# The impact of energy prices on firms' financial and environmental performance

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## Abstract

This dissertation examines the impact of energy prices on firms' financial and green performance. The analysis is conducted using firm-level data for more than 15 thousand firms of 14 different industries in Portugal between 2010 and 2017.

The motivation behind this study is related with the growing importance of sustainability and the need of more environmental-friendly practices on business, furthermore, the absence of an empirical research exclusively for Portugal and the current energy crisis also inspire the realization of this work.

The results show that increasing energy prices leads to a positive and significant effect on investment, however no significance for firms' profitability and not a conclusive effect is found for overall employment. Moreover, the idea that higher energy prices induce companies towards more green practises does not hold, in fact for green investment and green employment no significance is found and for green revenues and green expenses, an increase in energy prices leads to a decrease in these variables.

Additionally, an extension of the study to each industry and different energy dependence level is also performed to uncover some heterogeneity effects not shown in the aggregate results.

The conclusions shed light on how and to what extent energy price affects firms and calls to policy makers to design a more comprehensive energy-policy that contributes to shifting firms to a greener state of business.

# Resumo


A presente dissertação analisa o impacto dos preços da energia na performance financeira e ambiental das empresas. A análise é realizada usando dados ao nível da empresa para mais de 15 mil empresas de 14 indústrias diferentes em Portugal entre 2010 e 2017.

A motivação por detrás deste estudo prende-se com a crescente importância da sustentabilidade e da necessidade de incorporação de práticas verdes nas empresas, adicionalmente a ausência de uma investigação empírica exclusiva a Portugal e a atual crise energética também inspiram a realização deste trabalho.

Os resultados obtidos mostram que o aumento dos preços energéticos tem um efeito positivo e significativo no investimento das empresas, no entanto não têm um efeito significativo na rentabilidade e varia no que toca ao nível de emprego. Além disso, a ideia de que os aumentos dos preços energéticos induzem as empresas a práticas mais verdes não se verifica. De facto, para investimentos e emprego verde não foi encontrada significância nos resultados e no que respeita receitas e despesas verdes, um aumento nos preços da energia leva a uma diminuição das mesmas.

A análise é também estendida para cada indústria e para diferentes níveis de dependência energética com o intuito de evidenciar alguns efeitos divergentes dos resultados gerais.

As conclusões encontradas elucidam sobre como e em que medida o preço da energia afeta as empresas e apelam aos responsáveis políticos para que desenvolvam uma política energética mais abrangente que oriente as empresas a uma melhor performance ambiental.

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## Glossary

CAE – “Código de Atividade Económica” (Economic Activity Classification)

$CO_2$ – Carbon dioxide

DGEG – “Direção Geral de Energia e Geologia” (Energy and Geology Office)

Eur – Euros

FE – Fixed effects

GJ – Gigajoules

GVA – Gross value added

IPCC – The Intergovernmental Panel on Climate Change

kWh – Kilowatts per hour

Log – Logarithmic

MWh – Megawatts per hour

OECD – Organisation for Economic Co-operation and Development

OLS – Ordinary Least Squares

Toe – ton of oil equivalent

# 1. Introduction

According to the IPCC (2014), the industry sector emits about a fifth of the global greenhouse emissions directly and a significant part indirectly, consequently, concerns about the environmental issues of such emissions has risen. Moreover, the energy dependency of this sector to fossil fuels and therefore the fragility of industrial firms to energy prices' changes have incentivize a growing number of firms to direct their investment to low pollution or energy-efficient technology, create more job positions in roles related with environmental responsibilities, spend more in pollution prevention, reduction and control and shift their production to greener products and services.

However, the question whether economic and environmental performance can create a win-win situation has still no single answer and the doubt about it weighs on the decision of companies to transit to a cleaner way of doing business. On one hand the conventional view states a conflict between both economic and environmental performance since environmental policies restrict firms' lucrative opportunities, and in other hand some authors defend that well developed and targeted policies can create a competitiveness advantage to firms. A lot of studies have approached this question however no conclusive evidence was reached.

Due to the availability and comparability of energy prices between industries and countries, this variable has been used on literature to a proxy of environmental regulations, therefore this dissertation hopes to contribute to the large literature of sustainability and energy policy in two main ways, first by not only assessing the impact of energy price on green and non-green investment and employment of firms but also examines the impact of energy prices on the green profitability channel, looking over green expenditure and green revenues, which few studies do, and second by extending the analysis to different industries and different energy dependency levels that can contribute to a more efficient and targeted policy making.

Methodologically, the paper uses a multiple linear regression model in an OLS method with year and firm or industry fixed effects. The results show no significant effect of energy prices on firms' profitability, emphasizing that firms might not choose to mitigate this input price increase in their profits but other possible ways. For investment a positive and significant effect is found, a rise of 1% of the energy price leads to an increase between 2% and 3%, this relationship holds for most industries and different levels of energy dependency, evidencing a complementarity between both production factors. Lastly for employment no conclusive result is found as the impact felt by the price of the energy input varies on significance and sign depending on the fixed effects used.

When it comes to green performance, there is almost any economically meaningful effects. For green investment and green employment, no significance is found and for green expenditure and green revenues an increase of 1% on energy prices leads to a decrease of between 0.3% and 2% and between 2% and 3%, accordingly, however these findings are only statistically significant for the model considering both year and industry fixed effects.

Furthermore, for green performance, some divergent effects are found when analysing industries separately, for example the food, beverage, and tobacco, chemical and plastics, metal, and electro-metal-mechanical industries evidence a positive and significant effect of energy prices increase on the green revenues, and for the textile industry a 1% increase in energy prices leads to an increase in green investments around 2%, with statistical significance at a 10% level.

However dividing firms by energy dependency level doesn't not seem to explain heterogeneity between firms as most of the levels do not reveal any statistical significance.

This paper proceeds as follows: section 2 highlights the motivation behind the paper, section 3 outlines to what extend energy prices can be used as environmental regulation and section 4 reviews the literature of the impact of energy prices on firms' financial and green performance. Section 5 provides the methodology of this study, where section 6 describes the datasets and data used and in section 7 the summary of descriptive variables is presented. In section 8 the empirical results are analysed and in section 9 limitations to the study are discussed. Lastly, section 10 concludes the paper.

# 2. Motivation

Sustainability has become one of the main topics of the 21st century, growing concerns regarding climate change and its impact in the lives and business led to a transition in the direction of consumers and companies to operate in a more environmental-friendly way.

To cope with these apprehensions, governments designed environmental policies to alleviate possible related consequences and accelerate the green transition. The reach of these policies and if it fulfils its goal has become an increasing field of research, even though this dissertation does not focus on the impact of environmental policies, it covers the way that companies respond to energy prices shocks, which can be informative about the reaction to such policies (Dussaux, 2020).

The motivation behind this paper is also to seek deepening the knowledge regarding the impact of energy prices on the business of Portugal, since most studies consider a specific country, different than Portugal or a group of countries where Portugal makes part, not being possible to isolate the impact for this country.

The study of Portugal, and in specific the manufacturing sector, has a great interest since a constant increase in energy prices and lack of resources to take on alternatives could drive out business to neighbour countries, making it a disadvantage to Portuguese companies comparing to other countries.

Moreover, the current energy crisis, shed light in a major problem of the manufacture industry which was the lack of preparation and adaptability to deal with such energy increases. In fact, the recent and rapid rise of the energy prices impacted firm's margins, investment and financing leading to some manufactures to reduce or even stop production, and others to cease investment in Portugal (Silva, 2021).

Understanding the potential trade-off between environmental and economic performance, knowing what happens to companies when an energy shock happens is essential to mitigate and take advantage of future shocks.

# 3. Energy prices and environmental regulation

Concerns with climate change, led to policymakers to launch more restrict environmental regulation, consequently, a lot of new studies have appeared to measure and understand the true impacts of this environmental regulations. However, because environmental policies data its scare and difficult to make comparable across countries or sectors, to overcome this limitation, energy prices are often considered a proxy to these regulations (Ley, Stucki, & Woerter, 2016).

Dlugosch and Kozluk (2017) give some insights to what degree energy prices could be used to a direct proxy of environmental regulations. Environmental regulations act in the same way as energy prices in the sense that both increase the price of inputs to the firms. According to the authors:

> "*fluctuations in energy prices will reflect, inter alia, both market-based upstream policies (e.g. a carbon tax) and command and control regulations (e.g. air pollution norms) relevant to energy and the firm's exposure to a tightening of climate mitigation policies will to a large extent be via a higher energy price paid*" (Dlugosch & Kozluk, 2017, p. 9).

Therefore, the proximity regarding both, is an incentive to use energy prices as environmental regulation, for instance, part of the $CO_2$ emissions come from energy consumption, so regulation limiting it can also indirectly affect energy consumption.

Nevertheless, energy prices do not cover the full spectrum of environmental regulations, the major differences are related to the duration, concentration and reach of the effect. Energy prices happen mainly in short-run shocks and are not controlled by governments, whether environmental regulations are purposely done and last longer, therefore incentivizing more investment and adjustments in a long term. Energy prices global shocks do not have the same impact when compared with environmental regulations concentrated in a specific firm, sector, or country, the last can become an advantage to the ones not restricted by the regulation. Moreover, energy prices shocks influence companies to decrease their energy inputs, such as consumption, to invest in technologies related energy saving or just to cope with higher prices, whether environmental regulation have a much higher reach, also influencing companies to change their governance or management practises or investing in less pollutant or other technologies not necessarily related with energy.

# 4. Literature Review

## 4.1. The impact of energy prices and short-term responses

Rentschler, Kornejew and Bazilian (2017) identified two ways that firms can be affected by energy prices, one is directly felt in the price of the energy that they used, and the other is indirectly felt in the cost of intermediate goods, which has the strongest impact (Tambunam, 2015, as cited in Rentschler, Kornejew, & Bazilian, 2017).

To respond to these effects, the authors also characterized four ways that firms can take on to limit its impact. Regarding operational optimization firms can decide to absorb the increase of the input price into their profits without changing any output price or quantities, this decision is shown when analysing the changes on profit or costs shares as well as the change in the ratio between profits and energy costs and it affects the firm competitiveness. Additionally, firms can also opt for substitute their energy mixes, choosing cheaper types of energy, even if the total consumption of energy keeps the same. However, the inter-fuel substitution ability depends on various factors, such as regional and market access to other energy fuels, capacity of adapting production to the substitute fuel and financial capacity to take the necessary measures. Lastly regarding operations optimization firms can also focus on improving their energy efficiency.

In other hand, market wise, firms can also pass-on the costs associated with the energy prices increase to costumers, by increasing the price of the unit sale. Even though this measure protects firms' profits it has some limitations. First it depends on the costumer's wiliness to pay and the availability of market substitutes for costumers, second it is also influenced by the level of competition within an industry and the market power of a firm.

In a more medium- or long-term firms can decide to response to higher input prices by change other production factors, such as capital, by investing in technologies capable of responding to the energy prices shocks, for example energy-saving technologies or fuel-hybrid machines, and labour, by either increasing it or decreasing, according to their strategy. Firms can take advantage of financial markets and hedge energy prices so they can limit the direct effect felt (Gerken, Plantefève & Veillard, 2019) however this requires not only access to the markets but specific knowledge.

Additionally higher energy prices can also decrease firms profits and affect its competitiveness in the domestic country as outside competitors face a relative advantage (Dechezleprêtre & Kruse, 2018).

When it comes to empirical research on energy prices and profitability, Rentschler and Kornejew (2017) found that energy prices have a slight negative impact on the profits of manufacturing firms. However, his effect depends on the importance of an energy type in a firm and the sector at which it belongs. The study also found that firms respond to energy prices increases by adjusting their energy mixes, being more energy efficient and by passing the energy cost to costumers.

Moreover, profitability of firms in high energy intensity seems to be the most affected, Khattab (2007, as cited in Rentschler & Kornejew, 2017) found this effect for Egypt, when energy prices doubled.

Arlinghaus (2015) review the literature on profit margins and carbon taxes, an environmental policy that often turns in an energy price shock (Rentschler & Kornejew, 2017), and highlight that little or no negative impact was found between carbon taxes and firms' profits (Zachmann, Ndoye, & Abrell, 2011; Yu, 2013).

### 4.2. The impact of energy prices on employment

The impact of energy price on employment differs when considering short-run or long-term. In the short or medium run, the impact of energy prices has on employment could have contradictory effects. First as energy prices rise so does production costs and output prices leading to decrease in the quantity demanded. With the output contracted and demand falling, in other to cope with higher costs, firms might put in risk jobs positions especially in high energy dependent sectors due to less flexibility to adapt to higher costs. Second, if labour and capital are substitutes firms could increase their employment level. This effect happens because capital does not increase productivity, producing the same amount of goods but now at a higher cost, making capital goods more expensive relative to labour, therefore firms might choose to focus on getting more staff to compensate the higher rental rate of productive capital (Deschenes, 2018; Dechezleprêtre, Nachtigall, & Stadler, 2020). In other hand, firms can choose to invest in more energy-efficiency technologies, increasing not only output but also employment (Bijnens, Hutchinson, Konings, & Guilhem, 2021).

The dominated effect is not certain, the impact of energy prices on job positions in the short run has mainly an empirical approach, it depends not only if a firm is high energy dependent, but also on industry competition, market power, since market dominant firms can pass-on their costs to consumers, and financial constraints, companies with more financial constraints have lower access to financial resources or higher costs associated to them and therefore in order to cope with it need to lower more their employment (Bijnens et al., 2021).

However, in the long term these effects seem to vanish, with companies investing in more energy-efficiency technology and creating or adaption jobs to it, or job losses being offset by new ones in surviving firms, in less energy dependent industries or in other sectors. (Fankhauser, Sehlleier, & Stern, 2008). The transitional movement of jobs not shown in the long term could be reflected in adjustments cost in the short run (Dechezleprêtre et al., 2020).

Dechezleprêtre et al. (2020) found that, between 2000 and 2014 for the manufacture industry of 21 OECD countries, in which 26% of the firms in the sample were from Portugal, energy prices had a significant negative impact of on employment at a sector level, 1% increase of energy prices would lead to a decrease of employment of 0.05%, being most pronounced in energy-intensive sectors. Contrary at a firm-level the impact was significant and positive. The difference between both was due to business dynamics, the higher energy prices pushed firms out of the industry allowing surviving ones to growth and increase their employees.

Similarly, Marin and Vona (2017) estimated a negative relation between employment and energy prices at sector-level analysis for French manufactures between 1997 and 2010, being most concentrated in higher energy-dependent and trade-exposed subindustries.

Dussaux (2020) used data of 8,000 French manufacture firms over the period of 2001 to 2016 and by performing a short-run analysis using Two Stage Least Square model found that even though higher energy costs lead to decrease in energy use, the impact on aggregate industry employment was not significant, mainly due to the movement of employees from energy-intensive firms to energy-efficient. This justification was found after the authors analyse the net employment at a firm-level and uncover that large firms with high energy intensity decreased employment with the rise of energy prices whether energy-efficient ones increase and surviving small firms would not be affected.

## 4.3. The impact of energy prices on investment

As it was mentioned before, in a medium, long run companies can respond to higher energy prices and environmental regulation by updating their production factors such as capital and labour.

When it comes to capital investment, Hicks (1932) introduced the idea of induced innovation which states that relative prices of production inputs contribute directly to innovation in technologies less intensive in that factor, and therefore increases the investment of a firm. The innovation would allow to limit the decrease in output as well to enable an easier substitution of inputs (Marin & Vona, 2017), but the innovation might only compensate the cost associated with it in the long run (Dechezleprêtre & Kruse, 2018).

Another point of view looks to the increase or decrease of firms' investment when the production costs increase, due to higher energy prices, depending on if energy and capital are complements or substitutes, in the first case a rise in the energy input makes decrease the level of investment whether in the second makes it higher (Costantini & Paglialunga, 2014).

Bijnens, Konings, & Vanormelingen (2018) using a fixed effect model study the impact of electricity prices on the employment and investment in the manufacture sector of Belgium, Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, and United Kingdom, and showed that, for the period of 2008 to 2015, the employment elasticity was statistically significant and on average -0.30, and that the investment elasticity was also significant and on average -0.55.

In a more recent study by Bijnens et al. (2021), the results follow the same as previous, with elasticity of employment to electricity of -0.2 and next year investment elasticity between -0.2 and -0.5 for 200,000 manufacture firms in Belgium, France, Germany, Italy, the Netherlands, and the United Kingdom over the period of 2009 and 2017.

Dlugosch & Kozluk (2017) looked over listed manufacture firms of 30 OECD between the period of 1995 and 2011 and use a fixed-weight energy price level, with baseline 2010, to analyse the interaction between energy prices, environmental policies, and investment. The authors provide evidence that on average higher energy price led to lower investment, however the impact changes when considering the energy intensity of a sector, in the case of high energy sectors, increasing energy prices led to an increase in investment whether in low intensive sectors led to a decrease.

## 4.4. The impact of energy prices on firms' green output

The growing trend where firms need to comply with environmental regulation is shifting the business towards more sustainable practices. Energy prices shocks are expected to push in the same direction, as more sustainable fuels became cheaper as well as technology related to them.

Porter and van der Linde (1995), follow the concept of induced innovation, previously mentioned, and defended that environmental regulation can trigger innovation not only by incentivizing investment in new technologies but also by reducing costs due to opting for more cheap inputs or having less waste production process. The authors also introduced the Porter Hypothesis that states an early-mover advantage for the firms that engage in innovation due to the environment regulation.

Opposing to the Induced Innovation and Porter Hypothesis, the conventional view defends that firms seek profit maximization opportunities, so an increase environmental regulation creates inefficiencies to firms, since it takes away resources from productive investments to environmental related ones (Walley & Whitehead, 1994; Jaffe, Peterson, Portney, & Stavins, 1995) considering that the environmental don't have the highest return. And even if profit margins increase due to the early mover advantage, the cost of capital can be high, so the benefits might not translate in the rate of return on investment (Kruse et al., 2020), this happens because green innovations have a higher risk associated to them and are often outside of the topical's firm technology expertise (Ley et al., 2016).

For the green utility sector, the focus on green goods contributes to the firm's economic performance, making green firms improve their green revenues (Kruse, Mohnen, Pope, & Sato, 2020), some authors also found that energy prices shocks are one of the main driver's green energy stocks (Ahmad, 2017; Xia, Ji, Zhang, & Han, 2019; Dutta, Jana, & Das, 2020) however when it comes to firms in a non-green sector, such as most of the firms in the manufactory industry, there is still not enough market incentives that would make these firms change drastically to a greener market (Kruse et al., 2020) therefore there is still no conclusive evidence regarding the impact of energy prices on green practises.

Ley et al. (2016) analysed the relationship between energy prices and green investment innovation over 1980 and 2009 for 10 industries of 18 OECD countries and found that energy prices seem not only to promote the level of green innovation but also in the percentage of green innovation to non-green innovations, a 10% rise in the average price of the last 5 years results in more 3,4% number of green innovations and more 4,8% in the share of green to non-green innovations.

Popp (2002) uses data from 1970 to 1994 to examine the impact of energy prices on the share of energy efficient technologies, based on United States patent data. The author showed that a short-run elasticity of energy patents to energy price of 0.125 and a long-term elasticity of 0.625, both statistically significant.

Similarly, Aghion, Dechezleprêtre, Hemous, and Van Reenen (2016) also found a positive significant impact of energy prices on clean patents for the auto industry of 80 countries, between 1965 and 2005, more specific around 10% increase in the number of clean patents with 10% increase in energy prices. Firms with previous bigger stocks of clean patents were more encouraged to keep investing in clean patents when energy prices soar than the ones with more dirty patents in the past.

According to Johnstone, Hascic, and Popp (2008), who look over 25 countries between 1978 and 2003, firms increase their renewable energy technology investment when electricity prices go up, however it is only significant for solar related technology.

Dussaux (2020) also approached the effect of energy prices on green innovation investment. The author found that an increase in energy price of 10% encourage large firms to filed on average more 6,3% stocks of patents, and small firms less 3,5%. And at a plant-level, an increase of the input price of 10% would lead firms to increase 5% in their end of pipe investment, especially around 7% more in air and waste pollution control technologies and 5% more in water pollution abetment investments.

When it comes to green revenues and green costs, there is little doubt that introducing environmental policies leads to more pollution abatement costs (Kruse et al., 2020) or regulation costs associated with the policies, however there is little studies examining the impact of energy prices on it, most focus on the costs and benefits associated with green innovation or use the green costs as proxy to environmental regulation and study the impact on firms' economic performance. This paper aims to target this issue, contributing to new empirical studies on the impact of energy prices on green operational economic performance.

Lastly, as it was seemed before, whether labour increases or decreases with the shocks of energy price depends on substitutability or complementarity between both factors, however even if there is no consensus at the aggregate level, changes in energy prices can impact the creation or not of green jobs.

For policy makers this issue gets greater importance, since even though higher energy prices can influence the creation of green jobs, a lot of the jobs in manufacturing and energy-intensive jobs can be lost (Furchtgott-Roth, 2012).

Pestel (2019) founds that switching towards more renewable sources, which can be a result from the rising prices of dirty energies, increases employment in renewable energy sector, and by improving environmental quality, labour productivity also improves.

The job creation would be mainly influenced by the transition to a cleaner state of business and not only due to increasing higher energy prices. Green jobs can growth through the investment in cleaner technologies, Wei, Patadia and Kammen (2010) found that in fact cleaner technologies created more jobs per unit energy than dirty energies.

# 5. Methodology

## 5.1. Models and variables definition

To understand the impact of energy prices on firms, a log-log multiple linear regression model was applied using OLS method, the log-log transformation allows the results to be analysed as elasticity. First it is analysed financial variables, such as profitability, overall investment, and overall employment:

$$(1)\ \ln\left(Costs\ Shares_{i,t}\right) = \alpha_1 + \beta_1 \ln\left(EnergyPrice_{s,t}\right) + \beta_2\ Firm\ Size_{\ i,t} + \beta_3 \ln(Energy\ Intensity_{i,t}) + \beta_4 \ln(Productivity_{i,t}) + \xi_i\ or\ \eta_s + \mu_t + \varepsilon_{i,t}$$

$$(2)\ \ln\left(Employment_{i,t}\right) = \alpha_1 + \beta_1 \ln\left(EnergyPrice_{s,t-1}\right) + \beta_2\ Firm\ Size_{\ i,t-1} + \beta_3 \ln(Energy\ Intensity_{i,t-1}) + \beta_4 \ln(Productivity_{i,t-1}) + \xi_i\ or\ \eta_s + \mu_t + \varepsilon_{i,t}$$

$$(3)\ \ln\left(Investment_{i,t}\right) = \alpha_1 + \beta_1 \ln\left(EnergyPrice_{s,t-1}\right) + \beta_2\ Firm\ Size_{\ i,t-1} + \beta_3 \ln(Energy\ Intensity_{i,t-1}) + \beta_4 \ln(Productivity_{i,t-1}) + \xi_i\ or\ \eta_s + \mu_t + \varepsilon_{i,t}$$

Following Rentschler and Kornejew (2017) approach, to understand the energy price impact on profitability, it is used cost shares instead of profit margins. The reason for this is that profit margins are mainly negative, and a log transformation would result in larger loss of observations than considering cost shares. In this case the cost shares of a profitable firm will stay between 0 and 1. The variable Costs Shares is defined as the ratio between operational costs and revenues, both given in euros, of firm *i* on year *t.*

Additionally, Investment is defined as the value given in euros of a firm's investment in tangible assets, biologic assets, and investment proprieties per firm *i* and year *t,* and Employment is the number of employees per firm *i* and year *t.* Since employment and investment on year *t* is decided at year *t-1* (Bijnens et al., 2021), all explanatory variables of the models that include investment and employment are lagged one year.

Regarding the control variables, Firm Size is defined as the logarithmic value in euros of tangible assets for each firm *i* and each year *t*, Energy Intensity is defined as the ratio between the value of expenses related with energy and the gross value added, both given in euros, of a firm *i* on year *t*, and Productivity is defined as gross value added, given in euros, per employee of a firm *i* on year *t*.

Energy Price is defined as the industry price of energy for industry $s$ at year $t$. The price is given in euros per toe.

All estimations include year, $\mu_t$, and firm, $\xi_i$, or industry, $\eta_s$, fixed effects to account for any unobservable effect that could impacted energy prices or the dependent variables.

In the second part of the analysis, the paper focus on green data. The goal is to see how energy prices impact the green output of firms. The following OLS models are used:

$$(4)\ \ln\left(GreenRevenues_{i,t}+1\right)=\alpha_1+\beta_1\ln\left(EnergyPrice_{s,t}\right)+\beta_2\,Firm\,Size_{\,i,t}+\beta_3\ln(Energy\ Intensity_{i,t})+\beta_4\ln(Productivity_{i,t})+\ \xi_i\ or\ \eta_s+\ \mu_t+\ \varepsilon_{i,t}$$

$$(5)\ \ln\left(GreenExpenditures_{i,t}+1\right)=\alpha_1+\beta_1\ln\left(EnergyPrice_{s,t}\right)+\beta_2\,Firm\,Size_{\,i,t}+\beta_3\ln(Energy\ Intensity_{i,t})+\beta_4\ln(Productivity_{i,t})+\xi_i\ or\ \eta_s+\ \mu_t+\ \varepsilon_{i,t}$$

$$(6)\ \ln\left(Green\ Investment_{i,t}+1\right)=\alpha_1+\beta_1\ln\left(EnergyPrice_{s,t-1}\right)+\beta_2\,Firm\,Size_{\,i,t-1}+\beta_3\ln(Energy\ Intensity_{i,t-1})+\beta_4\ln(Productivity_{i,t-1})+\xi_i\ or\ \eta_s+\mu_t+\varepsilon_{i,t}$$

$$(7)\ \ln\left(Green\ Employment_{i,t}+1\right)=\alpha_1+\beta_1\ln\left(EnergyPrice_{s,t-1}\right)+\beta_2\,Firm\,Size_{\,i,t-1}+\beta_3\ln(Energy\ Intensity_{i,t-1})+\beta_4\ln(Productivity_{i,t-1})+\xi_i\ or\ \eta_s+\mu_t+\varepsilon_{i,t}$$

Green Expenditure is value of expenses, in euros, related to actions for pollution control, prevention, and reduction, including the contracting of specialized services and/or the payment of compensation for management purposes to waste management entities, per firm $i$ and year $t$.

Green Revenues is defined as the value in euros of income earned related to actions of control, prevent and pollution reduction, per firm $i$ and year $t$.

Green Investment is defined as the value of investment, given in euros, in technologies and/or equipment to reduce impacts on the environment, per firm $i$ and year $t$.

Green Employment corresponds to the number of employees with functions related with environmental roles, per firm $i$ and year $t$.

For all green dependent variables, it was added one, so that no observations are loss when employing the logarithmic transformation.

Furthermore, the same reasoning that was applied to Investment and Employment is applied to Green Investment and Green Employment, and all explanatory variables of these models are lagged one year. Moreover, control variables include firm size, energy intensity, and productivity and are defined as previously, as well as fixed effects.

All regressions results are clustered at firm level to overcome possible correlation errors.

For more detail regarding variables definition, see **Table *IX*** on Appendix A.

## 5.2. Construction of explanatory variable: Energy Prices

Following the Sato, Singer, Dussaux, and Lovo (2019) approach, energy prices were constructed considering the energy mixes of the different industries in the manufacture sector:

$$(8)\ Energy\ Price_{s,t} = \sum_j \frac{Fuel_s^j}{\sum_j Fuel_s^j} * P_t^j = \sum_j w_s^j * P_t^j$$

Energy prices are formed at industrial level, with Fuel being the consumption of the type of fuel *j* in industry *s*, P is the energy price of the type of fuel *j* on year *t* and *w* the weight of fuel *j* on year *t.* The fuels considered were electricity, natural gas, and diesel.

The formula given is a fixed weights energy price, using the fuel weights of 2010, therefore it assumes that any changes in the global price are due to changes in the fuels price and not in changes in the energy mix used by industries.

The prices of each fuel given in euros per unit was converted to euros per ton of oil equivalent allowing comparisons between the fuels and the construction of the energy price.

# 6. Data

## 6.1. Firm Data

Firms' data to construct the dependent and control variables, such as employment, investment, cost shares, productivity, energy intensity, and size, was taken from a database based on a national query - Sistema de Contas Integradas das Empresas (SCIE) - for companies located Portugal in sections A to S of CAE, excluding section K and O. The query covers the period from 2008 to 2019.

## 6.2. Green Data

The green practices data was obtained from a national query: Inquérito às Empresas Gestão e Protecção do Ambiente (IEGPA), between 2010 and 2017 to operating companies in Portugal, with main activity classified in the divisions 5 to 36 of CAE.

The query was made on an annual basis and covers the financial information regarding the amount of green investment, green expenditure, and green revenues and green employment which were used to construct the green dependent variables.

## 6.3. Energy Prices Data

Energy prices were gathered from DGEG – Estatística Energia. The database covers the price for natural gas, diesel, and electricity from 1985 to 2021 for all industrial consumers. All prices include all taxes and levies and can be found on **Table *X*** of Appendix B.

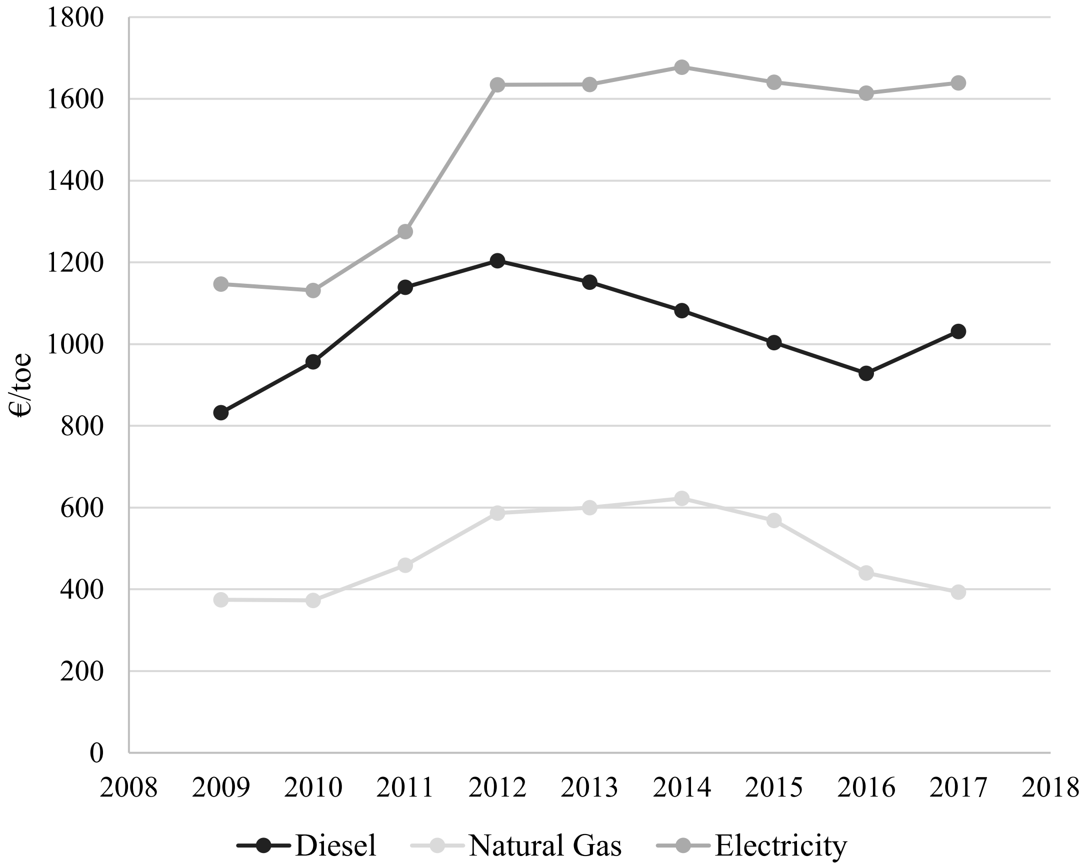
Electricity price refers to the 2-semester average price for industry consumers in the Eurostat consumption band IC, with annual consumption between 500 MWh and 2 000 MWh, and is given in euros per kWh.

The natural gas price is given in euros per GJ and corresponds to the 2-semester average price paid by industry consumers in the Eurostat consumption band I3, with an annual consumption between 10 000 GJ and 100 000 GJ.

Consumption bands are the standard chosen band by Eurostat in countries analysis.

Automotive diesel prices refer to the 12-month price averages and are given in euros per litres.

**Figure I - Evolution of energy prices per type of fuel**




*Source: Author, using data of industrial energy prices and conversion factors from DGEG. Electricity price refers to the price paid by industry consumers with annual consumption between 500 MWh and 2 000 MWh. Natural gas price refers to price paid by industry consumers with an annual consumption between 10 000 GJ and 100 000 GJ.*

#### 6.3.1. Conversion Factors

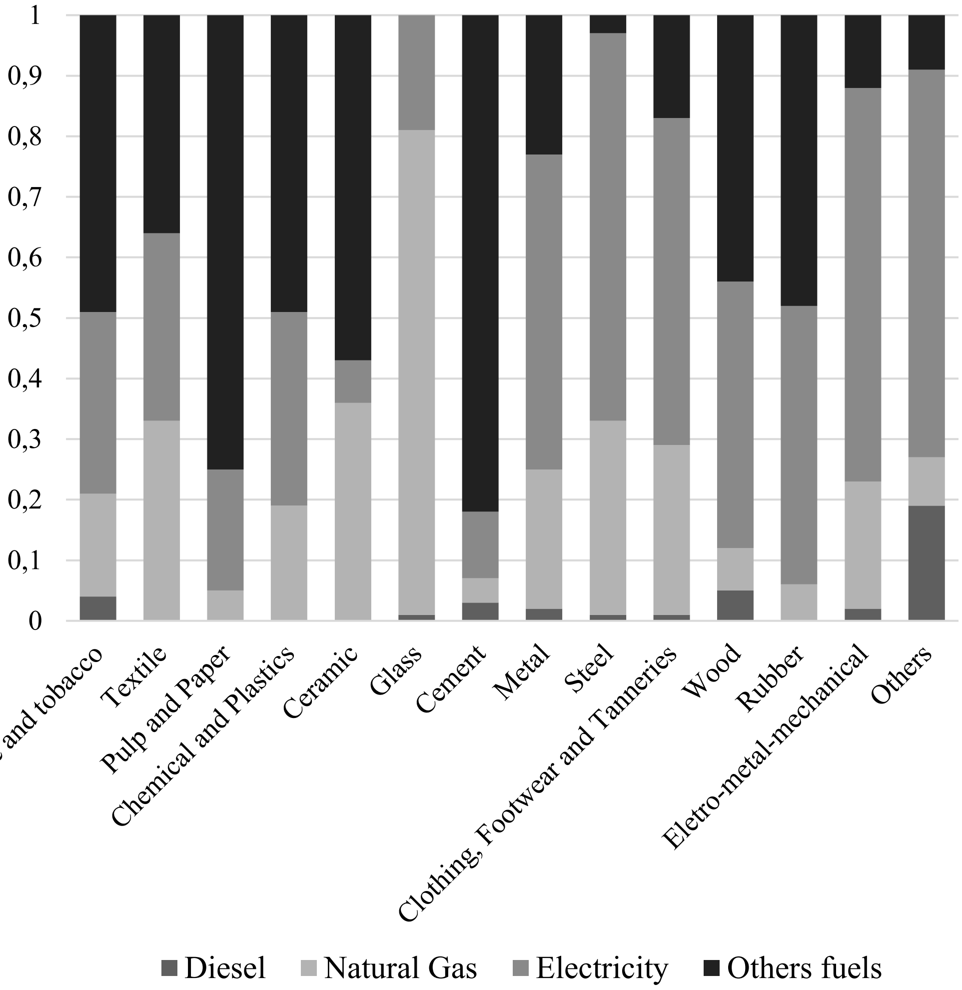
Conversion factors, to convert prices from euros per unit to euros per toe, were taken from DGEG – Estatística Energia, and are given annually and can be found on **Table *XI*** on Appendix B. The converted prices can also be found on Appendix B, on **Table *XII***.

#### 6.3.2. Fuel Consumption

To construct fuels weights, each type of fuel consumption was taken from the Balanço Energético files available in DGEG – Estatística Energia for the based period 2010. The data available allowed to have each type of fuel consumption annually, given in toe, for 14 different industries in the Portuguese manufactory sector, defined based on 5-digit CAE. The industry definition can be saw in **Table *XIII*** on appendix B.

The choice on the type of fuel to be considered in the energy price was due to data availability of price, consumption, and conversion factors. Nevertheless, the three types chosen: diesel, natural gas, and electricity, represent at minimum 19% of the energy mix of an industry and at maximum 99%. **Table *XIV*** on Appendix B details each fuel consumption per industry.

**Figure II - Weights of each fuel per industry on basis year 2010**




*Source: Author, using data of fuel consumption from DGEG*

## 6.4. Data cleaning and Target Data

The analysis will be focusing on the Portuguese manufactory industry. It was only considered firms with observations in the green and firms financial queries. Furthermore, the data is truncated between 1% and 99% of observations, excluding any outliers that could corrupt the results. In total it is analysed 15 103 companies for 14 industries between 2010 and 2017 for Portugal.

# 7. Descriptive Statistics

**Table I - Summary of descriptive Statistics**

| | N | Mean | Median | Min | Max |
|---|---|---|---|---|---|
| *Explanatory Variable* | | | | | |
| Energy Price | 86472 | 1216.98 | 1268.57 | 494.62 | 1546.83 |
| *Financial dependent variables* | | | | | |
| Costs Shares | 95567 | 0.97 | 0.931 | 0.245 | 3.11 |
| Investment | 98618 | 205246.99 | 10975 | 0 | 5317582 |
| Employment | 104199 | 33.84 | 12 | 1 | 428 |
| *Green dependent variables* | | | | | |
| Green Expenditure | 35024 | 33720.28 | 0 | 0 | 966838 |
| Green Revenues | 35026 | 19138.18 | 0 | 0 | 755572 |
| Green Investments | 35008 | 7096.70 | 0 | 0 | 308740 |
| Green Employment | 7970 | 7.21 | 3 | 0 | 133 |
| *Control Variables* | | | | | |
| Firm Size | 98618 | 13.74 | 13.68 | 8.86 | 18.61 |
| Energy Intensity | 98461 | 0.13 | 0.08 | -0.66 | 1.42 |
| Productivity | 98618 | 31703.41 | 18569.99 | -22007 | 636158 |

*Source: Author*
*Note: Variables are defined as presented o*n Table IX

# 8. Results

This section presents the empirical results of the previous discussed models. The section is organized into 2 parts, the first focus on the financial variables, the goal is to analyse the overall short- and medium-term effect that energy prices have on firms. The second part focus on the firms' green output, and the goal is to see if energy prices can act as a measure that leads to higher green output.

## 8.1. Results on Financial Variables

### 8.1.1. Impact on Costs Shares

**Table II - Energy Prices and Firms' Profitability**

| | Ln (Costs Shares$_t$) | | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| Ln (Energy Price$_t$) | 0.0294*** | 0.0260 | 0.0291 |
| | (0.0107) | (0.0280) | (0.0351) |
| Firm Size$_t$ | 0.0187*** | 0.0048* | 0.0183*** |
| | (0.0008) | (0.0028) | (0.0008) |
| Ln (Productivity$_t$) | -0.1310*** | -0.1241*** | -0.1325*** |
| | (0.0025) | (0.0037) | (0.0027) |
| Ln (Energy Intensity$_t$) | 0.0104*** | 0.0260*** | 0.0098*** |
| | (0.0013) | (0.0028) | (0.0015) |
| Constant | 0.7807*** | 0.9649*** | 0.8000*** |
| | (0.0741) | (0.1924) | (0.2396) |
| Observations | 74,605 | 74,605 | 74,605 |
| R-squared | 0.2744 | 0.2421 | 0.2775 |
| Year FE | YES | YES | YES |
| Firm FE | NO | YES | NO |
| Industry FE | NO | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (1) includes year fixed effects, model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table *II*** shows the estimated effects that energy prices have on costs shares, all columns include year fixed effect, column (2) also includes firm fixed effects and column (3) industry fixed effects.

When it comes to the variable of study, Costs Shares, a 1% increase in Energy Price leads to an increase, on average, of around 0.03% all models, however this effect is only significant in model (1).

In other hand, the control variables show at least a 10% significance in all models. As expected, Productivity is negatively correlated with Costs Shares, the more productive is a firm the more cost efficient it is, in this case a 1% increase in Productivity results, on average, in a decrease of around between 0.12% and 0.13% in Costs Shares, in all models this effect is significant at 1% level.

Contrarily Size has a positive relation with Costs Shares, looking over model (1) a 1% increase in the size factor leads to an average increase in costs share of 0.0187%, when including firm fixed effects, the increase is 0.0048% and with industry fixed effects is 0.0183%, both in model (1) and (3) the results are significant at a 1% level and in model (2) at a 10% level.

Regarding Energy Intensity, the table shows that Costs Shares rise when energy intensity increases, for model (1) and (3) this increase is on average, around 0.01% for each 1% increase in energy intensity of a firm and for model (2) around 0.03%.

Even though, that the results show no significant impact on Costs Shares by Energy Price, this does not mean that firms are unaffected, a possible explanation for this insignificance could be what was already mentioned previously in literature: an increase on input prices, such energy, can lead firms to substitute their fuels mix, higher their products market price, or increase their energy efficiency. The results showed focus only on the ability of absorb the rise of energy prices in firms' profits, and not of the previous methods that firms also apply and that can mitigate effects felt on costs shares.

### 8.1.2. Impact on Investment

**Table III - Energy Prices and Firms' Investment**

| | Ln ($Investment_t$) | | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| Ln (Energy $Price_{t-1}$) | -0.3440*** | 2.9490*** | 1.7868*** |
| | (0.1061) | (0.4548) | (0.6136) |
| Firm $Size_{t-1}$ | 0.7922*** | 0.0818*** | 0.7896*** |
| | (0.0086) | (0.0296) | (0.0087) |
| Ln ($Productivity_{t-1}$) | 0.3436*** | 0.1067*** | 0.3550*** |
| | (0.0220) | (0.0260) | (0.0232) |
| Ln (Energy $Intensity_{t-1}$) | 0.0322** | -0.1290*** | 0.0494*** |
| | (0.0135) | (0.0220) | (0.0151) |
| Constant | -1.8955** | -12.1286*** | -16.4100*** |
| | (0.7422) | (3.0950) | (4.1683) |
| Observations | 48,464 | 48,464 | 48,464 |
| R-squared | 0.4257 | 0.0304 | 0.4297 |
| Year FE | YES | YES | YES |
| Firm FE | NO | YES | NO |
| Industry FE | NO | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (1) includes year fixed effects, model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table *III*** focus on the results regarding overall investment. The differences in model (1), (2) and (3) are in the fixed effects used.

In model (1) the elasticity between Energy Price and Investment depends on the fixed effects considered, for model (1) a 1% increase on the price leads to a decrease of 0.3%, however when including firm or industry fixed effects the sign of the relationship changes to positive and a 1% increase of Energy Prices makes on average Investment increase almost 3% or almost 2%, accordingly. This positive relation in both model (2) and model (3) go in hand with idea of induced innovation due to changes in input prices presented by Hicks (1932). Moreover, the change of the sign of the elasticity between Energy Price and Investment, when considering different fixed effects, highlights the importance of adding more than just year fixed effects and can be a reason of why some studies have different results.

Size and Productivity shows a positive relation with Investment. An increase of 1% on Size leads on average to an increase around 0.8% on overall Investment and when it comes to Productivity, for model (1) a 1% increase leads to a rise between 0.1% and 0.4% of Investment depending on the model.

In other hand, the impact of Energy Intensity on Investment is positive and significant at least at 5% level, however investment if firm fixed effects are considered it changes to negative.

### 8.1.3. Impact on Employment

**Table IV - Energy Prices and Firms' Employment**

| | Ln ($Employment_t$) | | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| Ln (Energy $Price_{t-1}$) | -0.8318*** | 0.2619** | -0.1098 |
| | (0.0585) | (0.1133) | (0.1770) |
| Firm $Size_{t-1}$ | 0.7137*** | 0.3965*** | 0.7054*** |
| | (0.0046) | (0.0109) | (0.0046) |
| Ln ($Productivity_{t-1}$) | -0.5044*** | -0.0412*** | -0.4071*** |
| | (0.0148) | (0.0094) | (0.0152) |
| Ln (Energy $Intensity_{t-1}$) | -0.2506*** | -0.0444*** | -0.1656*** |
| | (0.0085) | (0.0079) | (0.0088) |
| Constant | 2.9251*** | -4.1297*** | -2.6103** |
| | (0.4188) | (0.7752) | (1.2103) |
| Observations | 64,509 | 64,509 | 64,509 |
| R-squared | 0.6599 | 0.1475 | 0.6872 |
| Year FE | YES | YES | YES |
| Firm FE | NO | YES | NO |
| Industry FE | NO | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (1) includes year fixed effects, model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

Lastly in the baseline regression considering financial variables, the price elasticity of Employment shows only significance for model (1) and model (2). In the second model a 1% increase in Energy Price makes next year Employment increase on average 0.26%. In opposite, when considering model (3), with industry fixed effects, the elasticity between Energy Prices and Employment is negative and not significant.

Moreover, firms increase their employment as size increases, the coefficient of the control variable Size is positive and significant, suggesting a complementary relation between capital and labour.

As expected, the coefficient of Productivity is negative and significant in all models, indicating that as value added per employee increases the need for more employees reduces.

Energy Intensity has also a negative and significant effect on Employment, a 1% increase in Energy intensity decreases, on average, Employment by 0.25%, 0.04% or 0.1%, in model (1), (2) or (3), accordingly.

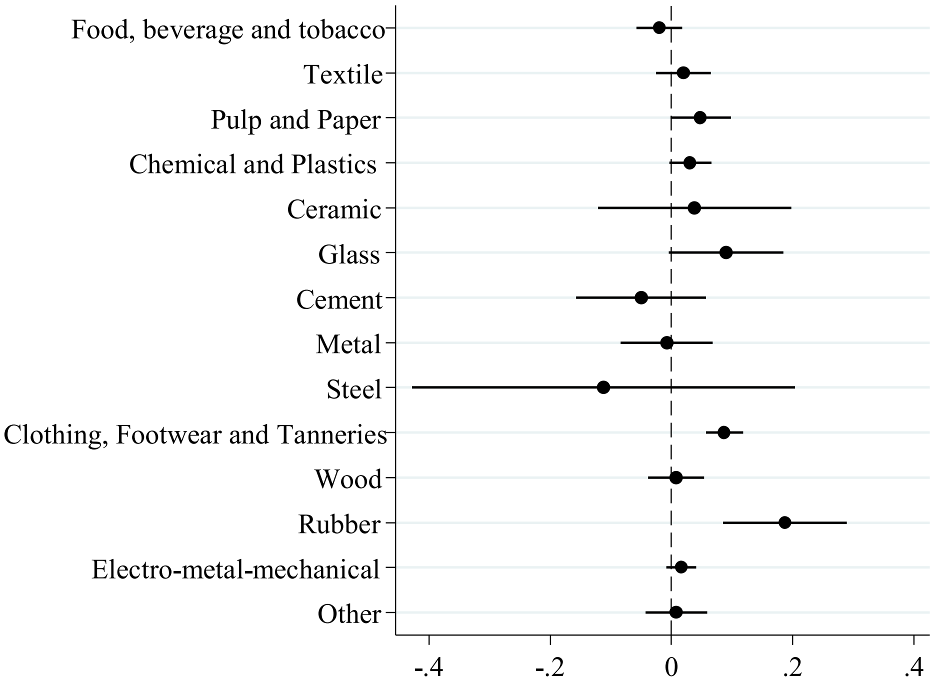
### 8.1.4. Extensions

The previous aggregate results are an average of all manufacturing firms, and consequently can hide possible heterogeneity between firms and industries, which could be important for policymakers. Therefore, in this sub-section a series of criteria is applied to uncover possible differences between firms and industries regarding the impact of energy prices.

#### *8.1.4.1. Impact by Industry*

The following figures show the impact of energy prices on the financial variables by each of the 14 industries. The detail regressions outputs corresponding of each industry can be found in Appendix CC: Detailed Regression Results of Financial Dependent Variables per industry. Additionally, since the regressions are industry based, only firm fixed effects and year fixed effects were considered.

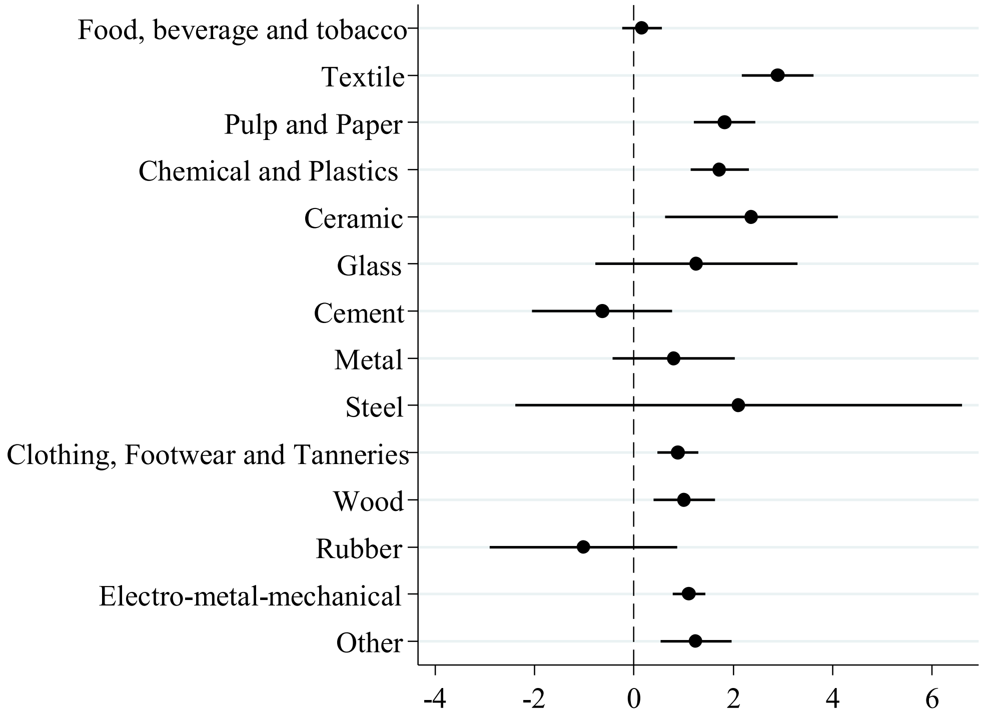
**Figure III - Energy Prices and Firms' Profitability, by Industry**




*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for each industry. Detailed regression results can be found in* Table XV *and* Table XVI *in Appendix C. The horizontal lines around the point represent the 95% confidence interval.*

**Figure *III*** shows the impact of Energy Prices on Costs Shares by industry. For most industries, the effect is positive and very close to zero, resembling the aggregate results of all industries, where the coefficient was between 0.02% and 0.03%. The industry of rubber, glass, cement, and steel seem to be the ones that deviate most from it, with the two last ones showing a decrease in costs shares when energy prices increase. Nevertheless, only the coefficients of pulp and paper, chemical and plastics, glass, clothing, and wood are statistically significant at least at a 10% level.

**Figure IV - Energy Prices and Firms' Investment, by Industry**



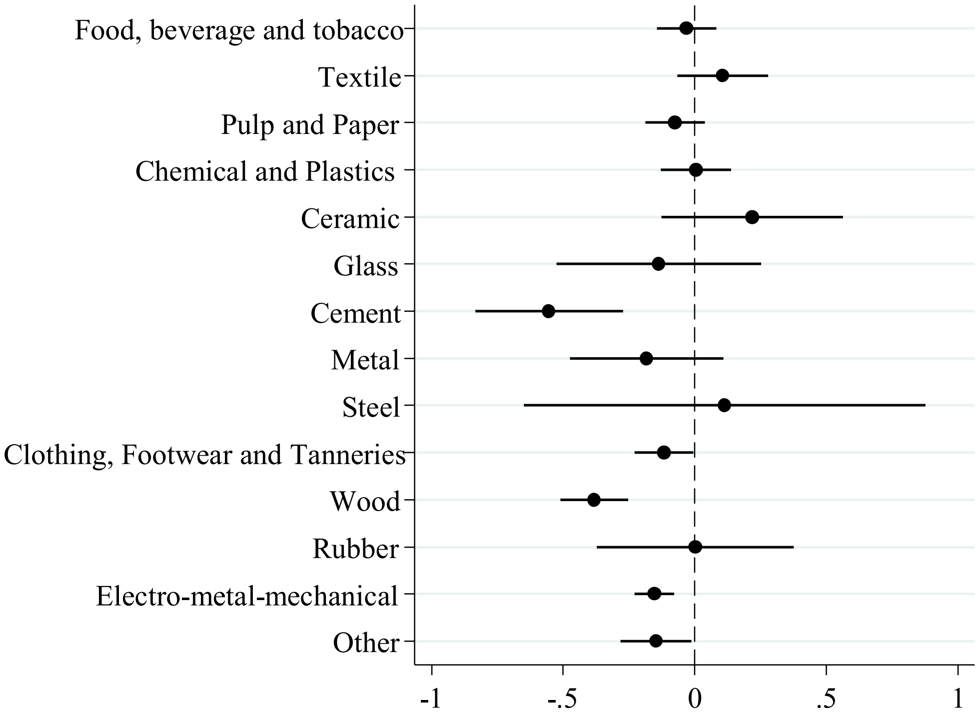

*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for each industry. Detailed regression results can be found in* Table XVII *and* Table XVIII *in Appendix C. The horizontal lines around the point represent the 95% confidence interval.*

Regarding Investment, **Figure *IV*** shows that in overall, Energy Price has a positive impact on this variable for almost all industries, with exception for cement and rubber, indicating for these a possibly a complementary relationship between energy and capital instead of a substitute one.

Moreover, when compared with the other financial variables, investment is also the one with higher value of coefficients, the range of change cause by 1% increase in Energy Price is between -2% to 6%.

The results are statistically significant at 1% level for all industries, with exception of food, beverage and tobacco, glass, cement, metal, steel, rubber, and electro-mechanical industry.

**Figure V - Energy Prices and Firms' Employment, by Industry**




*Source: Author*

*Note: Graphical representation of the coefficient of the Energy Price, for each industry. Detailed regression results can be found in* Table XIX *and* Table XX *in Appendix C. The horizontal lines around the point represent the 95% confidence interval.*

**Figure** ***V*** focus on the impact of Energy Prices on Employment by industry. Similar to what happens on the aggregate level, the rubber, steel, ceramic and textile industry have a small but positive coefficient for the elasticity between Energy Prices and Employment, and as also happens in Costs Shares and Investment, steel has the broadest confidence interval.

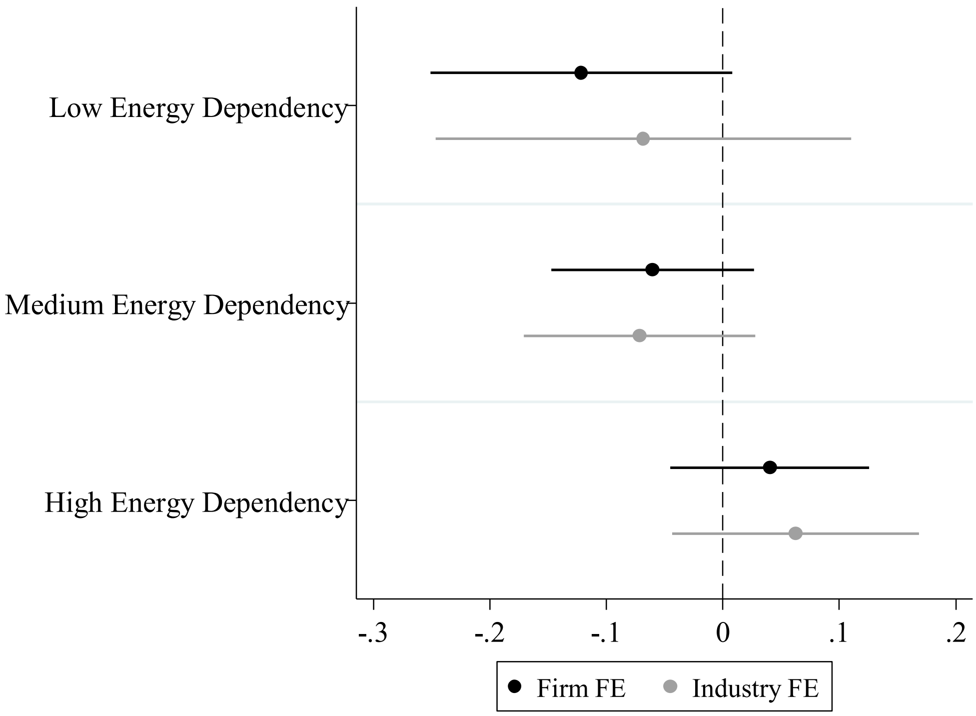
In other hand cement is the industry that deviates more, showing a negative coefficient, lower than 0.5%.

The results are only statistically significant, at least at a 5% level, for cement, clothing, wood, electro-metal-mechanical and other manufacturing industries.

#### *8.1.4.2. Impact by energy dependency level*

Secondly it is also examined the impact of energy prices by energy dependence level, which is defined as the ratio between energy related expenses and operational expenses. Firms are ranked by year by their energy dependency ratio and divided into 3 levels: low, medium, and high energy dependency. The regressions outputs corresponding of each level can be found in Appendix D.

**Figure VI - Energy Prices and Firms' Profitability, by Energy Dependency Level**



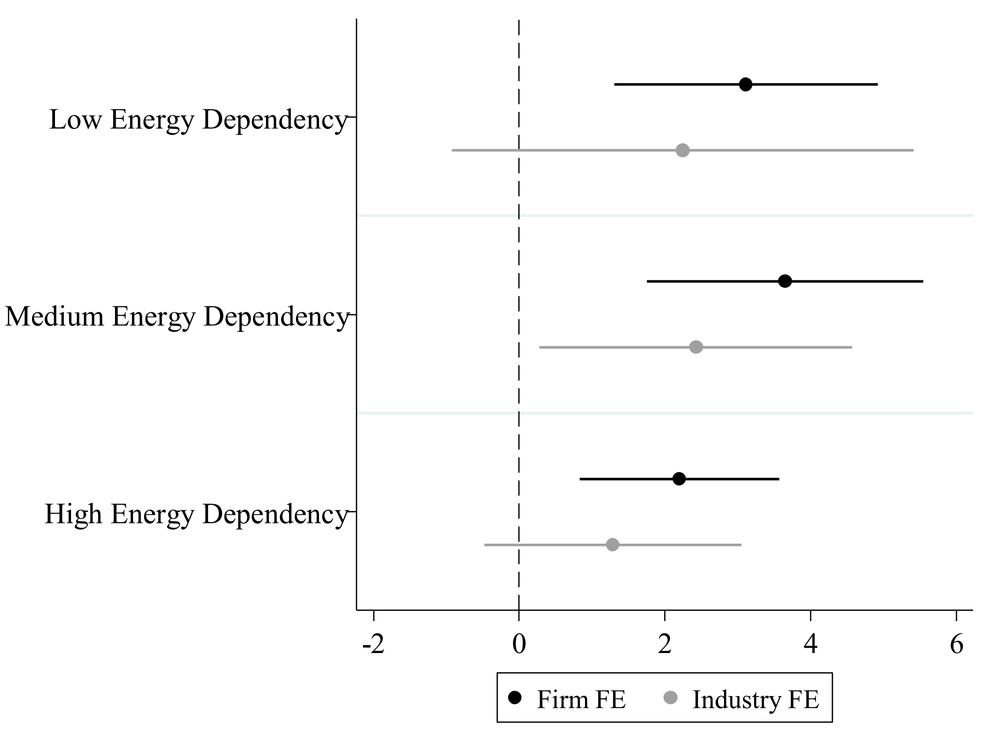

*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for energy dependency level. Detailed regression results can be found in* Table XXI *in Appendix D. The horizontal lines around the point represent the 95% confidence interval.*

**Figure *VI*** represents the impact of Energy Price on Costs Shares by each energy dependency level. The figure shows a clear pattern of as the level of energy dependency increase, the impact moves form negative to positive. As it can be seemed, high energy dependent firms are the one in the three levels positively affected by energy prices, with 1% increase on this input, lead to an increase in firms' Costs Shares of approximately 0.1%.

On possible justification for this difference can be that low and medium energy dependent firms can opt for adapt their production process to higher energy prices, for example by reducing their energy consumption, where high energy dependent firms, due to their dependency might not be able to do it, and therefore bear the costs of it.

The results are only significant for the model of the low-level considering firm fixed effects.

**Figure VII - Energy Prices and Firms' Investment, by Energy Dependency Level**



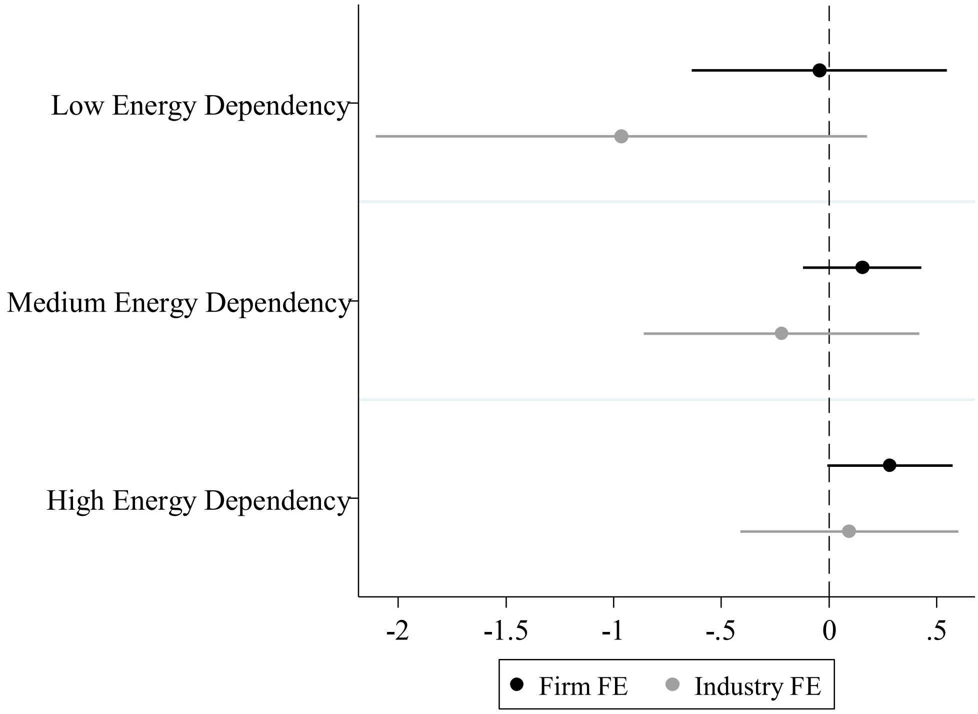

*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for energy dependency level. Detailed regression results can be found in* Table XXII *in Appendix D. The horizontal lines around the point represent the 95% confidence interval.*

**Figure *VII*** presents the impact of Energy Prices on Investment by each energy dependency level. All levels show a positive impact of Energy Prices on firms' investment, and medium energy dependent firms are the ones most affect, with 1% increase in Energy Prices corresponding to a between 2% and 4% increase in Investment.

All results are significant at least at a 5% level, except for models considering industry fixed effects on low and medium level.

The positive effect on all suggests that when it comes to investment, energy prices do not create heterogeneity between different energy dependencies of manufacturing firms.

**Figure VIII - Energy Prices and Firms' Employment, by Energy Dependency Level**




*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for energy dependency level. Detailed regression results can be found in* Table XXIII *in Appendix D. The horizontal lines around the point represent the 95% confidence interval.*

**Figure *VIII*** shows the impact of Energy Prices on Employment by each energy dependency level. The overall effects are relatively small, for all models, however as the level of energy dependency grows, the coefficient of the elasticity between the variables considered seems to move to the right side.

The results are only significant at a 10% level for low level considering industry fixed effects and for high level considering firm fixed effects.

## 8.2. Results on Green Variables

### 8.2.1. Impact on Green Expenditure

**Table V - Energy Prices and Firms' Green Expenditure**

| | Ln (Green Expenditure$_t$ + 1) | | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| Ln (Energy Price$_t$) | -0.3545 | -1.4971 | -2.3393* |
| | (0.3571) | (1.1207) | (1.3458) |
| Firm Size$_t$ | 1.7016*** | 0.3980*** | 1.7135*** |
| | (0.0244) | (0.1016) | (0.0241) |
| Ln (Productivity$_t$) | 0.1217** | 0.0994 | 0.0028 |
| | (0.0597) | (0.0692) | (0.0598) |
| Ln (Energy Intensity$_t$) | 0.3262*** | -0.0045 | 0.3197*** |
| | (0.0415) | (0.0678) | (0.0439) |
| Constant | -18.5733*** | 7.5787 | -4.0965 |
| | (2.4826) | (7.6859) | (9.1561) |
| Observations | 26,233 | 26,233 | 26,233 |
| R-squared | 0.4488 | 0.0045 | 0.4603 |
| Year FE | YES | YES | YES |
| Firm FE | NO | YES | NO |
| Industry FE | NO | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (1) includes year fixed effects, model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table *V*** focus on the results regarding firms' Green Expenditures. In all models an increase of 1% in Energy Price reduces the Green Expenditures of a manufacturing firm, however this decrease is only significant, at a 10% level, in model (3), which accounts for industry systemic variation in the fixed effects. In this model a 1% increase of Energy Price leads to a decrease of Green Expenditure around 2.3%.

Size coefficient is positive and significant at 1% for all models, indicating that the larger the firm the more it spends on green matters, such as actions for pollution control, prevention, and reduction. Similarly, Energy Intensity is also positive, and significant at 1% level for model (1) and (3), suggesting an increase in Green Expenses as more energy per output a firm need.

When it comes to Productivity, the coefficient is only significant at a 5% level for model (2) and (3), however the sign of relationship with green expenses changes differs on both models, in the second is positive, a 1% increase leads to 0.1% on green expenses, where on the third, a 1% increase in productivity leads to a decrease of green expenses of 0.003%.

### 8.2.2. Impact on Green Revenues

**Table VI - Energy Prices and Firms' Green Revenues**

| | Ln (Green Revenues$_t$ + 1) | | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| Ln (Energy Price$_t$ ) | 1.9674*** | -1.7059 | -3.0546** |
| | (0.4113) | (1.3060) | (1.3333) |
| Firm Size$_t$ | 1.1263*** | 0.3047*** | 1.1439*** |
| | (0.0329) | (0.0915) | (0.0315) |
| Ln (Productivity$_t$) | 0.0826 | 0.1329** | -0.1422** |
| | (0.0637) | (0.0649) | (0.0660) |
| Ln (Energy Intensity$_t$) | 0.1035** | 0.0159 | 0.1302*** |
| | (0.0433) | (0.0571) | (0.0480) |
| Constant | -28.3629*** | 7.7453 | 7.7780 |
| | (2.9033) | (8.9335) | (9.0780) |
| Observations | 26,233 | 26,233 | 26,233 |
| R-squared | 0.2653 | 0.0075 | 0.3125 |
| Year FE | YES | YES | YES |
| Firm FE | NO | YES | NO |
| Industry FE | NO | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (1) includes year fixed effects, model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

When it comes to Green Revenues, the impact of Energy Prices can be seen on **Table *VI***, and depends on the fixed effects considered, for model (1), only accounting year fixed effects, a 1% increase on Energy Price leads to increase on average of Green Revenues around 2%, however for model (2) and (3) the increase leads to a decrease on Green Revenues, specifically in the last model, model (3) this relationship is significant at 1% level.

The control variables follow the same relationship with Green Revenues that they follow with Green Expenditure. An increase of Size or Energy Intensity leads to an increase in Green Revenues for all models, and Productivity dependents if considering industry fixed effects or firms fixed effects.

### 8.2.3. Impact on Green Investment

**Table VII - Energy Prices and Firms' Green Investment**

| | Ln (Green Investment$_t$ + 1) | | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| Ln (Energy Price$_{t-1}$) | -0.1271 | 0.7715 | -1.8197 |
| | (0.3232) | (1.8279) | (1.6864) |
| Firm Size$_{t-1}$ | 0.5327*** | 0.2328** | 0.5320*** |
| | (0.0247) | (0.0936) | (0.0247) |
| Ln (Productivity$_{t-1}$) | 0.3738*** | 0.1494** | 0.3190*** |
| | (0.0548) | (0.0729) | (0.0601) |
| Ln (Energy Intensity$_{t-1}$) | 0.2496*** | 0.0641 | 0.2362*** |
| | (0.0329) | (0.0692) | (0.0378) |
| Constant | -8.9056*** | -8.7644 | 3.1066 |
| | (2.2901) | (12.4295) | (11.4538) |
| Observations | 23,081 | 23,081 | 23,081 |
| R-squared | 0.1495 | 0.0027 | 0.1531 |
| Year FE | YES | YES | YES |
| Firm FE | NO | YES | NO |
| Industry FE | NO | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (1) includes year fixed effects, model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * $p<0.01$, ** $p<0.05$ and *** $p<0.1$.*

Regarding **Table *VII***, considering Green Investments, model (1) and (3) show a decrease on this variables when Energy Price increases and model (2) an increase, but no model demonstrates statistical significance.

Size is significant and positive with Green Investment, a 1% increase in energy price increase on average green investments between 0.24% and 0.57%.

Productivity is also positive and statistically significant at least at 10% level, the sigh of the coefficient of this variable, suggests that more productive firms invest more in green technology.

Lastly, Energy Intensity is also positive, indicating that a firm that needs more energy to produce will also invest more in green energies, this relation is significant at a 1% level only for model (1) and (3).

#### 8.2.4. Impact on Green Employment

**Table VIII - Energy Prices and Firms' Green Employment**

| | Ln (Green Employment$_t$ + 1) | | |
|---|---|---|---|
| VARIABLES | (1) | (2) | (3) |
| Ln (Energy Price$_{t-1}$) | 0.1838 | 0.2763 | 0.5881 |
| | (0.1608) | (0.2963) | (0.5111) |
| Firm Size$_{t-1}$ | 0.2380*** | 0.1198*** | 0.2496*** |
| | (0.0163) | (0.0406) | (0.0165) |
| Ln (Productivity$_{t-1}$) | 0.1100** | -0.0102 | 0.0646 |
| | (0.0449) | (0.0293) | (0.0453) |
| Ln (Energy Intensity$_{t-1}$) | 0.0607** | 0.0019 | 0.0692** |
| | (0.0283) | (0.0302) | (0.0307) |
| Constant | -4.5844*** | -2.2514 | -7.0335** |
| | (1.1376) | (2.0969) | (3.4813) |
| Observations | 5,795 | 5,795 | 5,795 |
| R-squared | 0.1829 | 0.0079 | 0.2054 |
| Year FE | YES | YES | YES |
| Firm FE | NO | YES | NO |
| Industry FE | NO | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (1) includes year fixed effects, model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

When it comes to green employment, **Table *VIII*** shows that Energy Prices are not a factor that influences the number of green jobs in a manufacturing firm as no model is statistically significant.

Considering the control variables, only Size is significant in all models, a 1% increase on firm's size leads to around 0.24%, 0.12% or 0.25% increase in green jobs according if its considered model (1), (2) or (3), respectively. Energy intensity is also positive in all models, suggesting that more energy-intense firms increase more their employment related with green positions. Lastly, Productivity is positive for morel (1) and (3) but differs its coefficient when adding firm fixed effects, model (2).

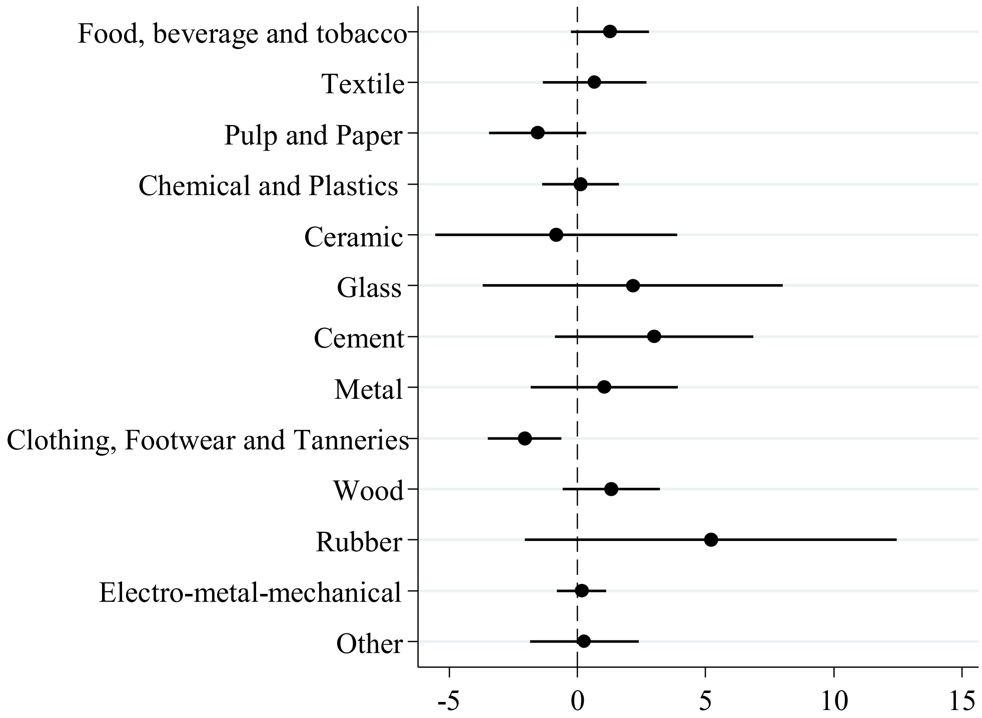
### 8.2.5. Extensions

Similarly, to previous section, to find possible heterogeneity effects of energy prices on green output, the sample was divided into industries and into different levels of energy dependency.

#### *8.2.5.1. Impact by industry*

The following figures show the impact of energy prices on the green variables by each industry. The regressions outputs corresponding of each one can be found in Appendix E. Additionally, since the regressions are industry based, only firm fixed effects and year fixed effects were considered.

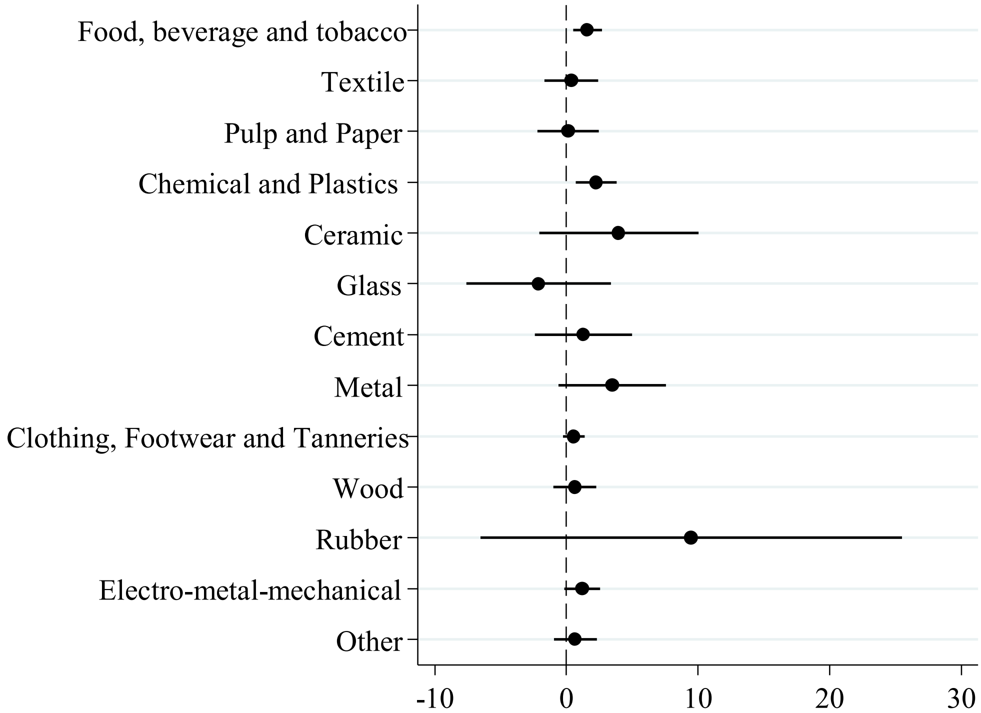
**Figure IX - Energy Prices and Firms' Green Expenditure, by Industry**




*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for each industry. Detailed regression results can be found in* Table XXIV *and* Table XXV *in Appendix E. The horizontal lines around the point represent the 95% confidence interval.*

**Figure *IX*** focus on the impact of Energy Prices on Green Expenditure by industry. For most industries the impact is positive and stays between 0% and 5%, only Pulp and paper, ceramic and clothing industry seem to reduce the Green Expenses when Energy Price increases. However, in all the results, only clothing, footwear and tanneries industry has a statistically significant one.

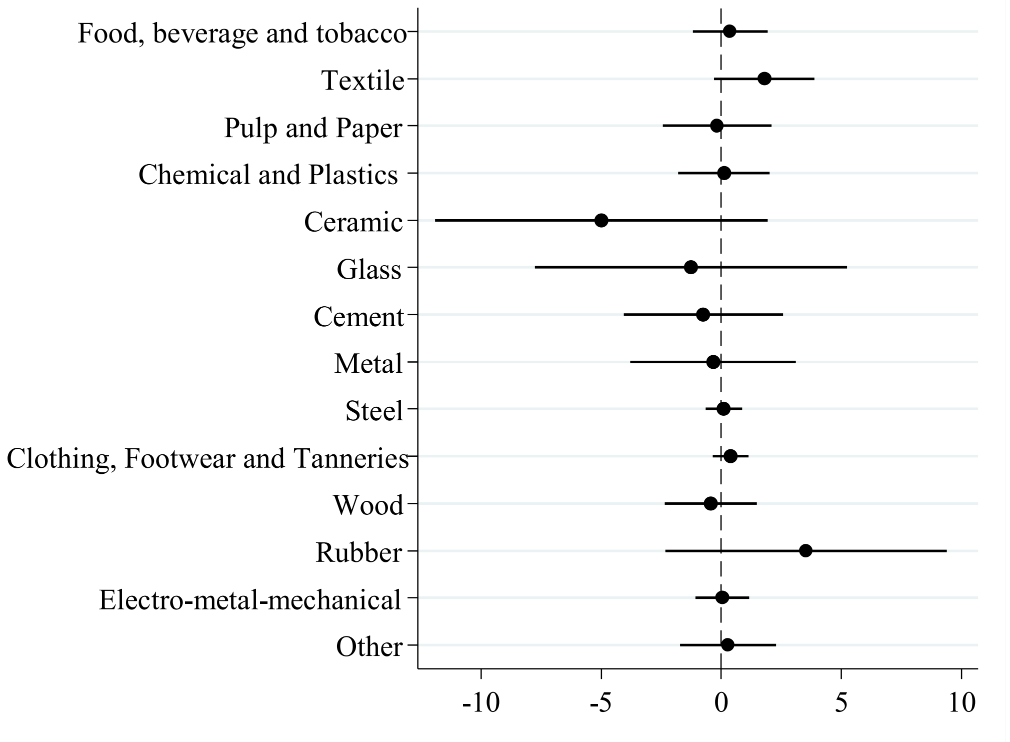
**Figure X - Energy Prices and Firms' Green Revenues, by Industry**




*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for each industry. Detailed regression results can be found in* Table XXVI *and* Table XXVII *in Appendix E. The horizontal lines around the point represent the 95% confidence interval.*

**Figure *X*** represents the impact of Energy Prices on Green Revenues by industry. As it can be seen only the glass industry has a negative coefficient, indicating that firms in this industry, on average, receive less revenues related with green actions when energy prices increase. Even though most industries present a positive coefficient, evidencing a heterogeneous effect from the aggregate results, there is only statistical significance for the food, beverage, and tobacco, chemical and plastics, metal, and electro-metal-mechanical industries.

**Figure XI - Energy Prices and Firms' Green Investment, by Industry**

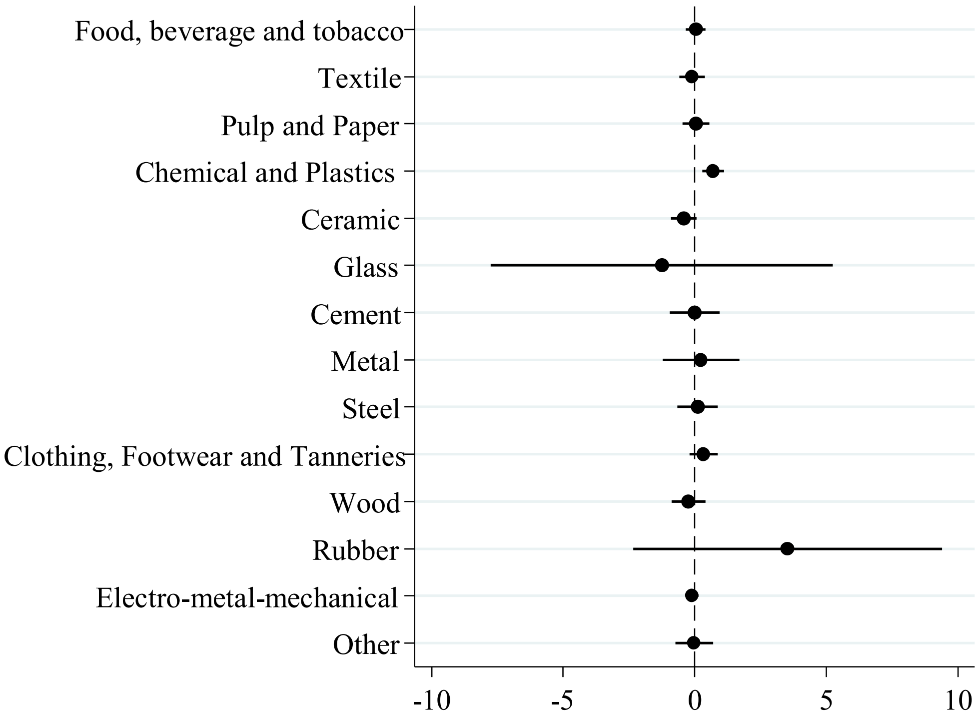



*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for each industry. Detailed regression results can be found in* Table XXVIII *and* Table XXIX *in Appendix E. The horizontal lines around the point represent the 95% confidence interval.*

The elasticity between Energy prices and Green Investment by industry is showed in **Figure *XI***. For industries more energy dependent as the case of glass, cement, steel and pulp and paper the relationship between the variables is negative, suggesting that on average the firms in these industries reduce their investment in green technology as Energy Price rises. However, most industries show a very small effect.

Only for the textile industry exists statistical significance at a 10% level, for this industry a 1% increase in Energy prices leads to an increase in Green Investments around 2%.

**Figure XII - Energy Prices and Firms' Green Employment, by Industry**



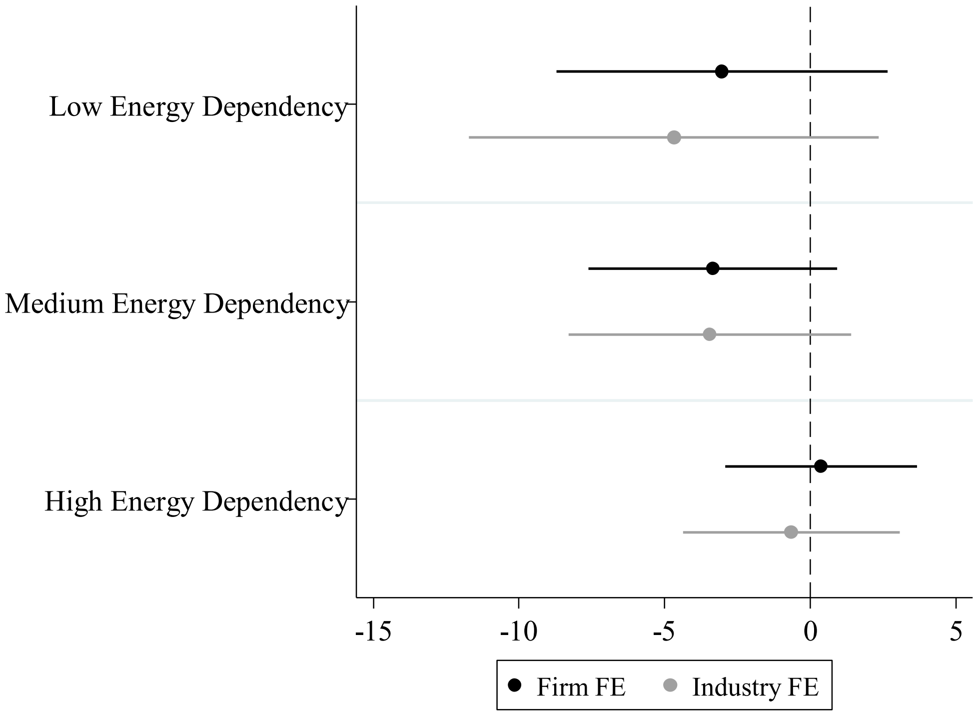

*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for each industry. Detailed regression results can be found in* Table XXX *and* Table XXXI *in Appendix E. The horizontal lines around the point represent the 95% confidence interval.*

Regarding green employment, the **Figure *XII*** shows a concentration of the coefficients near the zero line, suggesting a very small or no effect of energy prices on green employment. These results are only significant for the chemical and plastic, and ceramic industries.

*8.2.5.2. Impact by Energy Dependency*

It is also examined the impact of energy prices by energy dependence level, using the same logic as in previous section. The regressions outputs corresponding of each level and each green variable can be found in Appendix F.

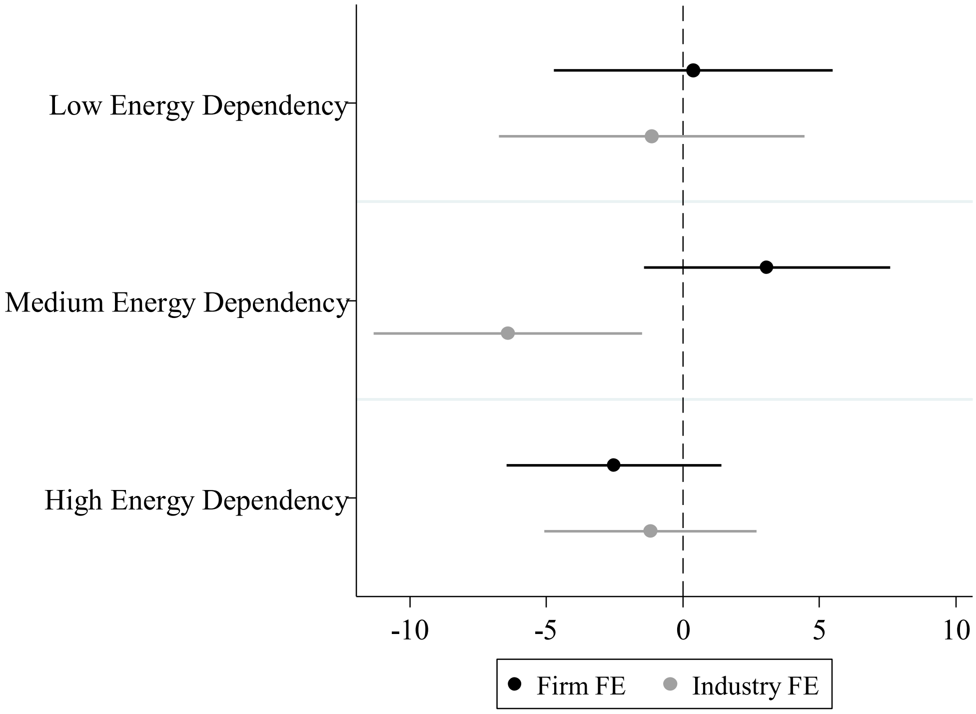
**Figure XIII - Energy Prices and Firms' Green Expenditure, by Energy Dependency Level**




*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for energy dependency level. Detailed regression results can be found in* Table XXXII *in Appendix F. The horizontal lines around the point represent the 95% confidence interval.*

When it comes to the impact of Energy Price on Green Expenditure by energy dependency level, **Figure *XIII*** shows a pattern of where the higher the level the right the coefficient is, however in none of the levels there is statistically significant for any of the models considered.

**Figure XIV - Energy Prices and Firms' Green Revenues, by Energy Dependency Level**

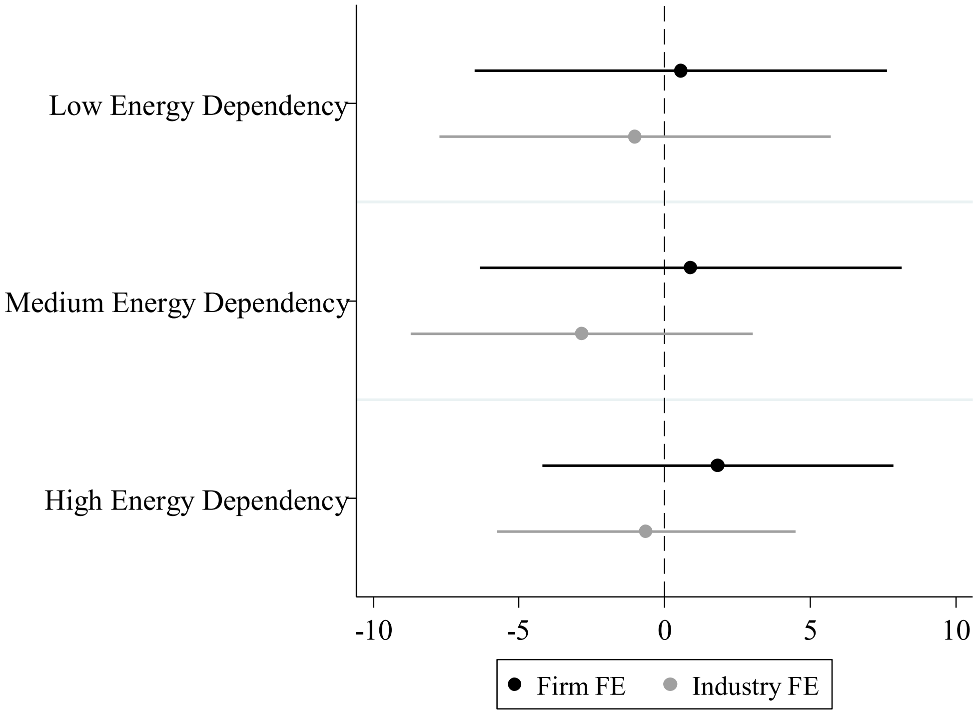



*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for energy dependency level. Detailed regression results can be found in* Table XXXIII *in Appendix F. The horizontal lines around the point represent the 95% confidence interval.*

Regarding the impact of Energy Prices on Green Revenues by each energy dependency level, **Figure *XIV*** shows for low and medium levels that the sign of the coefficient depends on the fixed effects considered, if firm and year fixed effects are used, then the sign is positive, otherwise is negative. In the case of high energy dependency an increase in energy price leads to a decrease of green revenues in both models.

Only for the model considering industry fixed effects in medium level, the results are significant.

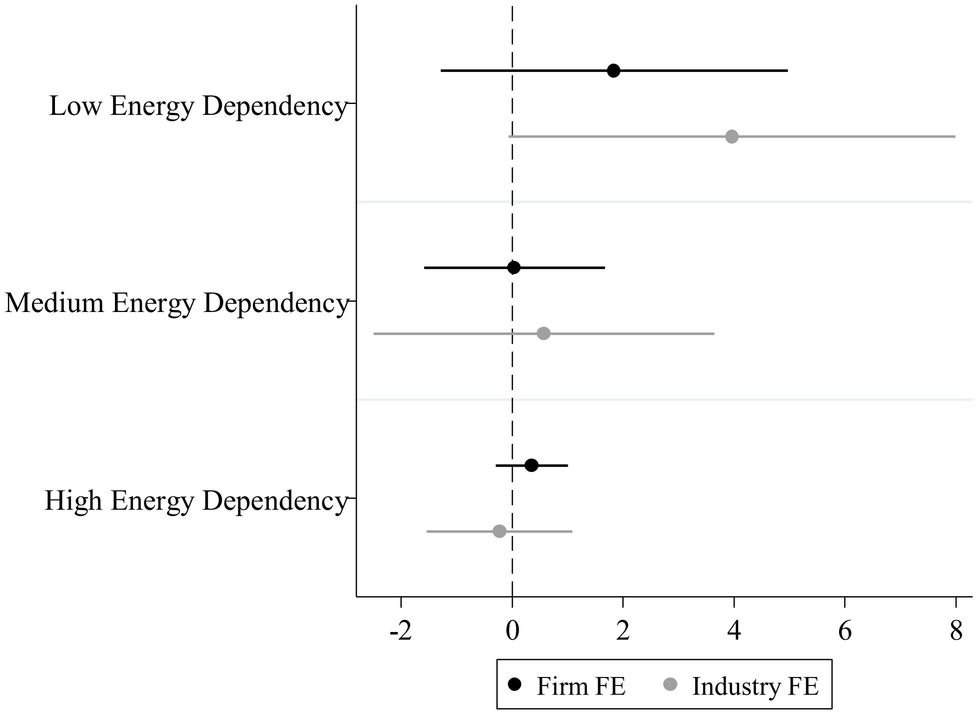
**Figure XV - Energy Prices and Firms' Green Investment, by Energy Dependency Level**




*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for energy dependency level. Detailed regression results can be found in* Table XXXIV *in Appendix F. The horizontal lines around the point represent the 95% confidence interval.*

In the case of Green Investment, as **Figure *XV*** shows the results of the impact of energy price on this variable also differ depending on fixed effects considered, for all levels, the models considering firm fixed effects show a positive sign and the ones considering industry fixed effects a negative sign. Furthermore, similar to what happen in an aggregate analysis of Green Investment fixed effects create different relation and no model for any level is statistically significant.

**Figure XVI - Energy Prices and Firms' Green Employment, by Energy Dependency Level**




*Source: Author*
*Note: Graphical representation of the coefficient of the Energy Price, for energy dependency level. Detailed regression results can be found in* Table XXXV *in Appendix F. The horizontal lines around the point represent the 95% confidence interval.*

Lastly, regarding **Figure *XVI***, considering Green Employment and Energy Prices, for most levels the impact of an increase in Energy Price is positive, especially for low dependency firms. In fact, for the low level of dependency, the model considering industry fixed effects is statistically significant at a 10% level and has the highest value, 1% increase in Energy Price would lead to an average increase of about 4% in firms' Green Employment on a low dependency level.

# 9. Limitations

Some limitations arise in this thesis. The main one is related with the data used. The energy prices considered cover only a specific band of consumption for electricity and for natural gas, which can create possible mismatches in the results since firms in the sample might not be affected by the energy prices considered if they don't belong to the consumption bands.

Furthermore, when analysing the impact of energy prices on green variables by industry, due to some industries only having a few observations, this can compromise the validity of the results found, and therefore estimations regarding these variables for industries should be interpreted with caution.

Lastly, even though energy prices are often used as a proxy to environmental regulation, firms might only take measures, such as changing employment and investment, with more prolonged effects, and therefore using the results of this analysis to directly compare what would happen if government had more energy tight policies in firms doesn't not represent the full spectrum of such policies.

# 10. Conclusion

This study aims to understand the effect of energy prices changes on firm-level financial and environmental performance of manufacturing firms in Portugal for the period between 2010 and 2017. This paper hopes to fill the gap for understanding the dynamic between energy prices and firms' responses for Portugal, since most studies focus on other countries on a group of countries not allowing for a target examination, furthermore it contributes for the increasing area of research that studies what can influence sustainable practices and green output of firms.

The study is conducted using an OLS model with fixed effects and clustered robustness errors and the analysis is extended to the different industries and different levels of energy dependency-level.

The results show no significance for the costs shares of firms, a positive and significant effect of energy prices on investment and for employment, in the last when considering firm fixed effects.

When examining the green variables, such as green expenditure, green revenues, green investment and green employment, the effects of energy prices is only significant for the first two variables on models considering industry fixed effects. In these cases, a 1% increase on energy prices leads to a decrease of green expenditures of around 2% and a decrease of green revenues of about 3%.

The findings on green variables might be demotivating for future environmental policies, since they suggest a negative or no effect on green output, however when analysing for different industries, some show positive and significant coefficients of energy prices effects and green outputs suggesting that maybe targeted future policies might work better than general policies.

The evidence provided can be used by managers to understand the results of an increase in their energy input and prepare better for mitigating possible losses, by investors that having a past analysis of what happen to firms where energy prices increased, have a better understanding of possible effects of future increases and by policy makers that can used the observed heterogeneities across industries and energy dependency levels to guide policy design and help governments to understand possible effects of environmental policies.

Furthermore, for a better understanding of the topic future research is needed, however data availability is crucial to achieve solid results, one possible path is trying to overcome some of this paper limitations, for example by incorporating more data on the energy prices that match firms' consumption band and by expanding the time frame used, improving the approximation of what the true impact of energy prices would be.

Lastly, extending this analysis to other sectors of activity would allow a full view of the impact of energy prices on the economic activity of Portugal. Other countries energy prices could also be an important topic of inclusion on the discussion of financial and green variables of the firms, since depending on the relative price of other countries to Portugal, firms can decide to instead to offshore their investment and employment.

# 11. Bibliography

Aghion, P., Dechezleprêtre, A., Hemous, D., & Van Reenen, J. (2016). Carbon Taxes, Path Dependency, and Directed Technical Change: Evidence from the Auto Industry. *Journal of Political Economy, 124*(1), 1-51. doi:10.1086/684581

Ahmad, W. (2017). On the dynamic dependence and investment performance of crude oil and clean energy stocks. *Research in International Business and Finance, 42*, 376-389. doi:10.1016/j.ribaf.2017.07.140

Arlinghausi, J. (2015). Impacts of Carbon Prices on Indicators of Competitiveness: A Review of Empirical Findings. *OECD Environment Working Papers, 87*. doi:https://doi.org/10.1787/5js37p21grzq-en

Bijnens, G., Hutchinson, J., Konings, J., & Guilhem, A. S. (2021). The interplay between green policy, electricity prices, financial constraints and jobs: firm-level evidence. *European Central Bank Working Paper Series, 2537*.

Bijnens, G., Konings, J., & Vanormelingen, S. (2018). The impact of electricity prices on jobs and investment in the Belgian manufacturing industry. *Working Papers of VIVES - Research Centre for Regional Economics*.

Costantini , V., & Paglialunga, E. (2014). Elasticity of substitution in capital-energy relationships: how central is a sector-based panel estimation approach? *SEEDS Working Paper Series* .

Dechezleprêtre, A., & Kruse, T. (2018). A review of the empirical literature combining economic and environmental performance data at the micro-level. *OECD Economics Department Working Papers, 1514*. doi:https://doi.org/10.1787/45d269b2-en

Dechezleprêtre, A., Nachtigall , D., & Stadler, B. (2020). The effect of energy prices and environmental policy stringency on manufacturing employment in OECD countries: Sector- and firm-level evidence. *OECD Economics Department Working Papers, 1625*. doi:https://doi.org/10.1787/899eb13f-en

Deschenes, O. (2018). Environmental regulations and labor markets. *IZA World of Labor*. doi:http://dx.doi.org/10.15185/izawol.22.v2

Dlugosch, D., & Kozluk, T. (2017). Energy prices, environmental policies and investment: Evidence from listed firms. *OECD Economics Department Working Papers, 1378*. doi: https://doi.org/10.1787/ef6c01c6-en

Dussaux, D. (2020). The joint effects of energy prices and carbon taxes on environmental and economic performance: Evidence from the French manufacturing sector. *OECD Environment Working Papers*(154). doi: https://doi.org/10.1787/b84b1b7d-en

Dutta, A., Jana, R. K., & Das, D. (2020). Do green investments react to oil price shocks? Implications for sustainable development. *Journal of Cleaner Production, 266*. doi:10.1016/j.jclepro.2020.121956

Fankhauser, S., Sehlleier, F., & Stern, N. (2008). Climate change, innovation and jobs. *Climate Policy, 8*(4), 421-429. doi:http://dx.doi.org/10.3763/cpol.2008.0513

Furchtgott-Roth, D. (2012). The elusive and expensive green job. *Energy Economics, 34*(1). doi:https://doi.org/10.1016/j.eneco.2012.08.034

Gerken, A., Plantefève , O., & Veillard, X. (2019, October 28). *Managing industrials' commodity-price risk.* McKinsey & Company.

Hicks, J. R. (1932). *The Theory of Wages.* London: Macmillan.

IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, Switzerland.

Jaffe, A. B., Peterson, S. R., Portney, P. R., & Stavins, R. N. (1995). Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us? *Journal of Economic Literature, 33*(1), 132-163.

Johnstone, N., Hascic, I., & Popp, D. (2008). Renewable Energy Policies And Technological Innovation: Evidence Based On Patent Counts. *National Bureau of Economic Research Working Paper Series, 13760*. doi:10.3386/w13760

Kruse, T., Mohnen, M., Pope, P., & Sato, M. (2020). Green revenues, profitability and market valuation: Evidence from a global firm level dataset. *Grantham Research Institute on Climate Change and the Environment Working Paper, 331*.

Ley, M., Stucki, T., & Woerter, M. (2016). The Impact of Energy Prices on Green Innovation. *The Energy Journal, 37*(1), 41-75. doi: https://doi.org/10.5547/01956574.37.1.mley

Marin , G., & Vona, F. (2017). The Impact of Energy Prices on Employment and Environmental Performance: Evidence from French Manufacturing Establishments. *SEEDS Working Papers*.

Pestel, N. (2019). Employment effects of green energy policies. *IZA World of Labor*. doi:10.15185/izawol.76.v2

Popp, D. (2002). Induced Innovation and Energy Prices. *The American Economic Review, 92*(1), 160-180. doi:10.1257/000282802760015658

Porter, M., & van der Linde, C. (1995). Towards a New Conception of Environment Competitiveness Relationship. *The Journal of Economic Perspectives, 9*(4), 97-118. doi:10.1257/jep.9.4.97

Rentschler, J., & Kornejew, M. (2017). Energy price variation and competitiveness: Firm level evidence from Indonesia. *Energy Economics, 67*, 242-254. doi:https://doi.org/10.1016/j.eneco.2017.08.015

Rentschler, J., Kornejew, M., & Bazilian, M. (2017). Fossil fuel subsidy reforms and their impacts on firms. *Energy Policy, 108*, 617-623. doi:https://doi.org/10.1016/j.enpol.2017.06.036

Sato, M., Singer, G., Dussaux, D., & Lovo, S. (2019). International and sectoral variation in industrial energy prices 1995–2015. *Energy Economics, 78*, 235-258. doi:10.1016/j.eneco.2018.11.008

Silva, B. (2021, September 22). *Capital Verde*. Retrieved from ECO Sapo: https://eco.sapo.pt/2021/09/22/industria-ve-fatura-de-energia-subir-ate-60-em-2021-almofada-extra-do-governo-e-insuficiente/

Walley, N., & Whitehead, B. (1994). It's Not Easy Being Green. *Harvard Business Review, 72*, 46-52.

Wei, M., Patadia, S., & Kammen, D. (2010). Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? *Energy Policy, 38*(2). doi:https://doi.org/10.1016/j.enpol.2009.10.044

Xia, T., Ji, Q., Zhang, D., & Han, J. (2019). Asymmetric and extreme influence of energy price changes on renewable energy stock performance. *Journal of Cleaner Production, 241*. doi:10.1016/j.jclepro.2019.118338

Yu, H. (2013). The EU ETS and Firm Profits: An Ex-post Analysis for Swedish Energy Firms. *Environmental Economics, 4*(3).

Zachmann , G., Ndoye , A., & Abrell, J. (2011). Assessing the impact of the EU ETS using firm level data. *Bruegel Working Paper*.

# 12. Appendixes

## 12.1. A: Variables Definition

**Table IX - Regression Variables' Definition**

| Variables | Description | Unit |
|---|---|---|
| *Explanatory variable* | | |
| Energy Price $_{s,t \text{ or } t\text{-}1}$ | Industry price of energy for industry *s* at year *t* or year *t-1*. | Euros/toe |
| *Financial dependent variables* | | |
| Employment | Number of employees per firm *i* and year *t* | Number of persons |
| Investment | Value of firm investment in tangible assets, biologic assets, and investment proprieties per firm *i* and year *t* | Euros |
| Costs Share | Ratio between operational costs and revenues of a firm *i* on year *t* $$Costs\ Share_{i,t} = \frac{Operational\ costs_{i,t}}{Revenues_{i,t}}$$ | Euros |
| *Green dependent variable* | | |
| Green Investment $_{i,t}$ | Value of investments in technologies and/or equipment to reduce impacts on the environment, per firm *i* and year *t* | Euros |
| Green Expenses $_{i,t}$ | Value of expenses related to actions for pollution control, prevention, and reduction, including the contracting of specialized services and/or the payment of compensation for management purposes to waste management entities, per firm *i* and year *t* | Euros |
| Green Revenues $_{i,t}$ | Value of income earned related to actions of control, prevent and pollution reduction, per firm *i* and year *t* | Euros |
| Green Employment $_{i,t}$ | Number of employees with functions related with environmental roles, per firm *i* and year *t* | Number of persons |
| *Control Variables* | | |
| Firm Size $_{i,t \text{ or } t\text{-}1}$ | Log value of tangible assets for each firm *i* and each year considered, *t* or *t-1* | Log of euros |
| Energy Intensity $_{i,t \text{ or } t\text{-}1}$ | Ratio of energy cost to operational costs of a firm *i* on year *t* or *t-1* $$Energy\ Intensity_{i,t\ or\ i,t-1} = \frac{Energy\ Expenditure_{i,t\ \ or\ i,t-1}}{GVA_{i,t\ or\ i,t-1}}$$ | Euros |
| Productivity $_{i,t \text{ or } t\text{-}1}$ | Ration of gross value added per employee of a firm *i* on year *t* or *t-1* $$Energy\ Intensity_{i,t} = \frac{GVA_{i,t\ or\ i,t-1}}{Number\ of\ Employees_{i,t\ or\ i,t-1}}$$ | Euros/Employee |

*Source: Author*

## 12.2. B: Energy Price Construction

**Table X - Energy Prices (eur/unit)**

| Initial Price (w/ taxes) | | | |
|---|---|---|---|
| | €/litre | €/GJ | €/kWh |
| YEAR | Diesel | Natural Gas | Electricity |
| 2009 | 1.00 | 8.94 | 0.1 |
| 2010 | 1.15 | 8.91 | 0.1 |
| 2011 | 1.37 | 10.97 | 0.11 |
| 2012 | 1.45 | 14.02 | 0.14 |
| 2013 | 1.39 | 14.33 | 0.14 |
| 2014 | 1.3 | 14.87 | 0.14 |
| 2015 | 1.21 | 13.58 | 0.14 |
| 2016 | 1.12 | 10.53 | 0.14 |
| 2017 | 1.24 | 9.39 | 0.14 |

*Source: Author, using data of energy prices from DGEG*

**Table XI – Conversion Factor of Each Fuel**

| Conversion Factors | | | |
|---|---|---|---|
| | litre/toe | GJ/toe | kWh/toe |
| YEAR | Diesel | Natural Gas | Electricity |
| 2009 | 0.001205 | 0.023885 | 0.000086 |
| 2010 | 0.001205 | 0.02389 | 0.000086 |
| 2011 | 0.001205 | 0.023878 | 0.000086 |
| 2012 | 0.001205 | 0.023892 | 0.000086 |
| 2013 | 0.001205 | 0.023894 | 0.000086 |
| 2014 | 0.001205 | 0.02389 | 0.000086 |
| 2015 | 0.001205 | 0.023876 | 0.000086 |
| 2016 | 0.001205 | 0.023901 | 0.000086 |
| 2017 | 0.001205 | 0.023888 | 0.000086 |

*Source: Author, using data of conversion factors from DGEG*

**Table XII - Energy Prices (eur/toe)**

| Converted price (w/ taxes) | | | |
|---|---|---|---|
| | €/toe | | |
| YEAR | Diesel | Natural Gas | Electricity |
| 2009 | 832.35 | 374.41 | 1147.09 |
| 2010 | 956.82 | 372.97 | 1131.4 |
| 2011 | 1138.92 | 459.2 | 1275.58 |
| 2012 | 1203.84 | 586.59 | 1634.88 |
| 2013 | 1151.71 | 599.74 | 1635.47 |
| 2014 | 1081.63 | 622.44 | 1677.91 |
| 2015 | 1003.38 | 568.78 | 1640.7 |
| 2016 | 928.78 | 440.37 | 1613.95 |
| 2017 | 1030.91 | 392.94 | 1638.95 |

*Source: Author*

**Table XIII - Industry definition by Portuguese CAE Rev.3**

| Industry Name | CAE Rev.3, 5 digits |
|---|---|
| Food, beverage, and tobacco | 10110 - 12000 |
| Textile | 13101-13105; 13201-13203; 13301-13303; 13910; 13920; 13930; 13941; 13942; 13950; 13961; 13962; 13991-13993 |
| Pulp and Paper | 17110; 17120; 17211; 17212; 17220; 17230; 17240; 17290; 18110; 18120; 18130; 18140; 18200 |
| Chemical and Plastics | 20110; 20120; 20130; 20141-20144; 20151; 20152; 20160; 20170; 20200; 20301; 20302; 20303; 20411; 20412; 20420; 20510; 20520; 20530; 20591; 20592; 20593; 20594; 20600; 21100; 21201; 21202; 22210; 22220; 22230; 22291; 22292 |
| Ceramic | 23200; 23311; 23312; 23321-23324; 23411-23414; 23420; 23430; 23440; 23490 |
| Glass<br>Cement<br>Metal | 23110; 23120; 23131; 23132; 23140; 23190<br>23510; 23521; 23522; 23610; 23620; 23630; 23640; 23650; 23690<br>24200; 24310; 24320; 24330; 24340; 24410; 24420; 24430; 24440; 24450; 24510; 24520; 24530; 24540 |
| Steel | 24100 |
| Clothing, Footwear and Tanneries | 14110; 14120; 14131-14133; 14140; 14190; 14200; 14310; 14390; 15111-15113; 15120; 15201; 15202 |
| Wood | 16101; 16102; 16211-16213; 16220; 16230; 16240; 16291-16295; 31091; 32995 |
| Rubber | 22111; 22112; 22191; 22192 |
| Electro-metal-mechanical | 25110; 25120; 25210; 25290; 25300; 25401; 25402; 25501; 25502; 25610; 25620; 25710; 25720; 25731-25734; 25910; 25920; 25931-25933; 25940; 25991; 25992; 26110; 26120; 26200; 26300; 26400; 26511; 26512; 26520; 26600; 26701; 26702; 26800; 27110; 27121; 27122; 27200; 27310; 27320; 27330; 27400; 27510; 27520; 27900; 28110; 28120; 28130; 28140; 28150; 28210; 28221;28222; 28230; 28240; 28250; 28291-28293; 28300; 28410; 28490; 28910; 28920; 28930; 28940; 28950; 28960; 28991; 28992; 29100; 29200; 29310; 29320; 30111; 30112; 30120; 30200; 30300; 30400; 30910; 30920; 30990; 31010; 31092 |
| Others | 19203; 23701-23703; 23910; 23991; 23992; 24460; 31020; 31030; 31093; 31094; 32110; 32121- 32123; 32130; 32200; 32300; 32400; 32501; 32502; 32910; 32991-32994; 32996; 35302; 38211; 38212; 38220; 38321; 38322 |

*Source: Author, using data of CAE of each industry from DGEG*

**Table XIV - Consumption per Fuel Type (toe), 2010**

| Consumption per fuel (toe), 2010 | | | | | | |
|---|---|---|---|---|---|---|
| INDUSTRY | Diesel | Natural Gas | Electricity | Total 1 | Other fuels | Total 2 |
| Food, beverage, and tobacco | 24 623 | 94 537 | 163 812 | 282 972 | 266 420 | 549 392 |
| Textile | 524 | 104 843 | 97 678 | 203 045 | 114 900 | 317 945 |
| Pulp and Paper | 3 794 | 69 885 | 262 849 | 336 528 | 949 984 | 1 286 512 |
| Chemical and Plastics | 1 865 | 113 770 | 195 427 | 311 062 | 291 761 | 602 823 |
| Ceramic | 2 913 | 236 846 | 43 135 | 282 894 | 372 606 | 655 500 |
| Glass | 1 367 | 185 175 | 44 185 | 230 727 | 1 674 | 232 401 |
| Cement | 23 179 | 31 000 | 80 657 | 134 836 | 573 059 | 707 895 |
| Metal | 774 | 10 263 | 23 388 | 34 425 | 10 257 | 44 682 |
| Steel | 907 | 40 865 | 81 893 | 123 665 | 4 455 | 128 120 |
| Clothing, Footwear and Tanneries | 336 | 13 733 | 26 064 | 40 133 | 8 059 | 48 192 |
| Wood | 6 061 | 8 021 | 50 576 | 64 658 | 49 560 | 114 218 |
| Rubber | 0 | 2 663 | 18 781 | 21 444 | 19 588 | 41 032 |
| Electro-metal-mechanical | 5 294 | 48 729 | 153 762 | 207 785 | 27 089 | 234 874 |
| Others | 26 168 | 11 396 | 88 883 | 126 447 | 11 638 | 138 085 |

*Source: Author, using data of fuel consumption from DGEG*

## 12.3. C: Detailed Regression Results of Financial Dependent Variables per industry

**Table XV - Energy Prices and Firm's Profitability, by Industry (1/2)**

| | Ln (Costs Shares$_t$) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Food, beverage, and tobacco | Textile | Pulp and Paper | Chemical and Plastics | Ceramic | Glass | Cement |
| Ln (Energy Price$_t$) | -0.0200 | 0.0196 | 0.0483* | 0.0312* | 0.0381 | 0.0903* | -0.0500 |
| | (0.0194) | (0.0231) | (0.0253) | (0.0179) | (0.0807) | (0.0478) | (0.0543) |
| Firm Size$_t$ | 0.0145** | 0.0177* | -0.0026 | -0.0035 | 0.0043 | -0.0324* | 0.0188 |
| | (0.0071) | (0.0092) | (0.0142) | (0.0081) | (0.0196) | (0.0164) | (0.0295) |
| Ln (Productivity$_t$) | -0.0882*** | -0.1430*** | -0.1497*** | -0.1334*** | -0.1568*** | -0.0821*** | -0.0926*** |
| | (0.0095) | (0.0111) | (0.0187) | (0.0135) | (0.0197) | (0.0229) | (0.0239) |
| Ln (Energy Intensity$_t$) | 0.0224** | 0.0101* | 0.0267* | 0.0200* | 0.0067 | 0.0776*** | 0.0549*** |
| | (0.0089) | (0.0057) | (0.0151) | (0.0114) | (0.0263) | (0.0161) | (0.0199) |
| Constant | 0.7766*** | 0.9631*** | 1.1499*** | 1.1434*** | 1.2077** | 0.7568** | 1.0454* |
| | (0.1459) | (0.1727) | (0.2001) | (0.1474) | (0.5472) | (0.3730) | (0.5321) |
| Observations | 11,755 | 4,687 | 5,308 | 5,060 | 1,009 | 827 | 1,268 |
| R-squared | 0.1479 | 0.2785 | 0.2462 | 0.2937 | 0.2804 | 0.4744 | 0.2458 |
| Number of firms | 1,743 | 716 | 791 | 752 | 148 | 125 | 199 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XVI - Energy Prices and Firm's Profitability, by Industry (2/2)**

| | Ln (Costs Shares$_t$) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Metal | Steel | Clothing, Footwear and Tanneries | Wood | Rubber | Electro-metal-mechanical | Other |
| Ln (Energy Price$_t$) | -0.0078 | -0.1122 | 0.0875*** | 0.0073 | 0.1878*** | 0.0164 | 0.0080 |
| | (0.0385) | (0.1293) | (0.0157) | (0.0236) | (0.0509) | (0.0126) | (0.0259) |
| Firm Size$_t$ | -0.0027 | -0.0805** | -0.0107* | 0.0151* | -0.0640*** | 0.0120** | 0.0032 |
| | (0.0179) | (0.0232) | (0.0057) | (0.0087) | (0.0225) | (0.0061) | (0.0110) |
| Ln (Productivity$_t$) | -0.0940*** | 0.0830 | -0.1181*** | -0.1179*** | -0.0951*** | -0.1506*** | -0.1177*** |
| | (0.0209) | (0.0556) | (0.0100) | (0.0102) | (0.0259) | (0.0074) | (0.0128) |
| Ln (Energy Intensity$_t$) | 0.0199 | 0.1015 | 0.0264*** | 0.0303*** | 0.0427* | 0.0288*** | 0.0288*** |
| | (0.0147) | (0.0646) | (0.0066) | (0.0100) | (0.0250) | (0.0052) | (0.0087) |
| Constant | 1.0112*** | 1.3153 | 0.6977*** | 0.8915*** | 0.5250 | 1.2129*** | 1.0425*** |
| | (0.2992) | (1.0807) | (0.1036) | (0.1590) | (0.3771) | (0.1003) | (0.2194) |
| Observations | 1,231 | 46 | 11,491 | 6,845 | 357 | 19,120 | 5,601 |
| R-squared | 0.2500 | 0.6153 | 0.2422 | 0.2385 | 0.3402 | 0.3005 | 0.2600 |
| Number of firms | 208 | 7 | 1,776 | 1,075 | 53 | 2,923 | 859 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XVII - Energy Prices and Firm's Investment, by Industry (1/2)**

| | Ln ($Investment_t$) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Food, beverage, and tobacco | Textile | Pulp and Paper | Chemical and Plastics | Ceramic | Glass | Cement |
| Ln ($Energy\ Price_{t-1}$) | 0.1619 | 2.8967*** | 1.8290*** | 1.7250*** | 2.3667*** | 1.2557 | -0.6397 |
| | (0.2018) | (0.3664) | (0.3149) | (0.2972) | (0.8768) | (1.0264) | (0.7166) |
| $Firm\ Size_{t-1}$ | 0.0749 | 0.1433 | 0.0423 | 0.0902 | 0.4958 | -0.0899 | 0.4018 |
| | (0.0722) | (0.1105) | (0.1231) | (0.1018) | (0.3516) | (0.3843) | (0.3215) |
| Ln ($Productivity_{t-1}$) | 0.0098 | 0.0421 | -0.0585 | 0.0448 | 0.4774** | 0.0394 | 0.0353 |
| | (0.0546) | (0.1246) | (0.1440) | (0.1116) | (0.2074) | (0.4015) | (0.1912) |
| Ln ($Energy\ Intensity_{t-1}$) | -0.1719*** | -0.2354** | -0.3453*** | -0.2046** | 0.0673 | -0.2516 | -0.1191 |
| | (0.0561) | (0.1193) | (0.0912) | (0.0961) | (0.1427) | (0.3913) | (0.1821) |
| Constant | 8.3011*** | -11.7951*** | -3.2694 | -2.8318 | -15.7886* | 2.9599 | 8.9245 |
| | (1.5695) | (2.2948) | (2.5104) | (2.0243) | (9.0352) | (8.6587) | (8.0125) |
| Observations | 8,289 | 3,078 | 3,276 | 3,537 | 717 | 562 | 826 |
| R-squared | 0.0118 | 0.0820 | 0.0501 | 0.0505 | 0.0932 | 0.0770 | 0.0793 |
| Number of firms | 1,604 | 622 | 687 | 680 | 137 | 117 | 178 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XVIII - Energy Prices and Firm's Investment, by Industry (2/2)**

| | Ln ($Investment_t$) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Metal | Steel | Clothing, Footwear and Tanneries | Wood | Rubber | Electro-metal-mechanical | Other |
| Ln (Energy $Price_{t-1}$) | 0.8023 | 2.1061 | 0.8864*** | 1.0145*** | -1.0150 | 1.1093*** | 1.2464*** |
| | (0.6223) | (1.8360) | (0.2080) | (0.3171) | (0.9354) | (0.1671) | (0.3644) |
| Firm $Size_{t-1}$ | -0.0102 | -0.0710 | 0.0433 | -0.1794* | 1.3285*** | 0.1432** | -0.0225 |
| | (0.1900) | (0.2935) | (0.0643) | (0.1002) | (0.4040) | (0.0658) | (0.1253) |
| Ln ($Productivity_{t-1}$) | 0.3194 | 0.4506 | 0.2225*** | 0.1628** | -0.1937 | 0.1409** | -0.0065 |
| | (0.2273) | (0.9592) | (0.0597) | (0.0770) | (0.3814) | (0.0584) | (0.0965) |
| Ln (Energy $Intensity_{t-1}$) | -0.0611 | 0.3448 | -0.1103** | -0.0334 | -0.0861 | -0.0542 | -0.2160*** |
| | (0.1651) | (0.6580) | (0.0473) | (0.0662) | (0.3519) | (0.0451) | (0.0743) |
| Constant | 2.4587 | -4.3786 | 0.8906 | 3.8604* | 1.0832 | -0.7018 | 1.0837 |
| | (4.2524) | (16.0179) | (1.3521) | (2.3233) | (7.0921) | (1.2914) | (2.8035) |
| Observations | 758 | 39 | 7,752 | 4,018 | 247 | 12,092 | 3,273 |
| R-squared | 0.0377 | 0.1967 | 0.0288 | 0.0236 | 0.0988 | 0.0382 | 0.0267 |
| Number of firms | 171 | 7 | 1,569 | 899 | 47 | 2,525 | 722 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XIX - Energy Prices and Firm's Employment, by Industry (1/2)**

| | Ln ($Employment_t$) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Food, beverage, and tobacco | Textile | Pulp and Paper | Chemical and Plastics | Ceramic | Glass | Cement |
| Ln ($Energy Price_{t-1}$) | -0.0311 | 0.1064 | -0.0746 | 0.0041 | 0.2187 | -0.1368 | -0.5539*** |
| | (0.0572) | (0.0884) | (0.0580) | (0.0683) | (0.1745) | (0.1969) | (0.1425) |
| $Firm Size_{t-1}$ | 0.3971*** | 0.4402*** | 0.3426*** | 0.5007*** | 0.4410*** | 0.3060*** | 0.5390*** |
| | (0.0296) | (0.0408) | (0.0461) | (0.0408) | (0.1258) | (0.0935) | (0.1090) |
| Ln ($Productivity_{t-1}$) | -0.0851*** | -0.0550 | -0.0850*** | -0.0634* | 0.0678 | 0.0372 | 0.0826 |
| | (0.0237) | (0.0421) | (0.0328) | (0.0331) | (0.0543) | (0.0866) | (0.0528) |
| Ln ($Energy Intensity_{t-1}$) | -0.0504** | -0.0401 | -0.0762*** | 0.0075 | -0.0235 | -0.1119 | 0.0194 |
| | (0.0220) | (0.0312) | (0.0209) | (0.0328) | (0.0440) | (0.0882) | (0.0458) |
| Constant | -1.7778*** | -3.4057*** | -1.0530 | -3.6389*** | -4.9071*** | -1.1440 | -2.0267 |
| | (0.4948) | (0.6015) | (0.8453) | (0.5566) | (1.8392) | (1.5118) | (2.3935) |
| Observations | 10,174 | 4,045 | 4,599 | 4,390 | 875 | 717 | 1,100 |
| R-squared | 0.1215 | 0.2201 | 0.1409 | 0.2401 | 0.1412 | 0.1391 | 0.2768 |
| Number of firms | 1,710 | 698 | 779 | 746 | 148 | 123 | 196 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XX - Energy Prices and Firm's Employment, by Industry (2/2)**

| | Ln ($Employment_t$) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Metal | Steel | Clothing, Footwear and Tanneries | Wood | Rubber | Electro-metal-mechanical | Other |
| Ln (Energy $Price_{t-1}$) | -0.1828 | 0.1136 | -0.1163** | -0.3811*** | 0.0020 | -0.1541*** | -0.1468** |
| | (0.1474) | (0.3116) | (0.0571) | (0.0656) | (0.1869) | (0.0387) | (0.0687) |
| Firm $Size_{t-1}$ | 0.2051*** | 0.1586 | 0.4124*** | 0.3724*** | 0.4423*** | 0.3712*** | 0.3844*** |
| | (0.0670) | (0.1017) | (0.0292) | (0.0299) | (0.1223) | (0.0196) | (0.0362) |
| Ln ($Productivity_{t-1}$) | 0.0686 | 0.3521 | -0.1137*** | -0.0104 | 0.1911** | -0.0123 | 0.0108 |
| | (0.0537) | (0.1847) | (0.0302) | (0.0221) | (0.0872) | (0.0183) | (0.0225) |
| Ln (Energy $Intensity_{t-1}$) | 0.0261 | 0.2075 | -0.1063*** | -0.0287 | 0.0897 | -0.0297** | -0.0157 |
| | (0.0477) | (0.1664) | (0.0247) | (0.0229) | (0.0710) | (0.0130) | (0.0186) |
| Constant | 0.4651 | -2.2667 | -0.6686* | 0.1117 | -4.6914*** | -1.2416*** | -1.9671*** |
| | (1.4556) | (4.5052) | (0.3643) | (0.5435) | (1.7324) | (0.3271) | (0.6301) |
| Observations | 1,063 | 39 | 9,904 | 5,912 | 310 | 16,526 | 4,855 |
| R-squared | 0.0864 | 0.4261 | 0.1639 | 0.1499 | 0.3202 | 0.1390 | 0.1514 |
| Number of firms | 207 | 7 | 1,744 | 1,057 | 52 | 2,871 | 852 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

## 12.4. D: Detailed Regression Results of Financial Dependent Variables per energy dependency level

**Table XXI - Energy Prices and Firm's Profitability, by Energy Dependency Level**

| | Ln (Costs Shares$_t$) | | | | | |
|---|---|---|---|---|---|---|
| | Low Dependency | | Medium Dependency | | High Dependency | |
| VARIABLES | (2) | (3) | (2) | (3) | (2) | (3) |
| Ln (Energy Price$_t$) | -0.1213* | -0.0683 | -0.0603 | -0.0715 | 0.0403 | 0.0624 |
| | (0.0661) | (0.0910) | (0.0444) | (0.0506) | (0.0436) | (0.0541) |
| Firm Size$_t$ | -0.0085* | 0.0088*** | -0.0106** | 0.0078*** | 0.0131*** | 0.0195*** |
| | (0.0044) | (0.0012) | (0.0043) | (0.0010) | (0.0045) | (0.0014) |
| Ln (Productivity$_t$) | -0.0988*** | -0.1026*** | -0.0947*** | -0.1208*** | -0.0876*** | -0.1341*** |
| | (0.0057) | (0.0040) | (0.0076) | (0.0038) | (0.0067) | (0.0048) |
| Ln (Energy Intensity$_t$) | 0.0201*** | 0.0156*** | 0.0946*** | 0.0654*** | 0.1091*** | 0.0648*** |
| | (0.0035) | (0.0029) | (0.0070) | (0.0026) | (0.0069) | (0.0035) |
| Constant | 1.9349*** | 1.3535** | 1.6496*** | 1.6585*** | 0.5035* | 0.6429* |
| | (0.4524) | (0.6210) | (0.3088) | (0.3462) | (0.2969) | (0.3683) |
| Observations | 21,400 | 21,400 | 28,019 | 28,019 | 25,186 | 25,186 |
| R-squared | 0.2286 | 0.2504 | 0.3154 | 0.3861 | 0.3008 | 0.3426 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | NO | YES | NO | YES | NO |
| Industry FE | NO | YES | NO | YES | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXII - Energy Prices and Firm's Investment, by Energy Dependency Level**

| | Ln ($Investment_t$) | | | | | |
|---|---|---|---|---|---|---|
| | Low Dependency | | Medium Dependency | | High Dependency | |
| VARIABLES | (2) | (3) | (2) | (3) | (2) | (3) |
| Ln ($Energy Price_{t-1}$) | 3.1140*** | 2.2449 | 3.6508*** | 2.4261** | 2.2040*** | 1.2880 |
| | (0.9217) | (1.6168) | (0.9686) | (1.0941) | (0.6982) | (0.9000) |
| $Firm Size_{t-1}$ | 0.0902* | 0.8374*** | -0.0560 | 0.8052*** | 0.0797 | 0.7532*** |
| | (0.0515) | (0.0154) | (0.0586) | (0.0138) | (0.0579) | (0.0149) |
| Ln ($Productivity_{t-1}$) | 0.1204** | 0.0710* | 0.1929*** | 0.4862*** | 0.0854* | 0.5053*** |
| | (0.0488) | (0.0392) | (0.0557) | (0.0379) | (0.0466) | (0.0386) |
| Ln ($Energy Intensity_{t-1}$) | -0.1210*** | -0.0297 | -0.0528 | -0.0680** | -0.1181** | 0.0593** |
| | (0.0347) | (0.0263) | (0.0517) | (0.0301) | (0.0476) | (0.0301) |
| Constant | -13.4787** | -17.6691 | -15.7836** | -22.6808*** | -6.6616 | -13.8443** |
| | (6.2814) | (11.0025) | (6.6203) | (7.4504) | (4.7627) | (6.0894) |
| Observations | 13,950 | 13,950 | 18,708 | 18,708 | 15,806 | 15,806 |
| R-squared | 0.0303 | 0.4179 | 0.0380 | 0.4432 | 0.0217 | 0.4377 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | NO | YES | NO | YES | NO |
| Industry FE | NO | YES | NO | YES | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXIII - Energy Prices and Firm's Employment, by Energy Dependency Level**

| | Ln ($Employment_t$) | | | | | |
|---|---|---|---|---|---|---|
| | Low Dependency | | Medium Dependency | | High Dependency | |
| VARIABLES | (2) | (3) | (2) | (3) | (2) | (3) |
| Ln ($Energy Price_{t-1}$) | -0.0446 | -0.9655* | 0.1551 | -0.2202 | 0.2831* | 0.0942 |
| | (0.3018) | (0.5816) | (0.1401) | (0.3261) | (0.1485) | (0.2577) |
| $Firm Size_{t-1}$ | 0.3774*** | 0.7528*** | 0.3210*** | 0.7513*** | 0.3272*** | 0.6934*** |
| | (0.0197) | (0.0077) | (0.0125) | (0.0060) | (0.0167) | (0.0077) |
| Ln ($Productivity_{t-1}$) | -0.0295 | -0.5108*** | -0.0508*** | -0.4943*** | -0.0526*** | -0.3125*** |
| | (0.0180) | (0.0230) | (0.0138) | (0.0191) | (0.0129) | (0.0269) |
| Ln ($Energy Intensity_{t-1}$) | -0.0119 | -0.2262*** | -0.0780*** | -0.4444*** | -0.0961*** | -0.2436*** |
| | (0.0101) | (0.0142) | (0.0126) | (0.0153) | (0.0134) | (0.0179) |
| Constant | -1.8470 | 3.2237 | -2.3060** | -2.3074 | -3.3515*** | -4.8198*** |
| | (2.0486) | (3.9689) | (0.9607) | (2.2235) | (1.0324) | (1.7597) |
| Observations | 18,444 | 18,444 | 24,222 | 24,222 | 21,833 | 21,833 |
| R-squared | 0.1616 | 0.7113 | 0.1702 | 0.7530 | 0.1163 | 0.6868 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | NO | YES | NO | YES | NO |
| Industry FE | NO | YES | NO | YES | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

## 12.5. E: Detailed Regression Results of Green Dependent Variables per industry

**Table XXIV - Energy Prices and Firm's Green Expenditure, by Industry (1/2)**

| | Ln (Green Expenditure$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Food, beverage, and tobacco | Textile | Pulp and Paper | Chemical and Plastics | Ceramic | Glass | Cement |
| Ln (Energy Price$_t$) | 1.2654 | 0.6699 | -1.5594 | 0.1139 | -0.8391 | 2.1547 | 2.9932 |
| | (0.7761) | (1.0292) | (0.9626) | (0.7601) | (2.3889) | (2.9572) | (1.9625) |
| Firm Size$_t$ | 0.5412* | 0.5685 | 0.8463* | 0.0463 | 0.6688 | 0.3176 | 0.6927 |
| | (0.2971) | (0.3603) | (0.4457) | (0.3396) | (0.8137) | (0.7679) | (0.8128) |
| Ln (Productivity$_t$) | -0.0891 | 0.1986 | 0.4022 | 0.0775 | 0.6528 | -1.8289 | -0.2019 |
| | (0.1516) | (0.2976) | (0.3436) | (0.2841) | (0.5763) | (1.7106) | (0.3225) |
| Ln (Energy Intensity$_t$) | -0.1361 | -0.0728 | -0.0271 | 0.0330 | 0.2838 | -1.9609 | -0.4570 |
| | (0.1648) | (0.2452) | (0.1689) | (0.2531) | (0.2703) | (1.5532) | (0.3599) |
| Constant | -11.3771 | -10.0813 | -0.4744 | 3.3421 | -3.4810 | -0.4563 | -26.3120 |
| | (7.0310) | (8.3095) | (10.1399) | (6.5673) | (17.2813) | (18.3968) | (21.7090) |
| Observations | 4,193 | 1,796 | 1,682 | 2,112 | 500 | 274 | 534 |
| R-squared | 0.0085 | 0.0168 | 0.0175 | 0.0058 | 0.0308 | 0.0471 | 0.0192 |
| Number of firms | 1,646 | 667 | 735 | 711 | 143 | 115 | 183 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXV - Energy Prices and Firm's Green Expenditure, by Industry (2/2)**

| | Ln (Green Expenditure$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Metal | Steel | Clothing, Footwear and Tanneries | Wood | Rubber | Electro-metal-mechanical | Other |
| Ln (Energy Price$_t$) | 1.0481 | 0.6876 | -2.0654*** | 1.3237 | 5.2074 | 0.1629 | 0.2663 |
| | (1.4543) | (1.5226) | (0.7315) | (0.9693) | (3.6061) | (0.4921) | (1.0871) |
| Firm Size$_t$ | -0.6830 | 1.7560** | 0.3702* | 0.0813 | -0.7087 | 0.5806*** | 0.1124 |
| | (0.4674) | (0.6587) | (0.2210) | (0.2775) | (1.2481) | (0.2193) | (0.2953) |
| Ln (Productivity$_t$) | 1.4632** | -0.1169 | -0.2080 | 0.1960 | -0.7769 | 0.1154 | 0.0968 |
| | (0.7273) | (1.4544) | (0.2062) | (0.2334) | (1.2057) | (0.1632) | (0.0983) |
| Ln (Energy Intensity$_t$) | 0.4616 | 0.0887 | -0.0530 | 0.0988 | -1.1127 | 0.0150 | 0.1551 |
| | (0.5831) | (1.1895) | (0.1762) | (0.2400) | (0.8023) | (0.1610) | (0.1563) |
| Constant | -5.8369 | -22.5666* | 13.6985*** | -9.5399 | -15.3416 | -6.3845 | -1.3316 |
| | (14.0415) | (10.0755) | (5.2682) | (8.1245) | (11.2357) | (4.0421) | (8.3732) |
| Observations | 598 | 38 | 4,007 | 1,982 | 118 | 6,747 | 1,652 |
| R-squared | 0.0574 | 0.4770 | 0.0077 | 0.0114 | 0.1454 | 0.0106 | 0.0076 |
| Number of firms | 186 | 7 | 1,637 | 988 | 48 | 2,718 | 798 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXVI - Energy Prices and Firm's Green Revenues, by Industry (1/2)**

| | Ln (Green Revenues$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Food, beverage, and tobacco | Textile | Pulp and Paper | Chemical and Plastics | Ceramic | Glass | Cement |
| Ln (Energy Price$_t$) | 1.5940*** | 0.3700 | 0.1402 | 2.2585*** | 3.9789 | -2.1211 | 1.2805 |
| | (0.5518) | (1.0344) | (1.1910) | (0.7842) | (3.0547) | (2.7694) | (1.8750) |
| Firm Size$_t$ | 0.2058 | 0.4914 | 1.4043** | 0.2659 | -0.5369 | 1.1650 | 0.7357 |
| | (0.1508) | (0.3363) | (0.5728) | (0.2648) | (1.0448) | (1.1883) | (0.5764) |
| Ln (Productivity$_t$) | 0.1330 | 0.2012 | 0.5766 | 0.2896* | 0.0190 | -0.1569 | -0.1475 |
| | (0.1475) | (0.2882) | (0.4897) | (0.1666) | (0.4574) | (1.7029) | (0.2796) |
| Ln (Energy Intensity$_t$) | 0.0194 | 0.1838 | -0.2836 | 0.1719 | -0.3490 | 0.7522 | 0.0065 |
| | (0.1177) | (0.3102) | (0.2751) | (0.1583) | (0.4095) | (1.8232) | (0.2871) |
| Constant | -13.7536*** | -9.2267 | -24.5740* | -19.8898*** | -13.5852 | 2.6913 | -16.3406 |
| | (4.6430) | (8.1398) | (12.7197) | (6.5984) | (24.4984) | (21.3316) | (19.6350) |
| Observations | 4,193 | 1,796 | 1,682 | 2,112 | 500 | 274 | 534 |
| R-squared | 0.0129 | 0.0111 | 0.0313 | 0.0195 | 0.0405 | 0.0465 | 0.0329 |
| Number of firms | 1,646 | 667 | 735 | 711 | 143 | 115 | 183 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXVII - Energy Prices and Firm's Green Revenues, by Industry (2/2)**

| | Ln (Green Revenues$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Metal | Steel | Clothing, Footwear and Tanneries | Wood | Rubber | Electro-metal-mechanical | Other |
| Ln (Energy Price$_t$) | 3.4732* | 10.0092 | 0.5631 | 0.6372 | 9.4746 | 1.1874* | 0.6713 |
| | (2.0692) | (8.3536) | (0.4273) | (0.8256) | (7.9530) | (0.7029) | (0.8273) |
| Firm Size$_t$ | -1.3207** | -2.3048 | 0.1782* | -0.0212 | -0.9707 | 0.4332* | 0.2250 |
| | (0.6649) | (4.9376) | (0.1062) | (0.2245) | (2.5402) | (0.2214) | (0.3240) |
| Ln (Productivity$_t$) | 1.4378** | -17.9103** | 0.0983 | 0.2808 | -0.1820 | 0.0487 | 0.1216 |
| | (0.6289) | (7.1005) | (0.0905) | (0.2272) | (0.8784) | (0.1628) | (0.0940) |
| Ln (Energy Intensity$_t$) | 0.7963 | -18.4129* | 0.0258 | 0.2652 | 0.4459 | -0.0469 | 0.0526 |
| | (0.6185) | (8.0473) | (0.0733) | (0.2096) | (0.8867) | (0.1269) | (0.0973) |
| Constant | -13.9097 | 148.1828** | -6.7513** | -5.2377 | -48.3720* | -12.1893** | -7.8909 |
| | (19.1239) | (59.7451) | (3.0082) | (6.3016) | (25.2044) | (5.3364) | (7.3412) |
| Observations | 598 | 38 | 4,007 | 1,982 | 118 | 6,747 | 1,652 |
| R-squared | 0.0533 | 0.4774 | 0.0087 | 0.0081 | 0.1445 | 0.0095 | 0.0143 |
| Number of firms | 186 | 7 | 1,637 | 988 | 48 | 2,718 | 798 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXVIII - Energy Prices and Firm's Green Investment, by Industry (1/2)**

| | Ln (Green Investment$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Food, beverage, and tobacco | Textile | Pulp and Paper | Chemical and Plastics | Ceramic | Glass | Cement |
| Ln (Energy Price$_{t-1}$) | 0.3686 | 1.7967* | -0.1595 | 0.1173 | -4.9866 | -1.2541 | -0.7460 |
| | (0.7938) | (1.0615) | (1.1534) | (0.9685) | (3.5036) | (3.2787) | (1.6776) |
| Firm Size$_{t-1}$ | 0.1122 | 1.2305*** | 1.1868** | -0.2030 | 0.9748 | -1.3413 | 0.4305 |
| | (0.3355) | (0.3164) | (0.5754) | (0.2706) | (2.0901) | (1.0757) | (0.5557) |
| Ln (Productivity$_{t-1}$) | 0.4300* | -0.7675* | -0.6288 | -0.0974 | 0.3330 | -0.4509 | -0.0215 |
| | (0.2446) | (0.3944) | (0.6056) | (0.2852) | (0.5679) | (0.9818) | (0.2380) |
| Ln (Energy Intensity$_{t-1}$) | 0.4926** | -0.5146** | -0.0888 | -0.0861 | 0.0068 | -2.0984 | -0.3359 |
| | (0.2044) | (0.2606) | (0.2854) | (0.1862) | (0.3873) | (1.6669) | (0.2783) |
| Constant | -6.1081 | -22.7872*** | -8.5189 | 4.5178 | 15.2764 | 30.2207 | 0.2773 |
| | (7.3108) | (8.3758) | (11.6378) | (8.2196) | (29.6693) | (23.3761) | (16.7768) |
| Observations | 3,712 | 1,579 | 1,482 | 1,883 | 426 | 252 | 457 |
| R-squared | 0.0041 | 0.0186 | 0.0221 | 0.0066 | 0.0220 | 0.1131 | 0.0675 |
| Number of firms | 1,528 | 623 | 693 | 683 | 127 | 113 | 167 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXIX - Energy Prices and Firm's Green Investment, by Industry (2/2)**

| | Ln (Green Investment$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Metal | Steel | Clothing, Footwear and Tanneries | Wood | Rubber | Electro-metal-mechanical | Other |
| Ln (Energy Price$_{t-1}$) | -0.3335 | 2.0764 | 0.3897 | -0.4337 | 3.5318 | 0.0410 | 0.2864 |
| | (1.7522) | (17.4589) | (0.3837) | (0.9792) | (2.9178) | (0.5686) | (1.0179) |
| Firm Size$_{t-1}$ | 0.0288 | -2.9245 | -0.0684 | 0.0539 | -0.6795 | 0.2296 | 0.5222* |
| | (0.4153) | (2.3935) | (0.1227) | (0.2978) | (1.3456) | (0.1732) | (0.3053) |
| Ln (Productivity$_{t-1}$) | 0.4714 | -9.1281 | -0.0194 | 0.3882** | 5.8951*** | 0.2690** | -0.0754 |
| | (0.5654) | (7.3388) | (0.0784) | (0.1977) | (1.2717) | (0.1223) | (0.0751) |
| Ln (Energy Intensity$_{t-1}$) | -0.3223 | -10.8936 | -0.0408 | 0.5740** | 5.1267*** | 0.1050 | -0.1252 |
| | (0.3642) | (5.7572) | (0.0640) | (0.2410) | (1.5337) | (0.1402) | (0.1193) |
| Constant | -1.7990 | 129.0098 | -1.3240 | 0.7319 | -59.1525*** | -4.6149 | -8.2968 |
| | (14.9983) | (147.9210) | (3.1471) | (7.8148) | (17.8303) | (4.3288) | (9.2423) |
| Observations | 530 | 33 | 3,557 | 1,740 | 111 | 5,905 | 1,414 |
| R-squared | 0.0180 | 0.1366 | 0.0019 | 0.0123 | 0.3409 | 0.0065 | 0.0138 |
| Number of firms | 178 | 7 | 1,525 | 894 | 49 | 2,481 | 716 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXX - Energy Prices and Firm's Green Employment, by Industry (1/2)**

| | Ln (Green Employment$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Food, beverage, and tobacco | Textile | Pulp and Paper | Chemical and Plastics | Ceramic | Glass | Cement |
| Ln (Energy Price$_{t-1}$) | 0.0361 | -0.1005 | 0.0420 | 0.6925*** | -0.4173* | -0.1300 | -0.0057 |
| | (0.1934) | (0.2433) | (0.2622) | (0.2101) | (0.2445) | (1.0822) | (0.4636) |
| Firm Size$_{t-1}$ | 0.1326 | 0.2574** | 0.0540 | -0.0194 | 0.2581** | -0.2841 | -0.0494 |
| | (0.1034) | (0.1044) | (0.1002) | (0.1448) | (0.1108) | (0.4336) | (0.2232) |
| Ln (Productivity$_{t-1}$) | -0.0121 | -0.0442 | -0.0093 | -0.1570 | -0.1194*** | -0.4223 | 0.1789 |
| | (0.0502) | (0.0753) | (0.1277) | (0.1997) | (0.0314) | (0.2491) | (0.1349) |
| Ln (Energy Intensity$_{t-1}$) | -0.1066* | -0.0680 | 0.0991 | -0.0937 | -0.0650 | -0.3639 | -0.0574 |
| | (0.0550) | (0.1135) | (0.0906) | (0.1860) | (0.0727) | (0.2180) | (0.0985) |
| Constant | -1.1007 | -1.8066 | 0.7722 | -1.4659 | 0.9547 | 11.5614 | 0.6778 |
| | (1.7647) | (2.0549) | (2.1867) | (2.6466) | (2.2247) | (12.4120) | (5.4295) |
| Observations | 962 | 436 | 442 | 625 | 240 | 51 | 101 |
| R-squared | 0.0376 | 0.0548 | 0.0234 | 0.0388 | 0.1456 | 0.1613 | 0.1558 |
| Number of firms | 298 | 123 | 146 | 198 | 67 | 16 | 35 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXXI - Energy Prices and Firm's Green Employment, by Industry (2/2)**

| | Ln (Green Employment$_t$ + 1) | | | | | | |
|---|---|---|---|---|---|---|---|
| VARIABLES | Metal | Steel | Clothing, Footwear and Tanneries | Wood | Rubber | Electro-metal-mechanical | Other |
| Ln (Energy Price$_{t-1}$) | 0.2368 | -0.3093 | 0.3387 | -0.2436 | 0.2360 | -0.1012 | -0.0230 |
| | (0.7275) | (0.3691) | (0.2704) | (0.3242) | (0.9893) | (0.1230) | (0.3586) |
| Firm Size$_{t-1}$ | 0.2723 | -0.3965* | 0.1839 | -0.1861 | 0.3256 | 0.0856 | 0.3199 |
| | (0.3027) | (0.1746) | (0.1363) | (0.1585) | (0.2764) | (0.0712) | (0.3213) |
| Ln (Productivity$_{t-1}$) | 0.0809 | -0.5146 | -0.0307 | 0.1054 | 0.6450*** | -0.0178 | -0.4053 |
| | (0.2337) | (0.6923) | (0.2101) | (0.1600) | (0.1796) | (0.0437) | (0.2665) |
| Ln (Energy Intensity$_{t-1}$) | 0.0227 | -0.5509 | 0.1223 | 0.1670 | 0.2785 | 0.0260 | -0.4898* |
| | (0.1411) | (0.7187) | (0.1987) | (0.2058) | (0.1683) | (0.0503) | (0.2531) |
| Constant | -5.3755 | 15.8184** | -3.5765 | 5.3967** | -11.2285*** | 1.1169 | -0.7440 |
| | (8.3498) | (5.0930) | (3.0534) | (2.6533) | (2.9091) | (1.6357) | (4.8539) |
| Observations | 195 | 29 | 386 | 255 | 41 | 1,812 | 220 |
| R-squared | 0.0472 | 0.3936 | 0.0621 | 0.0555 | 0.6483 | 0.0103 | 0.0994 |
| Number of firms | 53 | 5 | 162 | 93 | 13 | 527 | 76 |
| Year FE | YES | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | YES | YES | YES | YES | YES | YES |
| Industry FE | NO | NO | NO | NO | NO | NO | NO |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. The regressions include year and firm fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

## 12.6. F: Detailed Regression Results of Green Dependent Variables per energy dependency level

**Table XXXII - Energy Prices and Firm's Green Expenditure, by Energy Dependency Level**

| | Ln (Green Expenditure$_t$ + 1) | | | | | |
|---|---|---|---|---|---|---|
| | Low Dependency | | Medium Dependency | | High Dependency | |
| VARIABLES | (2) | (3) | (2) | (3) | (2) | (3) |
| Ln (Energy Price$_t$) | -3.0206 | -4.6830 | -3.3416 | -3.4370 | 0.3818 | -0.6448 |
| | (2.9024) | (3.5857) | (2.1798) | (2.4759) | (1.6795) | (1.8930) |
| Firm Size$_t$ | 0.3943** | 1.7954*** | 0.4785** | 1.6894*** | -0.0070 | 1.6005*** |
| | (0.1611) | (0.0420) | (0.1905) | (0.0399) | (0.1881) | (0.0412) |
| Ln (Productivity$_t$) | 0.0664 | -0.5471*** | 0.1122 | 0.1845* | 0.1661 | 0.3788*** |
| | (0.1312) | (0.0989) | (0.1974) | (0.1049) | (0.1475) | (0.0962) |
| Ln (Energy Intensity$_t$) | -0.0718 | 0.1268* | 0.1044 | 0.1455 | -0.1089 | 0.4586*** |
| | (0.1122) | (0.0732) | (0.2221) | (0.1017) | (0.1883) | (0.1014) |
| Constant | 18.0663 | 15.4149 | 19.1283 | 1.6039 | -0.0544 | -17.4691 |
| | (19.9864) | (24.4089) | (14.9355) | (16.8778) | (11.6378) | (12.8298) |
| Observations | 8,130 | 8,130 | 9,970 | 9,970 | 8,133 | 8,133 |
| R-squared | 0.0058 | 0.4539 | 0.0057 | 0.4644 | 0.0064 | 0.4942 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | NO | YES | NO | YES | NO |
| Industry FE | NO | YES | NO | YES | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXXIII - Energy Prices and Firm's Green Revenues, by Energy Dependency Level**

| | Ln (Green Revenues$_t$ + 1) | | | | | |
|---|---|---|---|---|---|---|
| | Low Dependency | | Medium Dependency | | High Dependency | |
| VARIABLES | (2) | (3) | (2) | (3) | (2) | (3) |
| Ln (Energy Price$_t$) | 0.3733 | -1.1539 | 3.0788 | -6.4250** | -2.5233 | -1.1920 |
| | (2.6061) | (2.8569) | (2.2981) | (2.5115) | (2.0109) | (1.9822) |
| Firm Size$_t$ | 0.0723 | 1.2863*** | 0.5627*** | 1.1512*** | -0.0618 | 0.9932*** |
| | (0.1289) | (0.0524) | (0.1845) | (0.0531) | (0.1993) | (0.0513) |
| Ln (Productivity$_t$) | -0.0978 | -0.4707*** | 0.3989** | 0.1418 | 0.2788* | 0.0765 |
| | (0.1377) | (0.0880) | (0.1900) | (0.1136) | (0.1560) | (0.1194) |
| Ln (Energy Intensity$_t$) | -0.1528* | 0.1004 | 0.3217 | 0.1756 | 0.0112 | 0.0971 |
| | (0.0851) | (0.0685) | (0.2014) | (0.1129) | (0.1848) | (0.1171) |
| Constant | -1.2223 | -4.0043 | -30.3630* | 28.1914* | 16.8884 | -5.2734 |
| | (18.0560) | (19.4774) | (15.9199) | (17.1325) | (13.7382) | (13.4437) |
| Observations | 8,130 | 8,130 | 9,970 | 9,970 | 8,133 | 8,133 |
| R-squared | 0.0117 | 0.3674 | 0.0117 | 0.3068 | 0.0109 | 0.2905 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | NO | YES | NO | YES | NO |
| Industry FE | NO | YES | NO | YES | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXXIV - Energy Prices and Firm's Green Investment, by Energy Dependency Level**

| | Ln (Green Investment$_t$ + 1) | | | | | |
|---|---|---|---|---|---|---|
| | Low Dependency | | Medium Dependency | | High Dependency | |
| VARIABLES | (2) | (3) | (2) | (3) | (2) | (3) |
| Ln (Energy Price$_{t-1}$) | 0.5619 | -1.0063 | 0.9068 | -2.8425 | 1.8266 | -0.6297 |
| | (3.6109) | (3.4239) | (3.6951) | (2.9945) | (3.0768) | (2.6118) |
| Firm Size$_{t-1}$ | 0.2134 | 0.5313*** | 0.1686 | 0.5545*** | 0.4295** | 0.5036*** |
| | (0.1534) | (0.0442) | (0.1710) | (0.0395) | (0.2107) | (0.0415) |
| Ln (Productivity$_{t-1}$) | 0.2645* | -0.0812 | 0.1060 | 0.3492*** | 0.0800 | 0.6432*** |
| | (0.1387) | (0.0683) | (0.1379) | (0.0908) | (0.1387) | (0.1215) |
| Ln (Energy Intensity$_{t-1}$) | 0.1142 | 0.0823** | 0.0845 | 0.1049 | -0.0621 | 0.3664*** |
| | (0.0898) | (0.0389) | (0.1644) | (0.0776) | (0.1912) | (0.0970) |
| Constant | -8.1185 | 1.1069 | -8.2746 | 9.1117 | -18.0604 | -7.5007 |
| | (24.2585) | (23.2482) | (25.0551) | (20.3967) | (21.0612) | (17.6781) |
| Observations | 7,184 | 7,184 | 8,797 | 8,797 | 7,100 | 7,100 |
| R-squared | 0.0055 | 0.1350 | 0.0010 | 0.1604 | 0.0062 | 0.1857 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | NO | YES | NO | YES | NO |
| Industry FE | NO | YES | NO | YES | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*

**Table XXXV - Energy Prices and Firm's Green Employment, by Energy Dependency Level**

| | Ln (Green Employment$_t$ + 1) | | | | | |
|---|---|---|---|---|---|---|
| | Low Dependency | | Medium Dependency | | High Dependency | |
| VARIABLES | (2) | (3) | (2) | (3) | (2) | (3) |
| Ln (Energy Price$_{t-1}$) | 1.8384 | 3.9644* | 0.0423 | 0.5723 | 0.3523 | -0.2245 |
| | (1.5946) | (2.0532) | (0.8295) | (1.5678) | (0.3310) | (0.6689) |
| Firm Size$_{t-1}$ | 0.1014 | 0.2527*** | 0.1041 | 0.2402*** | 0.1222** | 0.2857*** |
| | (0.1006) | (0.0328) | (0.0683) | (0.0252) | (0.0578) | (0.0286) |
| Ln (Productivity$_{t-1}$) | -0.0102 | -0.1042 | -0.1497** | 0.0250 | -0.0150 | 0.1369** |
| | (0.0456) | (0.0834) | (0.0734) | (0.0770) | (0.0390) | (0.0571) |
| Ln (Energy Intensity$_{t-1}$) | 0.0109 | 0.0004 | -0.1113* | -0.0356 | -0.0623 | 0.0498 |
| | (0.0512) | (0.0683) | (0.0651) | (0.0594) | (0.0491) | (0.0530) |
| Constant | -12.5949 | -28.5816** | 0.6898 | -6.6844 | -2.7514 | -2.8675 |
| | (11.0292) | (14.0240) | (5.9118) | (10.7271) | (2.3646) | (4.5097) |
| Observations | 1,784 | 1,783 | 2,216 | 2,216 | 1,795 | 1,795 |
| R-squared | 0.0095 | 0.1680 | 0.0119 | 0.2057 | 0.0141 | 0.3156 |
| Year FE | YES | YES | YES | YES | YES | YES |
| Firm FE | YES | NO | YES | NO | YES | NO |
| Industry FE | NO | YES | NO | YES | NO | YES |

*Source: Author*

*Note: Regressions are estimated using an OLS method with fixed effects. Model (2) includes year and firm fixed effects, and model (3) includes year and industry fixed effects. Variables are defined as mentioned previously, robust standard errors are shown in parentheses and are clustered at the firm level. Significance levels are given by: * p<0.01, ** p<0.05 and *** p<0.1.*