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Summary

This paper examines the effect of green investments on market power. I measure the market power as markup following the method provided in De Loecker and Warzynski (2012). For green investments, I consider specifically the investments of firms in energy efficient technologies, both as the binary variable and as the continuous variable. This allows the examination of how the presence of such investments as well as their intensity affect markups. I use firm, age, year, sector and country fixed effects with a representative sample of indicatively 12,000 firms from the European Investment Bank Investment Survey (EIBIS) in the panel from 2016 to 2022. I find the positive and statistically significant relationship that holds also when applying the 2SLS-IV methodology. This study is particularly relevant for firms that are willing to increase their market power and to improve their environmentally friendly image in the eyes of their customers without the need of engaging in greenwashing practices. Instead, the firms are invited to consider energy efficiency investments as a concrete way of improving both their markups and the loyalty of their customers.

Keywords: green investment, markup, market power, instrumental variable

JEL classification: Q56, L11, D22, C36, O13

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Abstract

This paper examines the effect of green investments on market power. I measure the market power as markup following the method provided in De Loecker and Warzynski (2012). For green investments, I consider specifically the investments of firms in energy efficient technologies, both as the binary variable and as the continuous variable. This allows the examination of how the presence of such investments as well as their intensity affect markups. I use firm, age, year, sector and country fixed effects with a representative sample of indicatively 12,000 firms from the European Investment Bank Investment Survey (EIBIS) in the panel from 2016 to 2022. I find the positive and statistically significant relationship that holds also when applying the 2SLS-IV methodology. This study is particularly relevant for firms that are willing to increase their market power and to improve their environmentally friendly image in the eyes of their customers without the need of engaging in greenwashing practices. Instead, the firms are invited to consider energy efficiency investments as a concrete way of improving both their markups and the loyalty of their customers.

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1 Introduction

Energy economics covers a wide range of topics. Early literature was focused more on energy demand as in Balestra and Nerlove (1966), while current literature seems to be shifting towards the discussion of the "carbon lock-in" as in Seto et al. (2016) and decarbonisation (Schmidt, Schneider, and Hoffmann 2012; Fankhauser and Jotzo 2017). This shift may be explained by the problem of oil dependency in geopolitical context, as well as the popularity of the discussion of alternative energy sources. The countries are locked into fossil fuel technologies because the use of these well-established technologies provides increasing returns to scale, and it may be costly to shift to alternatives (Unruh 2000). The consequences of this lock-in may create barriers in the adoption of alternative sources of energy. In addition to these technological barriers, there are political, economic and social barriers to reduce carbon emissions (Seto et al. 2016). A potential solution to this problem might be timely investments along the lines with the discussion by Grübler, Nakicenovic, and Nordhaus (2002), but it is unclear whether this solution will be effective in removing these barriers while increasing productivity and economic growth.

In parallel, the increasing emphasis on sustainability and environmental responsibility has led to a surge in green investments, particularly in energy-efficient technologies. Green investments have been recognized as a pivotal factor in achieving sustainable economic growth and combating climate change (Fu, Lu, and Pirabi 2023). Investments in energy efficiency technologies align firms with the broader trend of integrating environmental, social, and governance (ESG) factors into business strategies to achieve sustainable development goals (Wan and Sheng 2022).

Despite the global context of climate change issues, it is important to mention that there are also significant cross-country differences in barriers to investments in energy efficiency. There are some countries that are resource abundant and others that are resource scarce (Wei, Rizvi, Ahmad, and Zhang 2020). It may seem that the above-mentioned barriers are heavier in countries that are characterised by resource scarcity. The paradox here lies that often countries with resource abundance become inactive in energy investment, R&D and innovation as opposed to countries with resource scarcity. However, there are exceptions. For example, Norway has high levels of oil, but it has high investment in energy-saving technologies, because it is aware of scarcity of oil and its system is built on discipline in terms of thinking about the future. In line with this discussion, De Cian, Sferra, and Tavoni (2013) analysed resource scarcity, in particular fossil fuels scarcity and its link to energy investments, suggesting that resource abundance positively affects low-carbon energy investments. Previous literature has highlighted the positive impact of green investments on firm performance, including growth in output, employment, productivity, and export intensity (Liu, Bouri, and Jalkh 2021). However, the impact of such investments on market power has not been extensively explored in the literature. Thus, this paper focuses on this assessment of markups as indicators of market power that is hypothesised to rise as a result of the increased levels of green investment activity. Hence, the first research objective of this paper is to measure the impact of investment in energy efficient technologies on markup. The second research objective is to explore sectoral and regional heterogeneity in the examined relationship.

In order to address the aforementioned research objectives of this paper, I will briefly discuss the channels through which the explored relationship may be manifested. In order to understand how the investments in energy efficiency may increase markup, two broad channels may be identified, namely increase in prices and/or decrease in marginal costs. These channels arise from the definition of markup as price over marginal costs.

Green investments can help firms improve their image as environment-friendly firms, hence increasing demand for their products. Effectively, investments in energy efficiency may make demand less elastic, therefore giving firms pricing power (the firm knows that even if they increase the price, the demand will not decline significantly). A 2015 Nielsen report provides a more optimistic trend in growing demand for sustainable goods, noting that 66% of survey respondents were willing to pay more for these goods compared to 50% in 2013 (Nielsen 2015).

Moreover, such investments may create value for the firm by creating value for different stakeholders. By going green, the firm creates value for customers who are prioritizing green products, leading to a higher willingness to pay for these products. Indeed, green consumption is gradually starting to surpass traditional consumption (Jo and Shin 2017; Meng, Zhao, Shen, and Zhai 2022). Nevertheless, it is important to be aware of the greenwashing practices that may "cause the public to doubt the sincerity of greenization messages" (Du 2014).

The decrease in marginal costs is the second channel through which the investments in energy efficiency may increase markups. Energy costs are mostly marginal costs, except a small proportion which is fixed. Hence, if firms are investing in energy efficiency, then they are likely to reduce their marginal costs. That is likely to increase the markup but it could also imply a disconnect in the initial stage between accounting measures of performance and markup (because the accounting measures also consider fixed costs, and typically there are fixed in case of making energy transition possible).

The effect of marginal cost shock on prices is likely to be non-linear and firm prices are likely to be more responsive to marginal cost increases than to marginal cost decreases (Burya and Mishra 2022). Given the difference in energy prices in the US and EU, the marginal cost channel of energy efficiency investment on markup could be more important for firms in the EU.

In addition, energy prices vary across countries due to differences in taxation and duties on energy by local and federal government, so the cross-country variation driven by taxes or environmental regulation stringency may also be incentives for firms to invest in energy efficiency and reduce their marginal costs (this incentive should be higher in countries with higher taxes).

Furthermore, according to the the World Energy Investment report of the International Energy Agency (2024), there is a significant shift towards clean energy technologies. In 2024, global energy investment was projected to exceed USD 3 trillion, with approximately USD 2 trillion allocated to clean energy technologies and infrastructure. This marks a substantial increase from previous years, indicating a growing commitment to sustainable energy solutions. A notable development is the investment in solar power, which is set to reach USD 500 billion in 2024, surpassing all other energy investments. This positions solar energy as a leading force in the global energy transition, reflecting its increasing cost-competitiveness and scalability. Despite these positive trends, the report identifies a significant disparity in investment levels between advanced economies and developing countries. Over 90% of the increase in clean energy investment since 2020 has been concentrated in advanced economies and China, leaving other regions lagging. This imbalance poses challenges for achieving global climate goals and underscores the need for targeted policies to facilitate investment in emerging markets. The IEA also highlights the importance of policy support in driving clean energy investments. Government initiatives, such as subsidies and tax incentives, have been instrumental in reducing investment risks and enhancing the economic viability of renewable energy projects. However, the IEA warns that current policy measures may be insufficient to meet the investment levels required for achieving net-zero emissions by mid-century.

It is also relevant to compare the EU and the US given their differences in environmental targets. The EU has set a legally binding target of achieving net-zero emissions by 2050, alongside ambitious intermediate targets. One of the most notable is its Green Deal which aims to significantly reduce emissions by 55% by 2030 compared to 1990 levels. The EU is also committed to transitioning to a circular economy, scaling up the deployment of renewable energy, and decarbonizing energy-intensive sectors such as transport, industry, and agriculture. The EU has allocated substantial financial resources toward these goals, with a focus on green investments. It is worth noting that according to Cerniglia and Saraceno (2022), in Europe the investments in renewable energy, such as solar and wind power, yield cumulative multipliers as high as 1.19 over a one-year horizon, outperforming fossil fuel-based energy investments, which have multipliers of 0.65, based on the recent data analysed up to 2022. This discrepancy arises because renewable energy investments are more labor-intensive and have higher domestic content, fostering broader economic benefits. The economic ripple effects extend to supply chains and local businesses, generating more equitable wages and greater job creation than fossil fuel industries. Furthermore, renewable energy investments tend to retain their economic impact over longer horizons, as they do not face the same levels of crowding-out effects associated with fossil fuel spending. These findings underscore the strategic importance of prioritising renewable energy investments to achieve both economic growth and environmental sustainability.

In comparison, the US has set a net-zero emissions target by 2050 as well, but its path is less clearly defined compared to the EU. Under the Biden administration, the US has committed to reducing emissions by 50% to 52% by 2030 compared to 2005 levels, a more aggressive goal than the EU's intermediate target. However, the US faces political challenges that may affect the consistency of its climate policy. For instance, clean energy policy changes can fluctuate between administrations, leading to less predictability compared to the EU's longer-standing green agenda. While the US is increasing its commitment to green investments, it still faces high levels of investment in fossil fuel infrastructure, particularly oil and gas. The US has also been focusing on nuclear energy and clean hydrogen technologies as part of its energy future (International Energy Agency 2024).

This paper is organised as follows: first, the data is presented and discussed in section 2, followed by the methodology in section 3 and stylized facts in section 4. Then the results are reported in section 5, and the conclusions and policy implications are presented in section 6.

2 Data

The European Investment Bank Investment Survey (EIBIS) serves as a distinctive resource for understanding the investment behaviors and needs of companies within the European Union. Initiated in 2016, this annual survey includes a representative sampleof 12,000 firms from diverse sectors and sizes, ensuring comprehensive coverage at the EU, national, sectoral, and firm size levels (Brutscher, Coali, Delanote, and Harasztosi 2020). EIBIS focuses on collecting data regarding firms' investment activities, financing needs, and their responses to climate-related issues. This includes examining firms' views on climate risks and opportunities, their strategies for adapting to and mitigating climate change, and their investments in green technologies and practices. The survey employs a stratified sampling method, selecting its sample from the Bureau van Dijk ORBIS database (European Investment Bank 2023; Bureau van Dijk 2023).

To assess the influence of firm-specific attributes, sectoral factors, and national conditions on climate change investments, this study employs panel data from 2016 to 2022 for 27 EU countries. Firm-level data were sourced from the EIBIS, encompassing variables such as age, size, turnover, fixed assets, wages, employee count, total investment, profit, and energy efficiency investments across all available years. Additionally, variables indicate the country and sector of the firm, classified into four sectors (manufacturing, construction, services, infrastructure) and NACE 2-digit and 4-digit classifications. I also utilize the 11-sector classification (food, beverages & tobacco, textile, apparel & leather, wood & wood products, chemicals & pharmaceuticals, rubber & rubber products, metal & metal products, computer & optical products, electrical equipment, machinery & equipment, transportation, repair & installation of machinery) based on a more detailed NACE 2-digit classification, following the sector classification and aggregation methodology in Eurostat (2008). The following Table 1.1 provides a detailed description of the main variables used in this study.

Table 1.1: Summary of main variables and observations. Data: EIBIS:

Variable	Question in EIBIS or formula	Obs.
Capital	What is the firm's total investment spend across all these areas?*	12,600
Labour	How many people does your firm employ either full or part time?	12,832
Wages	How much was the spend on wages (gross, i.e. including benefits)?	12,052
Energy spend	How much was the total spend on energy?	11,973
Turnover	What is the turnover your company received?	12,555
Value added	Calculated as EBIT + wage bill	10,814
Profit or loss	Was there a profit or a loss before tax, or a break-even?	12,334
Profit %	Profit or loss (EBIT) as % of turnover in 5 categories of % ranges	10,990
Profit (cont.)	Profit or loss (EBIT) as the average % of turnover x turnover / 100	10,822
EE inv. (binary)	Did your company invest in improving EE?	12,087
EE inv. %	What proportion of the total investment is for improving EE?	10,349
EE inv. (cont.)	EE inv. % of total investment x total investment in euros / 100	10,349
Energy costs	Are energy costs a major obstacle to investment activities?	12,087
Avail. of finance	Is availability of finance a major obstacle to investment activities?	12,087
Energy audit	Was the energy audit conducted in the past 3 years?	11,633
Climate targets	Does your firm set and monitor targets for its own GHG emissions?	11,911
Total assets	Value of total fixed assets (incl. tangible assets & intangible assets)	11,241
Size (categ.)	Company size (Micro, Small, Medium, Large)	12,087

Notes: *The areas that are listed in the survey: A. Land, business buildings and infrastructure B. Machinery and equipment C. Research and Development (including the acquisition of intellectual property) D. Software, data, IT networks and website activities E. Training of employees F. Organisation and business process improvements, such as restructuring and streamlining. This question is followed by asking how much each business invested in each of the areas listed above with the intention of maintaining or increasing their company's profits.

3 Methodology

3.1 Markup estimation following De Loecker method

This paper employs the methodology developed by De Loecker and Warzynski (2012) and De Loecker, Eeckhout, and Unger (2020) to estimate firm-level markups. Both papers cited rely on the estimation of production functions and the use of cost-minimizing behavior of firms.

According to De Loecker and Warzynski (2012), the process of estimating a production function involves the use of plant-level data to derive a functional relationship between output and various inputs. The production function is mathematically represented as:

$$Q = f(L, K, M) \tag{1}$$

In this equation, (Q) denotes the output, (L) represents labor, (K) stands for capital, and (M) signifies materials. The estimation of this production function is a critical step in understanding the dynamics of production at the plant level. In this case, the Cobb-Douglas production function is used.

The polynomial option of the markupest command used in STATA specifies the order of the polynomial approximation used to estimate the control function that corrects for endogeneity in input choices. Production function estimation often faces endogeneity issues, where input choices (e.g., materials, labor) are correlated with unobserved productivity shocks. To address this problem, the method employs a proxy variable approach (commonly intermediate inputs or investments) to control for these unobservables.

A polynomial approximation is used to model the relationship between the proxy variable (e.g., investment or material costs) and unobserved productivity. The polynomial(4) option specifies that a fourth-degree polynomial is used, which allows for sufficient flexibility to capture non-linearities in the relationship between inputs and unobserved productivity. Choosing a fourth-order polynomial improves model fit and reduces bias by capturing subtle patterns in the data. However, they avoid overfitting issues that might arise with very high-order polynomials (Ackerberg, Caves, and Frazer 2015).

Furthermore, the elasticity of a variable input, such as materials, is estimated. This elasticity, which measures the responsiveness of output to changes in the input, is essential for the calculation of markups. The elasticity of materials, denoted as (θ_M), plays a pivotal role in this context.

Markups are subsequently calculated using the formula:

$$\mu = \frac{\theta_M}{\alpha_M} \tag{2}$$

Here, (μ) represents the markup, (θ_M) is the output elasticity of materials, and (α_M)

is the share of materials in total revenue. This formula provides a quantitative measure of the markup, which is a key indicator of market power and pricing strategy.

By integrating these elements, the study by De Loecker and Warzynski (2012) offers a comprehensive framework for analyzing production functions and calculating markups, thereby contributing to a deeper understanding of industrial economics.

In their paper, De Loecker, Eeckhout, and Unger (2020) introduce an important additional feature that significantly enhances the traditional production function framework. This extended production function incorporates a broader range of factors and dynamics, including overhead costs and variations in market power over time. By accounting for these additional elements, the extended production function provides a more comprehensive and realistic representation of production processes.

To ensure the accuracy of the estimations, it is crucial to deflate nominal variables using appropriate price indices. This deflation process adjusts for inflation and allows for a more accurate comparison of economic variables over time.

For variables such as sales, operating revenue turnover, costs of goods sold, and material costs, the price index at the NAC2D level from Eurostat is employed. This index provides a detailed and sector-specific measure of price changes, ensuring that the deflated variables accurately reflect real economic activity.

For capital-related variables, such as fixed assets, the price index of investment goods from the OECD is utilized. This index captures the price movements of investment goods, allowing for a precise deflation of capital variables and ensuring that the estimations of capital inputs are accurate and consistent over time.

By meticulously deflating nominal variables with these indices, the analysis achieves a higher level of precision and reliability, thereby enhancing the robustness of the findings. The data utilized in the estimation of markups encompasses a comprehensive set of variables, each playing a crucial role in the analysis. These variables include total revenue from sales, which represents the gross income generated from the sale of goods and services. Additionally, total operating revenue is considered, reflecting the overall income from the firm's core business operations.

Costs of Goods Sold (COGS) are also included, representing the direct costs attributable to the production of goods sold by the firm. This variable is essential for understanding the cost structure and profitability of the production process. Material costs, which account for the expenses incurred in procuring raw materials used in production, are another critical component.

Fixed assets, defined as long-term tangible assets employed in the production process, are included to capture the firm's investment in physical capital. The value added by the firm, calculated as the net output after subtracting intermediate inputs, provides a measure of the firm's contribution to the economy.

Employee-related variables are also integral to the analysis. These include the total compensation paid to employees, which encompasses wages, salaries, and benefits, as well as the total number of employees, providing insight into the firm's labor force. Operating revenue per employee, calculated by dividing operating revenue by the number of employees, offers a measure of labor productivity.

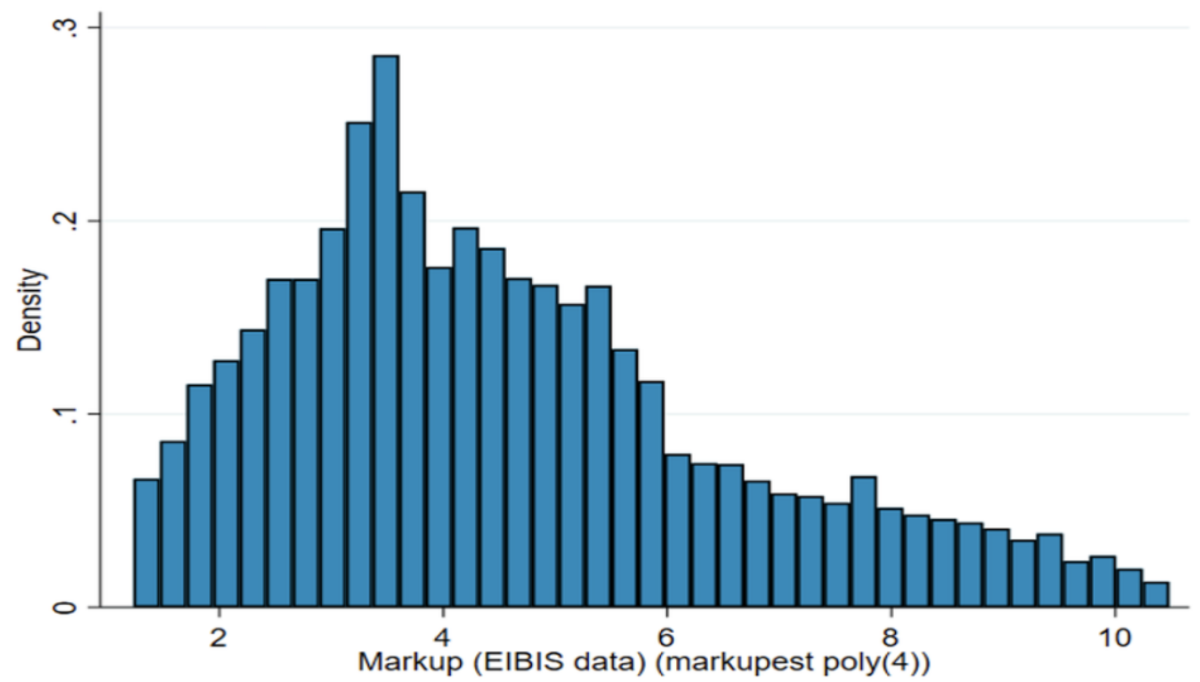
Finally, depreciation and amortization are considered. These non-cash expenses represent the reduction in value of fixed assets over time, reflecting the wear and tear or obsolescence of the firm's physical capital. By incorporating these variables, the analysis achieves a comprehensive understanding of the firm's economic activities, cost structures, and productivity, thereby facilitating a robust estimation of markups. By following these methodologies and using the specified deflators, I aim to provide robust estimates of firm-level markups and analyze their implications for market power and economic performance.

The following histogram reported in Figure 1 shows the distribution of estimated markups (EIBIS data) with the x-axis representing the markup values and the y-axis representing the density. The distribution is right-skewed similar to the markup distribution estimated in Raval (2023), indicating that most firms have lower markups, but there are a few with significantly higher markups.

The histogram exhibits several notable features. Firstly, it displays a right-skewed distribution, where the majority of the data is concentrated on the left side, with a long tail extending to the right. This pattern suggests that while most firms operate with lower markups, there are a few outliers with significantly higher markups. This phenomenon could be attributed to competitive pricing strategies or lower cost structures prevalent among these firms.

This distribution provides valuable insights into the pricing behavior of firms, showing that while most maintain lower markups, there is a significant variation with some firms achieving much higher markups. This can be crucial for understanding market dynamics and competitive strategies within the economy.

Figure 1: Estimated markup distribution.

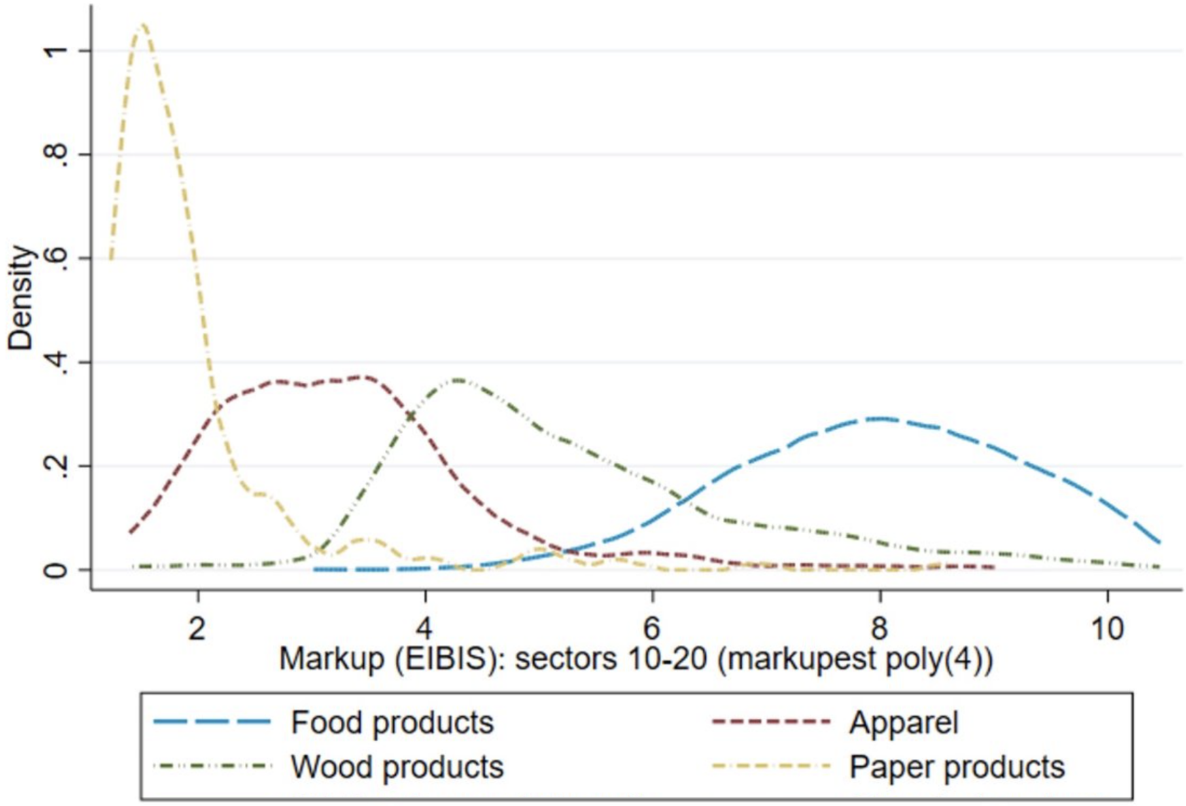


Below I provide some comments regarding the kernel density plot for markup estimations of selected sectors reported in the following Figure 2.

The yellow dashed line for paper products shows a peak around 1 but extends broadly, indicating that almost all firms in this sector show relatively low markups, with some exceptions at higher markup levels. We witness a long right tail extending towards higher markups. This suggests that while most firms in this sector have low markups, some have a power to charge significantly more, possibly due to higher quality or specialized products. Meanwhile, the dark-red dotted line for apparel sector shows that most of the firms in this sector have markups higher than paper products, but still quite low, i.e. from 2 to 4, with very few firms having higher markups.

The next sector shown as the green dashed-dotted line is wood productswith most firms showing average markups, from around 4 to 6, and a few firms having extremely low (e.g. 1) and high (e.g. over 10) markups. The last selected sector displayed in this graph as the dashed blue line is the food products sector. It shows generally high markups for most firms with a peak at 8, which may reflect the inelastic demand curve of certain foods and the ability of firms to charge higher prices without a significant risk of losing their customers.

Figure 2: Estimated markup distribution selected sectors I.

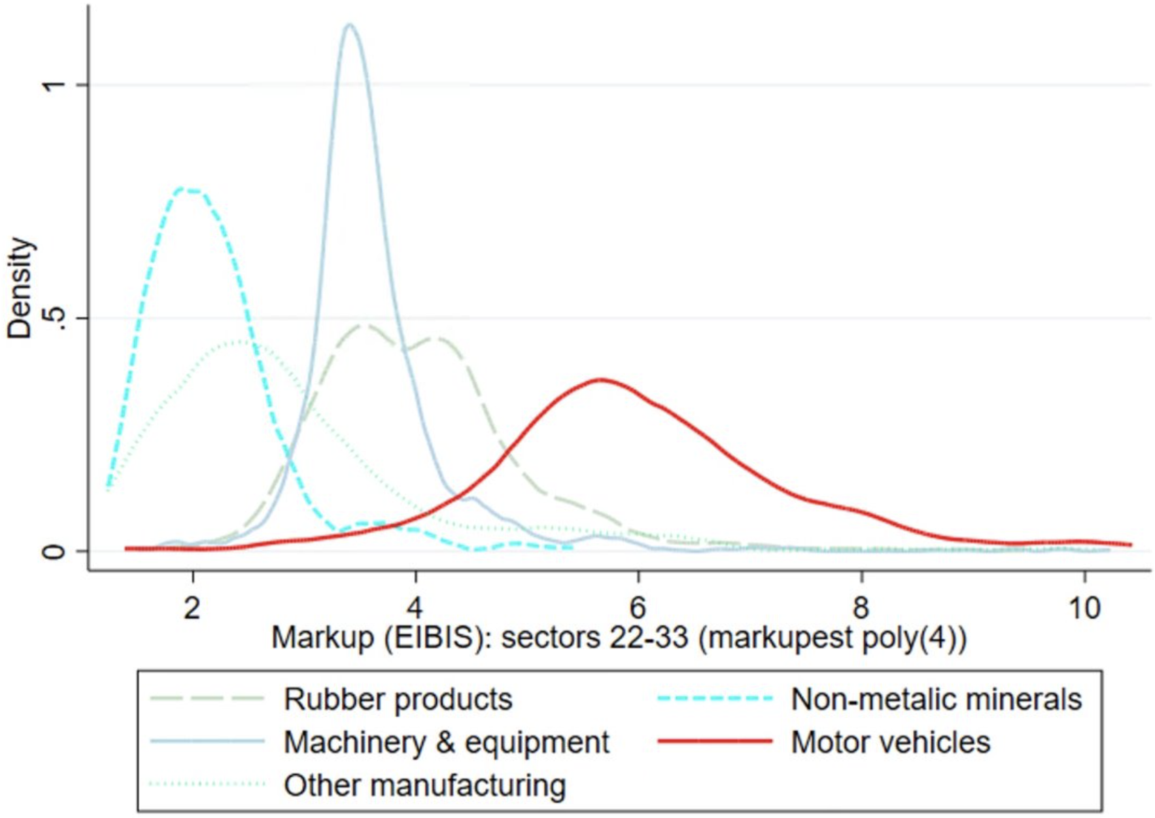


Analogically, below I provide further comments on kernel density plots for markup distributions of the remaining selected sectors as shown in the following Figure 3.

The dashed cyan-colored line represents non-metallic minerals, which peak at the level of 2 with low markups for most firms. The light-blie dotted line represents other manufaturing sectos with a peak at around 2.5. The next sector, machinery and equipment, is represented by the light-gray solid line where most firms are with lower than average markups with a peak at the level of around 3.5.

The rubber products sector, represented by a light-green dashed line, has two peaks, at around 3.5 and 4.5 respectively. Finally, we see the motor vehicles sector with the average markups, with a peak at around 6 and a symmetrical distribution, possibly indicating that there is an equal variety of firms charging possessing low or high market power, with the majority of firms indicating average-level markups. The heterogeneity in markup practices within a sector could be due to differences in quality, service types, or customer segments.

Figure 3: Estimated markup distribution selected sectors II.



3.2 Fixed Effects Ordinary Least Squares

In order to investigate the impact of green investments on markup, the following Ordinary Least Squares (OLS) Fixed Effects model is used:

$$Mkup_{it} = \alpha_i + \gamma \times GI_{it} + \sum_{k=1}^{n} \beta^k \times X_{it}^k + \varepsilon_{it} \tag{3}$$

The variable $Mkup_{it}$ represents the markup estimated using De Loecker and Warzynski (2012). The GI_{it} variable denotes Green Investments by the firm, specifically investments in energy-efficient technologies. This variable is available in both binary and continuous forms, which are used separately to capture the effect of the presence of the investment (yes/no) and its intensity (the amount invested, balanced by total wages to account for the firm's size).

The term X_{it}^k encompasses all control variables, including year, sector-year, country-year, and sector-country-year fixed effects. The parameter α_i captures the firm and firm's age fixed effects, accounting for everything that varies between firms but remains constant over time. Finally, ε_{it} represents the error term.

3.3 Two-Stage Least Squares (2SLS-IV)

I use the Two-Stage Least Squares (2SLS) Instrumental Variables (IV) model to address endogeneity that may occur due to omitted variable bias, measurement error, or simultaneity (Wooldridge 2010). The 2SLS-IV model tackles endogeneity by introducing an instrumental variable (IV) that is correlated with the endogenous explanatory variable but uncorrelated with the error term.

By using an IV, the model can provide consistent estimates even in the presence of endogeneity. For an instrument to be valid, it must satisfy two main criteria, relevance (the instrument must be correlated with the endogenous explanatory variable) and exogeneity (the instrument must be uncorrelated with the error term).

In the context of investments in energy-efficient technologies, a relevant instrument could be a policy change or subsidy specifically targeting energy efficiency. However, ensuring exogeneity is challenging, as such instruments must not be correlated with unobserved factors affecting the dependent variable.

In this paper, due to the lack of a valid instrument among the available variables, we employ a leave-one-out strategy for each sector-year. This involves calculating the averages for each sector-year in a loop in STATA, leaving each specific firm out one at a time. This strategy is defended on the grounds that the industry average in each year is likely to have spill-over effects on individual firms, thus making the instrument exogenous. I argue that the average behavior in the industry influences individual firms but is not directly affected by the unobserved factors specific to each firm. For example, if the average investment in energy-efficient technologies in an industry affects individual firms' decisions through spill-over effects, this can be considered exogenous.

Further I review the literature that employs sector or country averages as instrumental variables (IVs) in various empirical studies. As discussed previously, this approach is often used to address endogeneity issues by leveraging exogenous variation from related sectors or regions. Below, I summarize key studies that have utilized this methodology, highlighting their main features and contributions. Chen and Ma (2021) investigate the impact of green investment on firm performance. They employ the average green investment in the industry and city where the firm is located as an instrumental variable (IV). This methodological choice helps to isolate the exogenous variation in green investment, thereby mitigating potential endogeneity concerns related to firm-specific investment decisions.

Acemoglu, Naidu, Restrepo, and Robinson (2019) explore the relationship between democracy and economic outcomes. They utilize the democracy levels of other countries in the region as an IV for endogenous democracy. This regional average serves as a source of exogenous variation, allowing the authors to address potential issues of reverse causality and omitted variable bias. Furthermore, in the April 2019 World Economic Outlook, the International Monetary Fund (2019) employs the log of the median markup across all other firms in the same country-industry-year as an IV for a firm's (log of) markup. This method helps to control for endogeneity by using a sectoral average that is less likely to be influenced by individual firm characteristics.

Ilzetzki, Mendoza, and Végh (2013) follow Jaimovich and Panizza (2007) in using the weighted GDP growth of countries' trading partners as an IV for GDP. Finally, Alesina, Favero, and Giavazzi (2015) investigate the determinants of the output gap. They use the output gap of the region excluding the country in question as an IV for the country's output gap. This regional average provides exogenous variation, addressing potential endogeneity issues.

The output from the first stage is also reported in the results section. If the first stage coefficient in a 2SLS-IV regression is positive and statistically significant, we can conclude that the instrument (IV) is likely to be relevant, meaning it has a significant and positive correlation with the endogenous explanatory variable. This is a necessary condition for the IV to be valid. In terms of the potential strength of the IV; while statistical significance is a good sign, it alone does not confirm the instrument's strength. Hence, I also report the F-statistic from the first stage. If the F-statistic is greater than 10, it suggests that the instrument is not weak. To ensure the validity of the IV, in the results section I report the outcomes of the tests explained below.

The Anderson Canonical Correlation Lagrange Multiplier (LM) Statistic is employed as an underidentification test. This test is crucial for verifying whether the instruments are correlated with the endogenous regressors, thereby ensuring the relevance of the instrument. A significant result from this test indicates that the instruments are indeed relevant and appropriately correlated with the endogenous variables.

Futhermore, the Cragg-Donald Wald F Statistic is utilized to assess the strength of the instruments. This weak identification test is essential for determining whether the instruments are sufficiently strong to provide reliable estimates. A higher value of this statistic suggests stronger instruments, which enhances the robustness of the estimation results.

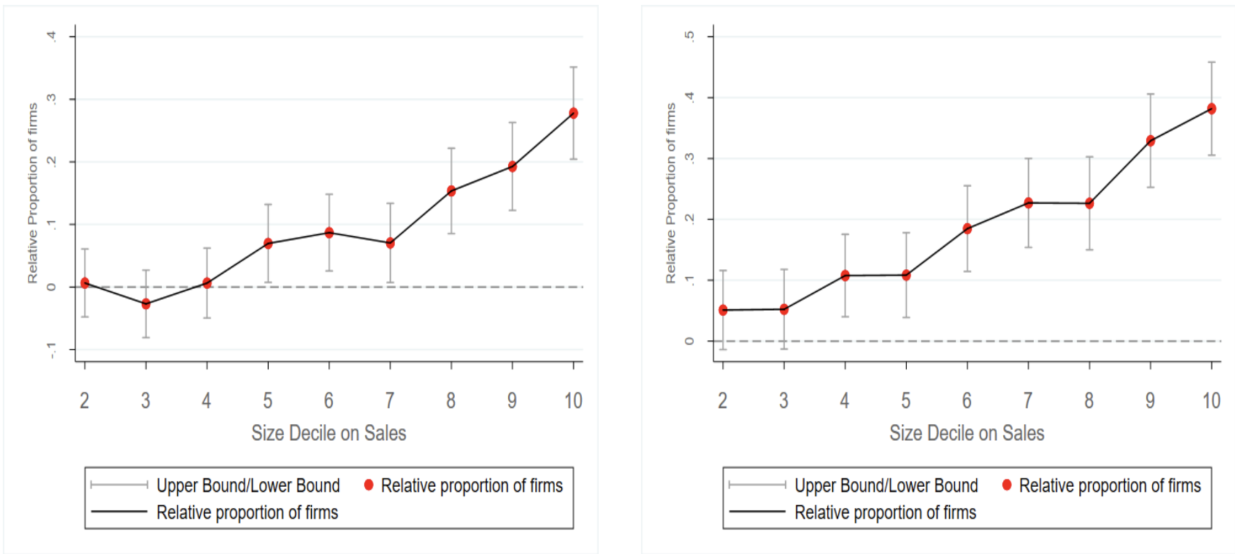
Additionally, the Stock-Yogo Weak ID Critical Values provide critical thresholds at various levels, specifically at 10%, 15%, 20%, and 25%. These critical values are used in conjunction with the Cragg-Donald statistic to determine if the instruments are weak. By comparing the Cragg-Donald statistic to these thresholds, one can ascertain the adequacy of the instruments and ensure the validity of their econometric analysis.

By employing the aforementioned tests, I ensure that our IV is both relevant and exogenous, providing robust and consistent estimates in the presence of endogeneity.

4 Stylized facts

This section is dedicated to the relevant stylized facts that are observed in the data. The first two graphs in Figure 4 illustrate two kinds of investments in relation to 10 size deciles, namely investments in new, less polluting business areas and technologies in (a), as well as the investments in energy efficient technologies in (b). I concentrate on the latter category in further analysis due to its data availability for a wider range of time periods as opposed to the other category. The graphs indicate a generally positive relationship between green investments and the growing firm's size.

Figure 4: Relative proportion of firms investing. Data: EIBIS



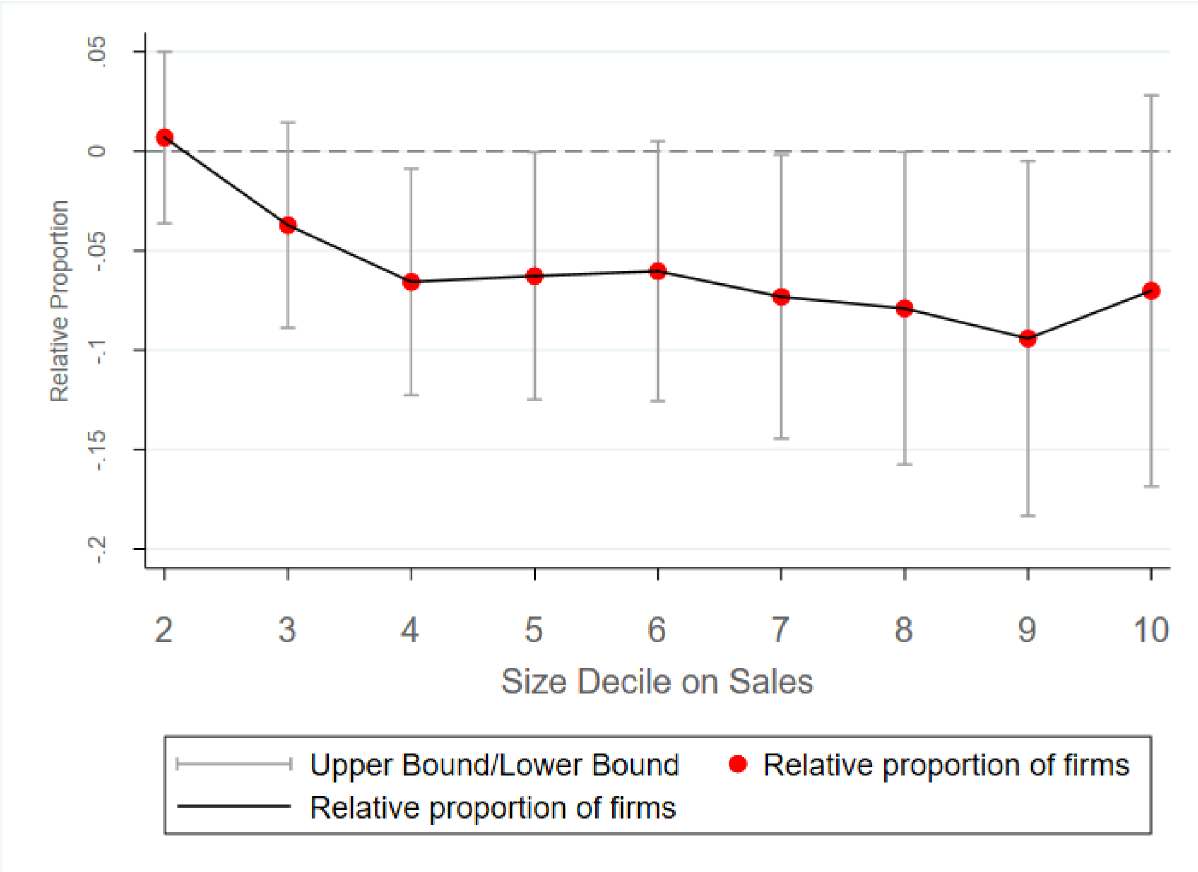
(a) Investments in new, less polluting business areas & technologies

(b) Investments in energy efficient technologies

While proceeding to describe the stylized facts from the data, it can be noticed that the channel through which bigger firms invest more in energy efficiency may be related to the financial constraints that firms are facing. The following graph in the Figure 5 indicates that higher size typically means firm faces less financial constraints. It can be seen that the difference across medium-sized firms is not as pronounced, while for very small firms it may be important to grow in order to fight against such constraints. It is also interesting that very large firms (going from the 9th to the 10th size decile) face higher constraints again. This may be due to very big firms enjoying such a high market power that they are no longer incentivised to invest or improve their production processes, as a result slowing down their accessibility to financing their future activity. They may have obsolete technologies and lack of investments aimed to boost efficiency, including those investments that are related to energy efficiency.

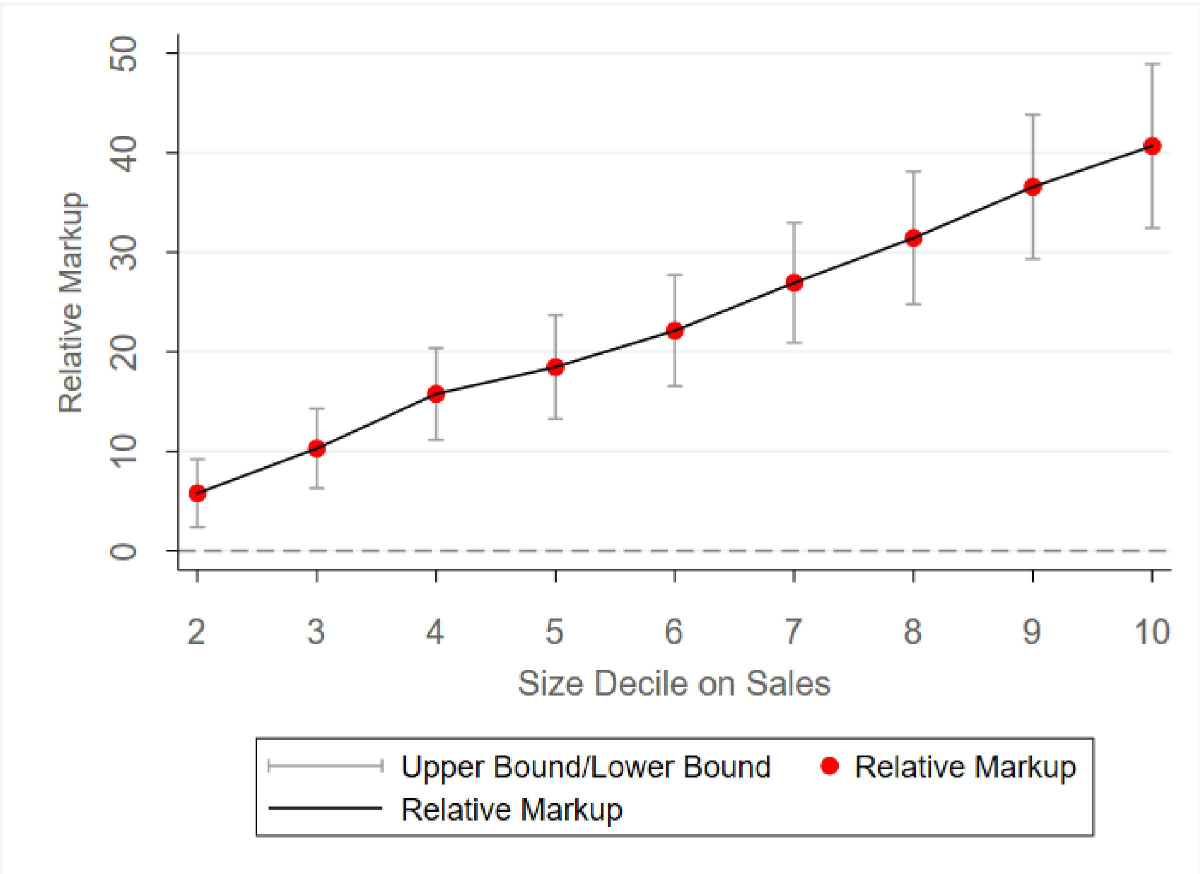
While examining the markup changes in relation to size deciles, we also notice a

Figure 5: Firms facing financial constraints across size deciles (based on Q33 from EIBIS). Data: EIBIS.



positive direction as shown in followowing Figure 6. Given the graphs discussed above, we may therefore hypothesize that higher markup (that is often feasible due to higher firm's size) is also manifested as a result of investments in energy efficient technologies. This will be discussed in further sections in relation to the results obtained in Fixed Effects OLS and 2SLS-IV specifications.

Figure 6: Relative markup across size deciles. Data: EIBIS.



5 Results

The following Table 1.2 reports the results of the Fixed Effects Ordinary Least Squares model with a binary version of the Green Investments (GI) variable, in which explanatory variables and fixed effects are gradually added (columns 1-8). These results indicate a positive and generally statistically significant impact of the presence of green investments on markup.

In this paragraph, I will comment on the most restricted specification (8), which includes country-sector-year fixed effects. The coefficient for green investments is 2.68, which is statistically significant at the 5% level ($p < 0.05$), as indicated by the one star next to the coefficient. The associated t-statistic is 2.01, suggesting that the coefficient is significantly different from zero. In terms of the economic interpretation, the positive coefficient of 2.68 implies that, on average, firms that engage in green investments have a markup that is 2.68% higher than firms that do not engage in such investments, holding all other factors constant. This result is statistically significant, indicating a strong likelihood that the observed relationship is not due to random chance. Moreover, the R-squared value of 0.622 indicates that approximately 62.2% of the variation in markup is explained by the model, which includes green investments and other control variables. This suggests a good fit for the model, as a substantial portion of the variability in markup is accounted for by the included predictors.

Table 1.2: Fixed Effects OLS Regression Results: GI as a binary variable. Data: EIBIS.

	(1) Mkup	(2) Mkup	(3) Mkup	(4) Mkup	(5) Mkup	(6) Mkup	(7) Mkup	(8) Mkup
GI (binary)	2.30	3.71**	3.41**	3.40**	2.24	2.39*	2.11	2.68*
	(1.76)	(3.05)	(3.24)	(3.22)	(1.89)	(2.09)	(1.82)	(2.01)
ln Sales		1.77	5.92***	5.87***	5.78***	6.33***	6.22***	7.42***
		(0.93)	(3.77)	(3.74)	(3.69)	(4.68)	(4.61)	(5.10)
ln Wages		-29.09***	-35.81***	-35.84***	-36.22***	-35.66***	-35.67***	-37.62***
		(-15.04)	(-19.80)	(-19.83)	(-19.65)	(-19.29)	(-19.18)	(-17.01)
ln Capital			16.01***	15.97***	16.02***	16.04***	16.08***	16.28***
			(16.68)	(16.57)	(16.64)	(17.14)	(17.10)	(18.26)
Constant	119.7***	510.6***	306.2***	300.2***	307.0***	258.5***	260.0***	172.7**
	(263.03)	(13.98)	(9.32)	(9.04)	(9.08)	(6.34)	(5.44)	(2.70)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	No	No	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes	Yes	Yes
S-Y FE	No	No	No	No	No	Yes	Yes	Yes
C-Y FE	No	No	No	No	No	No	Yes	Yes
S-C-Y FE	No	No	No	No	No	No	No	Yes
Obs.	9,965	9,965	9,965	9,961	9,961	9,961	9,961	9,961
R2	0.00102	0.133	0.351	0.352	0.356	0.403	0.418	0.622

Notes: t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001. GI = Green Investments, Mkup = ln Markup multiplied by 100, S = Sector, C = Country, Y = Year, FE = Fixed Effects.

As the next step, I substitute the binary variable representing Green Investments (GI) with another variable that is continuous in nature. There a question in EIBIS that asked the respondent firms to report their investments in energy efficiency as a percentage of their total investment activity. Due to the fact that many respondents rounded their reported numbers and their responses did not take firms' sizes into account, I proceeded by taking their reported percentages, dividing those by 100, and consequently multiplying by the total investment activity reported as a continuous variable in euros. In order to take size effect into account, I further balance the obtained number by total wages of the firm. The reason for using the continuous variable is to assess the effect of the intensity of green investments on markup, i.e. whether investing more or less matters. In this specification, the positive and significant relationship persists as indicated in the following Table 1.3.

Table 1.3: Fixed Effects OLS Regression Results: GI as a continuous variable. Data: EIBIS.

	(1) Mkup	(2) Mkup	(3) Mkup	(4) Mkup	(5) Mkup	(6) Mkup	(7) Mkup	(8) Mkup
GI (cont.)	10.00**	9.94**	10.81**	10.81**	10.73**	10.53**	10.35**	9.27*
	(3.21)	(3.17)	(2.91)	(2.91)	(2.87)	(2.76)	(2.72)	(2.40)
ln Sales		-2.56	2.08	2.01	1.76	2.55	0.91	0.90
		(-1.15)	(1.07)	(1.03)	(0.90)	(1.62)	(0.51)	(0.54)
ln Capital			12.76***	12.73***	12.79***	12.82***	13.50***	13.21***
			(12.58)	(12.51)	(12.54)	(13.29)	(13.80)	(13.12)
Constant	122.0***	161.1***	-98.63**	-116.3**	-112.3**	-118.2**	-93.88*	-90.69*
	(690.54)	(4.73)	(-3.00)	(-3.02)	(-2.91)	(-3.17)	(-2.06)	(-2.19)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	No	No	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes	Yes	Yes
S-Y FE	No	No	No	No	No	Yes	Yes	Yes
C-Y FE	No	No	No	No	No	No	Yes	Yes
S-C-Y FE	No	No	No	No	No	No	No	Yes
Obs.	7,354	7,354	7,354	7,353	7,353	7,353	7,353	7,353
R2	0.0106	0.0132	0.153	0.154	0.156	0.225	0.250	0.506

Notes: t statistics in parentheses, * $p<0.05$, ** $p<0.01$, *** $p<0.001$. GI = Green Investments balanced by wages, Mkup = ln Markup multiplied by 100, S = Sector, C = Country, Y = Year, FE = Fixed Effects.

In regards to the table reported above, I will now concentrate on the interpretation of the last specification (8), which is the most restricted one with size-country-year fixed effects. The dependent variable is the natural log of markup multiplied by 100. This transformation helps in interpreting the coefficients as percentage changes. The main explanatory variable is the investment in energy efficiency in euros, balanced by the total wages of the firm. The coefficient for this variable is 9.27, which is statistically significant at the 5% level (indicated by one star and a p-value < 0.05). It means that a one-unit increase in the investment in energy efficiency (balanced by total wages) is associated with an increase of 9.27% in the markup, holding other factors constant. The t-statistic for this coefficient is 2.40, which indicates that the coefficient is significantly different from zero. This further supports the statistical significance of the investment in energy efficiency. The R-squared value of 0.506 indicates that approximately 50.6% of the variation in the dependent variable (markup) is explained by the model. This suggests a moderate fit of the model to the data.

Both of the most restricted specifications in the above two Tables 1.2 and 1.3 control for firm fixed effects (FE), age FE, year FE, sector-year FE, country-year FE, and sector-country-year FE. These fixed effects account for unobserved heterogeneity that could bias the results if not included. In addition, in both cases I used the vce(robust) option in STATA to ensure that the standard errors are robust to heteroskedasticity, making the statistical inference more reliable.

The next step was to introduce the 2SLS-IV model specification, for which I conducted tests related to the constructed instrumental variable in accordance with the discussion presented in the Methodology section earlier. The results of the first stage are presented in the following Table 1.4. The obtained F-statistic associated with the first stage was equal to 455.38. It tests the joint significance of the instruments in explaining the endogenous variable. A high F-statistic (greater than 10) suggests that the instruments are strongly correlated with the endogenous variable, indicating they are not weak. In our case, an F-statistic of 455.38 is very high as opposed to 10, suggesting that the instrument is strong. The positive coefficient of 14.75 (obtained in the first stage) is significant at 5% level, indicating that the instrument is relevant and potentially strong.

Table 1.4: First SLS Regression Results: GI as a binary variable. Data: EIBIS.

	GI (bin.)	Std. Err.	t	P > |t|
IV	14.75	6.35	2.32	0.020
ln Sales	4.42	0.84	5.25	0.000
ln Capital	13.89	0.41	34.14	0.000
ln Wages	-25.97	0.91	-28.52	0.000

Furthermore, Cragg-Donald Wald F Statistic was obtained as 33.572. This statistic measures the strength of your instruments in the context of multiple endogenous variables. A higher value indicates stronger instruments. In terms of Stock-Yogo Weak ID Test Critical Values, these critical values provide thresholds to determine if your instruments are weak. In our case, for a 10% maximal IV size, the critical value is 16.38. This means that if the obtained Cragg-Donald Wald F Statistic is above 16.38, the instruments are considered strong at the 10% level. Since the obtained Cragg-Donald Wald F Statistic (33.572) is greater than the Stock-Yogo critical value of 16.38, I conclude that the instrument is not weak at the 10% maximal IV size level.

To further evaluate the identification of the model, I performed the Anderson canonical correlation Lagrange Multiplier (LM) statistic test. The obtained value of the Anderson LM statistic was 55.620, with a corresponding Chi-squared (1) p-value of 0.0000. The Anderson canonical correlation LM statistic tests the null hypothesis that the model is underidentified, meaning that the instruments do not provide enough information to identify the endogenous variables. A high value of the LM statistic, coupled with a very low p-value, strongly rejects the null hypothesis. In our case, the p-value of 0.0000 indicates that the null hypothesis is rejected at any conventional significance level, confirming that the model is well-identified.

The results from the first stage regression and the related tests provide strong evidence that the instrument used is both relevant and valid. The high F-statistic suggests that the instrument is sufficiently correlated with the endogenous regressor, ensuring that the first stage regression is robust. Additionally, the significant Anderson LM statistic confirms that the model is not underidentified, validating the use of the instrument in the 2SLS-IV estimation. These findings support the reliability of the second stage results presented further, as the instrument effectively addresses the endogeneity issue, leading to consistent and unbiased estimates of the parameters of interest.

The following Table 1.5 reports the results of the 2SLS-IV model with the binary version of the Green Investments variable. In terms of the economic interpretation of the most restricted specification (8), the positive coefficient of 3.09 implies that, on average, firms that engage in green investments have a markup that is 3.09% higher than firms that do not engage in such investments, holding all other factors constant.

Table 1.5: Fixed Effects 2SLS-IV Regression Results: GI as a binary variable. Data: EIBIS.

	(1) Mkup	(2) Mkup	(3) Mkup	(4) Mkup	(5) Mkup	(6) Mkup	(7) Mkup	(8) Mkup
pred.GI(bin.)	2.66**	2.72**	3.36***	3.35***	2.95***	2.71***	1.18**	3.09***
	(2.74)	(2.96)	(4.63)	(4.62)	(4.08)	(3.70)	(3.16)	(3.80)
ln Sales		6.42***	4.36***	4.34***	4.44***	4.57***	4.64***	5.03***
		(4.39)	(3.76)	(3.75)	(3.86)	(3.88)	(3.97)	(3.71)
ln Wages		-21.69***	-25.29***	-25.28***	-25.73***	-25.62***	-25.96***	-25.01***
		(-14.87)	(-19.98)	(-19.97)	(-19.82)	(-19.74)	(-20.75)	(-17.27)
ln Capital			13.58***	13.60***	13.62***	13.77***	13.82***	13.96***
			(18.72)	(18.75)	(18.59)	(20.30)	(20.31)	(19.12)
Constant	122.3***	335.4***	216.9***	200.1***	206.2***	197.0***	203.2***	179.7***
	(264.22)	(11.49)	(8.42)	(7.58)	(7.60)	(7.21)	(7.86)	(5.91)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	No	No	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes	Yes	Yes
S-Y FE	No	No	No	No	No	Yes	Yes	Yes
C-Y FE	No	No	No	No	No	No	Yes	Yes
S-C-Y FE	No	No	No	No	No	No	No	Yes
Obs.	7,383	7,383	7,383	7,389	7,389	7,389	7,389	7,389
R2	0.00335	0.147	0.436	0.437	0.447	0.483	0.501	0.656

Notes: t statistics in parentheses, * $p<0.05$, ** $p<0.01$, *** $p<0.001$. pred.GI(bin.) = predicted Green Investments (binary), Mkup = ln Markup multiplied by 100, S = Sector, C = Country, Y = Year, FE = Fixed Effects.

The next two tables, Table 1.6 and Table 1.7 respectively, report the results of first and second stages for the Fixed Effects 2SLS-IV model specifications with the Green Investments as a continuous variable balanced by wages.

The first stage of the Two-Stage Least Squares Instrumental Variables (2SLS-IV) estimation provides robust evidence supporting the validity of our instrument. The F-statistic for the first stage regression is 385.94, which is significantly high, indicating that our model is well-specified and the instrument is strong.

The underidentification test, represented by the Anderson canonical correlation LM statistic, yields a value of 32.777 with a Chi-squared (1) p-value of 0.0000. This strongly rejects the null hypothesis that the model is underidentified, confirming that our instrument is sufficiently correlated with the endogenous regressor (energy efficiency investments balanced by wages).

The weak identification test, using the Cragg-Donald Wald F statistic, results in a value of 19.565. This exceeds the Stock-Yogo critical value of 16.38 at the 10% maximal IV size, indicating that our instrument is not weak and thus provides reliable estimates.

From an economic perspective, the results suggest that sector-year averages, excluding

Table 1.6: First SLS Regression Results: GI as a continuous variable. Data: EIBIS.

	GI (cont.)	Std. Err.	t	P > |t|
IV	0.64	0.22	2.90	0.004
ln Sales	3.72	0.90	4.14	0.000
ln Capital	13.58	0.43	31.43	0.000
ln Wages	-22.51	1.58	-14.21	0.000

each firm one at a time, serve as a strong instrument for energy efficiency investments. The high F-statistic of 385.94 indicates that the instrument explains a significant portion of the variation in energy efficiency investments, balanced by wages.

The rejection of the underidentification test implies that the instrument is valid and relevant, meaning it is appropriately capturing the exogenous variation needed to identify the causal effect of energy efficiency investments. This is crucial for policy implications, as it suggests that sectoral trends, when isolated from individual firm effects, can drive investment in energy efficiency. The weak identification test further supports the strength of our instrument, ensuring that the estimates derived from the 2SLS-IV approach are reliable and not biased due to weak instruments. This reliability is essential for making informed decisions about promoting energy efficiency investments through sectoral policies. Overall, the statistical and economic interpretations of the first stage results underscore the robustness of our instrument and the validity of our econometric approach, providing a solid foundation for the second stage of the analysis that is reported in the next Table 1.7. The primary explanatory variable is the investment in energy efficiency in euros, adjusted by the total wages of the firm. The coefficient for this variable is 0.235, which is statistically significant at the 0.1% level (indicated by three stars and a p-value < 0.001). This means that a one-unit increase in the investment in energy efficiency (adjusted by total wages) is associated with an increase of 0.235% in the markup in the second stage of 2SLS-IV. The t-statistic for this coefficient is 11.48, indicating that the coefficient is significantly different from zero.

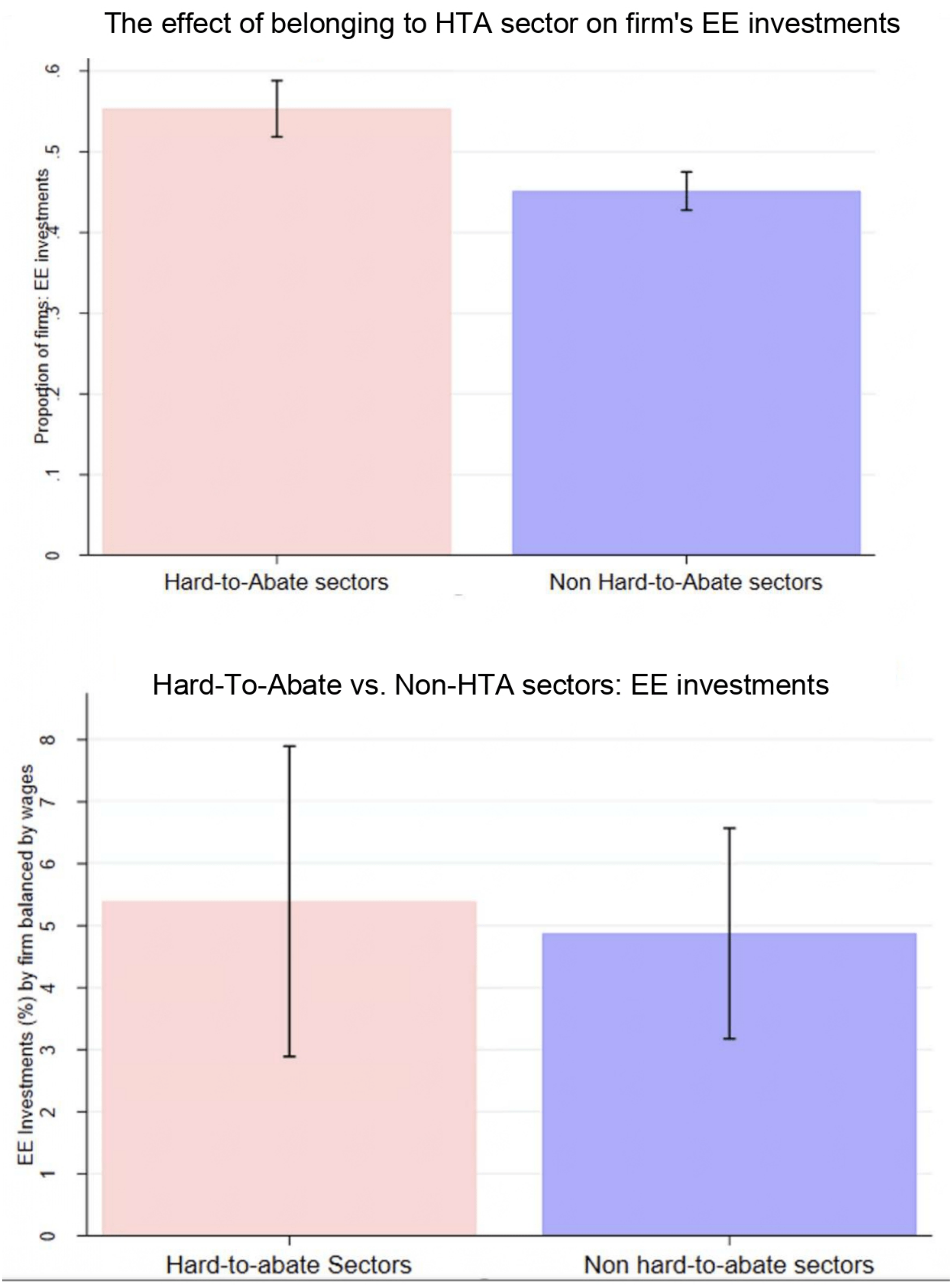
Table 1.7: Fixed Effects 2SLS-IV Regression Results: GI as a continuous variable. Data: EIBIS.

	(1) Mkup	(2) Mkup	(3) Mkup	(4) Mkup	(5) Mkup	(6) Mkup	(7) Mkup	(8) Mkup
pred. GI	0.24*** (8.40)	0.20*** (8.95)	0.20*** (9.33)	0.20*** (9.30)	0.20*** (9.43)	0.20*** (9.37)	0.19*** (9.06)	0.24*** (11.48)
ln Sales		5.51*** (4.14)	3.91*** (3.43)	3.88*** (3.40)	4.03*** (3.60)	4.25*** (3.68)	4.24*** (3.69)	4.89*** (3.55)
ln Capital			13.33*** (18.11)	13.36*** (18.16)	13.37*** (17.97)	13,42*** (19.40)	13.50*** (19.60)	13.79*** (18.74)
Constant	122.2*** (954.00)	332.2*** (12.26)	210.9*** (8.16)	194.1*** (7.38)	200.9*** (7.43)	193.5*** (7.07)	198.7*** (7.77)	175.8*** (5.69)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	No	No	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	Yes	Yes	Yes
S-Y FE	No	No	No	No	No	Yes	Yes	Yes
C-Y FE	No	No	No	No	No	No	Yes	Yes
S-C-Y FE	No	No	No	No	No	No	No	Yes
Obs.	7,016	7,016	7,016	7,014	7,014	7,014	7,014	7,014
R2	0.0427	0.173	0.452	0.453	0.465	0.497	0.517	0.680

Notes: t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001.
pred. GI = prediction of the Green Investments (cont.) balanced by wages, Mkup = ln Markup multiplied by 100, S = Sector, C = Country, Y = Year, FE = Fixed Effects.

In order to explore sectoral and regional heterogeneity, I limit myself to including several charts because the sample size for each region or sector turned out to be too small to be able to produce meaningful regression results. Figure 7 reports that both the proportion and the intensity of investments in energy efficiency is higher for Hard-To-Abate (HTA) sectors as opposed to non-HTA sectors. HTA sectors are industries that are particularly challenging to decarbonize due to their high energy intensity, reliance on fossil fuels, and the inherent carbon emissions from their production processes. These sectors include industries such as steel, cement, chemicals, and refining, which together account for a significant portion of global greenhouse gas emissions (Zhang et al. 2024). The higher proportion and intensity of energy efficiency investments in HTA sectors compared to non-HTA sectors are statistically significant. This means that the observed differences are unlikely to be due to random chance and suggest an underlying trend. The statistical significance indicates that firms in HTA sectors invest more in energy efficiency, likely due to factors such as regulation, cost savings, or better technology.

Figure 7: Hard-To-Abate (HTA) vs. non-HTA sectors. Data: EIBIS.

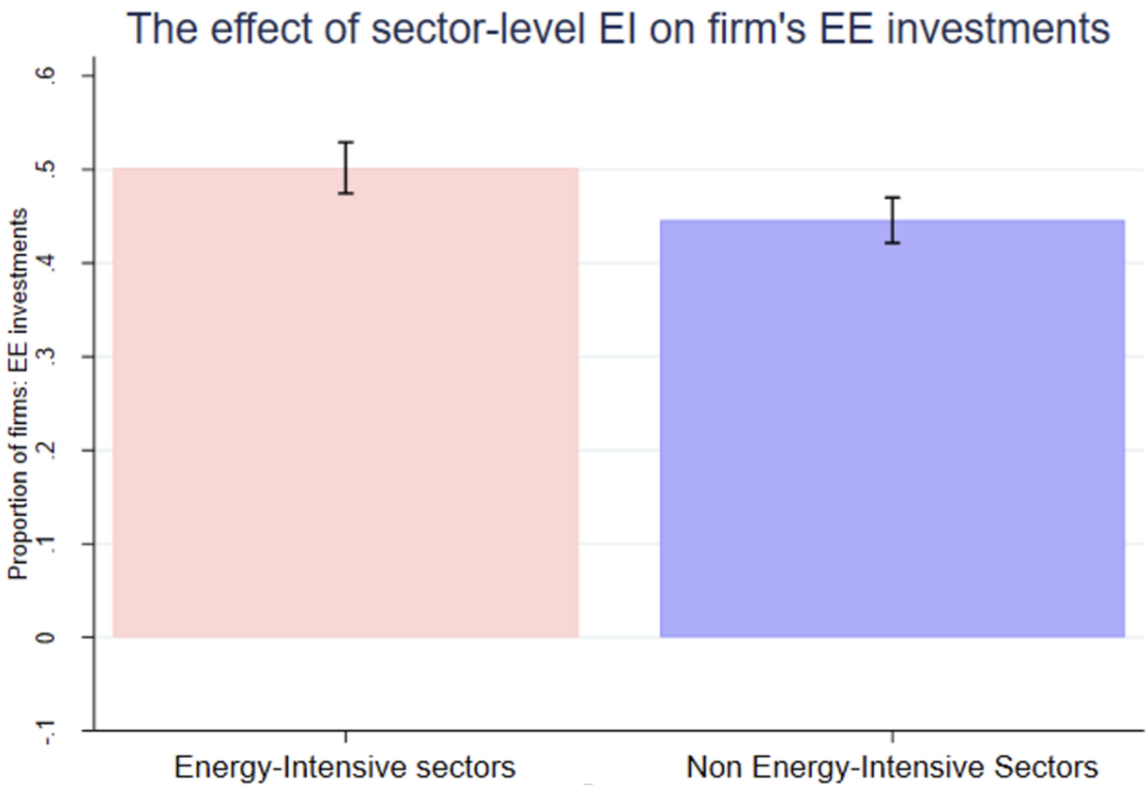


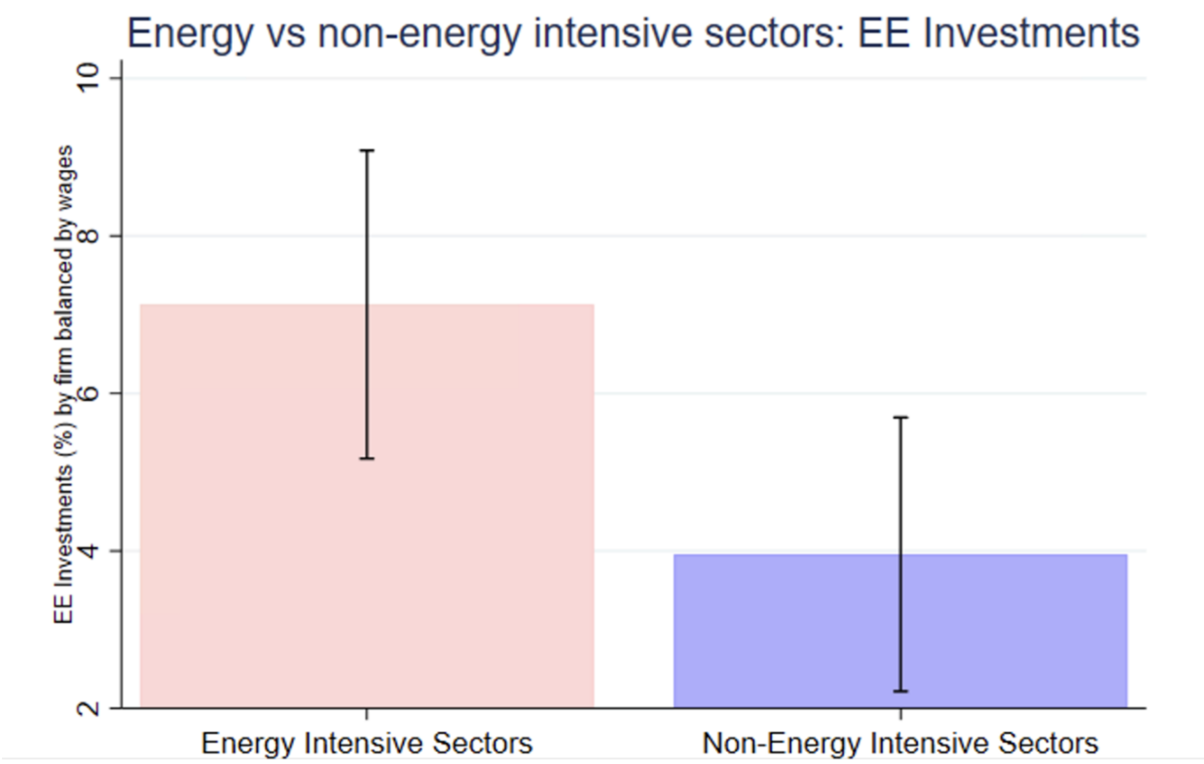
On the other hand, Energy Intensive (EI) sectors refer to industries that consume large amounts of energy as a significant part of their production processes. These sectors typically include industries such as chemicals, steel, paper, plastics, mining, extraction, refining, cement, wood, rubber, non-ferrous metals, glass, and ceramics (Bruyn et al. 2020).

The following Figure 8 reports that both the proportion and the intensity of energy efficiency (EE) investments are higher for Non-Energy Intensive (non-EI) sectors compared to Energy Intensive (EI) sectors. This suggests that firms within non-EI sectors are not only more likely to invest in energy efficiency but also invest more heavily when they do.

The differences observed are statistically significant, indicating that the higher EE investments in non-EI sectors are unlikely to be due to random chance. Potential reasons for this trend could include lower costs and complexities associated with implementing energy efficiency measures in non-EI sectors, more stringent regulatory pressures, or greater financial incentives available to these sectors.

Figure 8: Energy Intensive (EI) vs. non-EI sectors. Data: EIBIS





The following graph reported in Figure 9 shows the percentage difference in markups comparing the EU to the US. I will comment only on those sectors that are statistically significant:

In Sector 1, which includes food, beverages, and tobacco, the markup is around 30% lower in the US compared to the EU. Similarly, in Sector 3, covering wood and wood products, there is a 30% lower markup in the US as opposed to the EU.

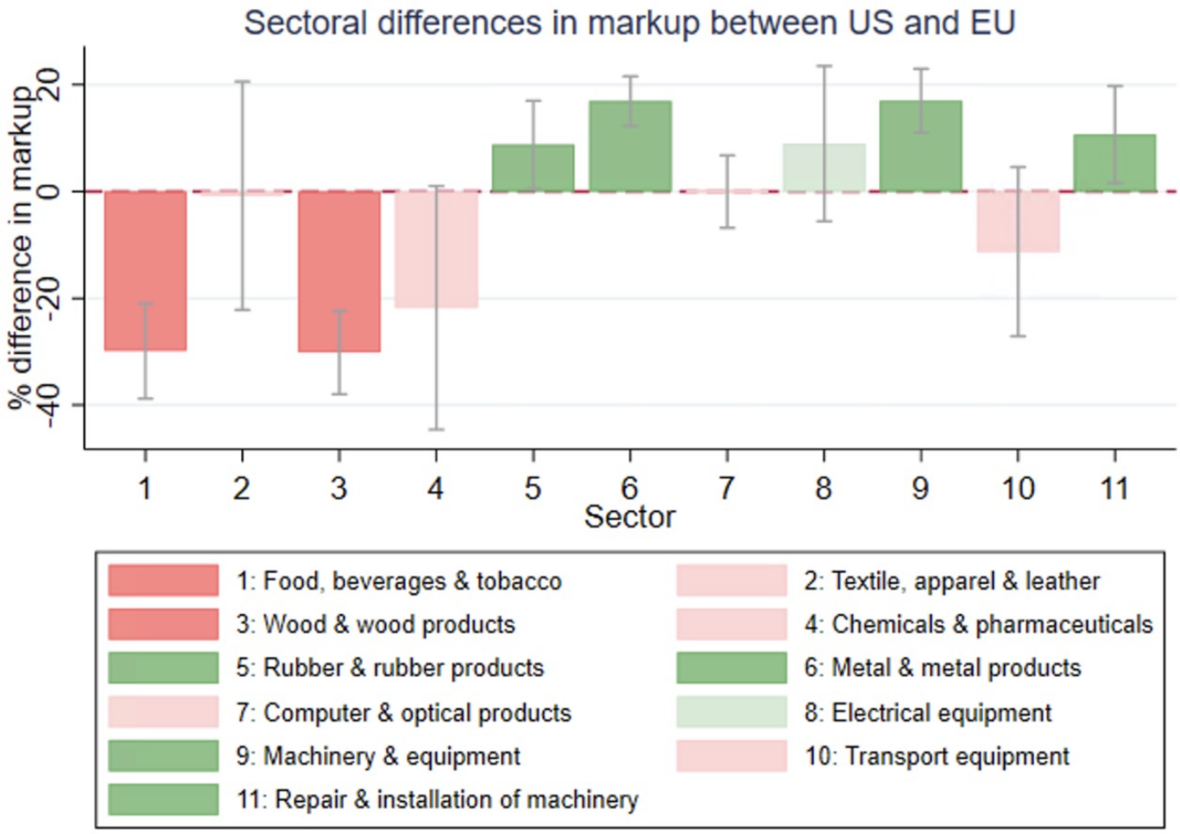
Conversely, Sector 5, which encompasses chemicals and pharmaceuticals, shows an almost 10% higher markup in the US relative to the EU. Likewise, in Sector 6, which includes metal and metal products, the markup is almost 20% higher in the US when compared with the EU. Furthermore, in Sector 9, which pertains to machinery and equipment, there is almost a 20% higher markup observed in the US than in the EU, similar to Sector 6 (metal and metal products). Finally, in Sector 11, repair and installation of machinery, we see a 10% higher markup level in the US as opposed to the EU, a similar number to sector 5 (rubber and rubber products).

These sectors show statistically significant differences as their confidence intervals do not cross the zero percent difference mark. Other sectors' confidence intervals cross over zero and thus are not considered statistically significant for this analysis.

In relation to sectoral heterogeneity, it is worth mentioning that intangible assets may play a pivotal role in amplifying the relationship between green investments and market power (measured through markups). De Ridder (2024) highlights that firms with higher shares of intangible capital, such as intellectual property, branding, and organizational capabilities, often leverage these assets to establish competitive advantages and sustain elevated markups (De Ridder 2024). In the context of green investments, intangible assets enhance firms' ability to innovate, differentiate their products, and build reputations as sustainable market leaders.

For example, firms investing in renewable energy technologies or energy-efficient processes can use patents and R&D as barriers to entry, thereby protecting market share and raising markups. Additionally, strong brand equity and organizational capital enable these firms to signal their environmental commitments effectively, making demand less price-elastic and allowing them to pass the costs of green investments onto consumers without significant demand loss (Porter and Linde 1995). This suggests that firms with extensive intangible assets are better positioned to capitalize on green investments, transforming sustainability efforts into sources of pricing power and long-term profitability.

Figure 9: US vs. EU: sectoral percentage differences in markups. Data: EIBIS

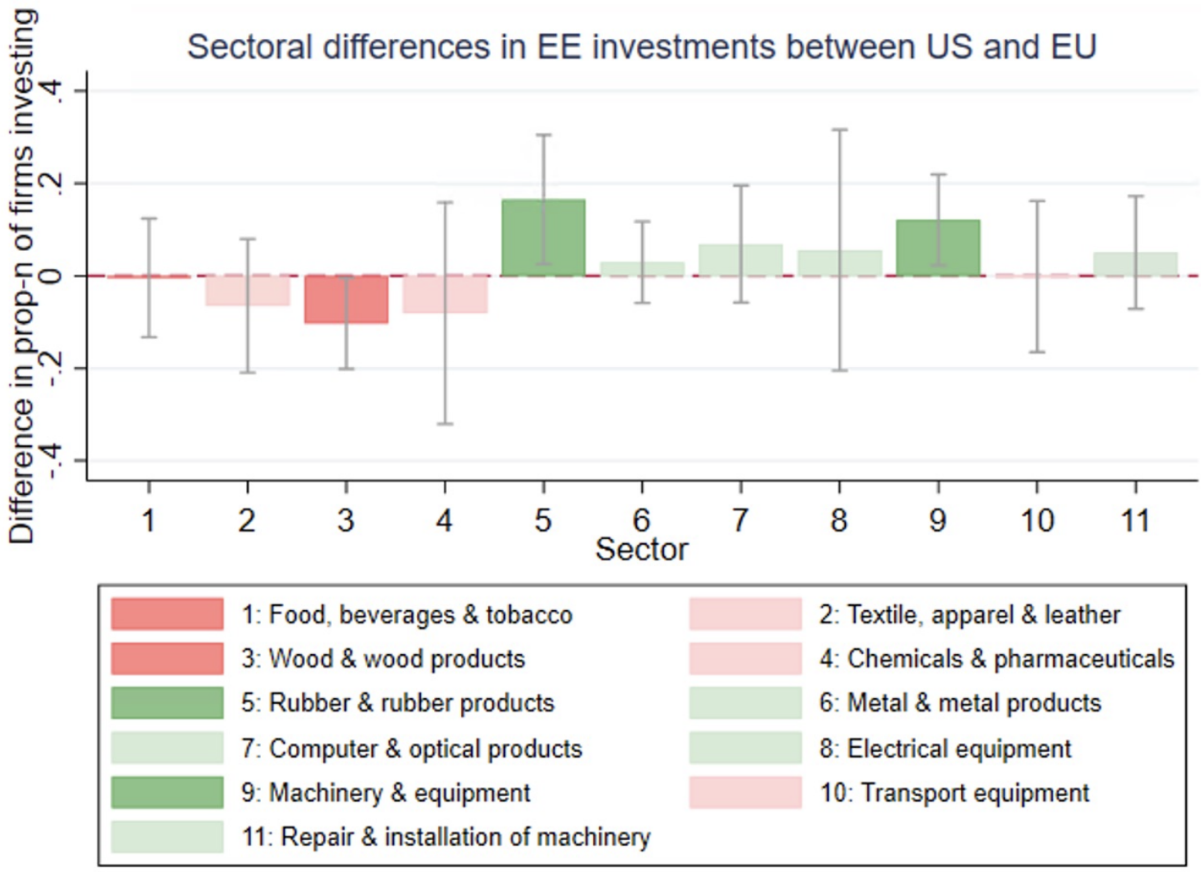


The following graph reported in Figure 10 shows the difference in proportion of firms investing in energy efficiency comparing the EU to the US. I will comment only on those sectors that are statistically significant in relation to what I previously discussed in terms of markups:

In Sector 5, which represents rubber and rubber products, we previously noted an almost 10% higher markup in the US relative to the EU. This graph also demonstrates that around 0.2 (20%) more firms are investing in energy efficiency (EE) in the US compared to the EU. Both markups and green investments show higher values in the US as opposed to the EU in this sector.

Similarly, in Sector 9, which covers machinery and equipment, we previously observed an almost 20% higher markup in the US than in the EU. Additionally, around 0.1 (10%) more firms are investing in EE in the US compared to the EU. Both markups and green investments trend positively in the US for this sector, suggesting higher values in the US in comparison with the EU.

Figure 10: US vs. EU: sectoral differences in proportion of firms investing in EE. Data: EIBIS.



I will now jointly discuss the next two graphs in Figure 11 and Figure 12. The first graph shows how firms perceive their regulatory environments, i.e. whether they are heavily regulated. Negative values mean that US firms face less regulation in comparison to EU, which is manifested in Manufacturing and Services (broad) sectoral classifications. In contrast, Infrastructure shows that US firms in that sector feel they are more heavily regulated. It is important to note that although firm-level responses provide useful insights, which may not be reflected in regulation indices, perceptions are also subject to bias.

Moreover, it is important to note that the arising bias in the perception of climate (environmental) regulation shown in Figure 11 may actually capture the perception of market regulation by firms. Market regulation and environmental regulation differ fundamentally in their objectives, mechanisms, and outcomes. On one hand, market regulation primarily aims to ensure fair competition, protect consumers, and enhance economic efficiency by addressing market failures, such as monopolies or information asymmetries (Tirole 1988). It focuses on price controls, market entry barriers, and anti-trust enforcement to promote efficiency and innovation (Posner 1974). On the other hand, environmental regulation seeks to internalize negative externalities, such as pollution, by imposing constraints on resource usage and emissions, thus protecting public goods and promoting sustainability (Porter and Linde 1995). Environmental regulations often employ standards, taxes, subsidies, and permit systems to achieve compliance, emphasizing long-term ecological stability (Baumol and Oates 1988). These regulations may result in higher costs for firms, but studies show they can also stimulate innovation by encouraging cleaner technologies (Porter and Linde 1995). Conversely, market regulation operates within established economic systems to optimize resource allocation and minimize distortions without necessarily prioritizing ecological outcomes. The trade-offs between these two forms of regulation highlight the challenge of aligning economic growth with environmental sustainability, requiring integrated approaches (Jaffe, Peterson, Portney, and Stavins 1995). Thus, while economic efficiency, productivity and profitability are likely to be improved by market regulation, it is the energy efficiency and energy productivity that are targeted by environmental regulation.

In relation to our findings, suggesting that Chemicals & pharmaceuticals as well as Machinery & equipment, which both belong to (broad) Manufacturing sector, what we see is that US firms both invest in EE and have higher markups in comparison to EU firms. Bringing it together with less regulatory environment suggests that there may be other channels than regulation that motivate firms to invest more. While exploring energy audit and alignment of firms with climate targets reported in Figure 12, I highlight lower figures for the US again. This means that indeed it may be the case that the traditional channels policy makers use to incentivise green investments, i.e. regulation, energy audit and climate targets are not the ones that in fact motivate these investments. It may be that those firms that invest are already aware of non-energy benefits of energy efficiency investments, such as productivity, profitability and markups, and exploit those. This brings to our attention the importance of changing the mindset of firms by bringing these channels to their awareness. In addition, customers are rapidly more aware of green consumption and green-washing, hence educating customers that create demand may be a more effective pressure for firms to invest in energy efficiency as opposed to traditional channels of influencing such investments. It may be the case that these awareness channels are more present in the US as opposed to the EU. Given that the environmental targets in the EU are noted as more stable compared to the US, the obtained results may reflect the insufficiency of current policy measures, as suggested in the World Energy Investment report of the International Energy Agency (2024). These results are in line with the discussion presented in Cerniglia and Saraceno (2022), which highlights that US policies prioritize innovation and clean technology leadership, supported by incentives rather than direct regulations as in the case of the EU. The US prioritises de-risking investments through government-backed guarantees, ensuring private investors feel secure financing large-scale renewable projects. Subsidies, particularly in emerging areas like hydrogen production and carbon capture, further incentivize industries to transition toward low-carbon technologies. Unlike Europe's regulatory-heavy model, the US leans on voluntary frameworks, public-private partnerships, and competitive grant programs to accelerate adoption. These incentives reflect a preference for market flexibility and technological competitiveness rather than mandated reductions, making the US approach more decentralized and innovation-driven compared to Europe's centralized, regulatory focus.

The United States promotes consumer awareness of environmental friendliness and climate targets through various policies and programs. These initiatives include incentives for adopting energy-efficient technologies, such as tax credits and rebates for purchasing electric vehicles and energy-efficient home appliances. Public campaigns and education programs are also used to raise awareness about sustainable practices and energy conservation. Similar measures are adopted in the EU, which promotes consumer awareness regarding environmental sustainability and climate targets through extensive public education campaigns, regulatory frameworks, and funding programs. One major initiative is the European Green Deal, which incorporates awareness programs aimed at promoting energy efficiency, renewable energy adoption, and sustainable consumption patterns (Cerniglia and Saraceno 2022). However, our results suggest that the initiatives that improve awareness may be more effective in the US given their less regulatory-based focus.

Figure 11: US vs. EU: Broad sectoral differences in perception of climate regulation. Data: EIBIS

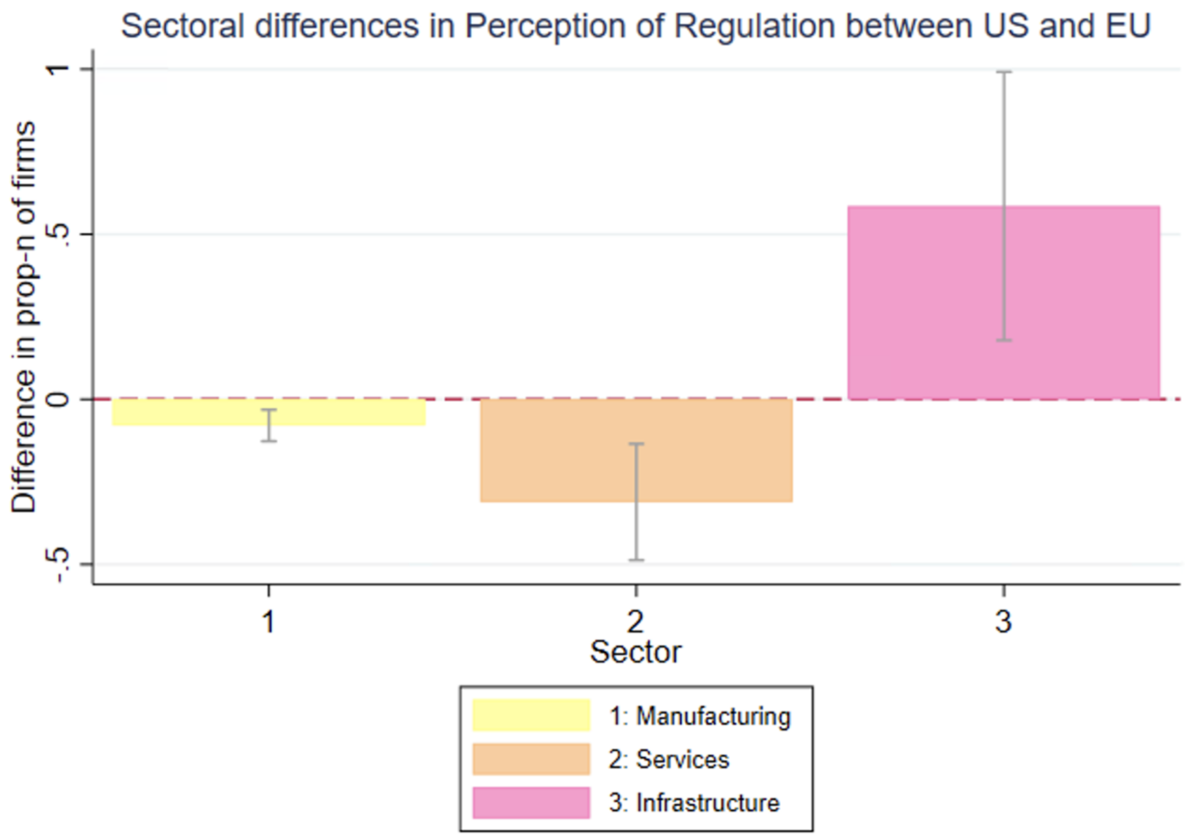
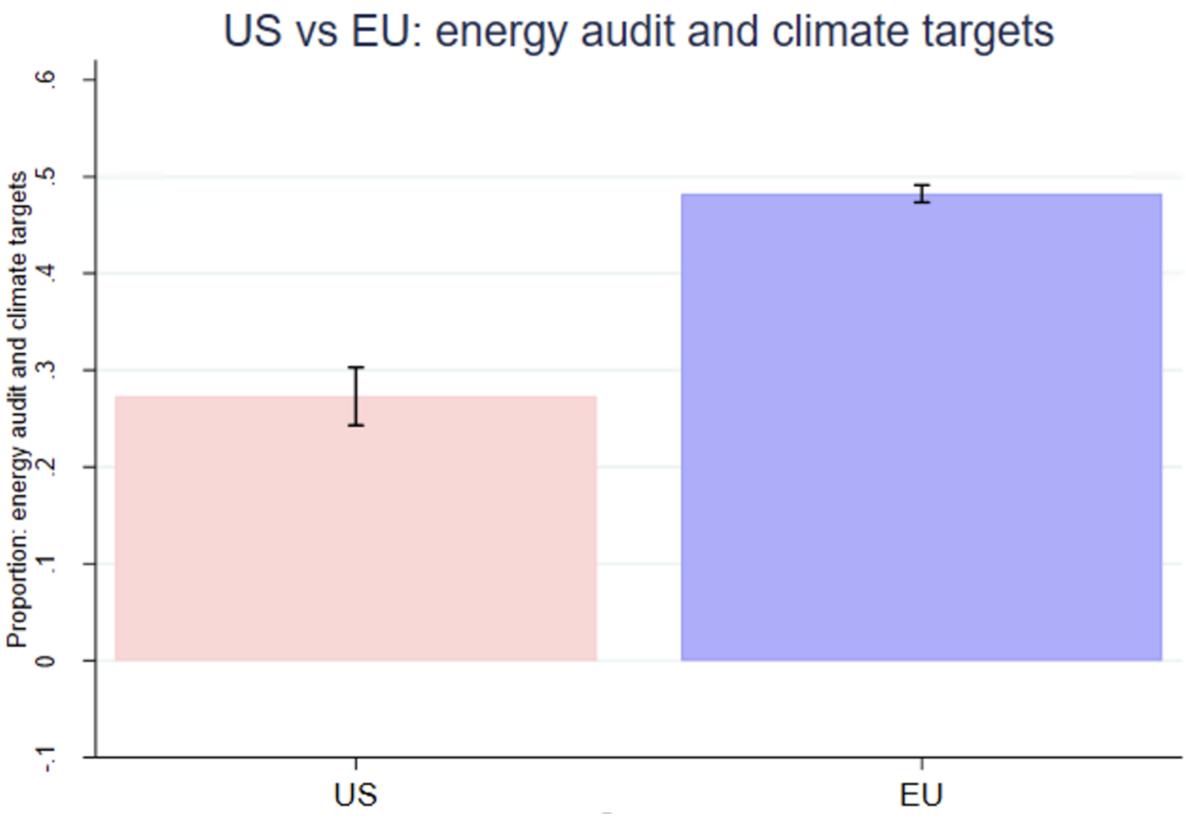


Figure 12: Firms engaged in energy audit and climate targets. Data: EIBIS.



6 Conclusions and policy implications

Positive and significant coefficients obtained in this paper suggest that investments in energy efficiency have a substantial positive impact on the firm's markup. This implies that firms investing more in energy efficiency tend to achieve higher markups, possibly due to cost savings or enhanced productivity.

For firms, the results suggest that allocating resources towards energy efficiency can be a win-win strategy. This could be particularly relevant for firms in energy-intensive industries where efficiency gains can lead to significant cost reductions.

Higher markups resulting from energy efficiency investments are likely to indicate improved competitiveness in the market. Firms that are more energy-efficient may be able to offer better prices or higher quality products, thus gaining a competitive edge.

The understanding of the impact of energy investment on market power as a firm's non-energy benefit of energy efficiency investments is crucial in the context of the United Nations Climate Change conference (COP). From a policy perspective, encouraging firms to invest in energy efficiency could lead to higher market power and potential profitability in the future, as indicated by the increased markup. This could be achieved through subsidies, tax incentives, or other support mechanisms designed to encourage firms while taking into account firm-specific as well as sectoral and geographical differences.

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Appendix

A Technical comments on STATA commands

A.1 markupest

The markupest command in STATA is designed to estimate markups using various methodologies, including the micro-approach proposed by De Loecker and Warzynski (2012). This approach is particularly useful for estimating firm-level markups from production data.

The estimation process begins with the production function estimation, which can be done using various methods such as OLS, GMM, or more advanced techniques like control function approaches. The next step involves estimating the output elasticity of a variable input, which is key to the De Loecker and Warzynski methodology. This is typically done by regressing output on inputs while controlling for productivity shocks. Finally, once the output elasticity is estimated, the markup is calculated as the ratio of the output elasticity to the share of the variable input in total revenue.

A.2 reghdfe

The reghdfe command in STATA is a powerful tool for performing linear regressions with multiple levels of fixed effects. It extends the capabilities of the traditional areg and xtreg commands by allowing for the absorption of multiple high-dimensional fixed effects, making it particularly useful for panel data analysis.

The key features of reghdfe include its ability to handle multiple fixed effects, which is essential for controlling for unobserved heterogeneity at different levels, such as industry and year. Additionally, the command is optimized for speed and memory usage, making it highly efficient and suitable for large datasets. Furthermore, reghdfe offers flexibility by supporting interactions of fixed effects and allowing for the inclusion of factor variables and time series in regression models.

A.3 ivreghdfe

The ivreghdfe command combines the functionalities of reghdfe and ivreg2, allowing for instrumental variable (IV) regressions with multiple levels of fixed effects. This is particularly useful for addressing endogeneity issues in panel data.

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