table (B2).

Regression discontinuity analysis Eligibility to preferential tax treatment in the post-reform years is a monotone and deterministic function of an assignment variable (the electro-intensity ratio) based on a clear threshold and with little evidence of precise manipulation (Table (A2)). In addition to the DiD specification, Figure (B11) presents graphical results from various regression discontinuity analyses of the impact of electro-intensity on the average cost of electricity. It includes results based on the full sample (described above) to increase the number of observations around the cutoff. Akin to the DiD conclusions, not only are results not statistically significant in the pre-reform period, the decrease in electricity costs is more pronounced among non-switcher firms in the post-reform period.

6 Discussion and concluding remarks

The 2016 electricity tax reform introduced new preferential tax treatment in the form of tax rate reductions on electricity consumption for firms with a gross electricity tax liability representing at least 0.5% of their value added. Firms that satisfy the cutoff requirement are electro-intensive. A reduction in tax should, all else equal, reduce the electricity cost burden among electro-intensive firms relative to ineligible firms. Findings from the event study and average DiD specifications provide evidence that electro-intensive firms experienced a relative drop in the average cost of electricity at a rate between 8.5% and 12.4 percent. Electro-intensive firms that remained electro-intensive throughout the panel experienced the largest relative drops in electricity costs. Furthermore, findings uncover heterogeneity in effects across manufacturing sectors, where electro-intensive firms in the more energy-intensive sectors experienced the more significant drops in electricity costs.

As full policy take-up in the panel data would suggest a relative drop of at least 15 euros per MWh on average: results therefore raise questions with regards to the extent to which eligible firms fill out the paperwork and request to benefit from the tax cut. Gerster and Lamp (2022) analyse the effects of similar threshold-based policies on German manufacturing and observe that around 72% of eligible plants claim their preferential tax treatment the first year it came into effect. Nevertheless, this average drops to 35% for firms just above the eligibility threshold and increases to 100% for the largest electricity consumers. In sum, policy take-up increases with electricity consumption, a proxy for firm size. They conclude that firms make a trade-off between the financial benefits of the preferential tax treatment and the compliance cost associated with its use. Similarly in the panel, decreases in average costs are less pronounced among firms with an electro-intensity close to the threshold. More generally, the policy effect is stronger among eligible firms that never change their electro-intensity status, which tend to have higher electro-intensity ratios, and therefore consume relatively more electricity.

Despite a statistically significant decrease in average electricity costs, findings do not uncover significant or robust effects on energy use input choices and on economic performance. Whereby Gerster and Lamp (2022) concluded that eligible firms increased their electricity consumption due to the tax cut in Germany, this paper does not. A possible explanation for this discrepancy lies in the energy mix: French firms may have less flexibility to substantially increase electricity inputs given their already relatively high share of total energy use. Another possible explanation for this discrepancy stems in policy design, and particularly in the policy's incentive structure, i.e. whether the magnitude of the tax cut was substantial enough to change corporate behavior. Results also underscore the importance of considering industry-specific dynamics when designing and evaluating policies aimed at mitigating electricity costs for electro-intensive businesses. Nevertheless, findings cast doubt on the usefulness and necessity of the public policy vis-à-vis tax revenues foregone which reached almost €2 billion by 2019.

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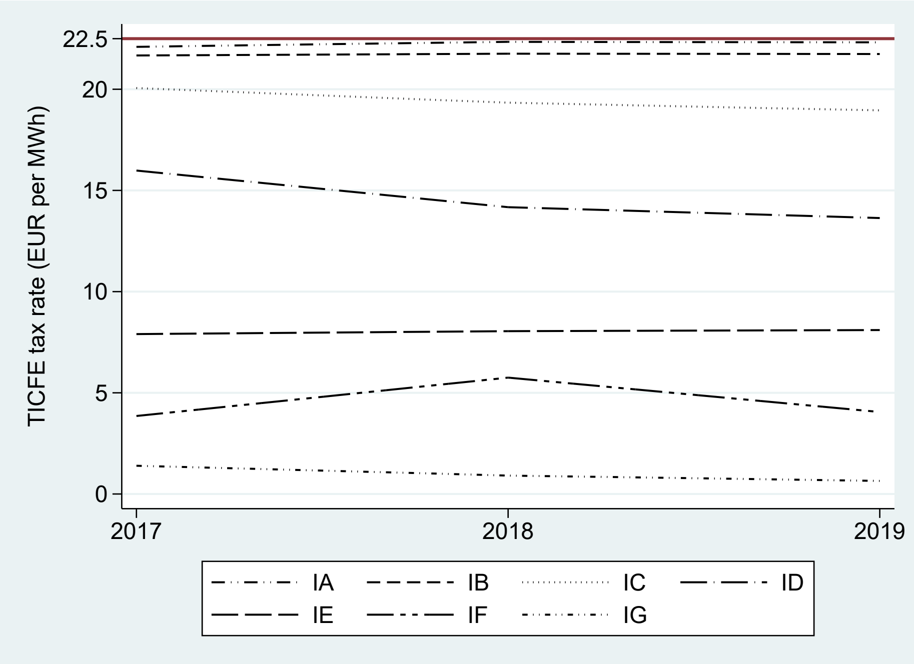
A Descriptive statistics

Table A1: Foregone tax revenues due to preferential tax treatment granted to electro-intensive businesses, 2016-2019

Characteristic	2016	2017	2018	2019
Not at risk of carbon leakage	561	1,014	1,035	1,245
At risk of carbon leakage	297	198	210	253
Hyper-electro-intensive	110	104	75	105
Total	968	1,316	1,320	1,603

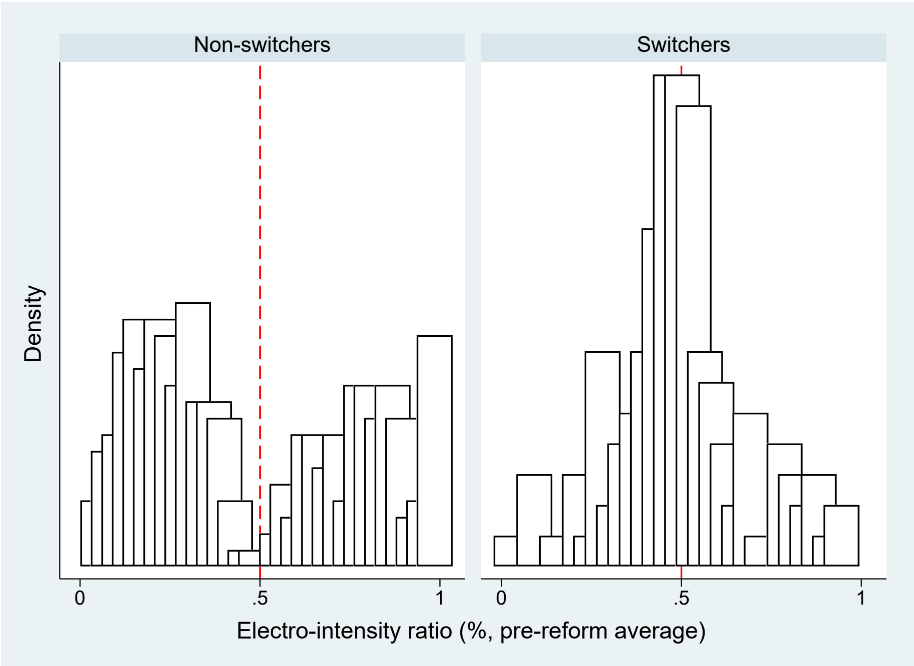
Note: Tax expenditures are in EUR million. Firms that consume over 6 kWh of electricity per euro of value-added or that estimate a negative value-added are considered hyper-electro-intensive. Carbon leakage is defined in European Commission (2012). Sources: PLF (2021), PLF (2020), PLF (2019) and PLF (2018).

Figure A1: Evolution of the average effective tax on electricity use rate by consumption brackets, 2017-2019



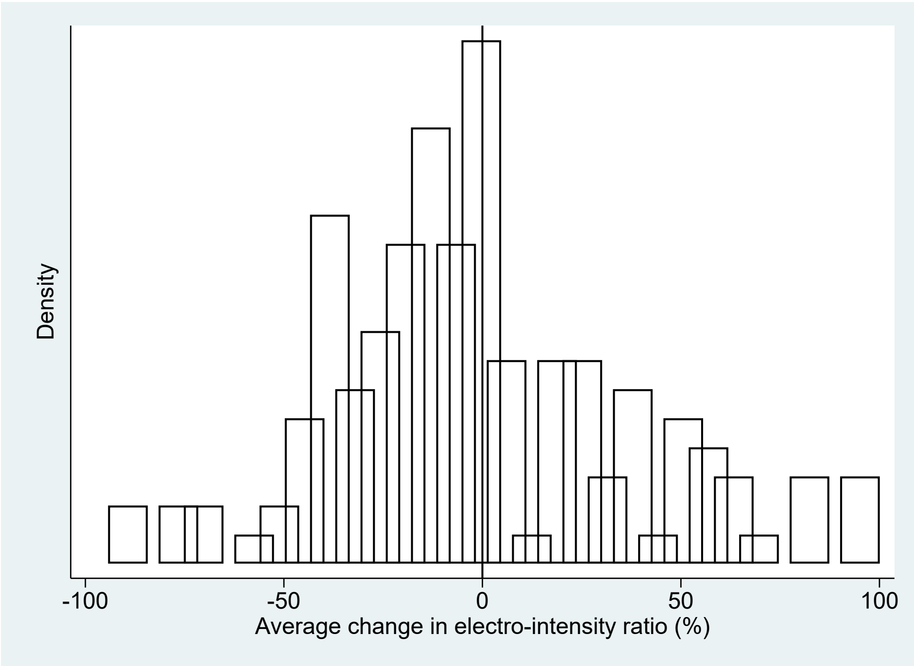
Note: Firms in consumption bracket (IA) consume below .02 GWh of electricity; in (IB) between .02 GWh and 0.5 GWh of electricity; in (IC) between 0.5 GWh and 2 GWh; in (ID) between 2 GWh and 20 GWh; in (IE) between 20 GWh and 70 GWh; in (IF) between 70 GWh and 150 GWh and firms in consumption level (IG) consume above 150 GWh of electricity. Figure (A1) shows that the effective tax rate paid on electricity is close to the statutory rate among the smallest consumers (€22.5 per MWh), whereas the larger ones benefit from more reduced rates. Source: Ministry of the Environment (2023).

Figure A2: Distribution of electro-intensity ratio by switcher status



Note: Figure (A2) plots the distribution of the pre-reform average electro-intensity ratio by switcher status. A firm is considered a switcher if it switches at least once across the electro-intensity cutoff (0.5%) any year in the panel. The bar width is 0.1 percent. For readability, the histogram is limited to an electro-intensity ratio between 0 and 1. It represents roughly 50% of all firms and around 86% of all identified switcher firms in the panel.

Figure A3: Distribution of change in electro-intensity ratio among switcher firms



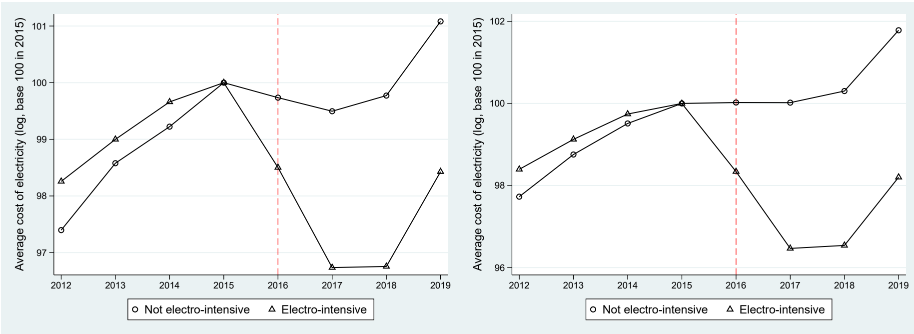
Note: Figure (A3) plots the distribution of the average percentage change in the electro-intensity ratio between the pre-reform and the post-reform period among switcher firms. A firm is considered a switcher if it switches at least once across the electro-intensity cutoff (0.5%) any year in the panel. The bar width is 10 percent. For readability, the histogram is limited to a change below 100 percent. The histogram represents 95% of all switcher firms (omits 8 firms).

Table A2: Test of manipulation based on density discontinuity of electro-intensity ratio

Policy period	Pre-reform	Post-reform
Test-statistic	1.6403	.0182
P-value	.1009	.9855

Note: The rddensity package (Cattaneo, Jansson, and Ma, 2018) tests the null hypothesis that the density of the running variable (the electro-intensity ratio) is continuous at the cutoff (0.5%), suggesting no strategic manipulation by firms. This test is based on a a local polynomial density estimator. The results fail to reject the null hypothesis of no manipulation in both the pre-reform and post-reform periods. Additional year-by-year manipulation tests do not change conclusions.

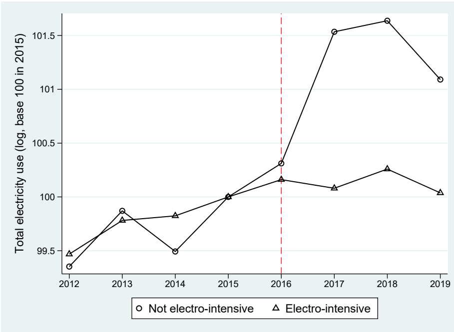
Figure A4: Common trends by electro-intensity status: average cost of electricity (log)



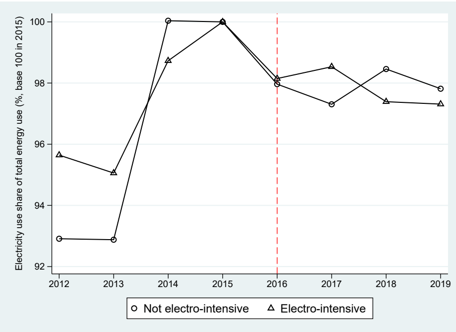
(a) Baseline (b) No switchers

<u>Note</u>: Figures (A4) shows the evolution of the average cost of electricity use between electro-intensive firms and non-electro-intensive firms, as defined in Equation (6). Figure (A4a) includes both switcher and non-switcher firms (Baseline), whereas Figure (A4b) only includes firms that never change their electro-intensity status across all years (No switchers). Average trends are indexed to year 2015.

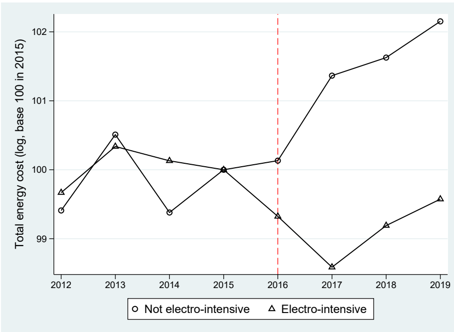
Figure A5: Evolution of input choice and economic performance indicators between electro-intensive and non-electro-intensive firms



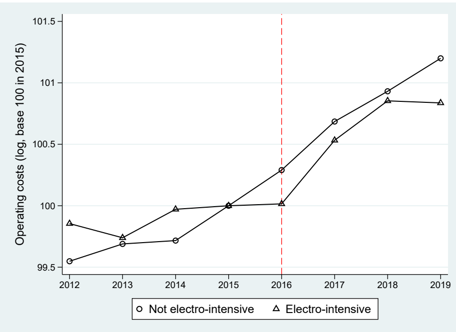
(a) Electricity use



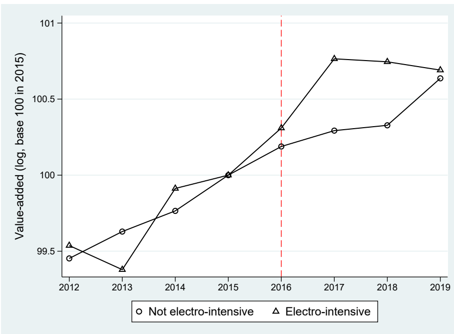
(b) Electricity use share



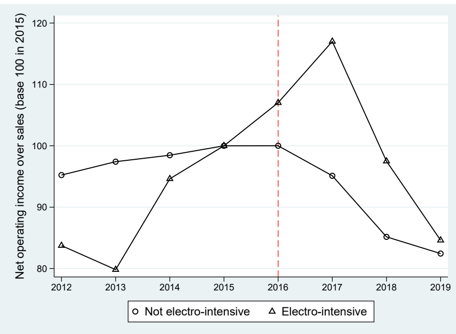
(c) Total energy costs



(d) Total operating costs



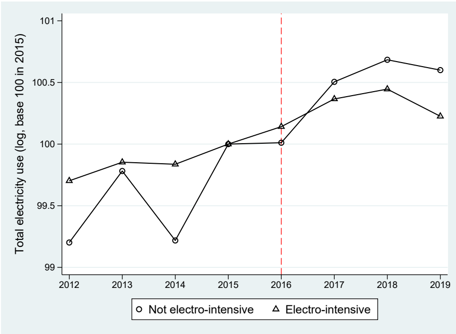
(e) Total value-added



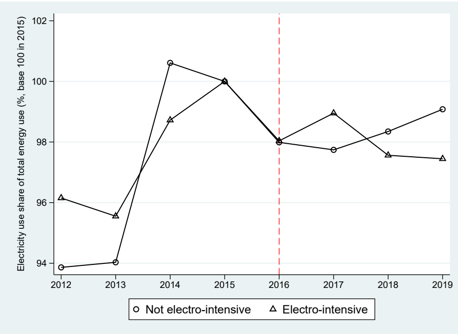
(f) Operating margin

Figures (A5a), (A5b), (A5c), (A5d), (A5e) and (A5f) show the evolution of total electricity use, the electricity use share of total energy use, total energy use, total employment, total value-added and the operating margin ratio (net operating income over sales), respectively, between electro-intensive firms and non-electro-intensive firms, as defined in Equation (6). Average trends are indexed to year 2015. The sample is the baseline.

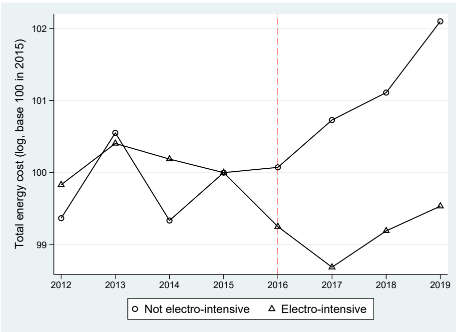
Figure A6: Evolution of input choice and economic performance indicators between non-switcher electro-intensive and non-electro-intensive firms



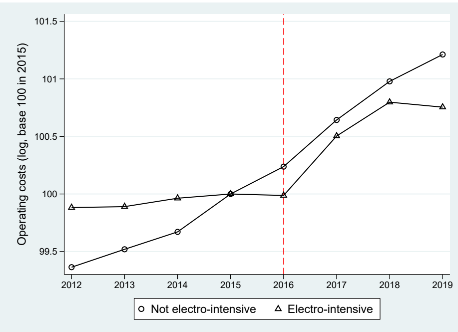
(a) Electricity use



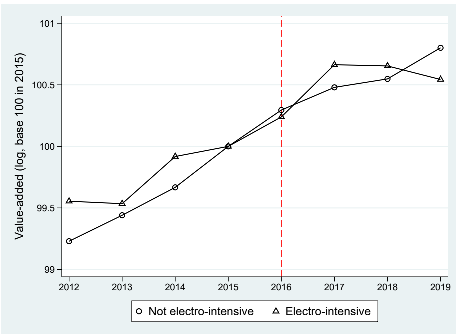
(b) Electricity use share



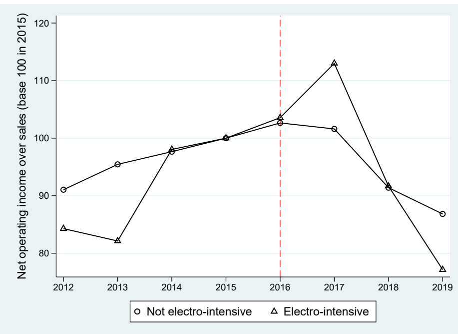
(c) Total energy costs



(d) Total operating costs



(e) Total value-added



(f) Operating margin

Figures (A6a), (A6b), (A6c), (A6d), (A6e) and (A6f) show the evolution of total electricity use, the electricity use share of total energy use, total energy use, total employment, total value-added and the operating margin ratio (net operating income over sales), respectively, between electro-intensive firms and non-electro-intensive firms, as defined in Equation (6). The sample only includes firms that never change theur electro-intensity status across all years in the panel. Average trends are indexed to year 2015. The sample is the baseline.

Table A3: Summary statistics by electro-intensity status in 2012

	Not electro-intensive					Electro-intensive				
	Mean	Median	Std.Dev.	Min	Max	Mean	Median	Std.Dev.	Min	Max
Electro-intensity ratio (%, pre-reform average)	.29	.29	.13	.01	.50	3.03	1.47	7.58	-25.79	123.91
Electricity average cost (€ per MWh)	82	79	14	48	148	73	72	12	31	123
Electricity use ('100 toe)	6	2	15	0	175	39	8	127	0	1 929
Total cost of electricity ('10 000 €)	49	18	117	0	1 236	248	68	650	0	6 900
Electricity cost share of total energy costs (%)	64	62	20	4	100	62	63	24	0	100
Electricity use share of total energy use (%)	54	52	22	3	100	50	48	27	1	100
Fossil fuel use share of total energy use (%)	44	46	26	0	95	42	46	26	0	97
Fossil fuel use ('100 toe)	6	2	17	0	140	86	8	385	0	5 523
Electricity over fossil fuel use	4	1	17	0	221	6	1	32	0	525
Total energy costs ('10 000 €)	81	28	194	1	1 931	615	120	2 251	6	38 005
Total energy use ('100 toe)	12	4	34	0	315	148	19	542	1	5 855
Employment (#)	511	234	1 244	20	11 649	394	203	613	19	5 803
Total net assets ('1 000 000 €)	177	37	651	1	6 473	96	33	225	1	2 929
Operating costs ('1 000 000 €)	181	47	554	3	5 955	130	54	231	3	1 975
Net operating income ('1 000 000 €)	12	4	38	-64	462	5	1	19	-84	216
Total sales ('1 000 000 €)	145	53	329	3	5 294	135	50	301	4	2 705
Net operating income over sales	.08	.07	.08	-.07	.55	.03	.02	.07	-.27	.40
Value added ('1 000 000 €)	39	15	96	-23	1 634	41	15	101	1	890
Value-added over sales	.36	.35	.13	.08	.92	.30	.28	.13	-.03	.78
Net operating income over gross operating surplus	.29	.29	.20	-.41	.99	.18	.20	.40	-5.33	4.27
Export share of total sales (%)	37	32	33	0	100	37	29	32	0	100
EU-ETS (%)	2.30	-	-	-	-	15.57	-	-	-	-

Industry sector composition (Freq., %)

Not electro-intensive		Electro-intensive	
Chemicals	18.89	Food	15.06
Fabricated metals	12.90	Chemicals	14.55
Electrical equipment	10.60	Other non-metallic minerals	9.81
Machinery and equipment n.e.c.	10.60	Paper	9.48
Other transport equipment	8.76	Fabricated metals	9.48
Computer, electronic and optical	5.53	Basic metals	7.95
Other manufacturing	32.72	Other manufacturing	33.67

Note: Values are rounded to the nearest integer. Electro-intensity status is based on Equation (6). Toe is an acronym for tons of oil equivalent. Average salary refers to the ratio of the sum of salaries over employment. Net operating income refers to gross operating revenues minus operating costs. Net assets refer to the difference between total assets and total liabilities. Gross operating surplus (or *Excédent Brut d'Exploitation*, EBE) refers to value-added including operating grants and minus labor costs.

B Results

Table B1: Average effect of electro-intensity on energy use input choices and economic performance indicators

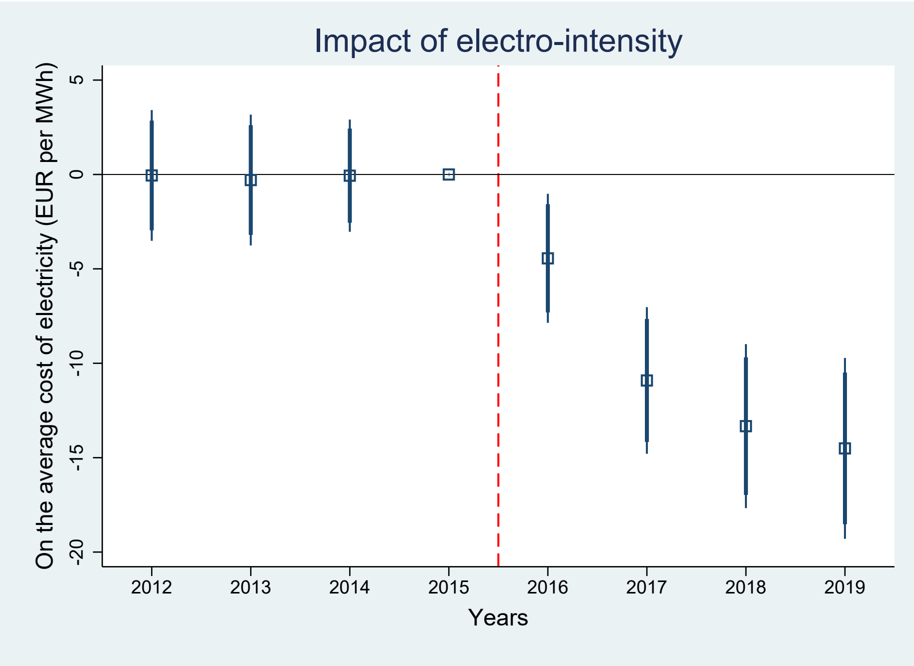
	I		II	
	Baseline		No switchers	
Electro-intensive × post	(i)	(ii)	(i)	(ii)
Outcomes				
Average cost of electricity (log)	-.117***	-.085***	-.152***	-.124***
	(.013)	*(.014)*	*(.017)*	*(.018)*
	.647	*.652*	*.664*	*.668*
Electricity use (log)	-.058**	-.001	-.017	-.028
	(.026)	*(.025)*	*(.026)*	*(.030)*
	.978	*.978*	*.989*	*.989*
Total cost of electricity (log)	-.175***	-.085***	-.170***	-.094***
	(.027)	*(.026)*	*(.027)*	*(.031)*
	.966	*.966*	*.982*	*.982*
Electricity cost share of total energy cost (%)	-1.891***	-1.546**	-2.312***	-2.307***
	(.695)	*(.718)*	*(.738)*	*(.837)*
	.902	*.902*	*.911*	*.911*
Electricity use share of total energy use (%)	-.448	-.462	-.019	-.669
	(.686)	*(.756)*	*(.756)*	*(.911)*
	.918	*.918*	*.923*	*.923*
Fossil fuel use (log)	.002	.043	-.002	.041
	(.051)	*(.068)*	*(.060)*	*(.086)*
	.938	*.938*	*.939*	*.939*
Total cost of energy (log)	-.144***	-.054**	-.132***	-.050*
	(.023)	*(.024)*	*(.026)*	*(.030)*
	.980	*.980*	*.984*	*.985*
Operating costs (log)	-.023	.012	-.048***	-.009
	(.020)	*(.025)*	*(.018)*	*(.022)*
	.977	*.977*	*.990*	*.990*
Value-added (log)	.036	.038	-.009	-.021
	(.024)	*(.031)*	*(.027)*	*(.036)*
	.952	*.953*	*.960*	*.960*
Net operating income over sales	.011**	.007	.003	-.002
	(.005)	*(.006)*	*(.0006)*	*(.006)*
	.704	*.705*	*.718*	*.718*
Value-added over sales	.011**	.006	.006	-.001
	(.005)	*(.006)*	*(.005)*	*(.006)*
	.908	*.908*	*.917*	*.918*

Note: Specifications (i) refers to the following equation regression:

$$y_{i,t} = \alpha_i + \beta_1(\text{Electro-Intensive}_{i,<2016,t}) + \gamma(\text{Industry}_{i,t}) + \varepsilon_{i,t}$$

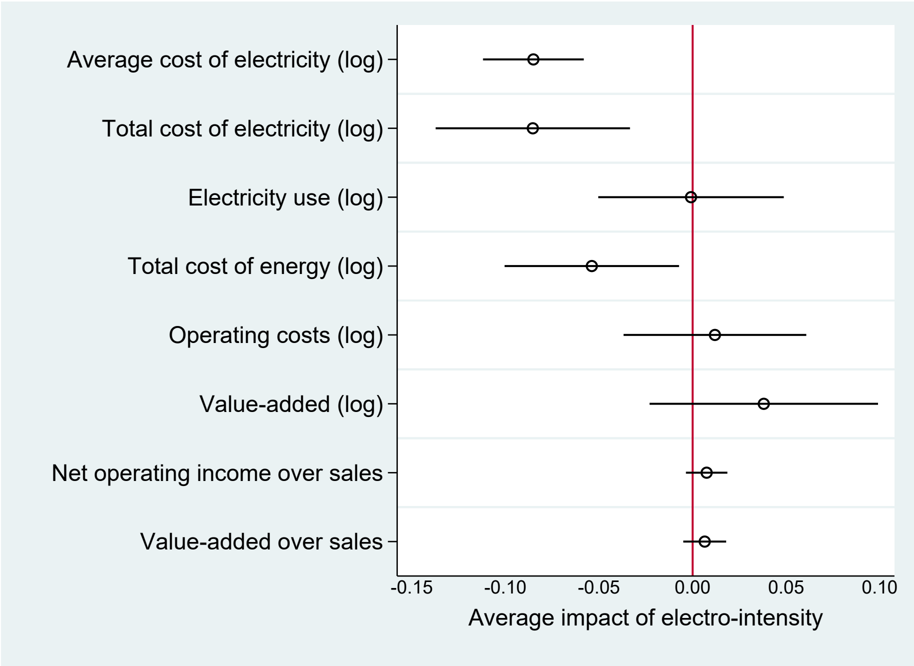
and Specifications (ii) refer to full specification. In the sample no firms have a negative value-added, hence the outcome is logged. Operating margin refers to the ratio of net operating income over sales, which can be negative. Standard errors are provided in parenthesis and are clustered at the firm level. Adjusted R squares are below the standard errors. Statistical significance is marked with *(0.1 > p-value> 0.05), **(0.05 > p-value > 0.01), ***(p-value < 0.01).

Figure B1: Event study effects of electro-intensity on the average cost of electricity (EUR per MWh) among non-switcher firms



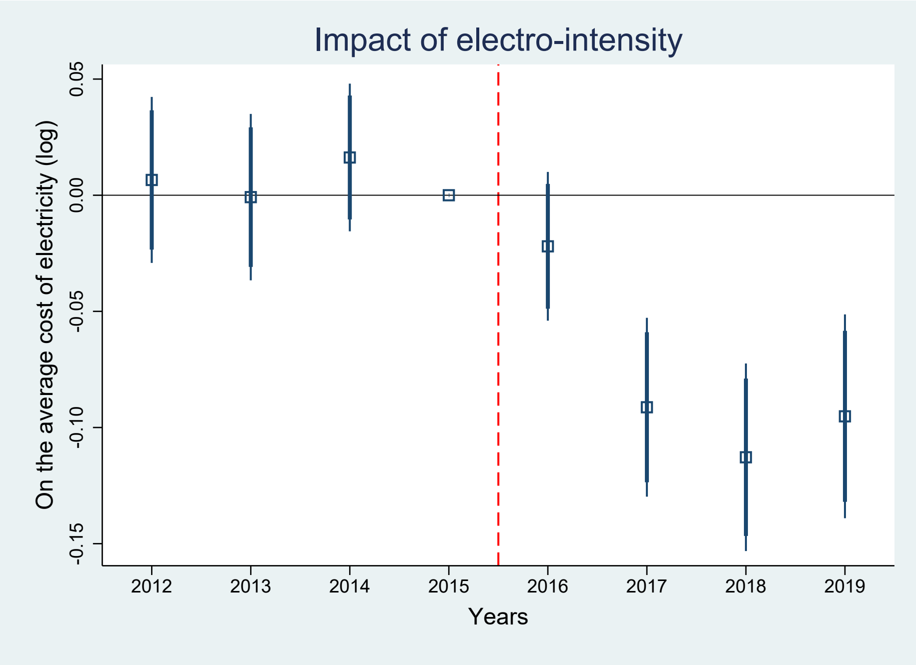
Note: Figure (B1) illustrates the event study DiD results of the effect of electro-intensity on the average cost of electricity (EUR per MWh) based on Equation (7). The sample only includes firms that never switch their electro-intensity status across all years (507 electro-intensive and 147 non-electro-intensive firms per year). Standard errors are clustered at the firm-level. Confidence intervals are set at the 10% level (thick line) and at the 5% level (thin line).

Figure B2: Average effects of electro-intensity on energy use and economic and financial performance indicators



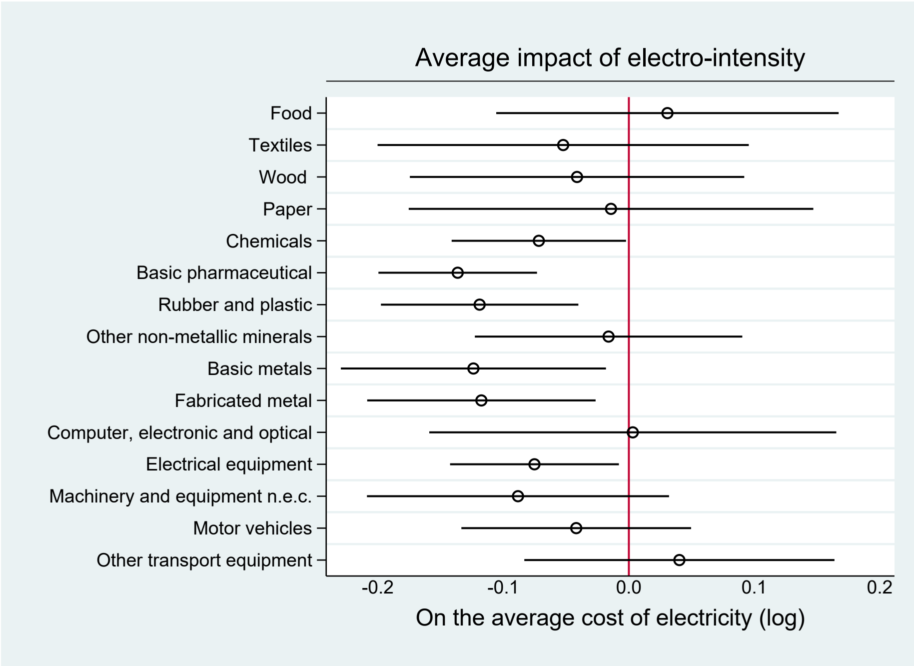
Note: Figure (B2) illustrates average effects of electro-intensity status on energy use and economic and financial performance indicators. It graphs results detailed in Table (B1) (columns I, ii). The baseline sample includes firms that may or never switch across their electro-intensity status across the years (591 electro-intensive and 217 non-electro-intensive firms per year). For readability, it omits the outcomes in percentage form. Standard errors are clustered at the firm-level. Confidence intervals are set at the 5% level.

Figure B3: Event study effects of electro-intensity on the average cost of electricity (log)



Note: Figure (B2) illustrates the event study DiD results of the effect of electro-intensity on the average cost of electricity (log) based on Equation (7). The baseline sample includes firms that may or never switch across their electro-intensity status across the years (591 electro-intensive and 217 non-electro-intensive firms per year). Standard errors are clustered at the firm-level. Confidence intervals are set at the 10% level (thick line) and at the 5% level (thin line).

Figure B4: Average effects of electro-intensity the average cost of electricity (log) by 2-digit NACE Rev.2 industry code



Note: Figure (B4) presents results based on a modification of Equation (4) as follows:

$$y_{i,t} = \alpha_i + \beta_1(\text{Electro-Intensive}_{i,<2016,t} \times \text{DIndustry}_{i,t}) + \gamma(\text{4digitIndustry}_{i,t}) + \eta(\text{ETS}_{i,t}) + \zeta(\chi_{i,2012,t}) + \varepsilon_{i,t} \tag{10}$$

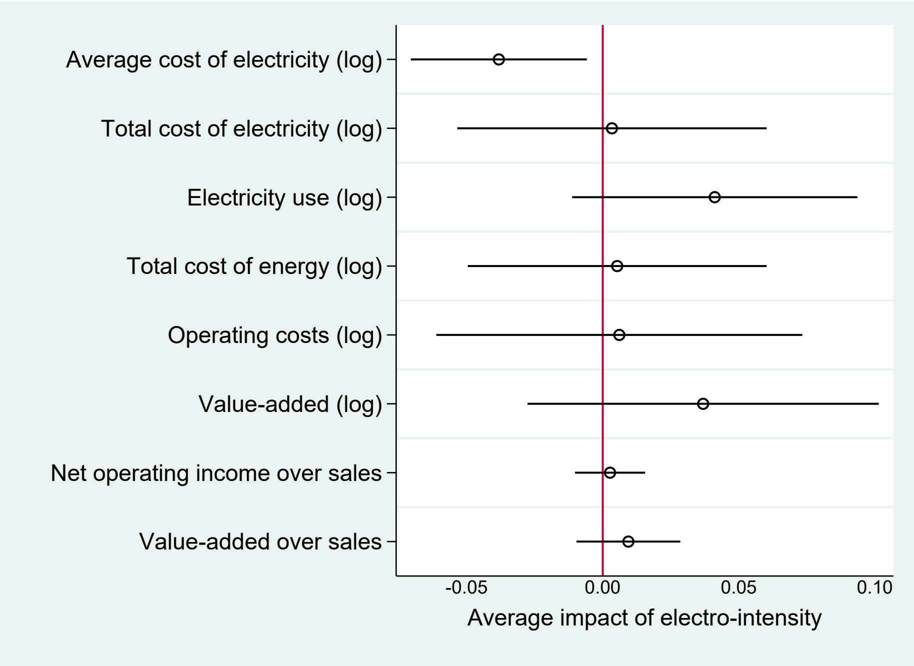
Where the coefficient of interest β_1 interacts the treatment variable with DIndustry, a dummy equalling for one if the firm belongs to each 2-digit NACE Rev.2 industry code, and zero otherwise. Coefficient γ includes 4-digit NACE Rev.2 industry codes fixed effects. Sectors included in the figure represent around 96% of all observations. Standard errors are clustered at the firm-level. Confidence intervals are set at the 5% level.

Table B2: P-values for two-sample t-tests comparing electro-intensive and non-electro-intensive firms close to the cutoff (0.5%)

		Restriction around cutoff	
	A	B	C
	Baseline	]0.1%,0.9%[	]0.2%,0.8%[
Electricity use	.000	.060	.477
Total cost of electricity	.000	.059	.468
Total energy use	.000	.032	.267
Electricity use share of total energy use	.000	.193	.230
Total energy costs	.000	.039	.313
Electricity over fossil fuel use	.092	.950	.959
Employment	.000	.320	.262
Operating costs	.000	.204	.214
Value-added	.000	.217	.231
Total net assets	.000	.120	.144
Gross operating surplus	.000	.138	.185
Export share of total sales	.129	.224	.648
Electro-intensive (# per year)	591	151	108
Non-electro-intensive (# per year)	217	201	158

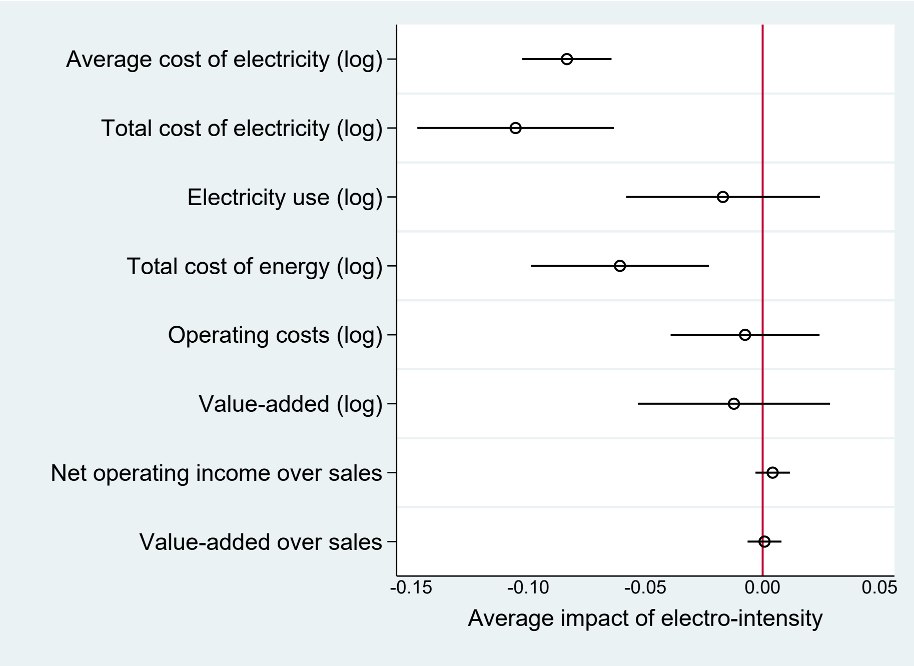
Note: Table (B2) details the estimated p-values from two-sample t-tests on the equality of means across electro-intensive firms and non-electro-intensive firms in 2012. Electro-intensity is based on the pre-reform average ratio. Specification A is based on the final baseline panel. Under specifications B-C, sample sizes are restricted according to the listed intervals and based on their pre-reform average electro-intensity ratios, Equation (5).

Figure B5: Average effects of electro-intensity among firms close to the electro-intensity cutoff



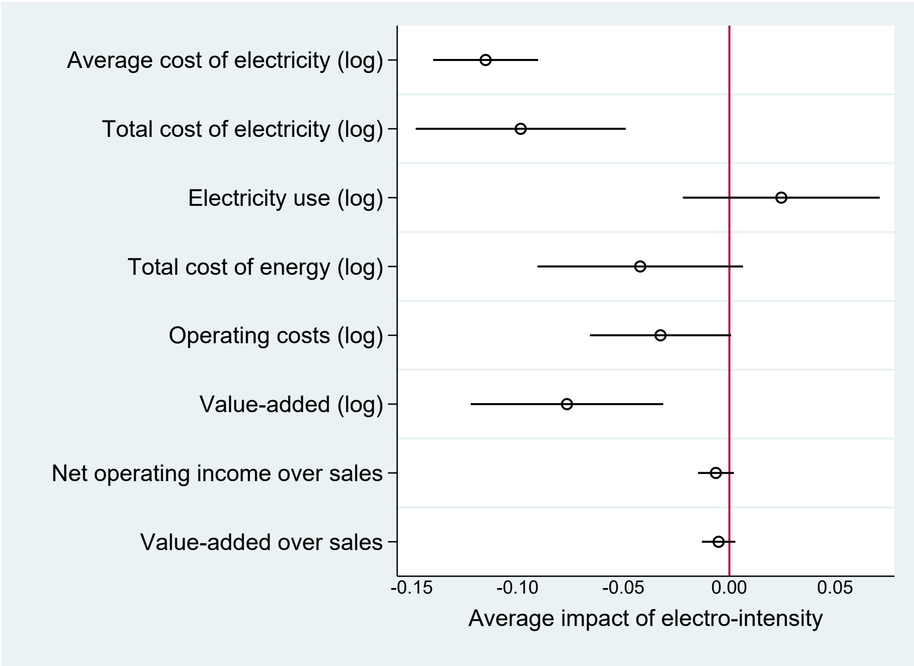
Note: Figure (B5) illustrates average effects of electro-intensity status on energy use and economic and financial performance indicators. The sample includes firms close to the electro-intensity cutoff (see column C in Table (B2)). For readability, it omits the outcomes in percentage form. Standard errors are clustered at the firm-level. Confidence intervals are set at the 5% level.

Figure B6: Average effects of electro-intensity among firms in full panel



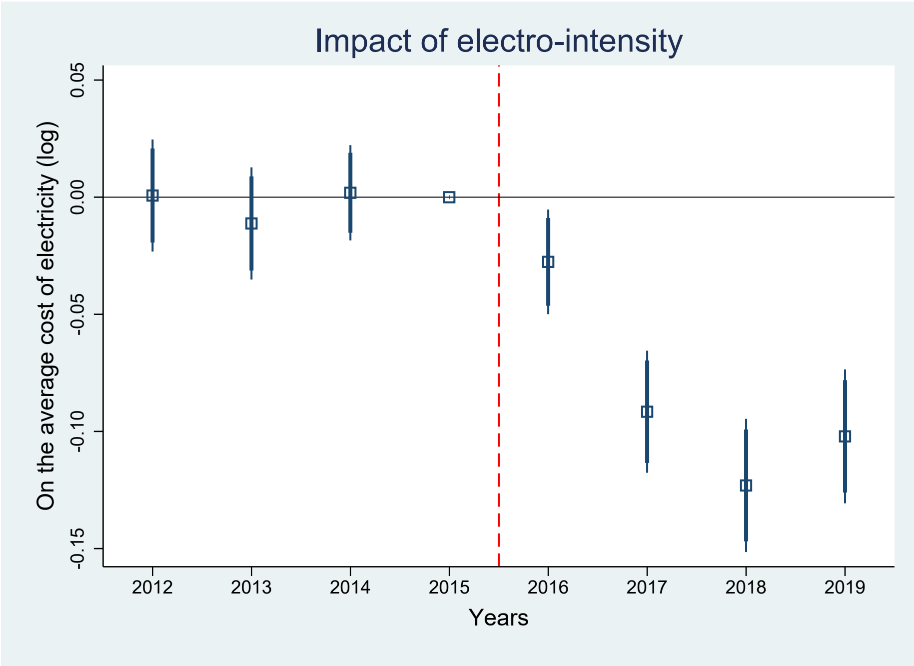
Note: Figure (B6) illustrates average effects of electro-intensity status on energy use and economic and financial performance indicators (1 608 firms per year). For readability, it omits the outcomes in percentage form. Standard errors are clustered at the firm-level. Confidence intervals are set at the 5% level.

Figure B7: Average effects of electro-intensity among non-switcher firms in full panel



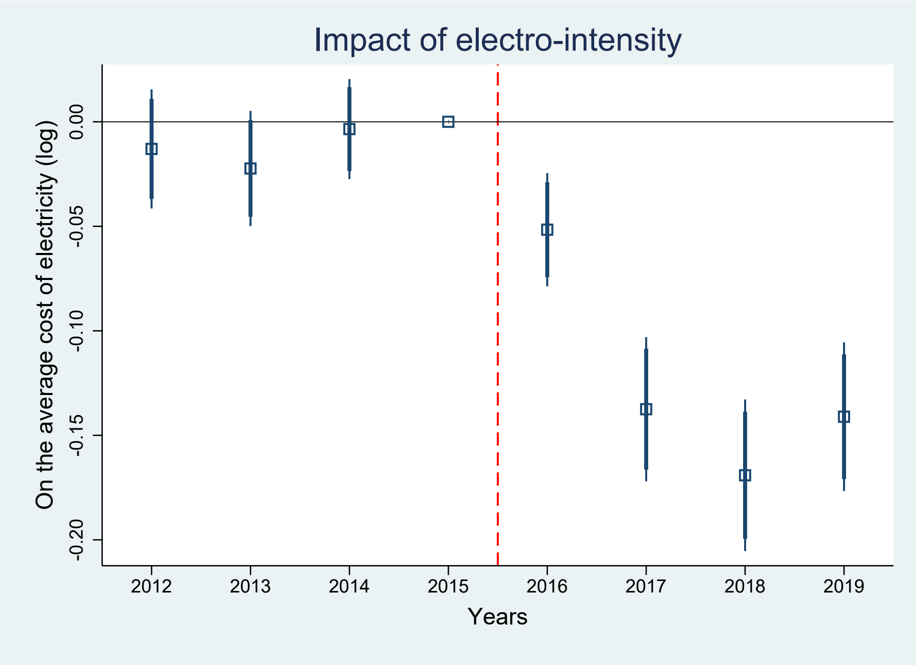
Note: Figure (B7) illustrates average effects of electro-intensity status on energy use and economic and financial performance indicators among non-switcher firms in the full panel (1 207 firms per year). For readability, it omits the outcomes in percentage form. Standard errors are clustered at the firm-level. Confidence intervals are set at the 5% level.

Figure B8: Event study effects of electro-intensity on the average cost of electricity (log) in full panel



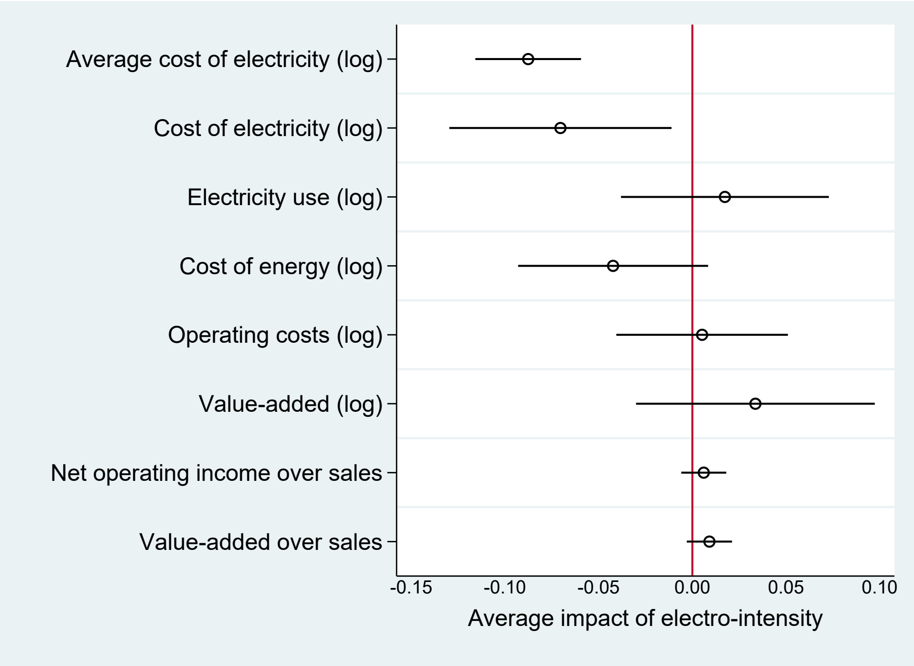
Note: Figure (B8) illustrates the event study DiD results of the effect of electro-intensity on the average cost of electricity (log) based on Equation (7) in the full panel (1 608 firms per year). Standard errors are clustered at the firm-level. Confidence intervals are set at the 10% level (thick line) and at the 5% level (thin line).

Figure B9: Event study effects of electro-intensity on the average cost of electricity (log) among non-switcher firms in full panel



Note: Figure (B9) illustrates the event study DiD results of the effect of electro-intensity on the average cost of electricity (log) based on Equation (7) among non-switcher firms in the full panel (1 207 firms per year). Standard errors are clustered at the firm-level. Confidence intervals are set at the 10% level (thick line) and at the 5% level (thin line).

Figure B10: Average effects of electro-intensity, _7gwh

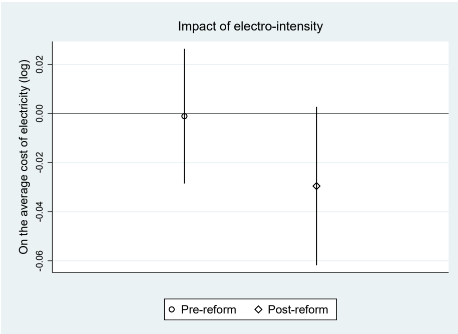


Note: Figure (B10) presents results based on a modification of Equation (4) as follows:

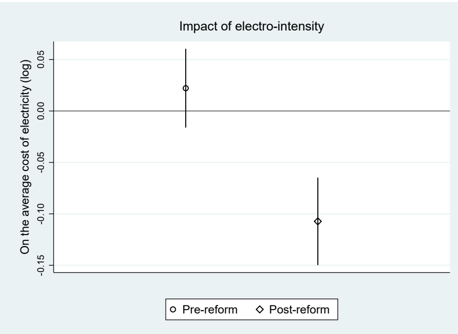
$$\begin{aligned} y_{i,t} = \alpha_i + \beta_1(\text{Electro-Intensive}_{i,<2016,t} \times \text{Above7GWh}) + \gamma(\text{Industry}_{i,t}) \\ + \eta(\text{ETS}_{i,t}) + \zeta(\chi_{i,2012,t}) + \varepsilon_{i,t} \end{aligned} \tag{12}$$

Where the coefficient of interest β_1 interacts the treatment variable (Equation (6)) with Above7GWh, a dummy equalling for one if the firm consumed over 7 GWh of electricity any year in the pre-reform years, and zero otherwise. Standard errors are clustered at the firm-level. Confidence intervals are set at the 5% level.

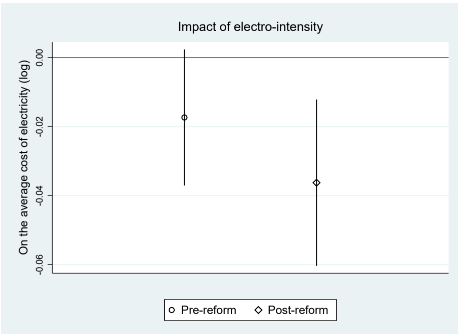
Figure B11: Regression discontinuity analysis



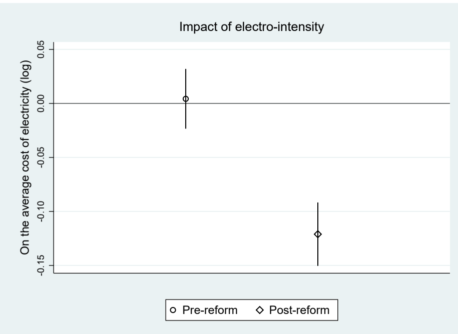
(a) Baseline



(b) No switchers



(c) Full



(d) No switchers, full

Note: Figure (B11) presents the average effect of the reform around the electro-intensity ratio threshold (0.5%) pooled in both the pre-reform and post-reform periods using the rdrobust package (Calonico, Cattaneo, and Titiunik, 2023) and its default functions.