The impact of energy tax refunds on manufacturing firm performance: evidence from Finland's 2011 energy tax reform

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Abstract

Attempts to cut back greenhouse gas emissions and reduce energy use have brought along increases in energy taxes or specific carbon prices in many countries. Carbon pricing has also raised concerns that energy intensive industries suffer a competitive disadvantage in terms of their cost competitiveness relative to countries with laxer environmental policies. Causal evidence on both the effect of environmental policies on manufacturing firm performance and on what market-based policies deliver in terms of emission reductions is still sparse, in particular in the context of climate policy. This paper contributes towards filling the gap by investigating the effect of an energy tax exemption on the economic and environmental performance of manufacturing firms. To secure the international competitiveness of Finland's energy-intensive export industries, these industries are entitled to notable refunds on energy taxes if their tax expenses exceed a threshold connected to their value added. We use a detailed data set on Finnish manufacturing plants, combined with comprehensive plant-level information on energy consumption. We exploit the detailed information to estimate the impact of the energy tax exemption by combining a difference-in-differences approach with semiparametric matching techniques.

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1 Introduction

Along with increasing policy effort to mitigate climate change, the impact of climate policy on firm performance has become a heated topic in the political debate. Especially in countries where climate policy has tightened significantly relative to competitors, concerns have been raised about adverse effects of unilateral climate policies on manufacturing firm performance. In theory, the effect of environmental policy on firm performance could go either way. Other things equal, environmental regulation increases firms' costs and thus reduces their cost competiveness. If firms compete in prices, the disadvantage relative to firms operating in locations with laxer environmental policies may harm regulated firms' sales and reduce their production, and eventually employment. Firms may also be pushed to shift production capacity to locations with laxer environmental policies with the consequence of pollution leakage, as predicted by the pollution haven hypothesis (Levinson and Taylor 2008). An alternative view is expressed in the Porter hypothesis, which states that environmental regulation may enhance the competitiveness of regulated firms, through pushing them to engage in environmentally friendly innovation and technology adoption that would not have happened in the absence of policy (Porter 1991). Both in Finland and in the EU many policy makers have expressed the concern that EU's ambitious climate policy will shift production to countries with laxer climate policy, while others have promoted the vision that low-carbon innovation will be a driver of competitive advantage and economic growth.

Given the two theories with opposite predictions, the effect of environmental policy on manufacturing firm performance remains an empirical question. The environmental policy tools used in practice have also been changing. Regulators are increasingly adopting market-based instruments to curtail emissions. The shift from command and control approaches towards market-based instruments raises questions about how well these instruments work in terms of their environmental objectives. Causal evidence on both the effect of environmental policies on manufacturing firm performance and on what market-based policies deliver in terms of emission reductions is still sparse, in particular in the context of climate policy.

This paper contributes towards filling the gap by investigating the effect of an energy tax exemption on the economic and environmental performance of manufacturing firms. We examine these two issues in the context of Finland's "green" energy tax reform that substantially increased the excise taxes on energy inputs, with the aim of promoting energy efficiency and reducing CO_2-emissions. The preparation of the tax reform was accompanied by controversy over the predicted effects on manufacturing firm competitiveness, with the consequence that firms above a certain energy tax threshold were granted exemption from energy taxes. While firms below the threshold pay energy taxes in full, firms above the threshold are refunded up to 85 percent of their energy taxes. Exempt and non-exempt firms, and in particular plants within these firms, can be otherwise very similar. The exemption rule is important from a statistical analysis point of view in that it allows us to compare plants that operate in the same manufacturing sectors and have otherwise similar history, but have been subject to different effective tax rates since the tax reform.

In order to evaluate the causal impact of the energy tax exemption on manufacturing firms' economic and environmental performance, we use a detailed data set on the universe of Finnish manufacturing plants, combined with comprehensive plant-level information on energy consumption. We exploit the detailed information to estimate the impact of the energy tax exemption by combining a difference-in-differences approach with semiparametric matching techniques.

2 Literature review

Literature on international trade generally groups the main determinants of firms' international competitiveness into three broad categories: firm level factors, sector level factors, and country/region specific factors. Firm level factors have generally been found to be the most important determinants of both domestic and international competitiveness (see e.g. Goddard et al. 2005, Goddard et al. 2009, Brakman et al. 2009, Wagner 2012). Hottman et al. (2016) and Crozet et al. (2012) have identified perceived product and firm quality (firm appeal) as the most important firm-level driver of competitiveness. Hottman et al. (2016) analyzed the sales and prices of millions of products in the United States in years 2004-2001. They found that product quality accounted for 50-75 percent of firm-level success factors and 90 percent of sales increases. Prices and costs instead explained only 25 of the general success of a firm, and for the majority of products changes in costs had no effect on sales development.

There are only few studies on the effect of energy or carbon taxes on the competitiveness of manufacturing firms. Arlinghaus (2015) provides a fairly recent literature review and concludes that carbon taxes or EU emissions trading have had little impact on competitiveness at the firm, sector or country level. According to Arlinghaus, carbon pricing has had some success in reducing firms' energy intensity and carbon emissions, while tax relief to energy-intensive industries has not affected competitiveness indicators in manufacturing.

The studies most closely related to the present paper have studied the effects of similar tax exemptions on manufacturing firm performance in other EU countries. Gerster and Lamp (2018) analyzed a tax exemption to large manufacturing plants in Germany. They examined a change in the tax schedule in 2012 that reduced the threshold of electricity use above which plants are exempt. Newly exempt plants were found to increase their energy use some but their sales did not increase. The number of employees in newly exempt plants decrased some, which Gerster and Lamp suggest could be because they substituted bought electricity for generation on site. Flues and Lutz (2015) studied the effects of German electricity taxation prior to EU Emissions Trading, in years 1999-2005. They used a regression discontinuity approach and exploited a threshold in the electricity tax system, which assigned a lower tax rate to industries with high electricity use. They found no effect of the tax relief on firm revenue, exports, value added, investments or employment. Martin et al. (2014) analyzed the effects of energy taxes in the United Kingdom, also prior to EU Emissions Trading. The United Kingdom granted energy-intensive manufacturing firms an 80 percent concession in their energy taxes if they committed to voluntary agreements to reduce their energy use or carbon emissions. The energy use or carbon emission targets, however, were not very ambitious. Martin et al. used a differences-in-differences approach and instrumental variables to study the effects of the tax relief. They found that paying the full tax had no effect on production, productivity or employment but that it reduced firm energy intensity notably relative to firms that obtained the tax relief.

Anger and Oberndorfer (2008) examined the effect of the free allocation of emissions permits to German firms participating in the EU Emissions Trading System. While the research design differs from those in Flues and Lutz (2015) and Martin et al. (2014), the initial free allocation of emission permits can be perceived as support to energy-intensive manufacturing, similar to tax relief. Anger and Oberndorfer found no difference in the profitability or employment in manufacturing firms that would have been attributable to a firm having been overallocated free emission permits or having to buy emissions permits from the market in 2005.

A closely related literature studies the effects of EU emissions trading on manufacturing firm performance and CO2-emissions. Dechezleprêtre et al. (2018) used data for all EU countries, for altogether 1800 firms that participate in emissions trading. They compared regulated firms to firms that are otherwise very similar but not regulated. They found no evidence of negative effects of EU emissions trading on firm performance. Regulated firms' revenue and fixed assets were instead found to have increased, perhaps due to investments by regulated firms in cleaner and at the same time more efficient technologies.

Similar conclusions can be drawn based on studies for individual EU countries. In France, EU emissions trading increased investment in regulated firms, without overall impacts on employment or value added (Wagner, Muûls, Martin and Colmer 2014). Results were similar for Germany (Petrick and Wagner 2014). In Norway, emissions trading appears to have increased productivity and value added some, although the result may be due to generous free allocation of emissions permits (Klemetsen, Rosendahl and Jakobsen 2016). For Lithuania, no effect was found on firm performance (Jaraite and Di Maria 2016).

Finally, Marin and Vona (2017) utilized a detailed data set on manufacturing plant energy expenditure and energy use, which allowed them to calculate plant-specific energy prices. They found energy prices to have a small negative impact on employment and productivity: a 10 percent increase in energy prices decreased employment by 2,6 percent and productivity by 1,1 percent.

3 Institutional setting and energy tax reform in 2011

Finland's 2011 energy tax reform markedly increased the excise tax rates on coal, natural gas, oil and electricity.[2] As a follow-up of the reform, a pre-existing tax exemption for large energy-intensive firms was expanded to a substantially larger set of firms.[3] The stated motivation for the tax exemption was securing the international competitiveness of Finland's energy-intensive export industries, by attenuating the energy cost increase brought along by the tax increase.

The exemption rule is based on firms' energy tax payments relative to its value added, a measure of energy intensity. The energy taxes are excise taxes, and energy tax payments are thus determined based on the quantities of energy inputs purchased. If a firm's taxes on electricity and fuels within an accounting period exceeded 0,5 percent of its value added, it will be refunded 85 percent of difference, subject to a 50 000 euro deductible. Formally, the tax exemption rule is

*Refund = (Energy taxes paid - value added*0.005)*0.85 - 50 000 (eur).* [4]

Energy taxes include excise taxes on electricity, district heat and process steam production, and carbon and energy content based taxes on heating fuels. Value added comprises operating profit (- loss), write-offs, depreciation, and labor costs (total of wages and social benefits). Firms apply for the tax refund annually based on certified accounts.

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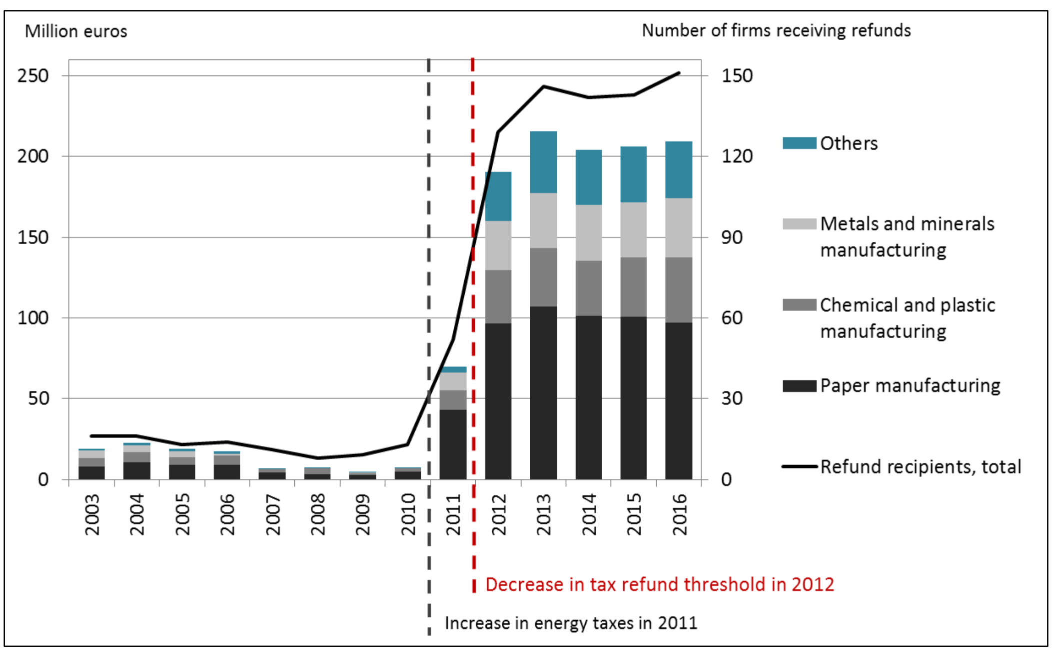
[2] The energy tax reform changed both the structure of energy taxation and energy tax rates so that the excise taxes on fuels comprised of an energy content component and a CO_2 component. The CO_2 tax rate used in computing the excise tax on different energy products increased from 20 EUR/tCO_2 to 30 EUR/tCO_2.
[3] The tax exemption was first implemented in September 1998.
[4] A negative value added replaced by zero in the calculation.

Through 2011, the exemption rule entitled only firms whose energy tax payments exceeded 3,7 percent of value added to be granted the exemption. The tax legislation was changed in December 2011 to reduce the threshold from 3,7 to 0,5 percent from January 2012 onwards, following an outcry from the industry after the energy tax rates were increased in the beginning of 2011. The changes in the energy tax rates and exemption threshold together brought along a notable increase in both the total amount of the tax refunds and the number of recipients. When only 13 firms received a refund in 2011, the number of recipients increased to around 140 in 2014. The total amount of taxes refunded increased from 7 million euros to over 200 million euros a year (Harju et al. 2016).

Figure 3.1. summarizes the change in the number firms receiving energy tax refunds (solid line), the amount of tax refunds paid from 2003 onwards, and the composition of the group of tax refund recipients in terms of the industrial sector. In terms of industries, paper manufacturing has received the largest proportion of the energy tax refunds, followed by chemical and plastic manufacturing and metals and minerals manufacturing.

Figure 3.1. The total amount of energy tax refunds and refund recipient firms from 2003 to 2016.



4 Research design

4.1 Difference-in-differences matching estimator

We seek to identify the average effect of energy tax exemption on plants within firms that qualified for the exemption as a consequence of the 2011-2012 energy tax reform. To identify this parameter, we adopt a difference-in-differences matching approach similar to the one used for example in Fowlie, Holland and Mansur (2012), Petrick and Wagner (2014), Wagner, Muûls, Martin and Colmer (2014) and Gerster and Lamp (2018). The approach exploits the longitudinal structure of our dataset and the rich information on plant characteristics, both in terms of economic variables and energy use.

In line with the potential outcome framework, let $Y_i(1)$ denote the outcome of plant *i* when the plant is energy tax refund recipient, and $Y_i(0)$ when the plant is not eligible for an energy tax refund. Let D_i denote the treatment indicator, and subscripts *t* and *t'* pre- and post-treatment periods, respectively. Let *X* denote a set of covariates. We seek to identify the average treatment effect on the treated (ATT):

$$\alpha_{ATT} = E[Y_{it'}(1) - Y_{it'}(0) \mid D_i = 1], \tag{1}$$

where *t'* refers to year following the 2011-2012 tax reform and α_{ATT} measures the average effect of the tax exemption on annual plant level outcome. The fundamental evaluation problem here is that outcome $Y_{it'}(0)$ is not observed for the treated plants. The matching approach constructs estimates of these counterfactual outcomes using outcomes observed for untreated plants that are observationally similar to the to the treated plant. The ATT can then be estimated from the sample equivalent of the expression

$$E[Y_{it'}(1) \mid X, D_i = 1] - E[Y_{it'}(0) \mid X, D_i = 0], \tag{2}$$

assuming conditional independence between outcomes and treatment status, $(y_{it}(0), y_{it}(1)) \perp D \mid X$. Unfortunately, in light of the energy intensity threshold for tax refund eligibility, the unconfoundness assumption appears too demanding for the policy context here.

However, the ATT can be identified under weaker assumptions by exploiting longitudinal information and focusing on differences-in-differences (DiD) outcomes. Heckman, Ichimura and Todd (1997) suggest estimating the ATT from the sample analogues of the population moments

$$D_{t',t}(X) = E\left[Y_{it'}(1) - Y_{it}(0) \mid X, D_i = 1\right] - E\left[Y_{it'}(0) - Y_{it}(0) \mid X, D_i = 0\right]. \tag{3}$$

To implement this, they suggest the following semiparametric conditional DiD matching estimator:

$$\widehat{\alpha_{ATT}} = \frac{1}{N_1} \sum_{j \in I_1} \left\{ \left(Y_{jt'}(1) - Y_{jt^0} \right) - \sum_{k \in I_0} w_{jk} \left(Y_{kt'}(0) - Y_{kt^0}(0) \right) \right\}. \tag{4}$$

Here, N_1 is the number of plants in the treatment group of refund recipients, I_1 the set of refund recipients and I_0 the set of plants not receiving energy tax refunds. The refund recipients are indexed by *j* and the non-recipients by *k*. Plant *k* is given weight w_{jk} when constructing the counterfactual estimate for treated plant *j*. The weight determines the extent to which counterfactual observation *k* contributes to the estimated treatment effect. The more similar a control plant *k* is to the treated plant *j*, the greater weight w_{jk} it receives. The specific weighting procedure depends on the matching algorithm.

The matching estimator identifies the ATT under the assumption that

$$E\left[Y_{it'}(0) - Y_{it}(0) \middle| P(X), D = 1\right] = E\left[Y_{it'}(0) - Y_{it}(0) \middle| P(X), D = 0\right]. \tag{5}$$

(Heckman, Ichimura and Todd 1998). In our application the assumption means that the counterfactual trends in the outcomes of the tax exempt plants do not systematically differ from those in the group of matched control plants.

A further identifying assumption is that matching is performed on a common support $X \in S\left(P\left(X\right)\middle|D=1\right)$ where the distributions of the covariates in the treatment and control groups overlap. Finally, in order to rule out spillovers and general equilibrium effects, it must also be the case the potential outcomes at one plant are independent of the treatment status of other plants. This assumption is generally referred to as the stable unit treatment value assumption (SUTVA). While the common support assumption is directly testable, unconfoundedness and SUTVA in principle are testable.

5 Data and matching algorithm

5.1 Data sources

Our principal dataset is the Longitudinal Database on Plants in Finnish Manufacturing (LDPM) panel from Statistics Finland. The LDPM panel starts from 1974 and comprises annual data from the universe of Finnish manufacturing plants that belong to firms with at least 20 employees. The dataset contains information on a wide range of economic variables such as revenue, value added, employment, wages, investment, total expenditure and the shares of electricity and other fuels in the total expenditure. The data are collected annually as part of a survey that compiles data for the Structural Business Statistics database of Statistics Finland. Firms are obliged to reply based on the Statistics Act (Act 280/04). We use LDPM data for the years 2007-2016.

Our other essential dataset is the Energy Use in Manufacturing database of Statistics Finland which starts from 2007 and provides establishment-level information on the use of electricity, heat and over 20 different fuel types. The data are collected through an annual survey that covers establishments in manufacturing and mining.[5] Again, firms are obliged to reply based on the Statistics Act (Act 280/04).

The complete list of energy tax refund recipient firms and refund sums for years 2007-2016 was obtained from the Finnish Tax Administration. The information was merged with the LPDM panel and energy use databases for years 2007-2016 by Statistics Finland on the basis of confidential firm identification numbers. The combined dataset contains information on establishment level economic outcomes, expenditure and energy use and firm level information on tax refunds for years 2007-2016.

[5] Establishments of ten or fewer employees are only included every fourth year.

5.2 Matching sample construction

The sample of plants that is used in each matching analysis is constructed as follows. From the overall combined dataset, we use plants that were in the data set in 2007 to 2010, the years before Finland's energy tax reform that our energy use data cover, and in at least one of the years 2015-2016. These plants are divided into treatment and comparison groups. The treatment group includes the plants that first qualified for the energy tax exemption in 2011 or 2012, and remained tax exempt through 2016. The comparison group only includes plants have never been tax exempt. That is, we remove plants that were exempt from energy taxes already prior to the 2011 energy tax reform, and plants that first became exempt after the tax reform but did not qualify in all the years 2012-2016. Furthermore, we remove plants for which information is missing on any of the observational characteristics that are used in matching and regressions for the pre-reform year 2010. For the baseline results on treatment effect on the treated for the post-reform years 2015 to 2016, we use all possible observations, irrespective of whether some or all of the information might be missing for some of the other years 2012 to 2016.

5.3 Matching algorithm

The nonparametric matching estimator constructs the counterfactual outcome estimate for each treatment plant using the control plants that most closely resemble the treatment plants. We use nearest neighbor covariate matching to construct the sample of plants that we use in the DiD matching analysis. We pair treatment and control plants by selecting for each treatment plant *i* the *m* nearest neighbors that most closely resemble it in terms of selected covariates. The *m* nearest neighbors receive a weight *1/m* while the weights for all other untreated (non-exempt) plants are set equal to zero. We impose a strict overlap condition in terms of the industry: only those non-exempt plants that operate in the same industries as the exempt plants are included in the pool of potential controls. In our base specification, we use 5 nearest neighbors.

As suggested by Abadie and Imbens (2006, 2011), we augment the matching estimation with a regression-based bias adjustment so as to mitigate potential bias indroduced by poor match quality. That is, after matching the treated plants with *m* nearest neighbors, within-pair differences are adjusted using a parametric regression of the control outcome on a set of covariates.

We require a strict match on the Statisticss Finland TOL 2008 two-digit sectoral classification code. The industry indicators are likely to be correlated with unobserved determinants of plant-level economic outcomes, including production technology characterisstics and demand for the good produced by the plant.

Our primary continuous matching variables are plant's total energy use and share of electricity in total energy use in the pretreatment period. Energy use is a better measure of plant size than the often-used measure employment in the case of energy intensive industries where production processes are highly automized. Electricity share is a proxy for plants energy tax burden. The taxes on most fossil energy sources were increased substantially more than the tax on industrial electricity use in the 2011 energy tax reform, and have also been on the rise in the consequent years while the tax on industrial electricity use has remained at its 2011 level. Our baseline specification matches on TOL2003 code, plant's energy use and plant's electricity share only. The larger the number of variables used for matching, the less accurately can one match on those variables that do not require exact matching. This speaks for a parsimonious specification.

Figure 5.1 illustrates the changes in the tax rates for different energy sources following the 2011 energy tax reform and the differences in the taxes for different energy sources. To enable straightforward comparison of energy taxes across energy sources we have expressed the taxes for all energy sources in terms of euro cents per MJ.

Figure 5.1. Tax rates for different energy sources 2010-2018. The taxes comprise the energy content tax and CO_2-tax (security of supply and value added taxes are not included).

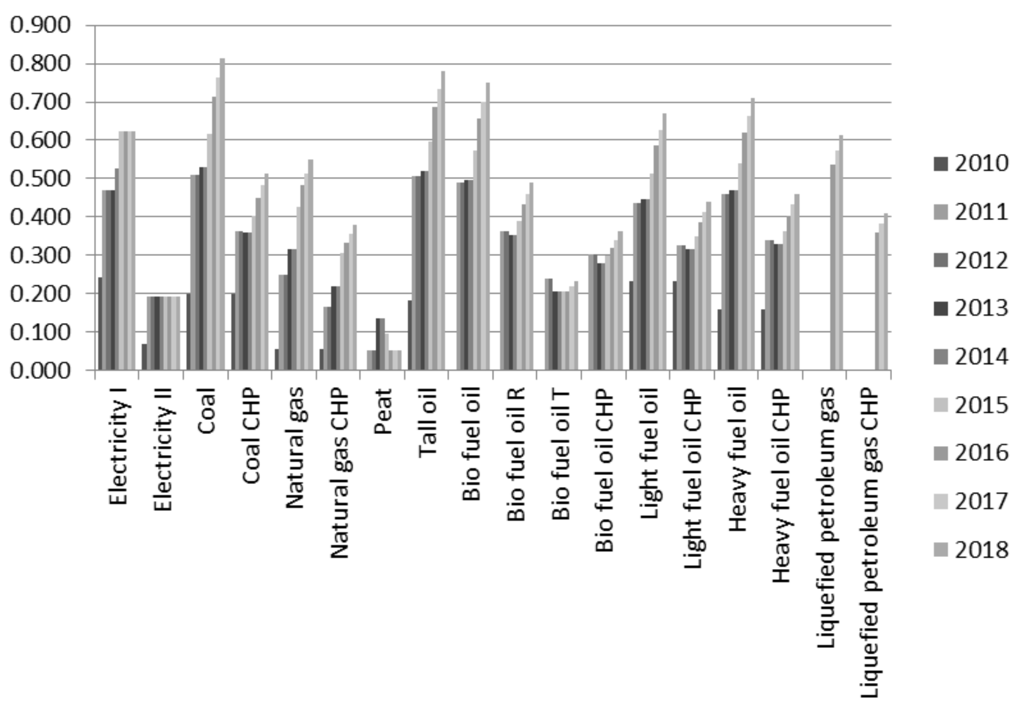


Table 5.1 presents descriptive statistics of the financial and energy use variables used in the econometric analysis. Altogether 128 establishments first became eligible for the tax refund in 2011 or 2012 and continued to receive tax refunds every year thereafter. The table displays the plants that have been eligible for the energy tax refund starting 2011 or 2012 but not before, then the matched control plants, and the overall group of newly tax exempt and control plants. Variable values are reported for the pre-treatment year 2010. The table shows that plants in the new energy tax refund recipient group are both larger on average and more heterogeneous than plants in the full sample or non-recipient control plants, as measured by gross value (output), turnover, value added, or number of employees.

The new tax refund recipients also used considerably more energy in total but were less energy efficient than the control plants. The energy mix of the newly exempt plants is less dominated by electricity (35 percent) than that of the control plants (44 percent).

The last row in the table shows the proportion of multiplant firms in each group. Of the new recipient plants, 91 percent belong in a multiplant firm. The proportion is lower in the group of the non-exempt control plants (41 percent).

Table 5.1. Descriptive statistics of the financial and energy use variables used in the econometric analysis.

	Energy tax exempt from 2011/2012			**Control**			**Total**		
Variable	**Mean**	**SD**	**Obs**	**Mean**	**SD**	**Obs**	**Mean**	**SD**	**Obs**
Gross value 2010, in million euros	98	125	128	22	29	116	62	100	244
Revenue 2010, in million euros	89	119	127	22	31	115	57	94	242
Value added 2010, in million euros	19	22	128	7	12	116	13	19	244
Wages 2010, in million euros	8	8	126	3	5	115	5	7	241
Employees 2010	184	193	128	85	117	116	137	169	244
Total energy use 2010, in TJ	767	1383	128	65	120	116	433	1063	244
Energy efficiency 2010, eur/GJ	669	1451	128	931	1462	116	794	1459	244
Share of electricity use 2010	0,35	0,22	128	0,44	0,23	116	0,39	0,23	244
Share of multiplant firms	0,91		128	0,41		116	0,67		244

Notes: We report the summary stastistics of the plants for which information is available for the pre-treatment years and years 2015-2016. The matched control group is restricted to plants in the same TOL 2008 two-digit industry sectors as exempt plants. The matching algorithm matches each exempt plant to many control plants. Matching is carried out with replacement, in order to avoid issues arising from the order in which matches for each plant are *selected. The overall number of matched controls is slightly smaller than the number of treated plants, which indicates that the same contro plants are used as matches for several treated plants.*

The summary statistics higlight a limitation of our matching strategy. Ideally, we would like to match each newly exempt plant with a large number of control plants in the same industry. However, the control plants with very similar historic outcomes is limited, which could have implications for match quality. In order to avoid any potential bias created by pre-treatment differences, our matching procedure is combined with a difference-in-differences approach. That is, we do not compare outomes (for example, revenue) between newly tax exempt matched non-exempt plants, but the change in the outcome (for example, revenue) between 2010 (before the tax reform) and post-reform years. Thus, the identification strategy is based on the assumption that conditional on the matching covariates, the outcomes of the exempt plants and non-exempt control plants would have followed parallel trends had the tax exemption not been extended to include the newly exempt plants in 2011-2012.

6 Results

We start out by plotting graphs of the economic and energy outcomes of the newly exempt plants and the matched control plants both before the 2011 energy tax reform and the change in the tax exemption threshold. The graphs in Figures 6.1 to 6.3 serve both to illustrate the post-reform differences, if any, in the outcomes of the exempt and non-exempt plants, and to evaluate the underlying assumption of parallel trends. While it is not possible to test the assumption of parallel trends in the outcomes of the tax exempt and matched control plants had the tax exemption rule not been changed, the assumption is more plausible if the two groups exhibited parallel trends prior to the 2011 tax reform.

Based on visual observation, the trends for the outcome variables mostly follow parallel trends 2011. Only for value added, we observe slightly different movement between 2007 and 2008. The trends also remain roughly parallel for the exempt and non-exempt plants after 2011 although there is notable year to year variation. No unidirectional difference is apparent in the movements of gross value, turnover, value added or wages for the two groups of plants. For employees, total energy use and gross value relative to energy use (a measure of energy efficiency) there is a gap between the exempt and non-exempt firms that seems to widen some for gross value relative to energy use, and close some for employment towards the end of the period that our data cover.

Table 6.1 shows how significant the differences in the outcomes of the exempt and non-exempt plants are from a statistical point of view. Our outcomes of interest are the changes in plant-level economic performance and energy use measures. For a long-term view of the overall effects of the tax exemption on the plants that became exempt in 2011-2012, we analyze changes in plant-level outcomes between the last pre-treatment year 2010 and years 2015-2016. We report results generated using log transformed data, so the average treatment effect on the treated[6] can be interpreted as the estimated average effect in percentage terms. Standard error estimates have been constructed using the Abadie and Imbens (2006) variance formula. Exempt plants were matched to the five nearest neighbors within the same TOL 2008 two-digit industry.

Recall that the estimates in Table 6.1. compare the most recent years in the data, 2016-2015, to the last pre-treatment year 2010. The estimated coefficient for gross output is -0,37, which suggests that gross output grew 37 percentage points less between 2010 and 2015-2016 among exempt plants than among non-exempt plants. The coefficient is significant at the 1 percent level. The 95 percent confidence interval for the coefficient also only spans negative values. However, the trends for gross output indicate substantial year to year variation in the average gross output development.

The estimated coefficients for turnover, value added, wages, employees and total energy use are not statistically significant at conventional levels. The point estimate for turnover (revenue) is negative, for value added positive but much smaller in magnitude. The point estimate for wages is negative, the point estimate for employees positive. Both are close to zero in magnitude. The 95 percent intervals for these coefficients are quite wide and encompass both negative and positive values. Thus, for these outcome variables both negative and positive effects are reasonably compatible with the data. Overall, the results are most compatible with the energy tax exemption having no effect on the long-run growth in turnover, value added, wages, employees or total energy use.

The estimated coefficient for energy efficiency (gross value per total energy use) is $-0{,}52$. Here, exempt plants appear to have become slightly less energy efficient between 2010 and 2015-2016 whereas the energy efficiency of non-exempt plants has overall remained close to its 2010 level (Figure 6.3). The 95 percent confidence interval for the coefficient only spans negative values. Thus, the results are most compatible with a widening gap between the energy efficiency of exempt and non-exempt plants, to the benefit of the non-exempt plants.

The trends in the outcome variables shown in Figures 6.1 to 6.3 exhibit notable year to year variation. This should be born in mind when interpreting the results. For most outcome variables, no clear pattern emerges

[6] That is, the average effect of the energy tax exemption on the plants exempt starting 2011-2012.

for the differences between the exempt and non-exempt plants after the 2011-2012 tax schedule changes. Based on visual observation, the difference is unidirectional to a degree for gross output and energy efficiency. Overall the results are most compatible with no important effect of the energy tax exemption on turnover, value added, wages, employees or total energy use, and if anything a negative impact on gross value and energy efficiency.

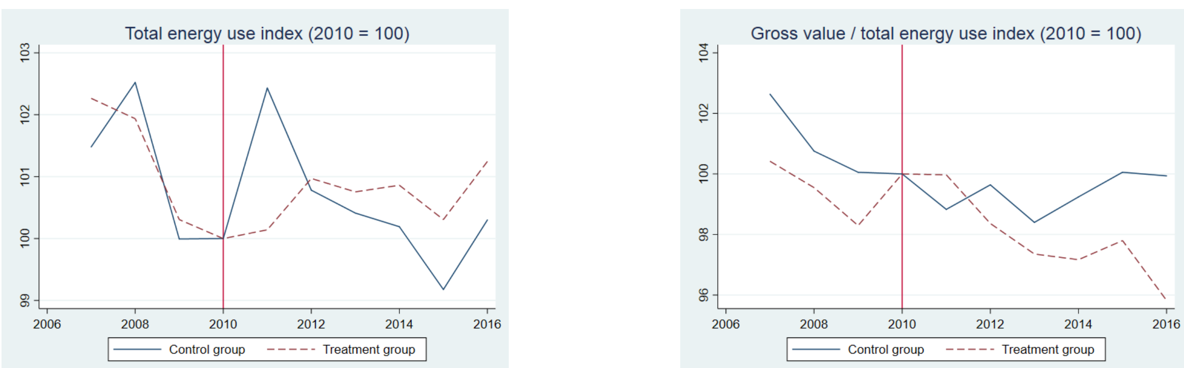
Figure 6.1. Gross value, revenue (turnover) and value added for newly exempt (from 2011/2012 onwards) plants and matched non-exempt plants, 2007-2016

Note: Graphical representation of the difference-in-differences approach. The effect of the energy tax exemption is assessed statistically by comparing the trends of the exempt plants and the matched non-exempt plants. Notation: treatment group includes plants that became tax exempt in 2011/2012, control group matched non-exempt plants.

Figure 6.2. Wages and employees for newly exempt (from 2011/2012 onwards) plants and matched non-exempt plants, 2007-2016

Note: Graphical representation of the difference-in-differences approach. The effect of the energy tax exemption is assessed statistically by comparing the trends of the exempt plants and the matched non-exempt plants. Notation: treatment group includes plants that became tax exempt in 2011/2012, control group matched non-exempt plants.

Figure 6.3. Total energy use and energy efficiency (gross value per energy use) for newly exempt (from 2011/2012 onwards) plants and matched non-exempt plants, 2007-2016



Note: Graphical representation of the difference-in-differences approach. The effect of the energy tax exemption is assessed statistically by comparing the trends of the exempt plants and the matched non-exempt plants. Notation: treatment group includes plants that became tax exempt in 2011/2012, control group matched non-exempt plants.

Table 6.1. The average effect of the energy tax exemption on 2015-2016 outcomes

Dependent variable	Gross value (Log)	Turnover (Log)	Value added (Log)	Wages (Log)	Employees (Log)	Total energy use (Log)	Energy efficiency (Log)
Coefficient	-0,37***	-0,16	0,07	-0,05	0,01	-0,09	-0,52***
SE	0,09	0,16	0,16	0,08	0,07	0,08	0,11
p	0,000	0,30	0,67	0,53	0,89	0,29	0,00
Lower bound of 95 percent confidence interval	-0,56	-0,47	-0,25	-0,21	-0,14	-0,25	-0,73
Upper bound of 95 percent confidence interval	-0,19	0,15	0,38	0,11	0,16	0,07	0,31
Number of observations	338	335	315	332	339	339	338
Number of treated	128	127	119	127	129	129	128
Number of controls	210	208	196	205	210	210	210

7 Conclusions

TBA

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