Analysing the determinants of energy efficiency investments by companies in the European Union and the United States: A policy perspective

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About this paper

This paper was prepared based on the Master Thesis of Marta Lasheras Sancho under the supervision of Dr. Marc Ringel, Chairholder at the European Chair for Sustainable Development and Climate Transition at Sciences Po Paris and Annamaria Tueske, Economist at the European Investment Bank. It employs data from the European Investment Bank Investment Survey (EIBIS) and the Bvd ORBIS databases. It presents preliminary findings and will be followed by a forthcoming paper by Annamaria Tueske and Marta Lasheras Sancho, titled "Regulatory and economic drivers of firms' energy efficiency investments".

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1. Introduction

Policy background

As defined in the EU Energy Efficiency Directive, energy efficiency quantifies the "*ratio of output of performance, service, goods or energy to input of energy*" (Directive EU 2023/1791[1]). Energy efficiency solutions aiming at improving this ratio through technology or through behavioural and economic incentives are becoming increasingly vital in achieving net zero emissions targets and transitioning towards clean, sustainable energy systems (Rosenow and Eyre, 2022). In fact, in the IEA's sustainable development scenario, energy efficiency plays a pivotal role, accounting for 40% of emissions reduction efforts (Fischer, 2021; IEA, 2020a). This explains why energy efficiency solutions are often referred to as "the first fuel in the clean energy transition" (IEA, 2021).

Recent disruptive events, including the invasion of Ukraine by the Russian Federation in February 2022 have triggered inflationary pressures and record-high energy prices which have fostered the recognition of energy efficiency solutions as a clear means to simultaneously tackle climate objectives and ensure the affordability and security of energy supply (IEA, 2022a) as highlighted by the (IEA, 2022a). Since, strengthened efforts to improve energy conservation and management have been observed worldwide, with global energy efficiency progress rapidly

[1](*Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (Text with EEA relevance)*, 2023)

increasing and reaching 2% in 2022, double the average of the preceding five years, but falling back to 1.3% in 2023 (IEA, 2023a, 2023b).

According to the IEA, to attain net zero by 2050, annual efforts must still be doubled, aiming for a 4% improvement each year throughout this decade (IEA, 2023a). Meeting this target would not only substantially reduce GHG emissions, with a predicted 11 Gt reduction in CO_2 emissions from fuel combustion by 2030, but also yield significant socio-economic benefits. These include improvements in health and alleviation of fuel poverty, as highlighted by Kerr, Gouldson and Barrett (2017) as well as Ringel, Laidi and Djenouri (2019). In fact, achieving the annual energy efficiency improvement target of 4% could enable 800 million people to gain access to electricity according to the IEA (IEA, 2023a).

In addition to commitments made by countries, active engagement from the corporate sector is crucial in ongoing efforts to reduce GHG emissions. In 2016, a report by We Mean Business, CDP et le New Climate Institute looked at the abatement potential that five key business initiatives[2] could achieve by 2030. These business-driven initiatives had the potential to reduce 3.7 billion metric tons of CO_2 equivalent annually, accounting for 60% of the total emissions abatement commitments outlined in the Nationally Determined Contributions (NDC) within the Paris Climate Change Agreement. Moreover, the report suggested that these "Business Determined Contributions" could potentially lead to a reduction of 10 billion metric tons of CO_2 equivalent per year, given the presence of the "right policy environment" supporting enhanced climate action (CDP et al., 2016). Energy efficiency and energy-saving solutions were significant components of the analysed business initiatives and have since steadily gained prominence within the We Mean Business coalition's advocacy for policy reforms, underscoring the recognised strategic character of these investments for the business sector. While commitments by enterprises are increasingly widespread, accountability to ensure transparency and that commitments align with actions remains key (CDP et al., 2023).

Initially targeting large corporations, these initiatives have now broadened their focus to include smaller businesses. A collaborative effort by the We Mean Business Coalition, the International Chamber of Commerce, the Exponential Roadmap Initiative and the UN Race to Zero Campaign led to the establishment of the “SME Climate Hub” in 2020, which aims to encourage climate

[2] These initiatives are: RE100; EP100; Science Based Targets; Zero De-forestation & LCTPi.

action among SMEs through the provision of tools to measure their carbon footprint and knowledge-based support to assist them in their emission reduction efforts (SME Climate Hub, 2020). In 2023, 1 777 SMEs joined the SME Climate Hub, marking a 33% increase with respect to 2022 (CDP et al., 2023). SMEs are key driving forces in economies around the world; they account for 99% of businesses and represent close to 60% of the value added generated in the business sector across OECD countries (OECD, 2021a). While their collective share in GHG emissions is considerable, amounting to 63% of the CO2 emissions of the corporate sector in the EU for instance (European Commission, 2022a), when taken individually, the environmental impact of an average SME is significantly lower than that of a large enterprise, amounting to 75 tons of greenhouse gases against 22 345 tons for an average large enterprise in 2018 (European Commission Directorate-General for Internal Market Industry et al., 2022). This gap partly explains why SMEs have often remained on the side-lines of government's emission reduction policies. In the U.S., Hill estimates that SMEs contribute around USD 60 billion in annual energy costs, equivalent to half a billion metric tons of annual CO2 emissions each year (Hill, 2014; OECD, 2021b). And, as highlighted by the IEA, a number of studies have emphasised the cost-effective energy-saving potential of SMEs, which ranges between 10% and 30% of their final energy demand (IEA, 2015). In the industrial sector particularly, Thollander and Palm (2013a) estimated that energy efficiency measures by SMEs could achieve over 25% reduction in energy consumption.

The need to increase the resilience of SMEs against external shocks has been emphasised by the impact of the energy crisis and the COVID-19 pandemic, underscoring the importance of sustainable and efficient energy practices in their daily operations (IEA, 2022b). In this context and in the face of increased pressure to achieve net zero emissions by 2050, both the US and the EU are increasingly prioritising energy efficiency in their policy agendas. In fact, energy efficiency policies were one of the key components of the response to the energy crisis that ensued from Russia's invasion of Ukraine, which fuelled pre-existing inflationary pressures (OECD, 2023a).

While less affected than the EU by the spikes in energy prices observed following Russia's invasion of Ukraine (OECD, 2023a), the Biden Administration recognised the importance of reducing the US's reliance on fossil fuels and accelerating the transition towards clean energy (The White House, 2023). The Inflation Reduction Act (IRA) announced in August 2022, represented a major turning point in the US's efforts to reduce GHG emissions and included measures to bring down energy costs (Climate Action Tracker, 2022; Larsen et al., 2022). It allocated USD 369 billion in financial incentives and support mechanisms, including tax credits, loans and grants to support the implementation of clean energy technologies and investments for the decarbonisation of the economy (Climate Action Tracker, 2022; OECD, 2023a). These include supports for the industrial sector but also energy efficiency measures directly targeted at SMEs. For instance, through tax credits for small business building owners to support energy efficiency investments and support for small businesses in the agricultural sector under the Rural Energy for America Program (The White House, 2022). Another relevant measure put in place in recent years is the "Infrastructure Investment and Jobs Act" (The White House, 2021) signed by President Biden in November 2021 to stimulate economic recovery and modernise the country's infrastructure, all while accelerating initiatives to address climate change (Climate Action Tracker, 2022; The White House, 2021). Amounting to USD 1.2 trillion, the legislation allocated funds towards the development of electric vehicle (EV) charging infrastructure, the enhancement of the grid, the promotion of energy efficiency and electrification in buildings (Climate Action Tracker, 2022). While there aren't any federal regulations specifically addressing emission reductions by SMEs in the United States, broadly defined as businesses having fewer than 500 employees[3] (Koirala, 2018), organisations like the U.S. Small Business Administration (SBA) do provide guidance on environmental regulations for SMEs and can support them to achieve energy savings by connecting them with relevant partners (SBA, 2023).

In their 2019 assessment of the energy policy landscape in the United States, the IEA estimated that current policies fell short of achieving the goal of reducing energy intensity by half by 2030 compared to 2005 levels. With a projected 1.6% annual decrease in energy intensity, the existing policy framework would only maintain energy consumption at current levels without significantly reducing it (IEA, 2019a). According to the Climate Action Tracker and while still insufficient to meet their target of halving its GHG emissions by 2030 from 2005 levels, the implementation of the IRA brought down the gap between their target and current policy projections (Climate Action Tracker, 2022). Some of the challenges hindering energy efficiency improvements in the US according to the IEA 2019 assessment of the US policy framework include limited extension of effective state-level policies like Energy Efficiency Resource Standards (EERS) to all states and

[3] It is important to note that the criterion to define SMEs varies by type of enterprise and the defining governmental body (United States International Trade Commission, 2010).

the financial misalignment between energy suppliers' interests and broader societal benefits such as economic growth and environmental protection (IEA, 2019a). Policy recommendations then included centralising federal building efficiency improvements, updating efficiency standards for appliances and vehicles, incentivising industry adoption of energy efficiency standards, and supporting states in updating building codes and implementing a nationwide building energy performance rating system(IEA, 2019a).

Within the framework of the European Green Deal's "Fit for 55" initiative, the European Commission committed to a binding goal of reducing energy consumption by 9% compared to the 2020 levels by 2030. In July 2023, another amendment to the 2012 Energy Efficiency Directive (Directive 2012/27/EU[4]) was proposed in response to the *REPower EU Plan*, featuring an even more ambitious objective of achieving at least an 11.7% reduction in energy consumption and reducing dependence on Russian fossil fuels as soon as possible (European Commission, 2022b). These revisions became effective on October 10, 2023, with the publication of Directive 2023/1791[5] by the European Parliament and the Council in September 2023.

Institutions like the IEA and the World Bank have produced detailed nomenclatures of energy efficiency policies classified in policy packages, and a number of authors have produced detailed analyses and categorisations of their own (Bertoldi, 2022; Markandya et al., 2014; Mushafiq et al., 2023; Saunders et al., 2021). In the European Union, energy efficiency policy is a shared responsibility of the EU and national governments, meaning that support for energy efficiency improvements is established at three different levels of governance: EU, national, and sub-national. In order to outline the division of competencies between the EU and national governments in the field of energy efficiency, we will use Saunders *et al.*'s (2021) policy classification, which includes five types of policies in this area:

1. ***Efficiency standards for appliances and equipment***, which are mandatory for businesses of all sizes as per EU regulation (Ecodesign Directive - 2009/125/EC)[6] and building codes

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[4] (*Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (Text with EEA relevance)*, 2023)
[5] (*Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (Text with EEA relevance)*, 2023)
[6] (*Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast) (Text with EEA relevance)*, 2009)

regulated by the Energy Efficiency Directive (Directive 2012/27/EU)[7] and the Energy Performance of Buildings Directive (2010/31/EU)[8].

2. ***Information and labelling to increase consumer awareness***, mandated by the Ecodesign Directive (2009/125/EC)[9] and Regulation (EU) 2017/1369[10].
3. ***Economic incentives*** encompass various financing mechanisms (e.g., loans, grants, tax incentives, subsidies, tradable certificates, etc.) and financial rewards like tax credits and rebates[11], often co-financed by EU funds (European Commission, 2021a), including:

    - The Recovery and Resilience Facility (RRF): amounting to EUR 723 billion, 37% of which are earmarked for green measures (European Commission, 2021b).
    - The Cohesion Policy Funds: including the European Regional Development Fund (European Commission, 2021c)and the Just Transition Fund (European Commission, 2021d) amongst others.
    - The Modernisation Fund: with a budget of EUR 14 billion to support the modernization of energy systems and energy efficiency improvements in the 10 EU countries with a lower average income (Directorate-Generral for Climate Action, 2020).
    - The LIFE Clean Energy Transition sub-programme: with a budget of 1 billion allocated to projects addressing market barriers and structural obstacles for energy efficiency policy implementation (European Commission, 2021e).

      The Horizon Europe or the Innovation Fund: for energy efficiency research and innovation projects (2024, 2023).

4. ***Behavioural incentives***, including providing feedback to consumers through smart metering or comparing user consumption to top-performing peers. These initiatives primarily

[7] (*Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance*, 2012)

[8] (*Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)*, 2010)

[9] (*Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast) (Text with EEA relevance)*, 2009)

[10] (*Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU (Text with EEA relevance.)*, 2017)

[11] Saunders et al. (2021) classify them as a separate category, they are here grouped with financing mechanisms as they are both implemented by national governments but often co-financed with European Union funds.

target non-corporate consumers (e.g. the initiatives *Evident* and *NUDGE* funded by Horizon Europe (European Commission, 2020a, 2020b).

5. ***Pledges*** where energy users commit to modifying their behaviour. An example of this type of policy is the platform "*Les entreprises s'engagent*", introduced by the French government in 2022 to encourage behavioural changes in the corporate sector (Ministère du Travail, de l'Emploi et de l'Insertion et al., 2018).

Most EU policies have traditionally been designed to address businesses of all sizes. This is for example the case of efficiency standards for products and labelling requirements for appliances and end-use equipment. Otherwise, policy efforts have traditionally prioritised large corporations due to their significant individual impact on greenhouse gas emissions and capacity to deal with regulatory requirements as previously discussed. Support for SMEs – defined in the EU as businesses with less than 250 employees and a turnover under EUR 50 million or a balance sheet that does not exceed EUR 43 million (Koirala, 2018)[12] – has primarily been channelled through the European Regional Development Fund and implemented at the subnational level.

However, SMEs are increasingly attracting policy scrutiny at the EU level, as highlighted by recent amendments to the Energy Efficiency Directive (Directive 2012/27/EU)[13]. Until September 2023, European Union regulations stipulated that, unlike large corporations, SMEs were not mandated to carry out energy audits. As per Article 8 of the 2012 Energy Efficiency Directive (Directive 2012/27/EU), large corporations are obligated to conduct energy audits every four years. However, member countries were only encouraged, not required, to prompt SMEs to undergo these audits and implement the subsequent recommendations. In fact, this is in part why a scarcity of data is observed regarding SMEs' energy consumption and energy sources, as highlighted by (Reuter et al., 2021), complicating the formulation of targeted policies for SMEs. However, the latest revision to the Energy Efficiency Directive as part of the *REPower EU Plan* mandates that enterprises consuming over 10 TJ of energy over the previous 3 years and that do not implement an energy management system must carry out an energy audit by an independent authority or

[12] The definition of an SME was established in (*Directive 2003/361/EC of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (Text with EEA relevance) (notified under document number C(2003) 1422)*, 2003)
[13] (*Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance*, 2012)

accredited expert, impacting SMEs that reach this consumption level. Further, businesses consuming 85 TJ of energy over the past 3 years must implement a certified energy management system by 2027. These revisions will require affected SMEs to allocate resources for certification, audits, and ongoing compliance[14]. Finally, a number of financing mechanisms specifically targeted to SMEs have emerged in recent years. For instance, the InvestEU investment support mechanism now includes a policy window dedicated to SMEs with a budget of EUR 6.9 billion.[15] The Recovery and Resilience Facility (RRF), a key component of the EU's pandemic recovery efforts, mandates that at least 37% of the funds in each national Recovery and Resilience Plan (RRP) be allocated to measures supporting the green transition. Many EU countries have exceeded this requirement, with the average allocation reaching 42% as of 2024. This includes substantial investments in energy efficiency, renewable energy, and related decarbonisation projects, supporting both public and private sectors in transitioning toward greener practices (European Commission, 2024).

In the 2020 EU energy policy assessment by the IEA, energy efficiency was highlighted as one of the key drivers of GHG reductions in the power sector, however achieving increasingly ambitious energy savings targets would necessitate "significant system transformation" according to the IEA (IEA, 2020b). While a significant role should be played at the national level through their National Energy and Climate Pans (NECPs), the EU can support these efforts in several ways. Policy recommendations at the EU level included the need to fully operationalise the "energy efficiency first" principle through the implementation amongst others of public sector funding instruments and policies to lift barriers to investments in efficiency in critical sectors like manufacturing and construction with important benefits for SMEs. They further added that institutions like EIB were expected to have a critical role in supporting energy efficiency investment in the private sector(IEA, 2020b).

Objectives and research questions

This paper aims to explore the determinants of energy efficiency investments by corporations in both the European Union and the United States, with a specific emphasis on SMEs. Using the

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[14] (*Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (Text with EEA relevance), 2023)*

[15] More information available on initiatives to support EU SMEs at: (European Commission, 2023)

World Bank's RISE energy efficiency policy scores, the main focus will be to analyse whether a comprehensive energy efficiency policy environment can drive energy efficiency investments by corporations.

In addition to the overall policy environment, this study will focus on analysing the influence of comparatively less explored determinants of energy efficiency investments, including organisational capabilities as measured by firm use of formal performance monitoring systems and degree of integration of digital tools in operations. Further, in accordance with findings outlined in the literature review below, we will explore the influence of the main type of finance the firm relies on in the decision to invest in energy efficiency in addition to controlling for firm profitability and total fixed assets.

A first model will explore the factors influencing investments in energy efficiency between 2018 and 2022. Following this, the study will analyse the factors linked to energy efficiency investments initiated in 2022 by businesses that had made no such investments in 2021. As the proportion of businesses investing in energy efficiency rose significantly in 2022, this approach allows for a more detailed examination of how the energy crisis may have influenced the decision to invest in energy efficiency.

While the policy environment in the EU and the US is very different and so has been the impact of the energy crisis, including the US in the analysis allows to put the findings for EU countries in perspective while providing additional insights into the trends and determinants of energy efficiency investments by SMEs on the other side of the Atlantic. At the EU level, the analysis will be conducted across different regions: West and North Europe (WNE), South Europe (SE) and Central and Eastern Europe (CEE) to understand variations across country groups sharing similar characteristics.

To achieve this, the paper will address the following research questions:

- What are the determinants driving the decision explore to invest in energy efficiency by companies of different sizes across the EU and the US?
- How has the energy crisis affected the probability and the determinants of investing in energy efficiency by corporations?

- Can the “conduciveness” of the policy environment as measured by the World Bank’s RISE index predict the level of energy efficiency investments by businesses of different sizes in the EU and the US?

The rest of the paper is organised as follows: Chapter 2 describes the methodology, including a literature review outlining determinants of investment by corporations identified in the literature which informs the theoretical framework. This is followed by a description of the data, its limitations and the model specifications. Chapter 3 then explores the results as well as steps taken to validate them. Chapter 4 contains the discussion of the results and outlines directions for future research, followed by the conclusion in Chapter 5.

2. Methodology

Literature review

Purpose and scope of the literature review

This literature review aims to construct a synthesis of determinants of energy efficiency investments by corporations and specifically by SMEs. The identification of the drivers and obstacles to investments in energy efficiency analysed in the existing literature will inform the theoretical framework for this study’s empirical analysis. Previous literature has often simultaneously explored drivers and barriers to energy efficiency investments (Brunke et al., 2014; Cagno et al., 2015; Neri et al., 2021), which explains the use of the term “determinants” rather than “drivers” of energy efficiency investments, to encompass a wider range of enablers that may both alleviate barriers and actively encourage energy efficiency investments.

Previous studies

Research on the determinants of energy efficiency investments made by corporations and SMEs has traditionally been limited in scope, primarily focusing on specific sectors within single countries or regions, especially emphasising the industrial sector. For instance, Walsh and Thornley (2012) studied the obstacles faced by process industries in the United Kingdom regarding energy efficiency enhancements, while Thollander and Palm (2013b) examined strategies for improving energy efficiency in industrial SMEs within the European Union (EU).

Abadie et al. (2012) investigated the factors influencing energy efficiency investments in small and medium manufacturing firms in the United States and Neri et al. (2021) on the chemical and metalworking sectors in the EU. Findings in the literature suggest that challenges encountered by businesses when undertaking energy efficiency improvements are specific to their size, sector, geographical location and age amongst other factors (Koirala, 2018; OECD, 2017), justifying the need for targeted policies and incentives to enable SMEs to realise their full energy efficiency potential (Blundel and Hampton, 2021). However, in recent years, there has been growing interest in analysing energy efficiency investments by SMEs, particularly in the EU with a number of working papers by the European Investment Bank investigating different aspects pertaining to the drivers and barriers of SME investments in energy efficiency, drawing on data from the European Investment Bank Investment Survey (EIBIS) (Kalantzis and Nakaris, 2020; Kalantzis and Niczyporuk, 2021; Kalantzis and Revoltella, 2019).

Despite the diverse challenges encountered by SMEs depending on the sector they operate in, geographical location and other characteristics, it is crucial to recognise that these businesses do share several common capacity and resource constraints and that certain factors influencing energy efficiency investments overlap with those affecting other types of investments. Regarding business characteristics, research indicates that SMEs often have limited investment capacity compared to larger companies, not only in energy efficiency but also in other areas (Mason and Kwork, n.d.; OECD, n.d.). Studies by Canio and Watkins (1998) and Caporale, Donati and Spagnolo (2023) find that smaller the business are less likely to invest in energy efficiency and Kalantzis and Revoltella (2019) find that having undergone an energy audit is a particularly important determinant of investment for small businesses but that this positive effect disappears in the case where SMEs are financially constrained. SMEs are more likely to experience financing constraints as identified by Johansen (1994) or Beck et al. (2005) who find that whether financial and legal constraints affect growth depends on the size of the business. As can already be inferred from the literature cited so far, there is extensive research linking business size to financial constraints and their impact on investment in different areas, including energy efficiency, with recent findings indicating that in the EU, SMEs are half as likely to invest in energy efficiency compared to their larger counterparts (Kalantzis and Nakaris, 2020). It equally important to acknowledge the influence of several other business characteristics on investment decisions. For example, SMEs operating in energy intensive sectors like manufacturing and infrastructure have been found to invest more in energy efficiency (Kalantzis and Nakaris, 2020), which isn’t surprising as the cost-effectiveness of energy efficiency solutions increases with energy intensity.

Otherwise, Beck et al. (2006) find that younger businesses are less likely to engage in investment activities as they tend to be more financially constrained.

Existing research strongly suggests that financial constraints pose significant limitations for corporate investment, particularly in the case of SMEs. Poderys (2015) finds that access to external finance is an important contributor to SME growth and development, however, SMEs are less likely to be able to access sources of external finance (OECD, 2022a, 2022b, “World Bank SME Finance,” 2024). Research by Fazzari, Hubbard, and Petersen (1988) underscores the significance of internal funds for SME financing, emphasising that financial constraints can substantially curtail their investment activities. Additionally, N. Berger and F. Udell (1998) argue that SMEs often resort to relationship lending, which helps alleviate information disparities and collateral limitations and Beatriz, Coffinet and Nicholas (2022) find that whether or not relationship lending has a positive effect on the cost of credit for SMEs depends on their ability to diversify their sources of finance. Collectively, these studies underscore the how limitations diversifying sources of finance impact SME investment decisions. As previously discussed, SMEs tend to be more financially constrained than their larger counterparts, a vulnerability exacerbated by macroeconomic fluctuations and the business growth cycle. N. Berger and F. Udell (1998) emphasise that SME finances are especially susceptible to macroeconomic challenges due to their "informationally opaque" nature, making it difficult to evaluate their creditworthiness. Determinants of investment can also depend on levels of investment itself as shown by Maçãs Nunes et al. (2012), who find that drivers and barriers differ at high and low levels of SME investment by using a quantile regression. The authors also explore the significance of determinants of corporate investment posited in previous literature, in the Neoclassical theory, the Free Cash Flow theory and the Agency theory. These theories respectively examine the effect of various factors on firm-level investment: the level of sales, cashflow, debt and complexities arising from conflicts between owners and managers, as well as between them and creditors (Maçãs Nunes et al., 2012).

It is important to highlight that SMEs face challenges that go beyond financial constraints. For instance, SMEs have been found to have more limited organisational and strategic planning capabilities compared to large businesses, which can in turn limit their ability to invest in energy efficiency projects (Bertoldi, 2022; European Court of auditors, 2020; IEA, 2015). While strategic planning is crucial for firm success, SMEs tend to engage less in this practice due to owners' short-term focus and time constraints amidst daily operational demands (Beaver, 2003; Fresner et al., 2017; Robinson Jr et al., 1984; Wang et al., 2007). Additionally, SMEs have a limited pool of resources, including manpower, compared to larger enterprises, which limits their ability to revert the same amount of resources to manage administrative functions (Koirala, 2018). SMEs also encounter more difficulties than their larger counterparts in dealing with complex regulations, a difficulty that in fact led to the introduction in the European Union of the "SME Test" as part of the EU Small Business Act (2008). This test was devised to evaluate the potential impacts that new EU legislation could have on SMEs, by directly involving them in the decision-making processes and systematically carrying out cost-benefit analyses before implementation.

Awareness about available energy-efficient technologies, their potential advantages and about availably of public supports to implement them remain a key issue for many businesses and particularly SMEs. Fresner et al. (2017), highlighting the potential that digital technologies present for energy efficiency and Agrawal et al. (2023) underscore the significance of developing energy efficiency strategies and providing training or appointing energy experts for SMEs. The authors also state the need to raise awareness about existing policy incentives, as many businesses tend to be unaware of the existence of government supports well suited for their needs. Similarly, the EIB (2021) found that investments in climate-related initiatives increase significantly when firms possess awareness about their business climate needs. Specifically, firms with dedicated climate staff, established climate targets, or those who have conducted an energy audit within the past three years are respectively 65%, 61%, and 55% more likely to invest in climate projects (EIB, 2021).

Impact evaluation of energy efficiency programmes targeting SMEs emphasise the vital role of a supportive policy environment (Johansson et al., 2022) and growing body of literature focusing on ex-post impact evaluations of energy efficiency programmes targeted at SMEs has emerged in recent years. Numerous studies have examined the impact of energy audits on SME energy efficiency, with research by Kalantzis and Revoltella (2019), Fresner *et al.* (2017), Fleiter *et al.* (2012), and Gruber et al. (2011) consistently indicating their positive influence in reducing information gaps hindering energy efficiency enhancements. Johansson et al. (2022) measure the impact of a pilot energy efficiency network policy programme for SMEs in Sweden, and find that in the network outperformed companies participating in past stand-alone energy audits in terms of GHG emissions reductions, which could reflect the beneficial effect of the programme’s lectures and knowledge-sharing activities but might also be ascribed to a general increase in awareness about potential energy savings.

While policy instruments – regulatory or financial – generally have positive effects on decarbonisation outcomes, some trade-offs in terms of distributional effects and competitiveness are noted by some authors, including Peñasco et al. (2021). Further, the impact of policies and regulations on energy consumption reduction innovations varies, with some studies showing their relevance (Segarra-Blasco and Jove-Llopis, 2019; Veugelers, 2012) and others indicating limited impact (Kammerer, 2009; Solnørdal and Foss, 2018). Galeazzi et al. (2023) use the World Bank's Regulatory Indicators for Sustainable Energy (RISE) to evaluate the impact of renewable energy policies on decarbonisation in developing countries. Their study found that only a few policy packages significantly influenced the decarbonisation of the energy mix in examined countries. Uncertainty regarding the implementation of supportive policies can also have a negative impact on the level of corporate climate-related investments. Verdolini, Bosetti and Jockers (2015) identified policy uncertainty as a significant factor negatively affecting investments in eco-innovation. Specifically, they observed a 5% decrease in innovation levels if policy uncertainty increased by one standard deviation in EU countries. Finally, the effectiveness of environmental regulation in achieving desired outcomes is subject to the wider macroeconomic environment. In the event of a shock like the one recently experienced in 2022 with the rise of energy costs, the implementation of emergency measures and other mechanisms and their appropriate phase out can be determinant in alleviating the effect of the shock and mitigating potential setbacks in achieving environmental goals (IEA, 2011; Parag et al., 2023).

Achieving optimal levels of energy efficiency and its associated improvements in environmental quality and cost reduction requires the alignment between government supports and the most recent research. The gap between the actual level of energy efficiency and its optimal, cost minimising level was termed the "energy efficiency gap" by Hirst and Brown (1990). This is therefore an issue that we have been aware of for some time now. However, in the EU, the funding gap for energy efficiency investments in the EU is projected to reach EUR 185 billion annually over this decade (European Commission, 2020c). Strengthening efforts to overcome market failures and facilitate the take-up of investments in energy efficiency is key (Jaffe and Stavins, 1994), particularly by SMEs (Fawcett and Hampton, 2020), limited by financial, informational or organisational capacity barriers. Especially in the aftermath of the COVID-19 pandemic and energy crisis, which highlighted the need to establish robust policy frameworks favouring business resilience that is aligned with sustainability goals (OECD, 2023b).

Theoretical framework

Based on the above literature review and in line with availability of data in the EIBIS BvD Orbis dataset, this study will analyse the impact of the following independent variables on the probability of investment:

- The RISE energy efficiency overall score and sub-scores: the lagged value of the policy scores for energy efficiency at the country level as defined by the World Bank (see Data sources section below for further details).
- Business characteristics (size, sector, age)
- Profitability: categorical variable indicating whether the firm made a profit, broke even or incurred losses in the last financial year.
- Type of finance: categorical variables indicating whether the firm relies predominantly on internal, external, or intra-group funding in the case of subsidiaries.
- Organisational capacity: whether a business tracks performance and considers that business regulation is not a barrier to investment will be used as a proxy for strategic planning capacity.
- Economic climate and shocks: this will be analysed in by looking at changes in investments through the covid-19 crisis and the energy crisis. A separate model will look at the impact of the energy crisis on investment.

Hypotheses development

This study will examine hypotheses concerning the factors influencing energy efficiency investments by businesses in the EU and the US from 2018 to 2022 with a focus on SMEs. A separate model will be considered to analyse the determinants of transitioning from no investment in energy efficiency before the energy crisis to investing in 2022.

- **Hypothesis 1:** Business characteristics as predictors of energy efficiency investments

Drawing on existing literature, this study posits that business characteristics serve as predictors of energy efficiency investments. Specifically, we anticipate that SMEs will exhibit lower energy efficiency investments due to inherent resource constraints, both financial and otherwise, in comparison to larger counterparts. Moreover, businesses operating in energy-intensive sectors – construction, manufacturing and infrastructure – are expected to demonstrate a higher likelihood of investing in energy efficiency than businesses in least energy intensive sectors (services) (see section **ANNEX 1 – Definitions** of sectors and energy intensity), given the substantial potential for cost reduction through the adoption of energy-efficient measures. Additionally, in line with the finding of Beck *et al.* (2006), younger businesses, established within the last five years as of 2022, are expected to invest less in energy efficiency as they are more likely to face resource constraints as they start operating.

- **Hypothesis 2:** Financing sources and energy efficiency investments

Building on the literature review, firms relying predominantly on internal finance are expected to be less likely to invest in energy efficiency than those primarily dependent on external finance. This is based on research indicating that SMEs, often constrained by limited access to external financing (OECD, 2022a, 2022b, "World Bank SME Finance," 2024), face challenges in diversifying their sources of finance (Beatriz et al., 2022), expanding their investment capacities and growing (Poderys, 2015). Making them mainly reliant on internal sources of finance or relationship lending (Fazzari et al., 1988; N. Berger and F. Udell, 1998). Additional financial controls including profitability and total fixed assets are expected to have a positive impact on investment.

- **Hypothesis 3:** Organisational capabilities as predictors of higher energy efficiency investments

While the literature has predominantly focused on measuring the impact of financial constraints on corporate growth and investment decisions (Beatriz et al., 2022; Beck et al., 2005; Fazzari et al., 1988; Johansen, 1994; Maçãs Nunes et al., 2012; Poderys, 2015), we also expect organisational capabilities, encompassing the firm's implementation of a formal performance monitoring system, to be a predictor of energy efficiency investments. We expect this based on findings showing the positive effect of energy audits on the probability of investing in energy efficiency and productivity (Fresner et al., 2017; Kalantzis and Niczyporuk, 2021; Kalantzis and Revoltella, 2019). The model further includes an independent variable measuring the degree of implementation of advanced digital solutions as an indicator of strategic decision-making capabilities, in light of the productivity gains that can be derived from the integration of these practices within businesses (IEA, 2023a, 2019b; OECD, 2021c). This will further allow us to explore the synergies between the implementation digital technologies and the decision to invest in energy efficiency, which we expect to be positive.

- **Hypothesis 4:** Sensitivity of energy efficiency investments to rising energy costs in 2022.

Anticipating a nuanced response to economic shocks, this study postulates that the Covid-19 pandemic in 2020 had a negative impact on the probability of investing in energy efficiency due to the strain induced by lockdown measures. The surge in energy prices in 2022, especially in the EU, is on the contrary expected to have led to higher energy efficiency investments to mitigate rising energy costs. While not analysing the impact of emergency measures within the framework of this study, we expect the established policy framework to influence firms' decision to invest in energy efficiency. As discussed in the literature review, emergency policy packages like the ones deployed in the context of the 2022 energy crisis can be determinant in mitigating the negative effects of rising energy costs on vulnerable consumers. Their appropriate and timely modification or phase out is however also key, to mitigate potential negative effects towards achieving environmental goals (IEA, 2011; OECD, 2023a; Parag et al., 2023).

- **Hypothesis 5:** RISE energy efficiency country scores and corporate energy efficiency investments.

Finally, a higher RISE energy efficiency country score is expected to positively impact the likelihood of firms investing in energy efficiency. The overall RISE score serves as an indicator of the robustness of a country's regulatory environment. The sub-scores that make up the overall score are generally expected to positively influence the likelihood of investment in energy efficiency. However, certain policy sub-scores, such as those targeting the public sector, may have a more limited direct impact on SMEs, instead influencing them indirectly through general equilibrium effects. Given the implementation delays between the announcement of regulations and their entry into force, as well as evidence from existing literature examining the impact of policies on firm investment behaviour and environmental outcomes, we will analyse the effects of varying time lags in energy efficiency policy scores. This approach aligns with methodologies used in other research exploring the effects of regulation on entrepreneurship, productivity, and environmental outcomes (Bailey and Coleman, 1971; Bansal et al., 2023; Galeazzi et al., 2023; Goldschlag and Tabarrok, 2018; Lanoie et al., 2008).

Data sources

This paper seeks to analyse the influence of regulatory landscapes and least explored investment determinants, including firm-level organisational capabilities, on corporate decisions regarding energy efficiency investments across the EU and the US by drawing on the European Investment Bank (EIB) Investment Survey and the BvD ORBIS database. The EIB Investment Survey, conducted annually since 2016, encompasses insights from around 12 000 businesses in EU27, 600 firms in the United Kingdom until 2021, and 800 in the United States (EIB, 2024). The investment survey includes questions covering various drivers and barriers of corporate investments. It also includes information about whether firms invest in energy efficiency and targeted questions about energy costs, particularly in the 2023 wave of the survey which collects information on the financial year 2022, including firms' reactions to the energy crisis.

Each wave of the survey is designed to collect information about the interviewed businesses' investment activities during the last (closed) financial year. Therefore, answers from wave 2019 contain information about the firms' investment activity in 2018 and so on. All companies surveyed are matched with the BvD ORBIS database, connecting survey responses to firms' financial and administrative data. A review by Brutscher *et al.* (2020) of the quality of the EIBIS database concludes on the representativeness[16] and the reliability of the sampling methodology. Furthermore, the survey is structured to establish continuous observations over time, with 40% of firms from the preceding wave being re-interviewed the following year (EIB, 2024, 2020; Pouliakas and Wruuck, 2022). The database's longitudinal component enables the analysis of determinants of energy efficiency investment decisions by EU and US firms between 2018 and 2022.

To assess the quality of the country-level policy environment for energy efficiency, this study takes as reference the Regulatory Indicators for Sustainable Energy (RISE) by the World Bank Group and the Energy Sector Management Assistance Programme (ESMAP), which assess the policy and regulatory environment of "the four pillars of sustainable energy", including access to electricity, clean cooking, energy efficiency and renewable energy. Covering 140 countries including 20 out of 27 EU countries and the US, the RISE will enable us to study the relationship between country policy scores and energy efficiency investments by firms. The third pillar, energy

[16] For more information about the representativeness of the dataset and a breakdown of businesses by sector please refer to **ANNEX 1 – Definitions, summary statistics and representativeness of the EIBIS database**.

efficiency, is composed of 11 sub-components[17] or policy packages as outlined in **Table 1** below and scored on a scale of 0 to 100. The overall energy efficiency policy score – also scored on a scale of 0 to 100 – per country is computed by averaging the scores of the eleven sub-components. The scores of the subcomponents are based on the presence or absence of different policies, grouped and weighted within categories at yet another level. These categories include a varying number of analysed policies, resulting in greater weight being assigned to groups with fewer policies under consideration (Galeazzi et al., 2023).

Table 1 – The RISE policy scores.

Sub policy headings	Evaluation criteria
1. National Energy Efficiency Planning	**1.1** Legal framework/action planning **1.2** Sub Sectoral Targets **1.3** Scope of Targets
2. National Energy Efficiency Entities	**2.1** Human capital **2.2** Roles of governmental and/or independent bodies
3. Incentives and Mandates: Industrial and Commercial End-Users	**3.1** For large consumers **3.2** Commercial and industrial consumers

[17] Referred to throughout the study as “sub-scores” “policy sub-components” or “policy packages”.

4. Incentives & Mandates: Public Sector	**4.1** Obligations for public infrastructure **4.2** Tracking and enforcement of obligations **4.3** Public procurement of energy efficiency products **4.4** Ability to retain energy savings.
5. Incentives and Mandates: Energy Utility Programs	**5.1** Utility EE programmes **5.2** Utility Consumer Pricing and Information
6. Financing Mechanisms Available for Energy Efficiency	**6.1** Financing mechanisms available in each sector **6.2** Share of financial and/or non-financial institutions
7. Minimum Energy Efficiency Performance Standards	**7.1** Have minimum energy performance standards been adopted for? **7.2** Verification and penalties for non-compliance
8. Energy Labelling Systems	**8.1** Have energy efficiency labelling schemes been adopted for? **8.2** Mandatory vs Voluntary labelling systems

9. Building Energy Codes	**9.1** New residential and commercial buildings **9.2** Compliance systems **9.3** Renovated buildings **9.4** Building energy information
10. Transport Sector	**10.1** Planning **10.2** Private transport **10.3** Commercial and/or industrial transport
11. Carbon Pricing and Monitoring	**11.1** GHG emissions regulations

Note: The second column displays summaries of the analysed policies.

Source: World Bank, RISE index. Available at: https://rise.esmap.org/ (World Bank, 2021)

Data processing and limitations

Seven EU countries are missing from the RISE index: Estonia, Cyprus, Latvia, Lithuania, Luxembourg, Malta, and Slovenia. This means that scores for 20 out of the 27 EU countries, in addition to the US and the UK, add up to 22 countries. A preliminary analysis of the EIBIS dataset reveals that the UK was dropped from the dataset in 2022, which made the analysis of the impact of Brexit, effective on the 30th of January of 2020 and the energy crisis (2022) on energy efficiency investments impossible. Therefore, and as this study focuses on investments by EU and US businesses, observations from the UK for the year 2021(wave 2022) were dropped from the dataset. The US was only introduced in the dataset in wave 2019 (financial year 2018), therefore, the analysis spans from financial years 2018 to 2022.

The energy efficiency pillar of the RISE index is composed of 11 sub-components as outlined above and the weighting methodology used to calculate the overall energy efficiency score has been criticized by Galeazzi, Steinbuks and Anadón (2023). As anticipated in the Data sources section, the number of policies varies between the eleven sub-components each with a policy score calculated based on the presence or absence of different policies nested and weighted within subgroups, giving more weight to subgroups with fewer policies within policy sub-components. To ensure the robustness of our analysis, we incorporate one of the alternative weighting methodology employed by Galeazzi, Steinbuks and Anadón (2023) and Cubbin and Stern (2006). It consists of adopting a uniform weighting methodology, where equal importance is assigned to each policy within the eleven policy sub-components, diverging from the original practice of weighting by policy sub-groups. While imperfect given that all policies are unlikely to affect energy efficiency investments by SMEs in the same way, this adjustment ensures a more equitable representation of the impact of individual policies, regardless of the number of policies within a given policy package or category. To assess the robustness of the results to different weighting methodologies, the analysis is however also conducted with the original RISE scores as will be discussed in the **Validation** section.

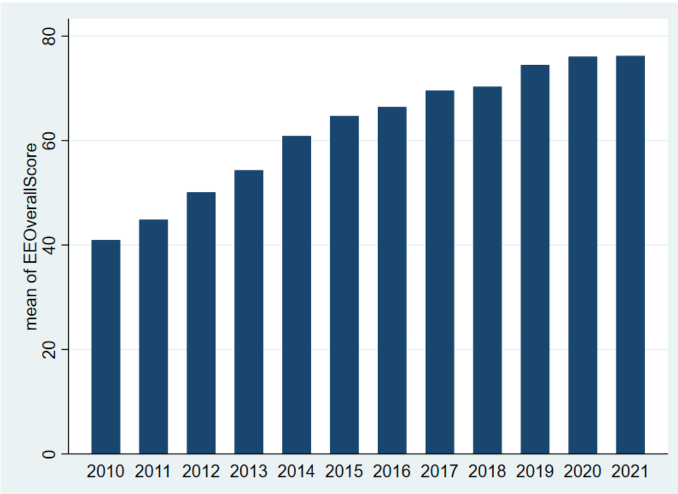
In **Figure 1** below, we can see the evolution of the original and the "summation" of country-level policy scores in the EU (left pane) and the US (right pane). As can be seen when looking at the original scores, the US policy score is higher and has remained so throughout the period reaching 83 out of 100 in 2021. However, a sharper increase in the average policy score is observed across EU countries going from 41 in 2010 to 76 in 2021. Looking at the summation scores, we observe a similar evolution in EU policy scores, going from 39 in 2010 to 78 in 2021. In the US however, scores become higher with the summation weighting methodology and little variation is observed between 2010 and 2021, the policy score consistently remaining above 80.

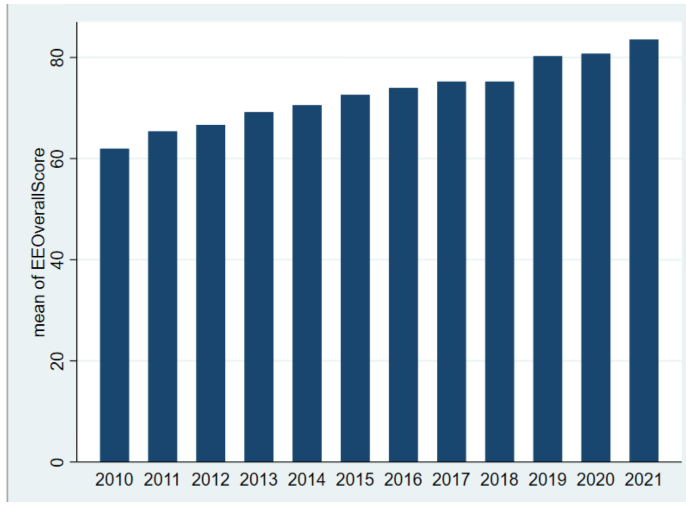
Figure 1 – Evolution of the Rise Energy Efficiency Policy Score (2010 – 2021)

RISE weighting methodology

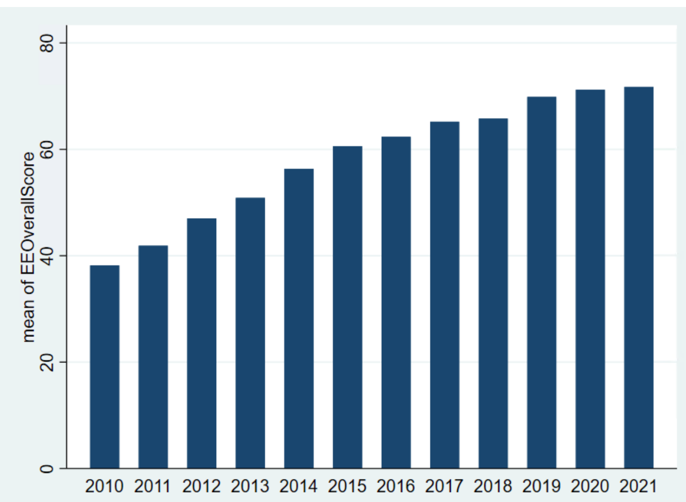
Average evolution in EU countries

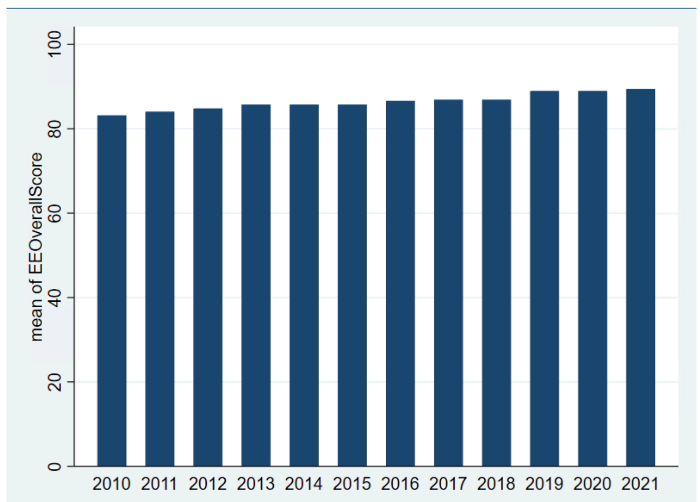
Evolution in the United States





Summation weighting methodology





Source: (World Bank, 2021) RISE index. Available at: https://rise.esmap.org/

Descriptive statistics

Within the framework of this study, we will be analysing the determinants of firms investing in energy efficiency. This variable is derived from a survey question introduced in 2018 in which interviewed businesses indicated the proportion of their total investment primarily used to improve energy efficiency during the previous financial year. The original variable is in percentage and as illustrated in **Table 2** below, the variable has a heavily skewed distribution towards zero, as most respondent businesses do not invest in energy efficiency throughout the analysed period (2018-2022). The skewed nature of the distribution suggests a binary choice model is appropriate. However, analysis of the proportion of investment allocated to energy efficiency is developed by Lasheras Sancho and Tueske (Forthcoming).

Descriptive statistics: proportion of investment allocated to energy efficiency.

As can be seen in **Table 2** below, the average share of investment allocated to energy efficiency reaches 9.37% of total investment on average across interviewed businesses in 2019, then drops to 8.08% the following year. In 2022, investment in energy efficiency starts increasing again but remains at 8.65%. In 2022, mean investment peaks in the observed period reaching 10.62% of total investment on average across surveyed businesses.

Table 2 – Proportion of investment primarily used for energy efficiency.

Year	Observations	Share of not investing (%)	Mean[18] (%)	Std deviation
2018	9 070	57.01	9.35	20.28
2019	9 561	57.84	9.37	20.49
2020	9 049	63.85	8.08	19.31
2021	8 683	61.51	8.65	19.68

[18] Excluding firms that refused to respond or replied “I don’ t know”.

2022	9 057	51.67	10.82	21.34
Total	45 420			

Note: Summary statistics reflect average values across all observations in the database.
Source: EIBIS (2023)

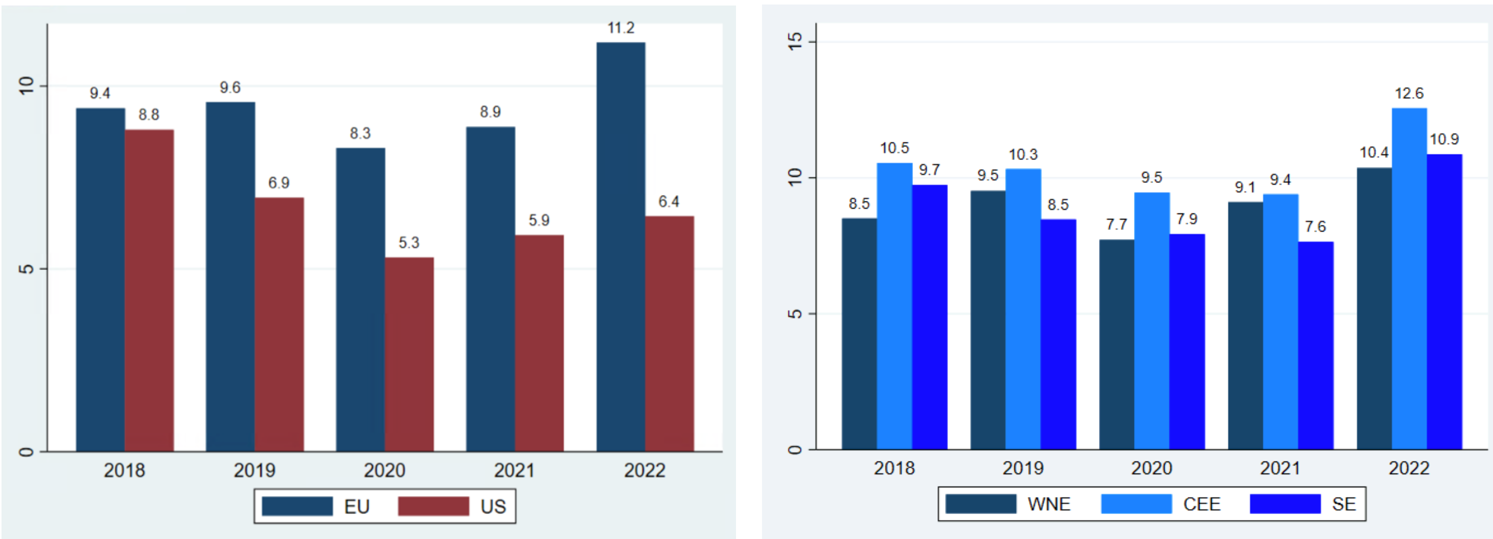
While the evolution of the average proportion of investment is different in the EU and the US, a common temporal trend can be observed. When comparing average investment in energy efficiency across the EU and the US in **Figure 2** (left panel), we can see how the EU consistently exhibits a higher mean investment in energy efficiency, averaging 9.05% in the observed period against 6.7% in the US. EU businesses exhibit an upward trend in the proportion of investment allocated to energy efficiency between 2018 and 2020, contrary to the US, where the share of investment allocated to this purpose only started to rise in 2021. However, a common temporal trend can be observed across the EU and in the US. In 2020, coinciding with the outbreak of the Covid-19 pandemic, there was a dip in the proportion of investment allocated to energy efficiency in both regions: a downturn that is likely to be associated with the economic disruptions and uncertainties that accompanied the global health crisis.

Conversely, the average proportion of investment allocated to this purpose by EU and US firms increases in 2022, by 1.5 percentage points in the US reaching 6.4% and peaking at 11.2% in the EU. This surge aligns with the energy crisis ensued by Russia’s invasion of Ukraine. While both the Covid-19 crisis and the energy crisis exerted strains on businesses across the US and the EU, the surge in energy efficiency investments in 2022 suggests a pronounced sensitivity to energy costs in shaping investment decisions in energy efficiency as outlined in Hypothesis 4. When looking at regional dynamics within the EU (**Figure 2**, right panel), another consistent pattern emerges: Central and Eastern EU (CEE) countries stand out for their sustained and notably higher investments in energy efficiency throughout the analysed period, underscoring the diverse strategies and priorities by different geographical entities within the EU when navigating the energy landscape.

Figure 2 – Average proportion of investment in energy efficiency in the EU and the US

Expressed as the average percentage of total firm level investment.

EU and US   EU macro-regions



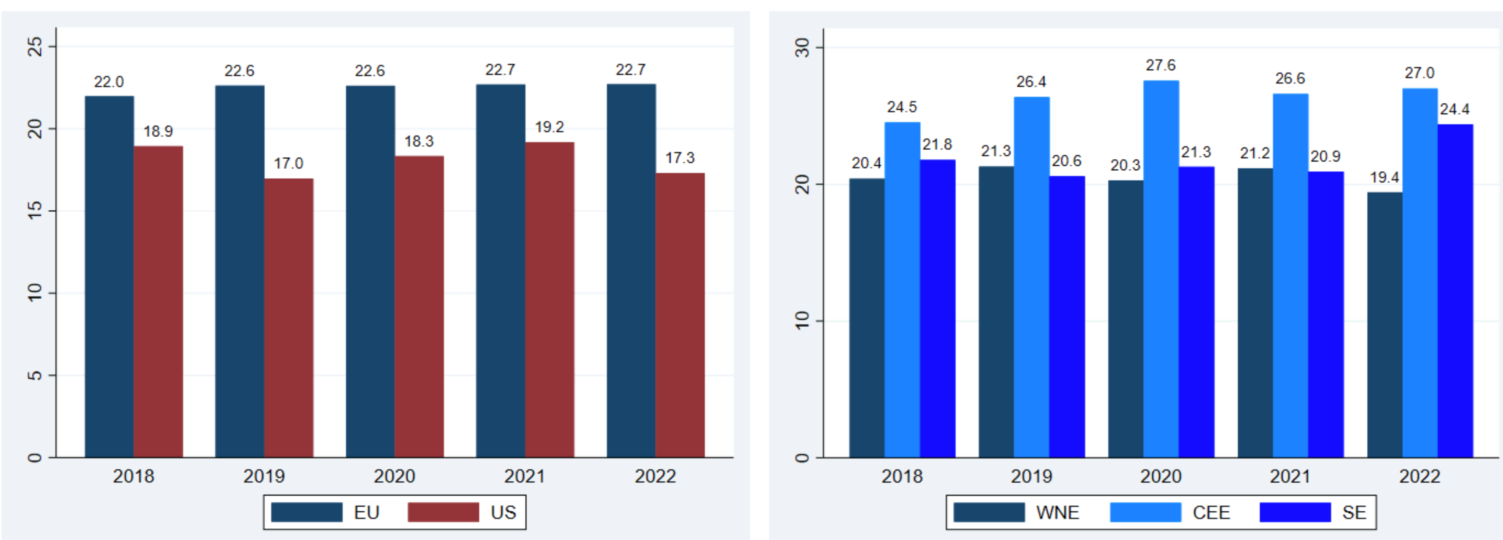
Note: Summary statistics reflect average values across observations in the database across the European Union (EU) and the United States (US) in the left panel; and across EU macro-regions, including Western and Northern Europe (WNE), Central and Eastern Europe (CEE) and Southern Europe (SE) in the right panel. Displayed values are in percentages. Total observations from the EU amount to 41 016 in the EU and 3 280 in the US.
Source: EIBIS (2023)

Excluding businesses that do not invest in energy efficiency from the sample, the average proportion of investment in energy efficiency rises considerably across the EU and the US. This is in line with the large proportion of businesses that do not invest in energy efficiency throughout the analysed period, as outlined in **Table 2**. As can be seen in **Figure 3** below, the share of total investment allocated to energy efficiency remains above 20% on average in the EU for businesses, with investments surpassing zero percent throughout the analysed period. Once more, the share of investment allocated to this purpose remains higher for this subgroup of businesses in the European Union than in the US, where average investment remains between 17% at its lowest point in 2019 and 19.2% at its peak in 2021. In fact, the proportion of investment allocated to energy efficiency stagnated with respect to 2021 at 22.7% in 2022 in the European Union and dropped by two percentage points in the US, suggesting that the increase in the average proportion of investment observed for the year 2022 in **Figure 2** was mainly due to an increased proportion of businesses investing in energy efficiency compared to previous years. A more detailed analysis of this trend is outlined in Model 2 – The impact of the energy crisis on firm investments in energy efficiency. Similarly, the proportion of investment in energy efficiency did not drop during the Covid-19 pandemic in the EU, and increased in the US, suggesting the need for a more detailed analysis of this subgroup of businesses.

When looking at the composition of this subset of firms that do invest in energy efficiency between 2018 and 2022, we can see that it is composed of a comparatively higher number of large businesses than in the entire sample, both in the US and the EU as can be appreciated in **Table 3**, in line with the hypothesis according to which there is stronger probability for larger businesses to undertake this type of investments compared to their smaller counterparts. Within the EU, Central European businesses tend to allocate a higher proportion of investment to energy efficiency in line with previous observations. In 2022, we observe a notable increase in the average proportion of investment allocated to energy efficiency among Southern European businesses, reaching 24.4%. This figure significantly surpasses the 19.4% allocated by firms in Western and Northern Europe, whereas businesses in these two macro-regions had remained mostly at the same level of investment in previous years.

Figure 3 – Proportion of total investment allocated to energy efficiency, excluding businesses that do not invest in energy efficiency.

Expressed as the average percentage of total investment at the firm level.



Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) in the left panel and across EU macro-regions, including Western and Northern Europe (WNE), Central and Eastern Europe (CEE) and Southern Europe (SE) in the right panel. Displayed values are in percentages. Total observations from the EU amount to 17 235 in the EU and 1 216 in the US.
Source: EIBIS (2023).

Table 3 –Businesses investing in energy efficiency by size (2018-2022)

Firm characteristics	EU		US	
	Sub-sample	Full sample	Sub-sample	Full sample
SMEs	75%	84%	76%	84%
Large businesses	25%	16%	24%	16%
Total observations	17 235	41 016	1 216	3 280

Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US).
Source: EIBIS (2023)

Descriptive statistics: businesses characteristics of businesses investing in energy efficiency

Building upon this preliminary exploration of the data and as previously advanced, this study will focus on the analysis of the probability of the binary outcome of investing in energy efficiency. As shown in **Table 2** above, the number of businesses investing in this field is surpassed by those that have not during the analysed period.

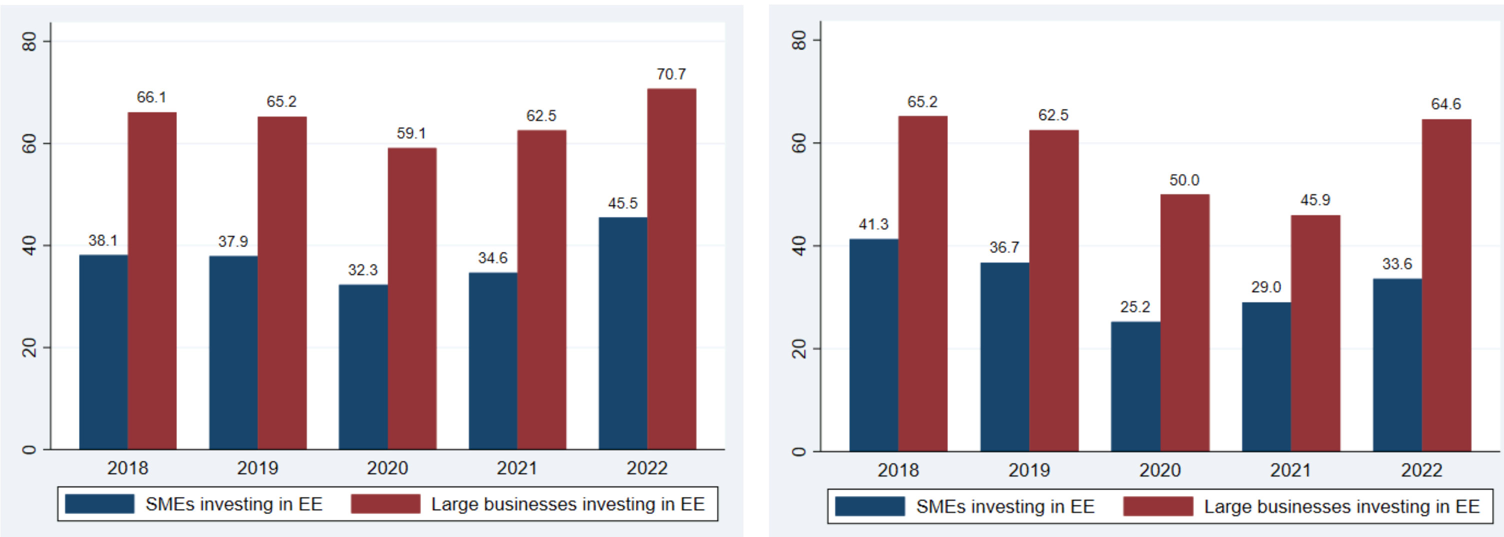
Size

Taking a closer look at the proportion of businesses investing in energy efficiency by size (**Figure 4**), we notice that in fact, a majority of large businesses invest in energy efficiency in the EU and the US, with respectively 64.5% and 57.6% of large businesses investing in energy efficiency on average between 2018 and 2022 and SMEs considerably lagging behind at 37.7% and 33.2%. Furthermore, in the US, the gap between large businesses and SMEs was larger in 2022 than it was at the beginning of the analysed period, with SMEs being less numerous to invest in 2022 than they were in 2018. In 2020, the share of SMEs investing in energy efficiency decreased by 11.5 percentage points with respect to 2019 in the US, from 36.7% to 25.2% and that of large businesses by 12.5. In the EU on the other hand, the decline in investment by large businesses and SMEs in 2020 was of about 6 percentage points for large businesses and SMEs alike. Finally, in 2022, the increase in the share of businesses investing in energy efficiency was significantly more pronounced among large businesses than SMEs in the United States, rising by nearly 19 percentage points compared to just 4.6 percentage points for SMEs. In contrast, within the EU, the growth was slightly more substantial among SMEs.

Figure 4 – Businesses investing in energy efficiency by size across the EU and the US

Expressed as percentage of businesses investing in energy efficiency by size category.

European Union United States



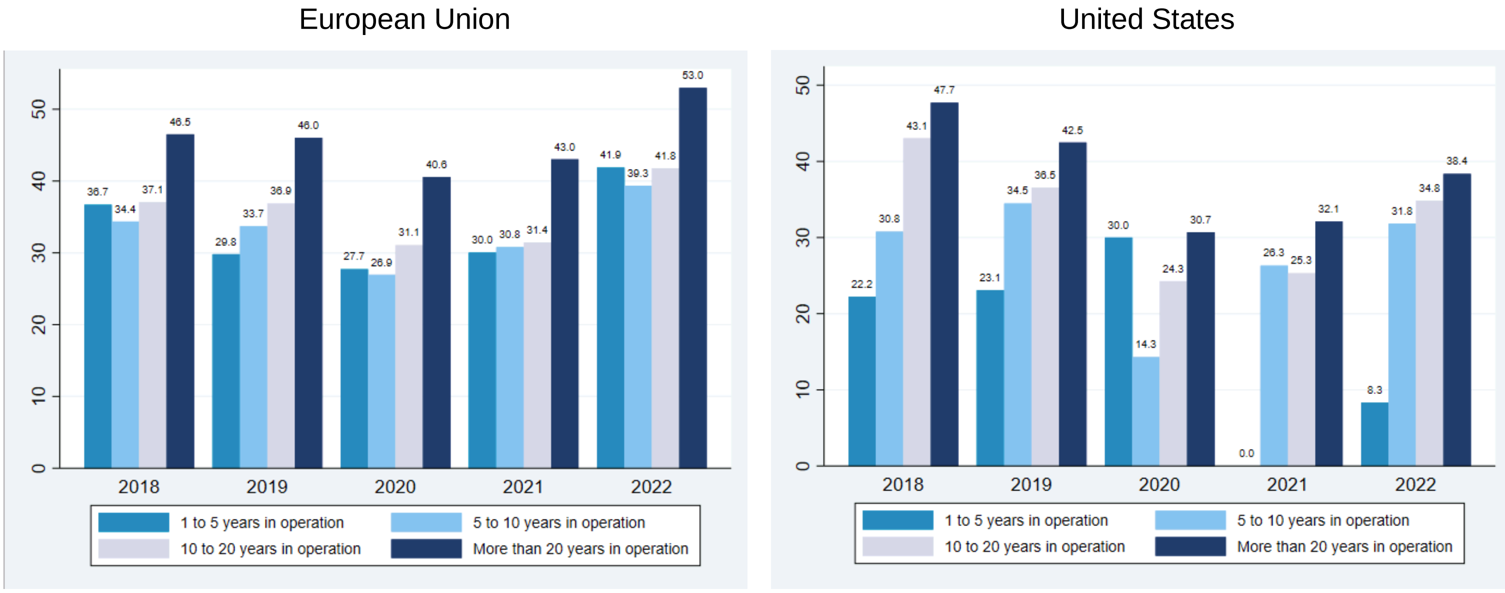
Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) by size category. Total observations from the EU amount to 41 016 in the EU and 3 280 in the US.
Source: EIBIS (2023).

Age

Older businesses are generally more numerous to invest in energy efficiency across the analysed period in the EU and the US. As can be seen in **Figure 5** below, more than half of the businesses that have been more than 20 years in operation invested in energy efficiency in 2022 in the European Union against 38.4% in the United States. The gaps between these businesses and the rest are larger in the EU where businesses in the first three age brackets generally present more similar levels of investments. However, the gap between the youngest age bracket (under 5 years in operation) and oldest age bracket (more than 20 years in operation) is starkest in the United States, where there seems to be more of a linear trend. The proportion of businesses investing in energy efficiency increases with each age bracket with the exception of 2020, where young businesses that had been less than 5 years in operation at the time surpassed businesses that had been between 5 and 10 years in operation. It is also noteworthy that none of the sampled businesses under 5 years in operation invested in energy efficiency in 2021 in the United States.

Figure 5 – SMEs investing in energy efficiency by age in the EU and the US.

Expressed as percentage of businesses investing in energy efficiency by age bracket.



Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) by age bracket. Total observations from the EU amount to 41 009 in the EU and 3 279 in the US.

Source: EIBIS (2023)

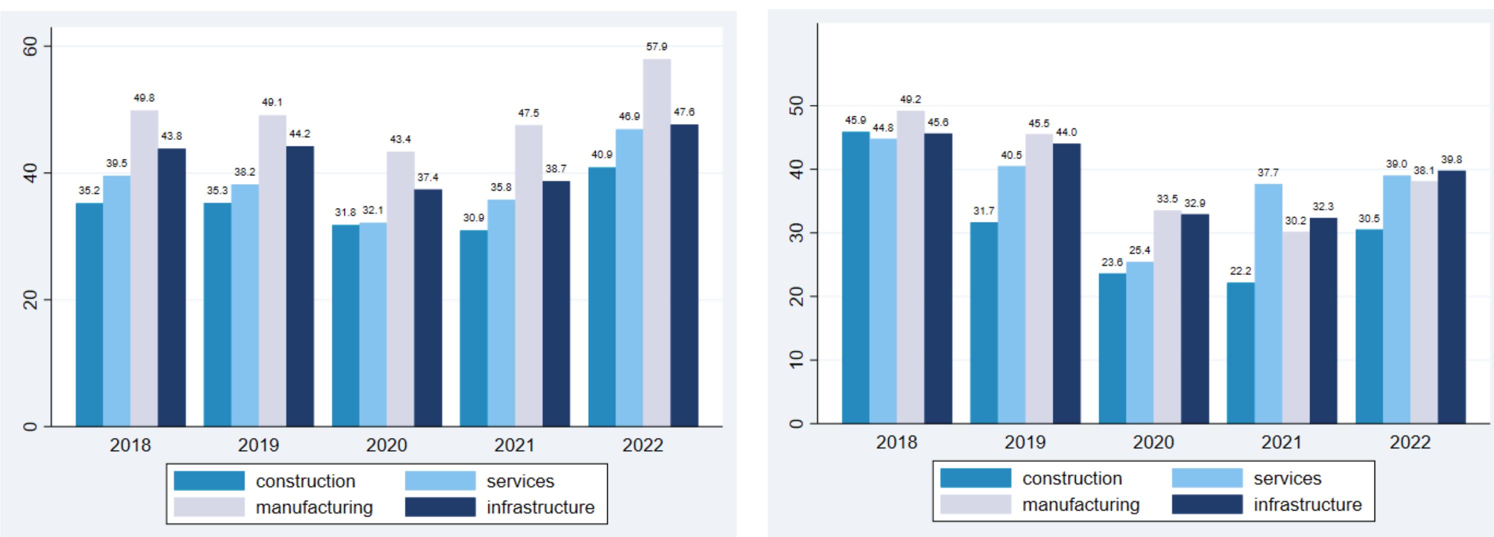
Sector

Businesses operating in the manufacturing and infrastructure are the most numerous to invest in energy efficiency. In the EU, manufacturing firms are noticeably more to invest in energy efficiency than businesses in other sector categories throughout the analysed period, followed by businesses operating in the infrastructure sector as can be seen in **Figure 6** below. This aligns with findings from previous analyses of the EIBIS data (Kalantzis and Nakaris, 2020) and supports the hypothesis that businesses in energy-intensive sectors have a stronger incentive to invest in energy efficiency, as the potential savings are particularly compelling when energy costs are higher. In the United States, the proportion of businesses in the infrastructure and manufacturing sectors investing in energy efficiency is almost levelled. Businesses in the construction and services sectors are comparatively less numerous to invest in energy efficiency in the EU and the US, with firms in services staying slightly ahead firms in construction. Businesses in construction lag further behind firms in services in the US in 2021 and 2022. In fact, we can see that while businesses in the service sector where the most numerous to stop investing in energy efficiency in 2020, probably as a result of lockdown measures which resulted in the closing of non-essential businesses or scaled-down operations, the service sector was also the one to “bounce-back” faster in 2021 with 37.7% of businesses in the service sector investing in energy efficiency, ahead of the share of businesses investing in this field in the manufacturing and infrastructure sectors that same year. The drop in the proportion of businesses investing in energy efficiency in 2020 is considerably more pronounced in the US than in the EU and while investment in all sectors in 2022 is above pre-pandemic levels in the EU, this isn’t the case for the US where the proportion of businesses investing in energy efficiency across all sectors remains below 40%.

Figure 6 – Businesses investing in energy efficiency by sector in the EU and the US

Expressed as percentage of businesses investing in energy efficiency by sector category.

European Union | United States



Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) by sector category. Total observations from the EU amount to 40 996 in the EU and 3 280 in the US.
Source: EIBIS (2023).

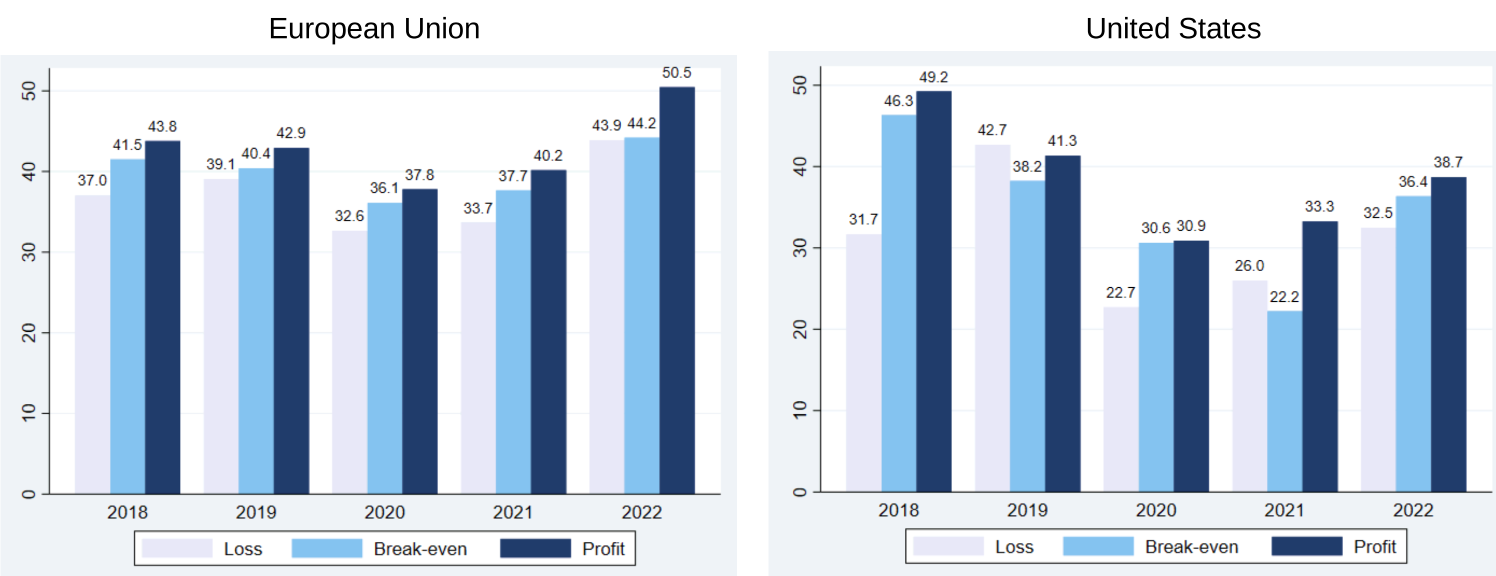
<u>Descriptive statistics: financial characteristics of businesses investing in energy efficiency.</u>

Profitability

In line with expectations, profitable businesses invest more in energy efficiency than businesses that break-even or incur losses across the EU and the United States. However, and contrary to what could be expected, the share of businesses incurring losses investing in energy efficiency isn't that far behind the share of profitable businesses investing in this field as can be seen in **Figure 7** below. This is with the exception of US businesses in 2018, where the gap between profitable businesses and businesses at loss is considerably wide at 17.5 percentage points. When looking at the breakdown of the businesses displayed in **Figure 7** by size (**Table 4**), we notice that profitable businesses are most represented among SMEs and Large businesses alike, with a lower share of US SMEs that are profitable at 69.19%, 10 percentage points below the share of profitable SMEs in the EU and about 14 percentage points below the share of Large businesses that are profitable in the United States. The gap between profitable SMEs and Large businesses is not as important in the EU, where it differs only by 3 percentage points.

Figure 7 – Businesses investing in energy efficiency by profitability across the EU and the US

Expressed as percentage of businesses investing in energy efficiency by profitability category.



Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) by sector category. Total observations from the EU amount to 40 456 in the EU and 3 189 in the US.
Source: EIBIS (2023).

Table 4 – Profitability of EU and US firms by size (2018-2022)

Profitability	EU		US		Total
	SMEs	Large businesses	SMEs	Large businesses	
Loss	11.50%	13.11%	13.78%	8.54%	5 304
Break-even	9.04%	5.03%	17.03%	8.13%	3 998
Profit	79.46%	81.85%	69.19%	83.33%	35 450
Total (observations)	34 825	6 634	2 801	492	44 752

Note: Summary statistics reflect the percentage of businesses in each profitability category by size across the European Union (EU) and the United States (US) by sector category. Businesses that didn't know or refused to answer the question about the proportion of investment allocated to energy efficiency are excluded from the statistics reflected in this table.

Source: EIBIS (2023).

Total Fixed Assets

As can be seen in **Table 5** below, businesses in manufacturing have larger total fixed assets, both in the US and the EU, followed by businesses in the construction sector, then services, then infrastructure. Total fixed assets can favour higher investments in energy efficiency by businesses, as they can increase the value of assets like buildings and utilities. In the case of manufacturing businesses, the IEA suggests that investments in equipment and facilities can lead to enhanced capacity and productivity, in addition to improving energy efficiency (IEA, 2019b).

Table 5 – Mean value of total fixed assets across in the EU and the US.

Sector	EU (EUR)	US (EUR)	Total (Count of businesses)
construction	24 173 334	48 758 564	8 731
services	22 231 132	47 748 264	10 016
manufacturing	38 798 665	82 420 819	12 658

infrastructure	10 230 647.8	3 916 978.8	9 765
Total (Count of businesses)	38 267	2 093	41 170

Note: Summary statistics reflect the mean value of total fixed assets by sector across the European Union (EU) and the United States (US) by sector category. Businesses that didn't know or refused to answer the question about the proportion of investment allocated to energy efficiency are excluded from the statistics reflected in this table.
Source: EIBIS (2023).

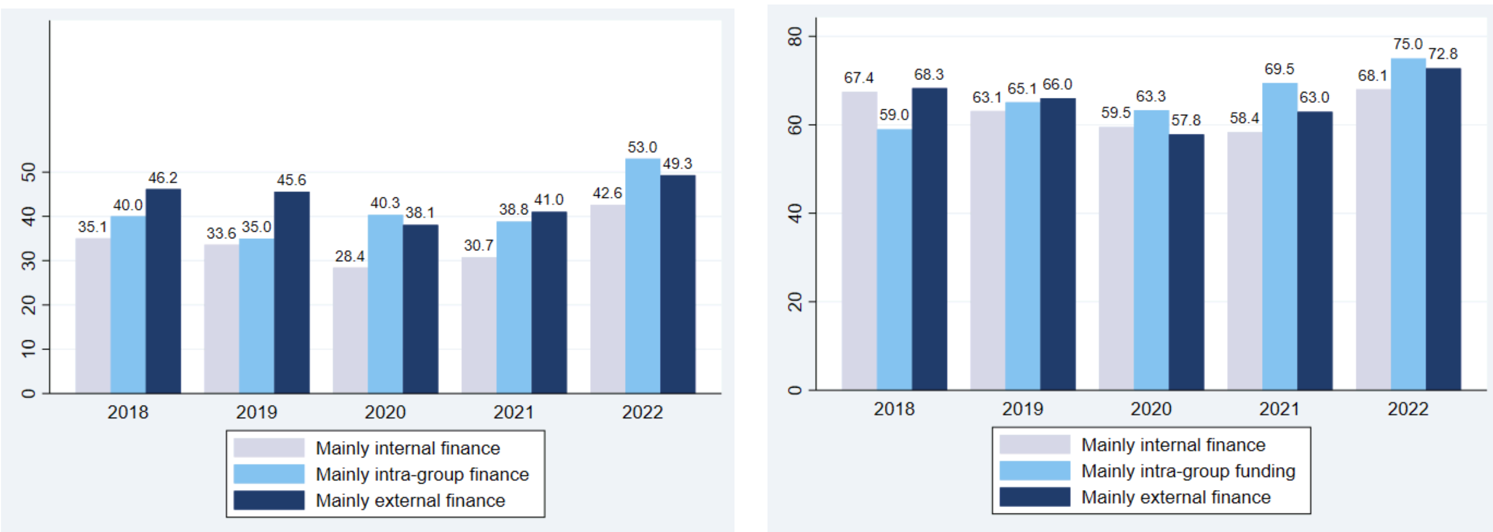
Type finance

SMEs that rely mainly on internal finance are less numerous to invest in energy efficiency compared to businesses relying on other types of funding. We observe that SMEs that rely mainly on intra-group funding and external finance are more numerous to invest in energy efficiency than businesses relying on internal finance (**Figure 8)**. While a majority of both large businesses and SMEs rely mainly on internal funds to finance their investments in the overall sample, we find that this is slightly more the case for SMEs in both regions with respectively 70% and 79% of EU and US SMEs relying mostly on internal funds for their investments against 63% and 73% of EU and US large businesses. This aligns with findings advanced in the literature review, suggesting SMEs tend to rely more on internal funds (Fazzari et al., 1988; N. Berger and F. Udell, 1998).

Figure 8 – Businesses investing in energy efficiency by main type of finance employed to finance investments.

Expressed as percentage of businesses investing in energy efficiency by category of main type of finance used to finance investments.

SMEs Large businesses



Note: Summary statistics reflect average values across all observations in the database in the European Union (EU) and the United States (US) by category of main type of funding used to finance investments and distinguishing between SMEs and Large businesses. Total observations from amount to 31 167 in the case of SMEs and 3 282 in the case of large businesses.

Source: EIBIS (2023).

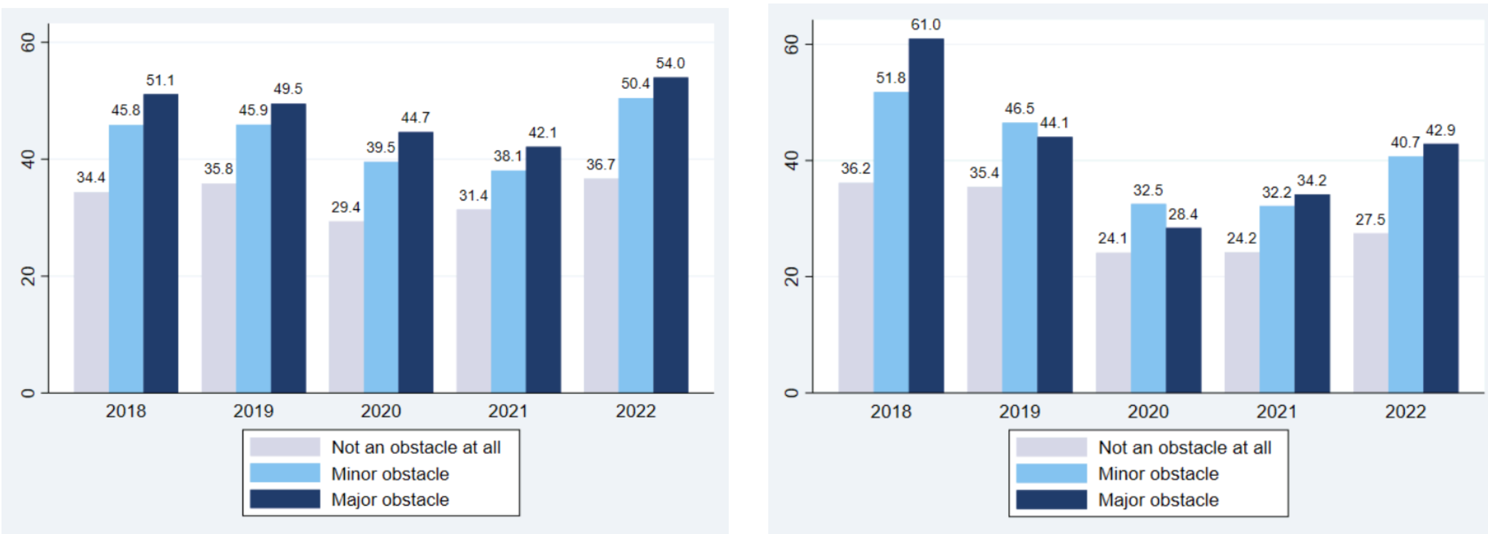
Energy costs as an obstacle to investment

Finally, and as shown in **Figure 9** below, businesses that view energy costs as a major barrier to investment are the most numerous to invest in energy efficiency. This is the case both across the EU and in the United States, except for in 2019, where US businesses that considered energy costs to be a minor barrier invested more in energy efficiency than businesses that considered them to be a major obstacle. This is again in line with expectations as improvements in energy efficiency can substantially bring down energy costs. Taking a closer look at the sector composition of these businesses, we note that in the EU, businesses in manufacturing are the most numerous to indicate that energy costs are a major barrier to investment, with 40.26% indicating this was the case between 2018 and 2020. In the US, businesses in infrastructure and construction were more burdened by this cost than businesses in manufacturing with respectively 23.05% and 20.53% of businesses reporting energy costs were a major obstacle to investment in the analysed period.

Figure 9 – *Businesses investing in energy efficiency by perception of energy costs as a barrier to investment.*

Expressed as a percentage of businesses investing in energy efficiency by the level of perception of energy costs as a barrier to investment.

European Union United States



Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) by sector category. Total observations from the EU amount to 40 811 in the EU and 3 270 in the US.
Source: EIBIS (2023).

<u>Descriptive statistics: digital uptake and organisational capabilities</u>

Strategic performance monitoring systems

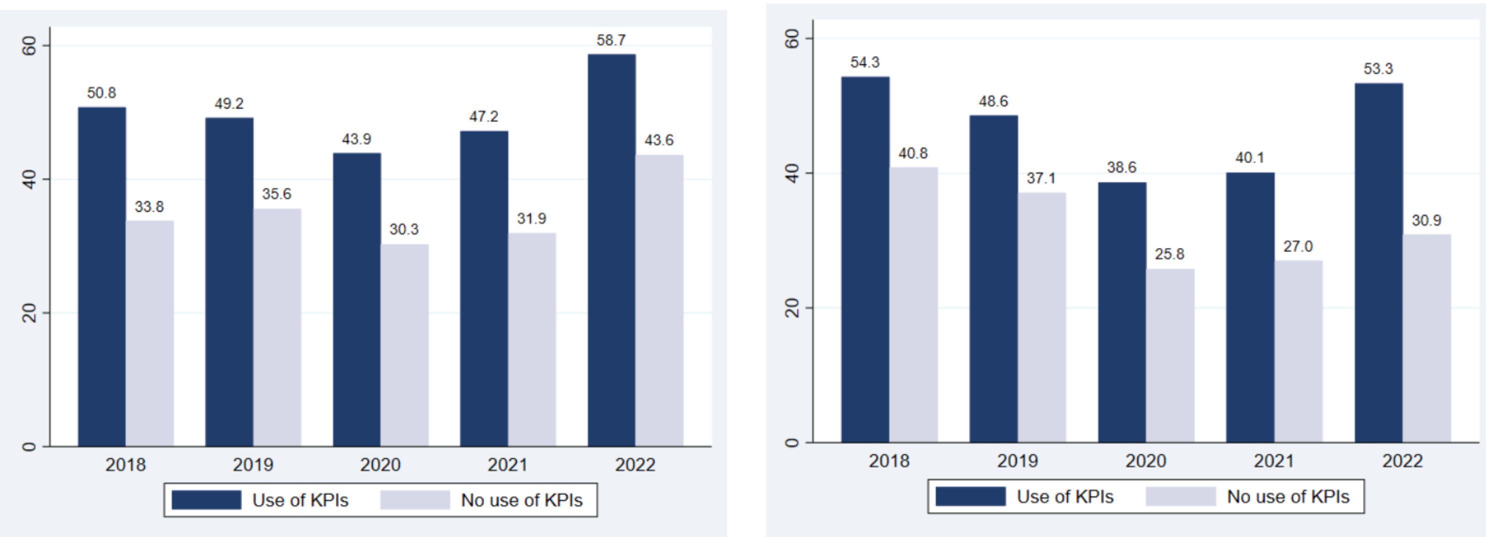
Businesses that track firm performance through strategic monitoring systems based on a set of Key Performance Indicators (KPIs) invest more in energy efficiency than those that do not as can be seen in **Figure 10** below. This is in line with expectations based on existing literature suggesting that businesses with stronger organisational capabilities are more resilient and are more likely to grow. The correlation between investments in energy efficiency and the use of strategic monitoring systems further points at the strategic character of energy efficiency investments. It is worth noting that in 2022 in the EU, the share of businesses investing in energy efficiency and employing strategic business monitoring systems significantly rose but so did that of businesses that did not use them, suggesting that the energy crisis served as a trigger and that the rise in energy costs revealed the strategic character of energy efficiency investments.

Figure 10 – Businesses investing in energy efficiency by strategic monitoring practices.

Expressed as percentage of businesses investing in energy efficiency by implementation of strategic monitoring practices

European Union

United States



Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) by perceived difficulty to invest due to high energy costs. Total observations from the EU amount to 40 371 in the EU and 3 228 in the US.

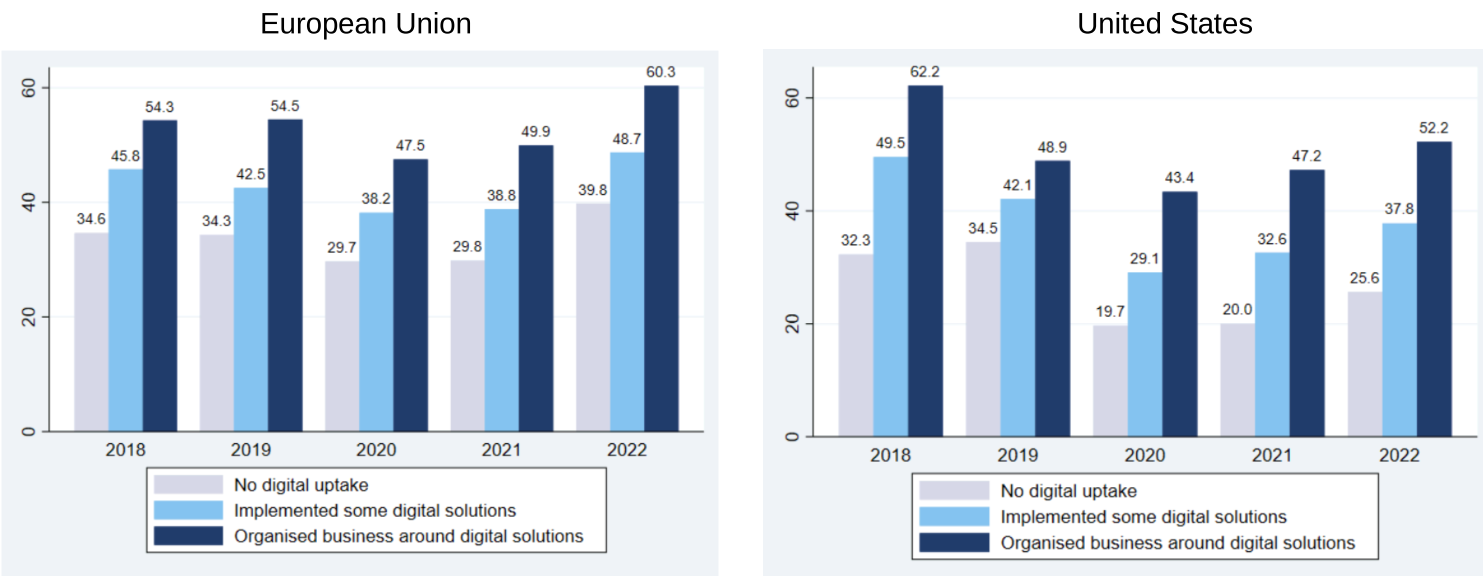
Source: EIBIS (2023)

Digital uptake

Businesses with a higher level of digital uptake invest more in energy efficiency than businesses that do not implement any digital solution. As can be seen in **Figure 11** below, 60.3% of firms that organise their operations around digital solutions in the EU and 52.2% in the US invested in energy efficiency in 2022, against respectively 39.8% and 25.6% of businesses that do not use digital solutions. This is in line with recent literature on the energy efficiency potential of digital solutions and the large share of SMEs investing in energy efficiency that monitor firm performance as shown in **Figure 10.** This is because there are a number of digital solutions that allow businesses to get a better sense of their energy consumption and optimise their energy use. For example, the use of smart metering and other sensor-based technologies enable the automated regulation of energy-consuming devices to optimise energy use (IEA, 2019b).

Figure 11 – Businesses investing in energy efficiency by level of digital uptake

Expressed as percentage of businesses investing in energy efficiency by level of digital uptake



Note: Summary statistics reflect average values across all observations in the database across the European Union (EU) and the United States (US) by level of digital uptake. Total observations from the EU amount to 40 864 in the EU and 3 245 in the US.
Source: EIBIS (2023).

Model Specification: determinants of investing in energy efficiency (2018-2022)

Model 1 – Analysing the determinants of investing in energy efficiency: random effects logit regression with Mundlak terms.

To identify the determinants of firm level investment in energy efficiency and to exploit the longitudinal component of the EIBIS database, this study employs a random effects logit regression with Mundlak terms, drawing on the methodology employed by Pouliakas and Wruuck (2022) in their analysis of determinants of investments in skills training using the EIBIS database. The objective is to estimate the probability of the binary outcome associated with investing in energy efficiency as a function of the above-described independent variables. Year dummies are incorporated to account for time-fixed effects, and the Mundlak terms (averages of time-varying covariates) are introduced to accommodate unobserved heterogeneity that may be correlated with the explanatory variables (Longhi and Nandi, 2015).

The underpinning methodology for this model was initially developed by Mundlak (1978), who demonstrated that incorporating entity-specific averages of time-varying covariates – Mundlak terms or Mundlak correction henceforth – in a random effects regression model is equivalent to conducting a one-way fixed effects regression model in the linear case (Mundlak, 1978).

Wooldridge (2010a, 2019) expanded on this approach, also referred to as Correlated Random Effects (CRE), to accommodate unbalanced panels. This extension requires the inclusion of time dummies and their averages, considering entities are observed in different numbers of time periods. This methodology is also applicable to the two-way fixed effects model through pooled OLS or random effects models incorporating Mundlak terms, as demonstrated by Wooldridge (2021). The Mundlak approach, may also be adapted to the non-linear case, including binary choice models like logit and probit (Wooldridge, 2010a, 2021).

Compared to the random effects or fixed-effects logit regression[19], the CRE or Mundlak approach allows for more flexibility in the model specification, relaxing the assumption in the random effects model that unobserved individual effects are uncorrelated with the independent variables (Mundlak, 1978) as the Mundlak terms capture the average impact of time varying entity-specific characteristics that might be correlated with covariates – thus mitigating endogeneity concerns – and allowing for the introduction of time invariant covariates which would be dropped from the analysis in the case of a fixed effects regression (Longhi and Nandi, 2015). The methodological choice of the Mundlak effects model is therefore further justified as we are interested in analysing the explanatory power of several variables with limited or absent within variation, including firm characteristics. Pouliakas and Wruuck (2022) also justify in this way their choice of the Mundlak model to analyse the determinants of firm level investments in training using EIBIS data.

The use of lagged values of the RISE energy efficiency policy scores aligns with established literature (Choi and Anadón, 2014; Galeazzi et al., 2023; Goldschlag and Tabarrok, 2018; Joskow and Rose, 1989) investigating the impact of policies on economic outcomes, accounting for the time it takes for policy changes to influence investment decisions. In particular Galeazzi et al. (2023) examine the effects of RISE Renewable Energy Policy Scores on GHG emissions using lags of 3, 5, and 7 years. Assuming a quicker manifestation of the impact of energy efficiency policies on the dependent variable (whether firms invest in energy efficiency or not), then on GHG emissions, we opt for 1-year and 2-year lags closer to the time-lags

[19] In line with the terminology adopted in the literature for social sciences, by fixed-effects panel logit model we refer to the conditional fixed effects logit model (Chamberlain, 1980).

implemented by Choi and Anadón (2014) analysing the impact of policy on the formation of networks for solar PV. The inclusion of different lags of the energy efficiency policy scores in the regressions further addresses potential endogeneity concerns, mitigating the risk of contemporaneous correlation between policy changes and some of the control variables including, for example, the main type of finance used to finance investments which could be influenced by the policy environment. Robust standard errors, clustered at the firm level, are applied to correct for heteroskedasticity.

Main independent variables of interest

Within the framework of this study and as previously explained, we are additionally interested in exploring the effect of a number of additional variables that have attracted less attention in the literature. These include digital uptake within the business the organisational capabilities of the firm, the extent to which they perceive energy costs as an obstacle to investment and the type of finance they are mainly reliant on to finance their investment activities.

The synergies between the digital and green transitions, particularly in the field of energy efficiency, have come under a lot of scrutiny in the literature in recent years. However, the analysis of firm-level dynamics at the international level remains scarce (IEA, 2019b; OECD, 2021c, 2017).

Established literature suggests that strategic planning and organisational skills positively impact the level of investment, including in energy efficiency (Agrawal et al., 2023; EIB, 2021; Kalantzis and Revoltella, 2019) and we are interested in analysing recent trends in how these determinants influence energy efficiency investments.

In line with existing literature suggesting that energy costs are an important driver of energy efficiency investments, we are interested in exploring the impact of firm's perception of energy costs as an obstacle to investment. While the survey question is about perception and not actual cost, investment decisions are likely to be influenced by these perceptions (Allcott, 2011).

Finally, we aim to analyse how the main source of finance firms rely in for their investment activities influence their decision to invest in energy efficiency. Literature findings suggest a strong reliance of SMEs on internal funds due to barriers to accessing external finance, which we expect to constrain energy efficiency investment.

A description of these independent variables and additional controls may be found in **Table 6**. The use of macro-region dummies (categorical variable with the US as base category and EU macro-regions as remaining categories: Western and Northern Europe, Central and Eastern Europe and Southern Europe) was preferred to country dummies due to their high level of multicollinearity with the main independent variables of interest: the RISE country-level scores. The use of EU macro-region dummies allows us to overcome this issue while capturing the effect of regional differences at an aggregated level. Summary statistics for all variables in the model may be found in

Table *24* and **Table 26**.

Model specification: determinants of investment in energy efficiency (2018-2022)

To assess the impact of the overall policy environment on the probability of investing in energy efficiency and conduct a more detailed analysis of how different policy components may affect it, we perform two versions of this model. The first only includes the country's overall policy score as an independent variable. The second includes the scores of the eleven sub-components making up the overall score, in an effort to understand in more detail the impact of each policy package (listed in **Table 1**) on the probability of investing in energy efficiency. In the second model, including the scores of the sub-policy packages, we interact the score of "Incentives and mandates for the Industrial and Commercial sectors" with the sector variable to understand how the effectiveness of incentives and mandates varies across different sectors.

The first model specification can thus be articulated as follows:

Equation 1 – Determinants of energy efficiency investments: overall energy efficiency score

$$log\left(\frac{p}{(1-p)}\right) = \alpha + \beta_1\ EE\ \ Score_{c\,t-1} + \ \ \beta_2 Z_{it} + \beta_3 \bar{Z}_i + \varepsilon_{\ it}$$

Equation 2 – Determinants of energy efficiency investments: policy sub-scores

$$log\left(\frac{p}{(1-p)}\right) = \alpha + \beta_1\ EE\ subscores_{c\,t-1} + \ \ \beta_2 EM\_IC_c \times Sector_i + \ \ \beta_3 Z_{it} + \beta_4 \bar{Z}_i + \varepsilon_{\ it}$$

Where:

- $log\left(\frac{p}{(1-p)}\right)$ is the natural logarithm of the odds of the event happening (firm investing in energy efficiency).
- p is the probability of the firm investing in energy efficiency.
- $EE\ Score_{c\,t-1}$ is the 1-year lag of the energy efficiency overall policy score in country *c.*
- $EE\ \ subscores_{c\,t-1}$ are the 1-year lags of the energy efficiency policy sub-scores in country *c.*

- $EM\_IC_c \times Sector_i$ is the interaction term between the "Incentives and Mandates for the Industrial and Commercial Sectors" Policy component in country *c* and the Sector categorical variable (see **Table *6***).

- Z_{it} is a vector of control variables including size, sector, age, region, financial indicators and year dummies (see **Table *6***).

- $\bar{Z}_i$ is the vector containing the mean of the independent variables (Mundlak terms) to correct for the potential correlation between the EE scores and the error term.

Table 6 – Description of independent variables and controls

Controls: firm characteristics	**Description**
SME	Binary: Large business with >250 employees (0), SME with <=250 employees (1)
Sector	Categorical: Construction, Services, Manufacturing, Infrastructure
Age (years in operation)	Categorical: under 5 years, 5 to 10 years, 10 to 20 years, more than 20 years
Region	Categorical: US, WNE, CEE, SE
Year	Year dummies

Controls: financial investment determinants	**Description**
Profit	Categorical: loss, break-even, profit

Log of total fixed assets	Continuous: includes tangible and intangible assets but excludes financial assets.
Main type of finance used for investment	Categorical: intra-group funding (for subsidiaries), internal funding, external funding
Energy costs as a barrier to investment	Categorical: not an obstacle at all, minor obstacle, major obstacle

Controls: firm practices	**Description**
Use of formal strategic monitoring system	Binary: No (0), Yes (1)
Uptake of digital solutions	Categorical: None (0), Yes, at least one advanced digital technology (1), Yes, multiple advanced digital technologies (3)

Model 2 – The impact of the energy crisis on firm investments in energy efficiency

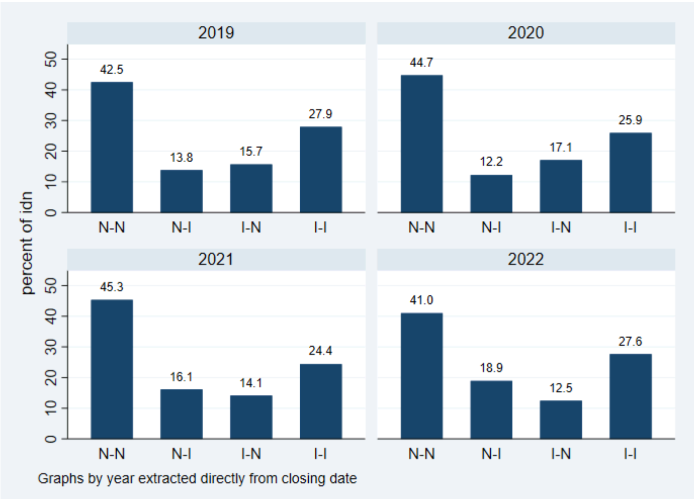
As depicted in **Figure 4** above, the share of businesses investing in energy efficiency significantly increased in 2022. In the EU, the share of businesses investing in energy efficiency increased by eleven percentage points in the case of SMEs – from 34.7% in 2021 to 45.7% in 2022 – and about eight percentage points in the case of large businesses – from 62.4% in 2021 to 70.3% in 2022. In the US, the uptake was larger in the case of large businesses, 66.3% of which invested in energy efficiency in 2022 compared to 45.2% in 2021 and against 29.6% of SMEs in 2021 and 33.8% in 2022. These trends are in line with expectations that the energy crisis pushed numerous businesses to prioritise energy savings. To explore this hypothesis and analyse the repercussions of the energy crisis on the decision to invest in energy efficiency, we start by analysing firm transitions into and out of investments in energy efficiency. This is in line with the methodological approach employed by Pouliakas and Wruuck (2022), who investigated the impact of the pandemic on firm-level investments in training.

The share of businesses that transitioned from no investment in energy efficiency the preceding year to investing in the current financial year is the highest in 2022 in the EU and the US. As can be seen in **Figure 12** below, the share of firms that transitioned from no investment to investing (N-I in the graphs below) is the highest in the observed period in 2022, both for the EU at 18.9% and the US at 15.7%. Conversely, in the EU, the share of businesses that discontinued investments in energy efficiency (I-N) is the lowest observed during the period, at 12.5%. In contrast, this figure was even lower in the US in 2021. In the EU, the share of businesses that renewed their energy efficiency investments in 2022 (I-I) reached the highest level since 2019. However, in the US, the proportion of businesses that renewed their energy efficiency investments was significantly higher in 2019, with 30.7% of US businesses maintaining their investments between 2018 and 2019. The sample of US firms is naturally more restricted, given that it represents a single country. To get a better understanding of the proportion of US firms transitioning in and out of investment, please refer to **Table 7**. However, the inclusion of the US serves as a benchmark to analyse dynamics across EU macro-regions, as was done in **Model 1**.

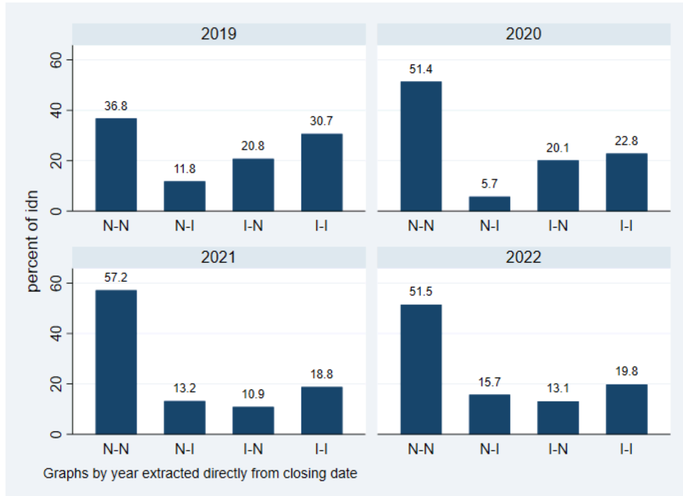
Figure 12. Year-on-year transitions in and out of energy efficiency investments by EU and US businesses.

Percentage of respondent businesses.

European Union



United States



Note: "N" stands for No investment in energy efficiency, and "I" stands for positive investment in energy efficiency. Specifically: No investment in the previous financial year – No investment in current financial year (N-N); No investment in the previous financial year – Investment in the current financial year (I-N); Investment in the previous financial year – No investment in the current financial year (I-N); Investment in the previous financial year – Investment in the current financial year (I-I).
Source: EIBIS (2023)

Table 7 – Businesses transitioning in and out of investments in energy efficiency between 2021 and 2022.

Count of businesses.

	EU		US		Total
	Did not invest in 2022	Invested in 2022	Did not invest in 2022	Invested in 2022	
Did not invest in 2021	1 281	591	177	54	2 103
Invested in 2021	389	863	45	68	1 365
Total	1 670	1 454	222	122	3 468

Source: EIBIS (2023).

<u>Model Specification: determinants of starting to invest in energy efficiency in 2022.</u>

The trends observed in **Figure 12** confirm there is a case to analyse the determinants of firms transitioning from zero to positive investment in energy efficiency in 2022, particularly in the case of EU countries. In their paper, Pouliakas and Wruuck employ a multivariate probit regression model with a dependent variable taking on a value of 1 when a firm that did not invest in employee training in 2019 but did in 2020. Following a similar analytical approach, this study employs a logit model using a dependent variable which assumes a value of 1 when a firm that did not invest in energy efficiency in 2021 starts investing in energy efficiency in 2022. As in the preceding model, controls include size, age, sector and region dummies (see **Table 6**). Additionally, the 2023 wave of the EIBIS survey introduced questions pertaining to the energy crisis which encompassed total spending on energy, concerns regarding the energy shock, implemented strategies, whether the firm invested in a sustainability area in 2021, including energy efficiency, or whether they had carried out an energy efficiency audit in the previous 3 years – all of which are integrated into this model. Robust standard error clustered at the firm level are also included in this model. A description of these additional independent variables can be found in **Table 8** and summary statistics in **Table 25**. This model is conducted using only the RISE overall score, without incorporating a specification that includes the policy sub-scores. This is because there was a high level of collinearity between the policy sub-scores and other predictors which would have significantly undermined the validity of the model.

The model specification can be articulated as follows:

Equation 3 – Crisis model with energy efficiency overall Score

$$log\left(\frac{p}{(1-p)}\right) = \alpha + \beta_1\ EE\ \ Score_{c\,t-1} + \ \beta_2 SE_i + \beta_3 C_i + \ S_i + \ \beta_4 Sust\ inv_{i\,t-1} + \ \beta_5 EA_{i\,t-3} + \beta_6 Z_i + \varepsilon\ _i$$

Where:

- $log\left(\frac{p}{(1-p)}\right)$ is the natural logarithm of the odds of the event happening (firm investing in energy efficiency).

- p is the probability of the firm investing in energy efficiency.

- $EE\ Score_{ic\,t-1}$ is the 1-year lag of the overall energy efficiency policy score in country *c.*

- SE_i is the log of total spending in energy.

- C_i is a binary variable taking on the value 1 if the firm reports being **concerned** about the energy shock.

- S_i is a binary variable taking on the value 1 if the firm has a **strategy** to face the energy shock in the case of the second variable.

- $Sust\ inv_{t-1}$ is a lagged variable indicating whether the firm already invested a sustainability area (waste management, sustainable transport, renewable energy, investing in less polluting areas).

- $EA_{i\ t-3}$ is a dummy variable taking on the value 1 if the firm reports having undergone an energy audit in the last 3 years.

- Z_i is a vector of control variables including size, sector, age, region and year dummies (see **Table *6***).

Table 8 – Description of independent variables introduced in Model 2

Variables	**Description**
Investment in a sustainability area in 2021	Binary: No (0), Yes (1)
Energy audit in the past 3 years	Binary: No (0), Yes (1)
Any concern about the energy crisis	Binary: No (0), Yes (1)
Any strategy for the energy crisis	Binary: No (0), Yes (1)
Log of Total Spending in energy	Continuous: log transformed value of total spending in energy

<u>Descriptive statistics: independent variables related to the energy crisis.</u>

Investment in a sustainability area in 2021

In the EU, manufacturing businesses were the most likely to report investments across all considered sustainability areas in 2021, with the exception of sustainable transport. As expected, businesses in the infrastructure sectors were the most likely to invest in sustainable transport (**Figure 23** in ANNEX 1). We further observe that large businesses indicate more often that they did invest in these areas than SMEs. In the US, identifying a clear pattern is less straightforward, as can be seen in

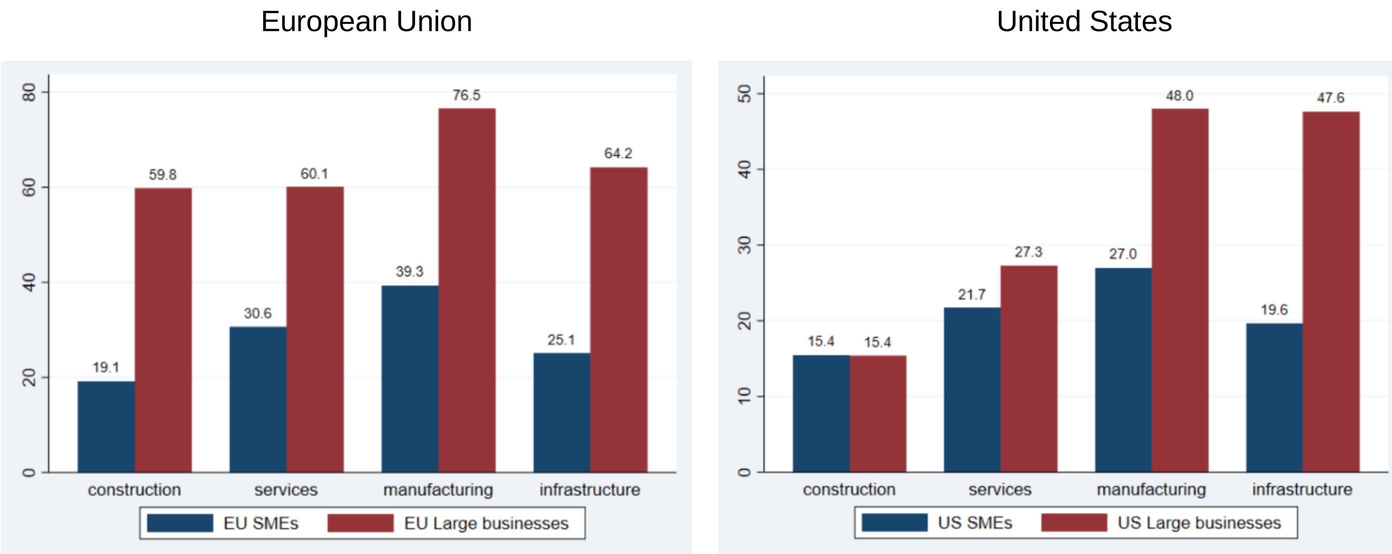
Figure 24 in ANNEX 1, with more variance across sectors and business sizes. For instance, businesses in the infrastructure sector were the most likely to indicate they invested in less polluting areas and sustainable transport, but manufacturing businesses invested more in energy efficiency and renewable energy. As for waste management, large businesses in construction were the most numerous to invest in this area while SMEs in the same sector were the least likely to invest. This greater variance is likely due to the limited number of observations compared to the EU. Nevertheless, it does give a sense of differences in sustainable investment practices between EU countries and the US. We notice, for instance, that there are more noticeable differences between SMEs and large businesses in the US than in the EU, with large businesses and SMEs almost equally likely to invest in energy efficiency in 2021, for example.

Energy audit in the last 3 years

In line with expectations due to EU regulations, large businesses are generally more than twice as likely to report having undergone an energy audit in the past three years. Businesses in the EU are more likely to report having conducted an energy audit in the past three years than US businesses but in both countries, large businesses are more likely to have conducted an energy audit than SMEs – except for US construction SMEs and large businesses, equally likely to have undergone an energy audit. As shown in **Figure 13** below, businesses in manufacturing were the most likely to answer positively to this question, followed by businesses in infrastructure. It is interesting to note, however, that the gap between large businesses and SMEs is particularly large in this sector, with SMEs in services and manufacturing being more likely to report having undergone an energy audit in the past 3 years than SMEs in infrastructure. Beyond the legal obligations biding large companies to undergo energy audits every four years in the EU, it must also be noted that the share of SMEs operating across different sectors varies, and that, for instance, SMEs are more present in the service sector than in the infrastructure sector.

Figure 13 – Percentage of businesses reporting they had undergone an energy audit in the last 3 years in 2023.

Percentages are expressed by business size and sector in the EU and the US



Note: Total number of EU respondent businesses is 9 622 and total number of US respondent businesses is 759.
Source: EIBIS (2023)

Concerns and strategies for the energy crisis

Over 90% of businesses in the EU reported being concerned about the energy crisis in 2023 and having implemented a strategy to address it. In the US, 87% of businesses reported being concerned about the energy crisis and 84% indicated they had implemented a strategy in response. Firms that were concerned were also more likely to implement a strategy, with respectively 94% and 87% of concerned EU and US firms indicating they had implemented a strategy as a response to the energy crisis compared to 65% and 52% on non-concerned businesses. Possible concerns that firms were able to report included energy prices, energy availability, energy regulatory frameworks and stricter climate standards or uncertainty about any of these aspects. In the regression specification, we include a composite variable equal to 1 if the businesses reported being concerned about at least one of the above, but in **Table 9** below, we can see in more detail which of these burdened EU and US firms the most. Contrary to what could be expected based on the elevated share of businesses that indicated that energy costs were a major obstacle to investment in 2022 – particularly in the EU with 79.44% of businesses indicating energy costs were either a minor or a major obstacle to investment compared to 71.65% of US businesses – energy prices was the least selected concern among EU and US businesses. Energy regulations and stricter climate standards, on the other hand, were the most likely to be reported as major concerns by businesses across the EU and in the US. In the EU, stricter energy or climate regulations and uncertainty were considered to be a minor or a major concern related to the energy shock by respectively 72.2% and 85.2% businesses (**Table 9**).

Table 9 - Perception of obstacles related to the energy crisis in the EU and the US

Region	EU			US		
Perception of obstacle	Not an obstacle	A minor obstacle	A major obstacle	Not an obstacle	A minor obstacle	A major obstacle
Energy prices	88.8%	4.4%	6.8%	83.2%	9.2%	7.6%
Energy availability	37.3%	39.3%	23.1%	44%	39.3%	16.7%
Energy regulations and stricter climate standards	27.8%	41.3%	30.9%	36.7%	36.2%	27.1%
Uncertainty about any of the above	14.7%	43.7%	41.5%	25%	45.2%	29.9%

Note: Percentages are calculated per level of perceived difficulty across respondent EU businesses and respondent US businesses. The total number of respondent EU businesses is 9 629 and the total number of respondent US businesses is 759.
Source: EIBIS (2023)

Strategies implemented in the face of the energy crisis by respondent businesses differ across EU and US businesses. The survey explored five different strategies in reaction to the energy crisis. In the regression specification, we only include a composite variable indicating whether the firm implemented any of these strategies, but in **Table 10** we can see a more detailed breakdown of the share of businesses that adopted each strategy. As can be seen, while US businesses were slightly more likely to pass rising energy costs onto consumers or reduce production of certain goods and services compared to EU businesses, the latter were significantly more likely to adjust their energy mix in response to the crisis or renegotiate their energy supply contracts. These results align with the distinct nature of the energy shock experienced in the EU and the US (OECD, 2023a).

Table 10 - Strategies implemented by businesses in reaction to the energy crisis.

Region	EU	US
Focusing on energy savings	69%	51.9%
Changing the company energy mix	42.7%	19%
Renegotiating the energy supply contract	57.5%	30%
Passing the rising energy costs to consumers	56.9%	58%
Stopping or reducing the production of certain goods and services	25.1%	27.3%

Note: Percentages are calculated per level of perceived difficulty across respondent EU businesses and respondent US businesses. The total number of respondent EU businesses is 9 614 and the total number of respondent US businesses is 757.
Source: EIBIS (2023)

Total spending in energy

Mean total spending on energy in 2022 was the highest for EU large businesses in construction. We will be using the log of total spending on energy in the regression specification, however, in

Table *11* below, a more detailed breakdown of reported total spending in energy can be appreciated across business sectors and sizes in the EU and the US. Standing at EUR 17 000 000, mean spending on energy was the highest for large businesses in construction, followed by large businesses in infrastructure at EUR 11 200 000. In the US, large businesses in infrastructure had the highest average spending on energy at EUR 9 186 739. Spending by businesses of all sizes is considerably higher in the EU than in the US. In the case of SMEs, this difference is the starkest in the manufacturing sector, with EU SMEs spending twice as much as US SMEs on average. It must be noted that the number of US businesses observed is well below that of EU businesses. Nevertheless, these results are in line with expectations, given that the energy crisis affected EU businesses more due to their stronger reliance on Russian gas (OECD, 2023a).

In fact, this is broadly in line with EU and US firm's reported perception of energy costs as a barrier to investment, as can be seen in **Figure 14** below. While a majority of businesses in the EU and the US consider energy costs to be an obstacle to investment, businesses in the US were more likely to report energy costs were a minor obstacle contrary to EU businesses, more likely to report it as a major obstacle. A sectoral breakdown reveals that SMEs in the services sector were the second most likely to report energy costs as a major barrier to investment, following businesses in manufacturing. Overall, SMEs in the services sector were more likely to cite energy costs as a barrier compared to those operating in the infrastructure sector (**Figure 15**). This remains true of EU large businesses with manufacturing firms taking the lead. Specifically, 58.2% of large manufacturers report energy costs as a major barrier, followed by businesses in the service sector with at 52.7%. This was however only the case for 42% of large businesses in construction, despite their considerably higher average spending in energy as displayed in **Table 11** and 48.1% of businesses in infrastructure. These results could indicate that the increase in energy costs was more strongly felt by businesses in services as they are less energy intensive and support mechanisms to shield businesses from rising energy costs in the EU were mainly targeted to energy-intensive businesses (OECD, 2023a). However, a more accurate analysis of the alignment of firm perceptions and actual energy costs would require collecting data on energy spending during multiple waves.

Table 11 – Total spending on energy by business size and sector in the EU and the US

	EU		US		
	SMEs	Large businesses	SMEs	Large businesses	Average
Services	187 568.8	2 892 927	295 841.1	1 987 296	1 340 908.2
Construction	192 349.2	17 000 000	150 710.5	2 342 208	4 921 316.9
Manufacturing	594 935.8	9 516 184	223 884.2	3 190 083	3 381 271.7
Infrastructure	721 671.8	11 200 000	887 976.3	9 186 739	5 499 096.8

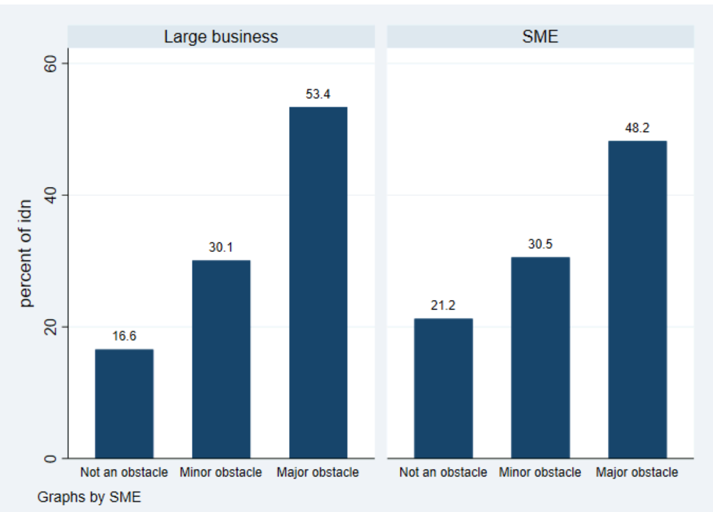
Average	424 131.4	40 609 111	382 103	3 379 060.7	

Note: Average values are calculated per sector and size across respondent EU businesses and respondent US businesses and refer to spending in 2022. The total number of respondent EU businesses is 9 622 and the total number of respondent US businesses is 759.
Source: EIBIS (2023)

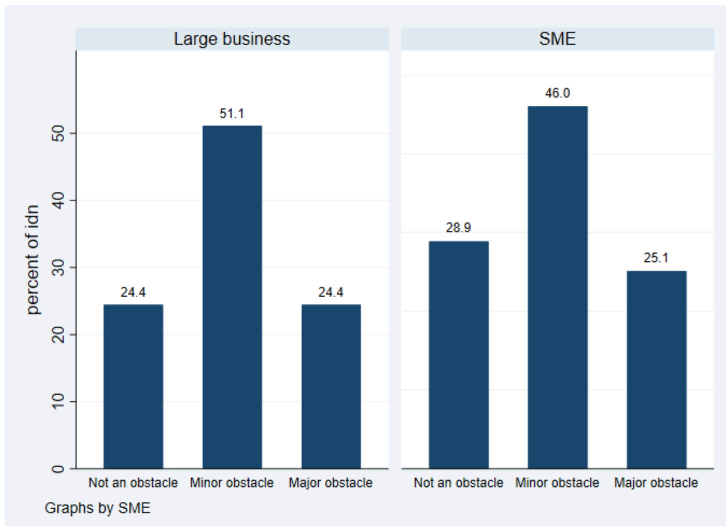
Figure 14 – Perception of energy costs as an obstacle to investment by size in the EU and the US

Expressed as percentage of businesses by perception of energy costs as an obstacle to investment and size

European Union



United States

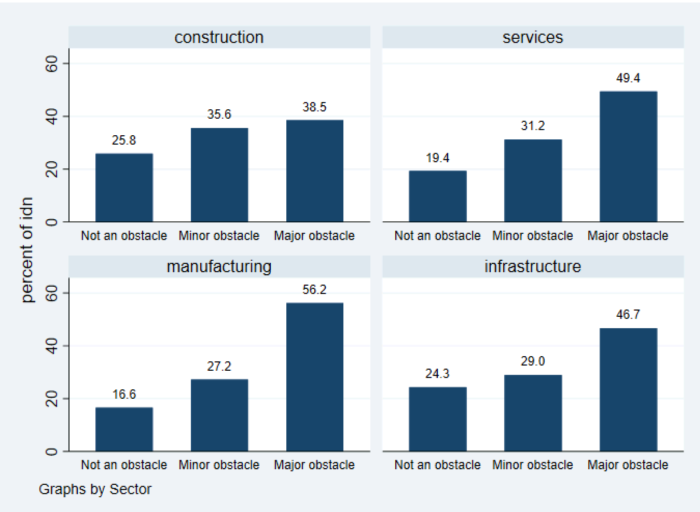


Note: Summary statistics reflect the percentage of EU and US businesses that indicated this was a barrier to investment
Source: EIBIS (2023)

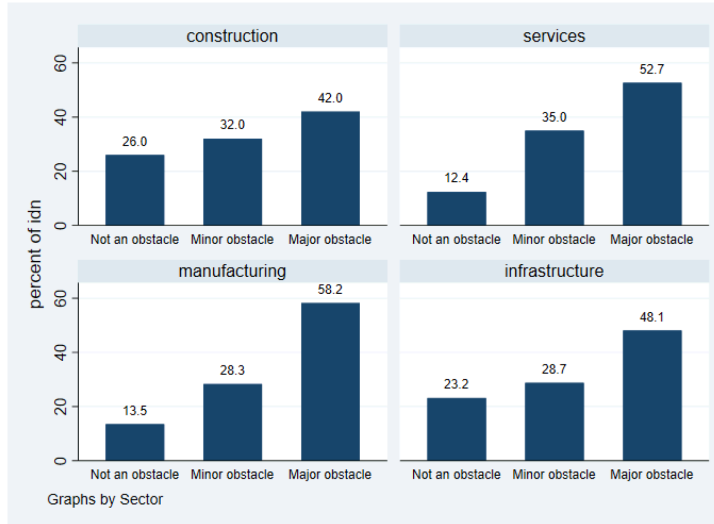
Figure 15 - Perception of energy costs as a barrier to investment by size and sector

Expressed as percentage of businesses by perception of energy costs as an obstacle to investment and sector.

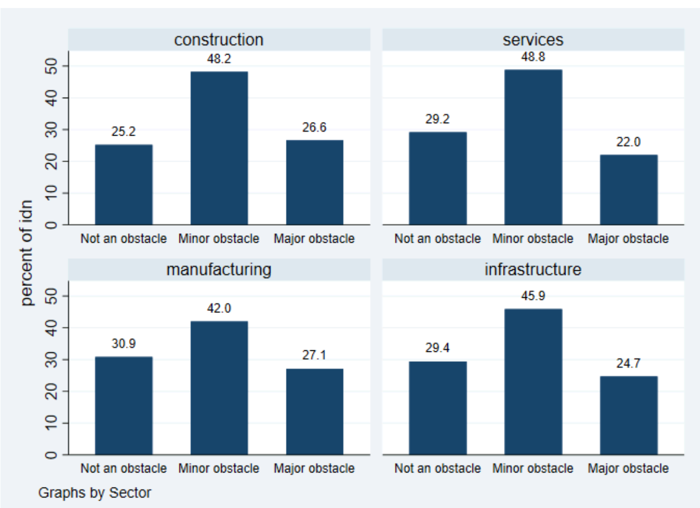
EU SMEs



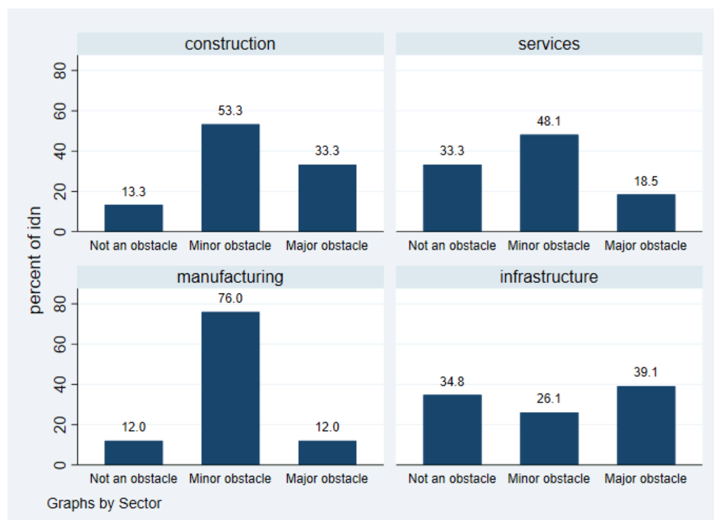
EU Large businesses



US SMEs



US Large businesses



Note: Summary statistics reflect the percentage of EU and US businesses that indicated this was a barrier to investment

Source: EIBIS (2023)

3. Results

Results – Model 1: Analysing the determinants of energy efficiency investments (2018-2022)

Model 1, Equation 1 – Determinants of energy efficiency investments: overall energy efficiency score

The results from our main regression model are expressed in odds ratios, as specified in **Equation 1**, with the 1 and 2-year lags of the overall policy sores can respectively be found in **Table 12** and **Table 13** below. Average Marginal effects (AMEs) for both specifications (with the 1- and 2-year lags of the overall policy score) are presented in **Table 14**. Robustness checks for this model are discussed in the **Validation Section**.

The coefficient for the 1-year and 2-year lags of the RISE Energy Efficiency overall score remains positive and statistically significant in the basic, intermediate, and full specification of the model as can be seen in **Table 12** and **Table 13** below. The increase in the odds of a firm investing in energy efficiency associated with a one-point increase in the score for the overall policy framework in energy efficiency is 1.017 using the 1-year lag in the full specification; it is, however, only significant at the 10% level (**Table 12**). This means that an increase of 1 point in the overall policy score, leads to an increase in the odds of a firm investing in energy efficiency by a factor of 1.017. To avoid any confusion in the interpretation of the odds ratios, the Average Marginal Effects for these odds' ratio can be found in column 1 of **Table 14**. The Average Marginal Effect of a one-point increase in the 1-year lag of the RISE overall energy efficiency policy score leads to an increase in the probability of investing in energy efficiency of 0.3 percentage points. While seemingly small, this suggests that incremental improvements in the overall policy framework for energy efficiency over time were positively associated with the probability of firms starting to invest in energy efficiency throughout the analysed period (2018-2022).

When using the two-year lag of the energy efficiency overall policy score (**Table 13**), we find that the positive effect becomes stronger, with a 1-point increase in the score increasing the odds of investing by a factor of 1.027 at the 1% significance level. In other words, a one-point increase in the 2-year lag of the policy score increases on average the probability of investing in energy efficiency by 0.4 percentage points. As may be seen in **Table 14** including the average marginal effects for both model specifications including the 1- and 2-year lags of the policy score, the results obtained for remaining covariates are almost identical. Below we comment only the results obtained using the 1-year lag to avoid repetition. However, it must be noted that the fact that the

2-year lag has a higher level of statistical significance may indicate that a 2-year lag is more accurate to measure the effect of changes to the policy framework on firm-level investment.

Considering energy costs to be either a major or a minor obstacle to investment both had a positive impact on the probability of investing in energy efficiency with the odds of investing respectively increasing by a factor of 1.299 and 1.24 (**Table 12**) compared to businesses that did not consider energy costs to be an obstacle. This corresponds to an increase in the probability of investing in energy efficiency of 4 percentage points in the case where the respondent indicated it was a major obstacle and 3.3 percentage points in the case where the business considered this was a minor obstacle compared to businesses for which energy costs weren't an obstacle at all (**Table 14**). Using a strategic business monitoring system increases the probability of firms investing in energy efficiency over the analysed period by 1.9 percentage points, this result is however only significant at the 10% level while having implemented either one or multiple advanced technologies increases the odds of investment respectively increases the probability of investment by 2.2 percentage points and 6 percentage points on average compared to businesses that haven't implemented any digital technologies within their business (**Table 14**). These coefficients are respectively significant at the 5% and 1% levels and are in line with our hypothesis that businesses that are more digitally advanced are more likely to invest in energy efficiency.

In line with expectations, the odds of investing in energy efficiency decrease by a factor of 0.442 for SMEs compared to large businesses (**Table 12**). This means that the probability of investing in energy efficiency in the analysed period is on average 12.4 percentage points lower for an SME than for a large business (**Table 14**).

The coefficients for Age are all statistically insignificant but suggest, contrary to expectations, that younger businesses are more prone to invest in energy efficiency. The reference category for the variable Age in **Table 12** and **Table 13** is start-ups or businesses that were founded less than two years ago. Compared to these businesses, mature and old businesses, respectively in operation for 10 to 20 years and over 20 years are less likely to invest in energy efficiency in the analysed period. Young businesses, in operation between 5 and 10 years, have, however, higher odds of investing in this area than start-ups but only by 0.6 percentage points (**Table 14**).

As for sector, we can see that in the full model specification, the odds of investing in energy efficiency for businesses in manufacturing are higher than those of firms in construction, while those of firms in services and infrastructure are lower. The coefficient for the manufacturing sector is the only one which is significant at the 5% level and is in line with expectations that energy-intensive businesses should have a higher propensity to invest. Specifically, on average in the analysed period, the probability of investing in energy efficiency is 2.3 percentage points higher for firms in manufacturing than firms in construction **Table 14**. We can see that in the first and second model specifications, the coefficient for infrastructure was also positive and significant at the 10% level. With the inclusion of the digital uptake and strategic monitoring variables in the full model specification, however, the coefficient becomes negative: the odds associated with investing in energy efficiency decrease by a factor of 0.979 compared to businesses in construction. It must be noted that, given that the variable sector has no within variation, this reflects between effects (across different businesses in the sample).

A 1% increase in the value of total fixed assets is associated with a 1.059 increase in the odds of investing in energy efficiency, and the odds of investing in this area increase by a factor of 1.428 for profitable businesses compared to businesses experiencing losses (**Table 12**). In terms of average marginal effects, a 1% increase in total fixed assets increases on average the probability of investing in energy efficiency by 0.9 percentage points at the 5% significance level and profitable businesses are 5.4 percentage points more likely to invest than businesses incurring losses. This is in line with our hypotheses and previous findings in the literature, for example by Maçãs Nunes *et al.* (2012) who found that cashflow and sales were key determinants of investment. Relying mainly on intra-group finance or external finance also increases the probability of investing by respectively 6.9 and 6.1 percentage points compared to businesses relying mainly on internal funds (**Table 14**), which aligns with findings in the literature and suggests that firms experiencing difficulties in accessing external finance are less likely to invest in energy efficiency. It is important to note that this tends to be the case for SMEs, as highlighted by Fazzari, Hubbard, and Petersen (1988) and N. Berger and F. Udell (1998).

Businesses from Central and Eastern or Western and Northern EU have a significantly higher probability of investing in energy efficiency compared to US businesses in the analysed period, being respectively 12 and 13 percentage points more likely to invest in energy efficiency compared to US businesses. As for Southern EU businesses, they had a 0.6 percentage points higher probability of investing in energy efficiency than US businesses (**Table 14**). This confirms trends observed in the descriptive statistics and points to interesting differences across EU macro-regions deserving further analysis. Finally, year dummies indicate that the probability of investing in energy efficiency is lower in 2019, 2020, 2021, and 2022 than in 2018. The coefficients are the lowest for the pandemic years, 2020 and 2021, respectively, at 0.563 and 0.572 (**Table 12**), and the least low for the year 2022, in line with expectations and with the hypothesis that the pandemic lowered the odds of investing in energy efficiency, contrary to the energy crisis which pushed businesses to improve their energy efficiency to bring down energy costs.

Table 12 – Results Model 1, **Equation 1** with the 1-year lag of the Overall Policy Score: stepwise integration of independent variables.

	(1)	(2)	(3)
VARIABLES	Basic	With financial vars	Full
1-year lag of overall EE policy score	1.019**	1.017*	1.017*
	(0.010)	(0.010)	(0.010)
Energy cost = 1, Minor obstacle to investment		1.245***	1.240***
		(0.088)	(0.088)
Energy cost = 2, Major obstacle to investment		1.306***	1.299***
		(0.112)	(0.112)
Using a formal strategic business monitoring system			1.136*
			(0.074)
Implemented one advanced digital technology			1.158**
			(0.084)
Implemented multiple advanced digital technologies			1.474***
			(0.131)
SME	0.412***	0.437***	0.442***
	(0.101)	(0.106)	(0.107)
Age is 5-10 years	1.065	1.043	1.040
	(0.254)	(0.250)	(0.248)

Age is 10-20 years	1.009	0.983	0.994
	(0.273)	(0.268)	(0.269)
Age is >20 years	0.844	0.824	0.831
	(0.235)	(0.230)	(0.231)
Sector = 2, services	1.089	1.086	0.943
	(0.084)	(0.083)	(0.072)
Sector = 3, manufacturing	1.416***	1.338***	1.161**
	(0.105)	(0.098)	(0.086)
Sector = 4, infrastructure	1.145*	1.146*	0.979
	(0.088)	(0.088)	(0.075)
Log of Total Fixed Assets		1.061**	1.059**
		(0.028)	(0.028)
profit = Break-even		1.257*	1.265*
		(0.164)	(0.165)
profit = Profit (positive)		1.432***	1.428***
		(0.142)	(0.141)
Type finance = Mostly intragroup finance		1.571**	1.559*
		(0.360)	(0.354)
Type finance = Mostly external finance		1.475***	1.481***
		(0.119)	(0.119)
region = SE	1.680***	1.285**	1.042
	(0.196)	(0.151)	(0.122)
region = CEE	2.881***	2.431***	2.263***
	(0.374)	(0.318)	(0.293)
region = WNE	2.902***	2.787***	2.424***

	(0.320)	(0.308)	(0.266)
d2019	0.830**	0.848**	0.849**
	(0.060)	(0.062)	(0.062)
d2020	0.538***	0.560***	0.563***
	(0.050)	(0.052)	(0.053)
d2021	0.602***	0.585***	0.572***
	(0.061)	(0.061)	(0.060)
d2022	0.896	0.882	0.870
	(0.098)	(0.098)	(0.097)
Mundlak terms	YES	YES	YES
Constant	0.001***	0.001***	0.001***
	(0.001)	(0.000)	(0.000)
Observations	20,266	20,266	20,266
Number of idn	9,950	9,950	9,950

Robust standard errors clustered at the firm level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 13 – Results Model 1, **Equation 1** with the 2-year lag of the Overall Policy Score: stepwise integration of independent variables.

	(1)	(2)	(3)
VARIABLES	Basic	With financial vars	Full
2-year lag of overall EE policy score	1.027***	1.027***	1.027***
	(0.009)	(0.009)	(0.009)

Energy cost = 1, Minor obstacle to investment		1.242***	1.237***
		(0.088)	(0.088)
Energy cost = 2, Majorobstacle to investment		1.307***	1.301***
		(0.113)	(0.112)
Using a formal strategic business monitoring system			1.142**
			(0.075)
Implemented at one advanced digital technology			1.163**
			(0.085)
Implemented multiple advanced digital technologies			1.472***
			(0.131)
SME	0.410***	0.438***	0.443***
	(0.101)	(0.107)	(0.108)
Age is 5-10 years	1.049	1.033	1.031
	(0.249)	(0.249)	(0.247)
Age is 10-20 years	0.994	0.971	0.983
	(0.267)	(0.265)	(0.266)
Age is >20 years	0.829	0.810	0.819
	(0.229)	(0.227)	(0.228)
Sector = 2, services	1.183**	1.092	0.949
	(0.092)	(0.084)	(0.073)
Sector = 3, manufacturing	1.911***	1.348***	1.171**
	(0.143)	(0.099)	(0.087)
Sector = 4, infrastructure	1.476***	1.154*	0.986
	(0.115)	(0.088)	(0.076)
Log of Total Fixed Assets		1.063**	1.061**

		(0.028)	(0.028)
profit = Break-even		1.259*	1.268*
		(0.165)	(0.165)
profit = Profit (positive)		1.426***	1.423***
		(0.142)	(0.141)
Type finance = Mostly intragroup finance		1.575**	1.565**
		(0.360)	(0.355)
Type finance = Mostly external finance		1.477***	1.483***
		(0.119)	(0.120)
region = SE	1.440***	1.268**	1.022
	(0.172)	(0.149)	(0.121)
region = CEE	1.965***	2.376***	2.186***
	(0.260)	(0.312)	(0.284)
region = WNE	2.304***	2.756***	2.383***
	(0.260)	(0.305)	(0.262)
d2019	0.785***	0.802***	0.803***
	(0.060)	(0.061)	(0.062)
d2020	0.540***	0.557***	0.560***
	(0.047)	(0.049)	(0.050)
d2021	0.558***	0.538***	0.526***
	(0.059)	(0.059)	(0.058)
d2022	0.809*	0.788**	0.777**
	(0.095)	(0.094)	(0.093)
Mundlak terms	YES	YES	YES

Constant	0.228***	0.001***	0.001***
	(0.076)	(0.000)	(0.000)
Observations	20,229	20,229	20,229
Number of idn	9,927	9,927	9,927

Robust standard errors clustered at the firm level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 14 – Average Marginal Effects of **Model 1**, **Equation 1** with 1 and 2-year lags of the overall policy score.

Mundlak random effects logit with the 1-year and 2-year lags of the Overall Policy Score.

	(1)	(2)
VARIABLES	AMEs Mundlak Correction Logit 1-year lag	AMEs Mundlak Correction Logit 2-year lag
1-year lag of overall EE policy score	0.003*	
	(0.001)	
2-year lag of overall EE policy score		0.004***
		(0.001)
Energy cost = 1, Minor obstacle to investment	0.033***	0.032***
	(0.011)	(0.011)
Energy cost = 2, Major obstacle to investment	0.040***	0.040***
	(0.013)	(0.013)
Using a formal strategic business monitoring system	0.019*	0.020**

	(0.010)	(0.010)
Implemented at one advanced digital technology	0.022**	0.023**
	(0.011)	(0.011)
Implemented multiple advanced digital technologies	0.060***	0.060***
	(0.014)	(0.014)
SME	-0.124***	-0.124***
	(0.037)	(0.037)
Age is 5-10 years	0.006	0.005
	(0.037)	(0.037)
Age is 10-20 years	-0.001	-0.003
	(0.041)	(0.042)
Age is >20 years	-0.028	-0.030
	(0.042)	(0.042)
Sector = 2, services	-0.009	-0.008
	(0.012)	(0.012)
Sector = 3, manufacturing	0.023**	0.024**
	(0.011)	(0.011)
Sector = 4, infrastructure	-0.003	-0.002
	(0.012)	(0.012)
Log of Total Fixed Assets	0.009**	0.009**
	(0.004)	(0.004)
profit = Break-even	0.035*	0.035*
	(0.019)	(0.019)
profit = Profit (positive)	0.054***	0.053***

	(0.015)	(0.015)
Type finance = Mostly intragroup finance	0.069*	0.069*
	(0.036)	(0.036)
Type finance = Mostly external finance	0.061***	0.061***
	(0.013)	(0.013)
region = SE	0.006	0.003
	(0.016)	(0.016)
region = CEE	0.121***	0.115***
	(0.018)	(0.018)
region = WNE	0.131***	0.129***
	(0.015)	(0.015)
d2019	-0.025**	-0.033***
	(0.011)	(0.012)
d2020	-0.088***	-0.088***
	(0.014)	(0.013)
d2021	-0.085***	-0.098***
	(0.016)	(0.017)
d2022	-0.021	-0.038**
	(0.017)	(0.018)
Mundlak terms	YES	YES
Observations	20,266	20,229

Robust standard errors clustered at the firm level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Results Model 1, Equation 2 – Determinants of energy efficiency investments: policy sub-scores

The results from our main regression model expressed in odds ratios, as specified in **Equation 2**, with the 1 and 2-year lags of the policy sub-scores can respectively be found in **Table 15** and **Table 16** below. Corresponding Average Marginal Effects (AMEs) are displayed in **Table 17**. Robustness checks for this model are discussed in the **Validation Section**.

When analysing the results of the model as specified in **Equation 2**, we find that most policy packages do not have statistically significant coefficients. In fact, only two out of the eleven policy sub-scores specified in the regression equation are statistically significant at the 5% level (**Table 15** and **Table 17**). A one-point increase in the policy score for National Planning results in an increase of 0,1 percentage point increase in the probability of a firm investing in energy efficiency in the analysed period and a one-point increase in the policy score for Energy Utility Programmes appears to entail a decrease of 0,6 percentage points in the probability of a firm investing in energy efficiency (**Table 17**).

An increase in four of the remaining policy sub-scores also seems to have a slightly negative impact on the probability of investing in energy efficiency while the score for Energy Efficiency Entities bears no impact. The remaining three, including the scores for Minimum Standards, the Transport Sector and Financing mechanisms for energy efficiency seem to have a positive impact (**Table 15** and **Table 17**). We observe that while the odds ratio of the score for Incentives and Mandates in the Industrial and Commercial sector is below zero in **Table 15**, suggesting it has a negative impact, when calculating the average marginal effects in **Table 17** we find that a one point increase in this policy sub-score leads 0.1 percentage point increase in the probability of investing in energy efficiency. This discrepancy can be explained by the introduction of the interaction term between this policy score and the Sector categorial variable, which has a positive effect in the case of businesses operating in the manufacturing and infrastructure sectors, but is only significant at the 10% level in the case of the latter (**Table 15**).

In fact, when computing the marginal effects for this policy component interacted with the sector categorical variable, we find that it only has a negative effect for businesses in the construction sector (-0.1 percentage points). Otherwise, a one-point increase in the 1-year lag of this policy score increases the probability of investment for businesses in services and manufacturing by about 0.1 percentage points and 0.2 percentage points in the case of businesses in infrastructure.

These results highlight the complex nature of policy impacts on firm-level investment decisions and will be further discussed in the **Error! Reference source not found.** section below. The direction and strength of the remaining coefficients remain in line with what was observed within the framework of **Model 1**, **Equation 1**, including only the overall score as an independent variable. An exception is that businesses located in Southern EU (SE) appear to be 0.5 percentage points less likely to invest in energy efficiency than businesses in the US (**Table 17**).

Using the two-year lag of the policy sub-scores, we find that 7 out of the eleven policy scores have a positive impact on the odds of a firm investing in energy efficiency (**Table 16**). However, only two are statistically significant: the coefficient for National Planning, which remains at 1.006 at the 5% level as in the specification with the one-year lag and the coefficient for Financing Mechanisms, which indicates that a one-point increase in the score for this policy package increases the odds of investing in energy efficiency by 1.018. The coefficient, however, is only significant at the 10% level. Policy scores having a negative – albeit small – impact on the odds of investing in energy efficiency are those associated with Incentives and Mandates for Energy Utility Programmes, Incentives and Mandates for the Industrial and Commercial Sectors, Policies for the Transport Sector and Building Codes.

When looking at the Average Marginal Effects (**Table 17**), we find however that most of the coefficients (positive and negative) have a negligeable impact on the probability of investing in energy efficiency, much like when using the 1-year lag. The interaction term between the policy score for the Industrial and Commercial sectors and the Sector categorical variable is no longer significant when using the two-year lag, but the coefficients remain positive for businesses in the services, manufacturing, and infrastructure sectors. Coefficients for remaining independent variables remain broadly in line with results in the previous model, with the region dummy for Southern European businesses becoming positive again: businesses located in Southern EU are 0.2 percentage points more likely to invest in energy efficiency than US businesses.

Table 15 – Results Model 1, **Equation 2** with the 1-year lag of the policy sub-scores: stepwise integration of independent variables.

Results are expressed in odds ratios.

	(1)	(3)	(5)
VARIABLES	Basic	With Financial vars	Full

All Policy Scores are lagged by 1 year

National Planning	1.007**	1.006**	1.006**
	(0.003)	(0.003)	(0.003)
Energy Efficiency Entities	1.001	1.000	1.000
	(0.004)	(0.004)	(0.004)
Incentives and Mandates for the Public Sector	0.997	0.996	0.998
	(0.014)	(0.014)	(0.014)
Incentives and Mandates for the Industrial and Commercial Sectors	0.990	0.991	0.990
	(0.014)	(0.013)	(0.014)
Incentives and Mandates for Energy Utility Programmes	0.962**	0.961**	0.961**
	(0.016)	(0.016)	(0.016)
Labelling System	0.984	0.985	0.984
	(0.013)	(0.013)	(0.013)
Minimum EE Standard	1.004	1.005	1.004
	(0.004)	(0.004)	(0.004)
Building Codes	0.993	0.993	0.994
	(0.011)	(0.011)	(0.011)
Transport Sector	1.010	1.007	1.008
	(0.012)	(0.013)	(0.013)
Carbon Pricing Mechanism	0.997	0.994	0.994
	(0.005)	(0.005)	(0.005)
Financing Schemes for EE	1.008	1.007	1.006

	(0.013)	(0.013)	(0.013)
Construction Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)
Services Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.014	1.016	1.017
	(0.016)	(0.016)	(0.016)
Manufacturing Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.019	1.020	1.020
	(0.015)	(0.015)	(0.015)
Infrastructure Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.027*	1.026*	1.026*
	(0.015)	(0.015)	(0.015)
Energy cost = 1, Minor obstacle to investment		1.248***	1.243***
		(0.089)	(0.089)
Energy cost = 2, Major obstacle to investment		1.304***	1.298***
		(0.113)	(0.112)
Using a formal strategic business monitoring system			1.131*
			(0.074)
Implemented at one advanced digital technology			1.167**
			(0.085)
Implemented multiple advanced digital technologies			1.474***
			(0.131)
SME	0.416***	0.445***	0.450***

	(0.103)	(0.108)	(0.109)
Sector = 2, services	0.860	0.864	0.745
	(0.206)	(0.201)	(0.173)
Sector = 3, manufacturing	1.376	0.991	0.881
	(0.301)	(0.210)	(0.187)
Sector = 4, infrastructure	1.464*	1.202	1.068
	(0.334)	(0.267)	(0.234)
Age is 5-10 years	1.045	1.030	1.029
	(0.247)	(0.247)	(0.245)
Age is 10-20 years	0.994	0.972	0.985
	(0.267)	(0.265)	(0.267)
Age is >20 years	0.828	0.809	0.818
	(0.228)	(0.226)	(0.227)
Log of Total Fixed Assets		1.073***	1.071**
		(0.029)	(0.029)
profit = Break-even		1.249*	1.257*
		(0.165)	(0.165)
profit = Profit (positive)		1.426***	1.422***
		(0.142)	(0.141)
Type finance = Mostly intragroup finance		1.568**	1.561*
		(0.359)	(0.355)
Type finance = Mostly external finance		1.478***	1.484***
		(0.119)	(0.120)
region = SE	1.441**	1.095	0.966
	(0.268)	(0.199)	(0.175)

region = CEE	1.467*	1.834***	1.931***
	(0.306)	(0.373)	(0.390)
region = WNE	1.622***	2.045***	1.996***
	(0.241)	(0.297)	(0.288)
d2019	0.825**	0.842**	0.843**
	(0.062)	(0.064)	(0.064)
d2020	0.528***	0.549***	0.550***
	(0.059)	(0.061)	(0.062)
d2021	0.633***	0.610***	0.596***
	(0.080)	(0.078)	(0.077)
d2022	0.969	0.951	0.934
	(0.132)	(0.130)	(0.129)
Mundlak terms	YES	YES	YES
Constant	0.914	0.002***	0.002***
	(0.469)	(0.001)	(0.001)
Observations	20,266	20,266	20,266
Number of idn	9,950	9,950	9,950

Robust standard errors clustered at the firm level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 16 – Results Model 1, **Equation 2** with the 2-year lag of the policy sub-scores: stepwise integration of independent variables.

Results are expressed in odds ratios.

	(1)	(3)	(5)

VARIABLES *All Policy Scores are lagged by 2 years*	Basic	With financial vars	Full
National Planning	1.006**	1.006**	1.006**
	(0.003)	(0.003)	(0.003)
Energy Efficiency Entities	1.001	1.002	1.001
	(0.003)	(0.003)	(0.003)
Incentives and Mandates for the Public Sector	1.005	1.003	1.004
	(0.013)	(0.012)	(0.013)
Incentives and Mandates for the Industrial and Commercial Sectors	0.987	0.987	0.987
	(0.013)	(0.013)	(0.013)
Incentives and Mandates for Energy Utility Programmes	0.997	0.997	0.998
	(0.007)	(0.007)	(0.007)
Labelling System	1.003	1.003	1.002
	(0.004)	(0.004)	(0.004)
Minimum EE Standard	1.002	1.002	1.002
	(0.004)	(0.004)	(0.004)
Building Codes	0.991	0.992	0.994
	(0.010)	(0.010)	(0.010)
Transport Sector	0.996	0.996	0.996
	(0.009)	(0.009)	(0.009)
Carbon Pricing Mechanism	1.000	1.001	1.001
	(0.003)	(0.003)	(0.003)

Financing Schemes for EE	1.019*	1.018*	1.018*
	(0.011)	(0.011)	(0.011)
Construction Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)
Services Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.015	1.013	1.014
	(0.015)	(0.015)	(0.015)
Manufacturing Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.022	1.020	1.020
	(0.014)	(0.014)	(0.014)
Infrastructure Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.023	1.020	1.021
	(0.015)	(0.015)	(0.016)
Energy cost = 1, Minor obstacle to investment		1.239***	1.234***
		(0.088)	(0.088)
Energy cost = 2, Major obstacle to investment		1.302***	1.295***
		(0.112)	(0.112)
Using a formal strategic business monitoring system			1.144**
			(0.075)
Implemented at one advanced digital technology			1.166**
			(0.085)
Implemented multiple advanced digital technologies			1.470***
			(0.131)

SME	0.420***	0.446***	0.451***
	(0.104)	(0.109)	(0.110)
Sector = 2, services	0.938	0.924	0.800
	(0.214)	(0.206)	(0.177)
Sector = 3, manufacturing	1.471*	1.047	0.922
	(0.308)	(0.213)	(0.187)
Sector = 4, infrastructure	1.487*	1.206	1.071
	(0.326)	(0.258)	(0.225)
Age is 5-10 years	1.042	1.027	1.024
	(0.248)	(0.248)	(0.245)
Age is 10-20 years	0.986	0.966	0.976
	(0.266)	(0.264)	(0.265)
Age is >20 years	0.824	0.806	0.815
	(0.229)	(0.227)	(0.227)
Log of Total Fixed Assets		1.061**	1.059**
		(0.028)	(0.028)
profit = Break-even		1.251*	1.260*
		(0.164)	(0.165)
profit = Profit (positive)		1.424***	1.421***
		(0.141)	(0.141)
Type finance = Mostly intragroup finance		1.575**	1.566**
		(0.361)	(0.356)
Type finance = Mostly external finance		1.479***	1.485***
		(0.119)	(0.120)
region = SE	1.408*	1.146	1.014

	(0.256)	(0.204)	(0.180)
region = CEE	1.613**	2.102***	2.239***
	(0.327)	(0.417)	(0.441)
region = WNE	1.849***	2.342***	2.282***
	(0.263)	(0.326)	(0.315)
d2019	0.810**	0.830**	0.833**
	(0.073)	(0.075)	(0.075)
d2020	0.552***	0.573***	0.576***
	(0.056)	(0.058)	(0.059)
d2021	0.570***	0.552***	0.535***
	(0.073)	(0.072)	(0.071)
d2022	0.841	0.825	0.804
	(0.120)	(0.119)	(0.117)
Mundlak terms	YES	YES	YES
Constant	0.858	0.001***	0.001***
	(0.389)	(0.001)	(0.001)
Observations	20,229	20,229	20,229
Number of idn	9,927	9,927	9,927

Robust standard errors clustered at the firm level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 17 – Average Marginal Effects Model 1 Equation 2 with 1 and 2-year lags of policy sub-components

Mundlak random effects logit with the 1-year and 2-year lags of policy sub-components.

VARIABLES	(1) AMEs Mundlak Correction Logit 1-year lag	(2) AMEs Mundlak Correction Logit 2-year lag
National Planning	0.001**	0.001**
	(0.000)	(0.000)
Energy Efficiency Entities	0.000	0.000
	(0.001)	(0.001)
Incentives and Mandates for the Public Sector	-0.000	0.001
	(0.002)	(0.002)
Incentives and Mandates for the Industrial and Commercial Sectors	0.001	0.000
	(0.002)	(0.001)
Incentives and Mandates for Energy Utility Programmes	-0.006**	-0.000
	(0.003)	(0.001)
Labelling System	-0.002	0.000
	(0.002)	(0.001)
Minimum EE Standard	0.001	0.000
	(0.001)	(0.001)
Building Codes	-0.001	-0.001
	(0.002)	(0.002)
Transport Sector	0.001	-0.001
	(0.002)	(0.001)

Carbon Pricing Mechanism	-0.001	0.000
	(0.001)	(0.000)
Financing Schemes for EE	0.001	0.003*
	(0.002)	(0.002)
Energy cost = 1, Minor obstacle to investment	0.033***	0.032***
	(0.011)	(0.011)
Energy cost = 2, Major obstacle to investment	0.040***	0.039***
	(0.013)	(0.013)
Using a formal strategic business monitoring system	0.019*	0.020**
	(0.010)	(0.010)
Implemented one advanced digital technology	0.024**	0.023**
	(0.011)	(0.011)
Implemented multiple advanced digital technologies	0.060***	0.059***
	(0.014)	(0.014)
SME	-0.121***	-0.121***
	(0.037)	(0.037)
Sector = 2, services	0.117	0.103
	(0.153)	(0.142)
Sector = 3, manufacturing	0.172	0.183
	(0.143)	(0.132)
Sector = 4, infrastructure	0.265*	0.214
	(0.139)	(0.144)
Age is 5-10 years	0.004	0.004

	(0.036)	(0.037)
Age is 10-20 years	-0.002	-0.004
	(0.041)	(0.042)
Age is >20 years	-0.030	-0.031
	(0.042)	(0.043)
Log of Total Fixed Assets	0.010***	0.009**
	(0.004)	(0.004)
profit = Break-even	0.034*	0.034*
	(0.020)	(0.019)
profit = Profit (positive)	0.053***	0.053***
	(0.015)	(0.015)
Type finance = Mostly intragroup finance	0.069*	0.069*
	(0.036)	(0.036)
Type finance = Mostly external finance	0.061***	0.061***
	(0.012)	(0.013)
region = SE	-0.005	0.002
	(0.026)	(0.025)
region = CEE	0.098***	0.119***
	(0.029)	(0.028)
region = WNE	0.103***	0.122***
	(0.020)	(0.019)
d2019	-0.026**	-0.028**
	(0.011)	(0.014)
d2020	-0.091***	-0.084***
	(0.017)	(0.015)

d2021	-0.078***	-0.095***
	(0.019)	(0.020)
d2022	-0.010	-0.033
	(0.021)	(0.022)
Observations	20,266	20,229

Robust standard errors clustered at the firm level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Results – Model 2: Analysing determinants of the probability of starting to invest in energy efficiency in 2022.

Results Model 2, Equation 3 – Crisis model with energy efficiency overall Score

The results from our main regression model expressed in odds ratios, as specified in **Equation 3**, with the 1 and 2-year lags of the overall energy efficiency scores can respectively be found in **Table 18** and **Table 19** below. Corresponding Average Marginal Effects (AMEs) are displayed in **Table 20**. Robustness checks for this model are discussed in the **Validation Section**.

The regression results show a positive and significant effect of the 1- and 2-year lags of the RISE Energy Efficiency overall score (**Table 18** and **Table 19**). The results in **Table 18**, expressed in odds ratios, indicate that a one-point increase in the overall energy efficiency score in 2021 increases the odds of firm-level investment in energy efficiency by a factor of 1.02 in the full model specification using the 1- or the 2-year lag. This corresponds to an increase in the probability of starting to invest in 2022 of 0.4 percentage points (**Table 20**). This is higher than the Average Marginal Effect obtained using the 1- and 2-year lags in **Model 1** but remains small. It must however be noted that this is for a single point increase in the policy score, highlighting how incremental changes can lead to more substantial effects on the probability of investing.

Indicating that energy costs were a minor or a major obstacle to investment increased the likelihood of a firm starting to invest in energy efficiency in 2022 by respectively 8.4 and 15.2 percentage points (**Table 20**). The odds of investing in energy efficiency for businesses that indicated that energy costs were a major obstacle to investment were 2.324 higher than for businesses that indicated that energy costs were not an obstacle to investment and 1.646 higher for those that indicated that it was a minor obstacle (**Table 18**). The log of total energy spending had a positive albeit insignificant impact on the odds of a firm starting to invest in energy efficiency in 2022, at 1.035. These results could indicate that the perception of cost influences the probability of firm-level investment more strongly than the cost of energy itself but an analysis over a longer time-period would be better suited to ascertain this.

Firms with a strategic business monitoring system were more likely to initiate energy efficiency investments in 2022. Specifically, using a strategic monitoring system increased the probability of a firm starting to invest in energy efficiency in 2022 by 6.7 percentage points in the model specification using the 1-year lag and 6.4 percentage points using the 2-year lag, compared to businesses without any formal strategic monitoring system (**Table 20**). Firms concerned with the energy shock, or that reported having implemented a strategy in response to the energy crisis were also more likely to start investing in 2022 crisis (**Table 18** and **Table 19**). This suggests that energy efficiency emerged as a favored strategy to navigate the challenges associated with the energy . We attempted to introduce interaction terms to understand whether businesses that were concerned and implemented a strategy where more likely to invest in energy efficiency or whether businesses with a strategic monitoring system and a strategy to face the energy shock had higher odds of investing, but these interaction terms were found to be statistically insignificant and removed in the final specification of the model.

We can also see that firms reporting they have conducted an energy audit in the past 3 years are about 5 percentage points more likely to invest in energy efficiency, in line with our hypothesis that organisational capabilities, including proactive management practices, increase the likelihood of investing in energy efficiency. Further, using multiple advanced digital technologies increased the probability of starting to invest in energy efficiency in 2022 by 7 percentage points (**Table 18**).

Finally, the probability of starting to invest in energy efficiency in 2022 was also close to 15 percentage points higher for firms that were already investing in a sustainability area in 2021 compared to those that weren't. This is the second highest average marginal effect observed after perceiving energy costs as a major barrier to investment and suggests that beyond costs, having already engaged in a sustainable investment other than energy efficiency in 2021[20] significantly

[20] The variable was designed to include energy efficiency investments within the broader category of sustainability investments; however, the dependent variable takes on a value of 1 to signify the initiation of energy efficiency

increases the likelihood of engaging in energy efficiency investments and hinting at the existence of a certain path dependency in sustainability investments.

Relying mostly on external finance also increases the probability of starting to invest in 2022 by 5 percentage points compared to businesses relying mostly on internal funds. In Model 1, firms relying either on intra-group funds or external funds were more likely to invest in energy efficiency than firms relying on internal funds, the former being a stronger predictor than the latter (**Table 17**). The fact that only the coefficient for external finance is significant in this case hints at the importance of access to external finance in times of crisis. Controls for firm size, age, sector and profit become insignificant in the full model specification, but their direction remains in line with expectations, and the log of total fixed assets displays a positive and significant coefficient at the 10% level, indicating a tangible link between firm assets and the propensity to invest in energy efficiency (**Table 18** and **Table 19**). In line with the results in the previous model and as can be seen in **Table 19**, the direction and strength of the coefficients remain very close using the 2-year lag of the overall policy scores.

Table 18 – Results Model 2, **Equation 3**, Logit with 1-year lag of the overall policy score: stepwise introduction of independent variables.

Results are expressed in odds ratios.

	(1)	(2)	(3)
VARIABLES	Basic	With financial vars	Full
1-year lag of overall EE policy score	1.023***	1.027***	1.020***
	(0.006)	(0.007)	(0.008)
SME	0.465***	0.693**	0.762
	(0.068)	(0.125)	(0.150)
Sector = 2, services	1.441**	1.404**	1.293
	(0.211)	(0.233)	(0.234)

investments in 2022 by firms that had not previously done so, thereby excluding businesses that had already invested in energy efficiency in 2021.

Sector = 3, manufacturing	1.753***	1.468**	1.231
	(0.251)	(0.240)	(0.219)
Sector = 4, infrastructure	1.200	1.110	1.099
	(0.177)	(0.188)	(0.202)
Age is 5-10 years	1.253	0.978	0.838
	(0.506)	(0.462)	(0.417)
Age is 10-20 years	1.248	0.868	0.662
	(0.474)	(0.386)	(0.311)
Age is >20 years	1.670	1.117	0.937
	(0.617)	(0.489)	(0.432)
region = 1, SE	2.067***	1.721**	1.332
	(0.432)	(0.408)	(0.346)
region = 2, CEE	2.425***	2.123***	1.810**
	(0.568)	(0.572)	(0.526)
region = 3, WNE	2.440***	2.466***	1.754**
	(0.496)	(0.578)	(0.440)
Log of Total Fixed Assets		1.098***	1.065*
		(0.036)	(0.038)
profit = Break-even		1.321	1.225
		(0.348)	(0.354)
profit = Profit (positive)		1.507**	1.369
		(0.275)	(0.277)
Type finance = Mostly intragroup finance		1.246	1.247
		(0.379)	(0.377)
Type finance = Mostly external finance		1.266*	1.312**

		(0.162)	(0.181)
Energy cost = 1, Minor obstacle to investment		1.800***	1.646***
		(0.290)	(0.288)
Energy cost = 2, Major obstacle to investment		2.541***	2.324***
		(0.402)	(0.409)
Log of total spending in energy		1.051	1.035
		(0.040)	(0.044)
Using a formal strategic business monitoring system			1.435***
			(0.181)
Implemented at one advanced digital technology			1.249
			(0.178)
Implemented multiple advanced digital technologies			1.456**
			(0.213)
Energy audit in the past 3 years			1.368**
			(0.182)
Any concern energy shock			1.704*
			(0.533)
Any strategy energy shock			2.053**
			(0.578)
Any sustainable investment in the past year			2.215***
			(0.365)
Constant	0.038***	0.002***	0.001***
	(0.027)	(0.002)	(0.001)
Observations	2,101	1,762	1,618

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 19 – Results Model 2, **Equation 3**, Logit with 2-year lag of the overall policy score: stepwise introduction of independent variables.

Results are expressed in odds ratios.

VARIABLES	(1) Basic	(2) With financial vars	(3) Full
2-year lag of overall EE policy score	1.024***	1.029***	1.022***
	(0.006)	(0.007)	(0.007)
SME	0.469***	0.713*	0.774
	(0.069)	(0.130)	(0.153)
Sector = 2, services	1.453**	1.432**	1.323
	(0.214)	(0.239)	(0.240)
Sector = 3, manufacturing	1.772***	1.490**	1.255
	(0.255)	(0.244)	(0.224)
Sector = 4, infrastructure	1.211	1.122	1.114
	(0.179)	(0.191)	(0.206)
Age is 5-10 years	1.252	0.981	0.843
	(0.506)	(0.463)	(0.420)
Age is 10-20 years	1.257	0.871	0.664
	(0.478)	(0.388)	(0.314)
Age is >20 years	1.675	1.115	0.938
	(0.619)	(0.488)	(0.435)
region = 1, SE	2.060***	1.755**	1.368
	(0.424)	(0.410)	(0.350)

region = 2, CEE	2.499***	2.301***	1.950**
	(0.584)	(0.621)	(0.570)
region = 3, WNE	2.438***	2.534***	1.811**
	(0.489)	(0.587)	(0.451)
Log of Total Fixed Assets		1.099***	1.067*
		(0.037)	(0.038)
profit = Break-even		1.330	1.229
		(0.352)	(0.356)
profit = Profit (positive)		1.499**	1.365
		(0.275)	(0.277)
Type finance = Mostly intragroup finance		1.257	1.269
		(0.384)	(0.384)
Type finance = Mostly external finance		1.270*	1.319**
		(0.163)	(0.182)
Energy cost = 1, Minor obstacle to investment		1.808***	1.652***
		(0.293)	(0.291)
Energy cost = 2, Major obstacle to investment		2.541***	2.323***
		(0.404)	(0.411)
Log of total spending in energy		1.057	1.039
		(0.040)	(0.044)
Using a formal strategic business monitoring system			1.414***
			(0.179)
Implemented at one advanced digital technology			1.242

			(0.177)
Implemented multiple advanced digital technologies			1.457**
			(0.214)
Energy audit in the past 3 years			1.356**
			(0.182)
Any concern energy shock			1.836*
			(0.589)
Any strategy energy shock			1.995**
			(0.563)
Any sustainable investment in the past year			2.193***
			(0.362)
Constant	0.036***	0.001***	0.001***
	(0.025)	(0.001)	(0.001)
Observations	2,094	1,756	1,613

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 20 – Average marginal effects Model 2, **Equation 3** with the 1- and 2-year lags of the overall policy score.

	(1)	(2)
VARIABLES	AMEs Logit with 1-year lag of policy score	AMEs Logit with 2-year lag of policy score

1-year lag of overall EE policy score	0.004***	
	(0.001)	
2-year lag of overall EE policy score		0.004***
		(0.001)
SME	-0.050	-0.047
	(0.036)	(0.036)
Sector = 2, services	0.047	0.051
	(0.033)	(0.033)
Sector = 3, manufacturing	0.038	0.041
	(0.032)	(0.032)
Sector = 4, infrastructure	0.017	0.019
	(0.033)	(0.033)
Age is 5-10 years	-0.033	-0.032
	(0.095)	(0.095)
Age is 10-20 years	-0.075	-0.074
	(0.090)	(0.090)
Age is >20 years	-0.013	-0.012
	(0.089)	(0.089)
region = 1, SE	0.048	0.052
	(0.042)	(0.041)
region = 2, CEE	0.104**	0.117**
	(0.049)	(0.048)
region = 3, WNE	0.098**	0.103***
	(0.041)	(0.040)

Log of Total Fixed Assets	0.012*	0.012*
	(0.007)	(0.007)
profit = Break-even	0.036	0.036
	(0.051)	(0.051)
profit = Profit (positive)	0.056	0.055
	(0.035)	(0.035)
Type finance = Mostly intragroup finance	0.041	0.045
	(0.058)	(0.058)
Type finance = Mostly external finance	0.051*	0.052**
	(0.026)	(0.026)
Energy cost = 1, Minor obstacle to investment	0.084***	0.085***
	(0.029)	(0.029)
Energy cost = 2, Major obstacle to investment	0.152***	0.151***
	(0.030)	(0.030)
Log of total spending in energy	0.006	0.007
	(0.008)	(0.008)
Using a formal strategic business monitoring system	0.067***	0.064***
	(0.023)	(0.023)
Implemented at one advanced digital technology	0.041	0.039
	(0.026)	(0.026)
Implemented multiple advanced digital technologies	0.070**	0.070**

	(0.028)	(0.028)
Energy audit in the past 3 years	0.058**	0.056**
	(0.025)	(0.025)
Any concern energy shock	0.098*	0.112*
	(0.058)	(0.059)
Any strategy energy shock	0.133***	0.127**
	(0.051)	(0.052)
Any sustainable investment in the past year	0.147***	0.145***
	(0.030)	(0.030)
Observations	1,618	1,613

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Conditional Average Marginal Effects: analysing the determinants of SME investments in energy efficiency across regions.

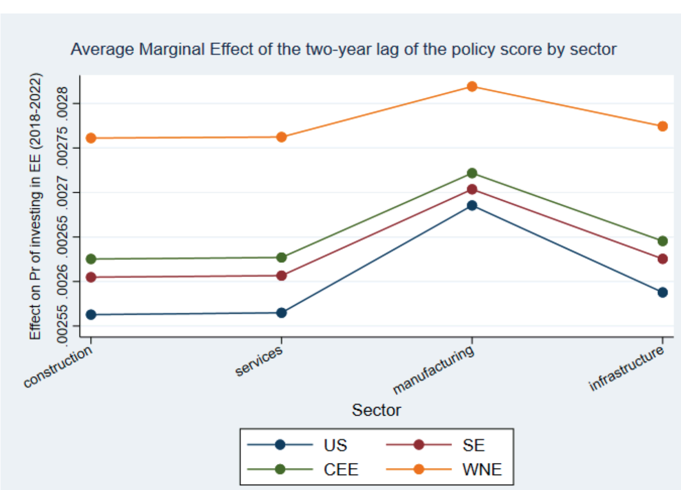
In order to get a better sense of how predictors of interest affect the probability of investing in energy efficiency for SMEs across the different analysed regions we calculate Conditional Average Marginal Effects for Model 1 and Model 2 including the overall energy efficiency score. In the previous section, we have looked at average marginal effects, here, we look at the decomposition of the average marginal effects of certain predictors to understand how their impact the probability of investing in energy efficiency varies depending on businesses size, region or across the levels of other covariates of interest.

Within the framework of Model 1, we find that the effect using the 1-year and the 2-year lags is very similar but the latter has a higher level of statistical significance, in line with the results presented in **Table 14**. We will therefore present results from the specification using the 2-year lag of the energy efficiency overall score in the case of Model 1. Within the framework of Model 2 and as shown in **Table 20**, the 1-year and 2-year lags of the overall policy score appear to uniformly impact the outcome variable when the coefficients are approximated to three decimal places. Within the framework of Model 2, we calculate Conditional Average Marginal Effects using the 1-year lag of the overall policy score. This is in line with literature analysing the impact of policy measures in the context of energy shocks including the recent energy crisis (Gao and Cevik, 2023) but also on the effect of emergency measures in the context of previous electricity shortfalls (IEA, 2011) which suggest that businesses should be more responsive to changes in the energy policy framework as a result of rising energy costs.

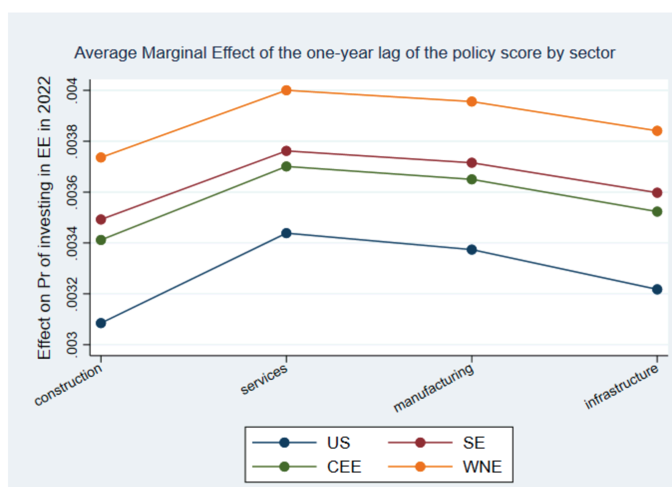
We start by calculating the average marginal effect of a one-point increase in the 2-year lag of the overall energy efficiency policy score on the probability of SMEs investing in energy efficiency across different sectors. We find that this increase is more likely to positively affect the likelihood of investment in the case of businesses in the manufacturing sector as may be seen in **Figure 16** (left panel) below. Within the framework of Model 2 using the 1-year lag of the overall energy efficiency score to analyse the probability of starting to invest in energy efficiency in 2022, we find that the effect is stronger for both businesses in services and manufacturing (**Figure 16**, right panel).

Figure 16 – CAME of the energy efficiency overall score on the probability of SMEs investing in energy efficiency across sectors.

Model 1



Model 2



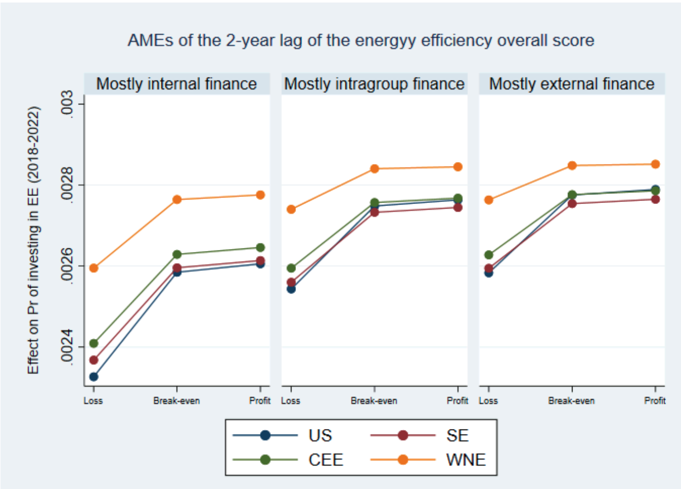
Note: Displayed Conditional average marginal effects (CAMEs) of the impact of the Overall Policy Score for energy efficiency on the probability of SMEs investing in energy efficiency are calculated at different levels of the sector variable and over the region variable. Results are statistically significant at the 1% level in both models.
Source: EIBIS (2023).

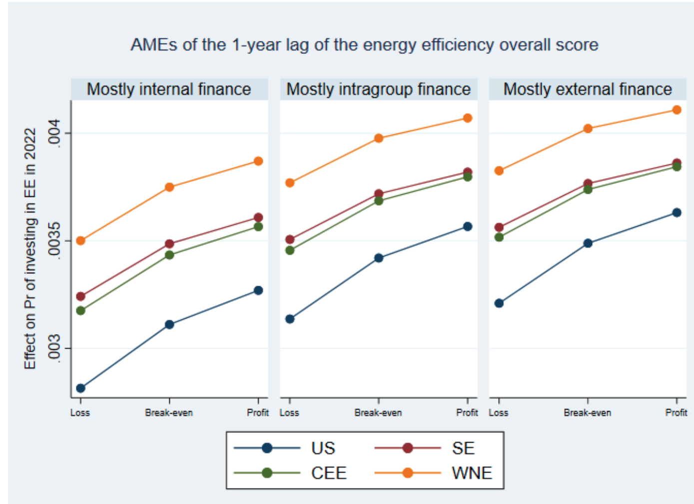
We then analyse the average marginal effect of the policy score on the likelihood of investment across different levels of the profit and type of finance categorical variables to analyse whether the effect of regulation varies depending on the financial situation of the firm. In line with expectations, we find that the marginal effect of an increase in the policy score is less likely to positively impact the probability of investing in energy efficiency when the firm is experiencing losses and predominantly relies on internal finance (**Figure 17**). We can also observe an incremental impact of the marginal effect of the policy score across the levels of the energy cost as an obstacle to investment variable (**Figure 18**), with the marginal effect of a one-point increase in the policy score being higher for SMEs considering energy costs to be either a minor or a major obstacle to investment than businesses considering it is not.

Figure 17 – CAME of the energy efficiency overall score at different levels of profitability and by the type of finance the business predominantly relies on.

Model 1

Model 2



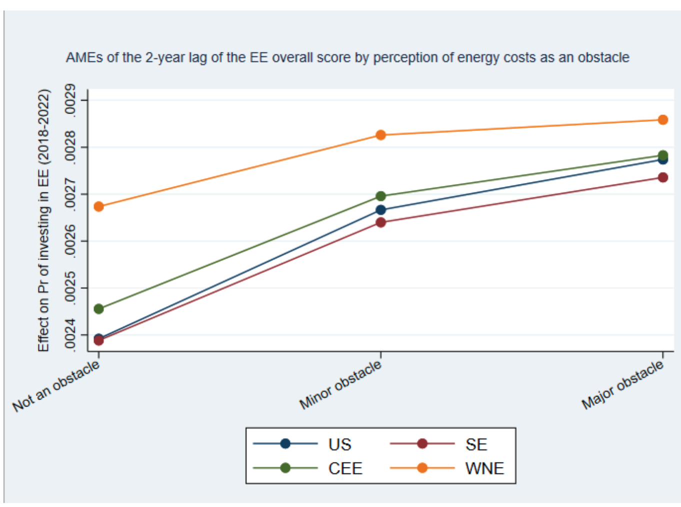


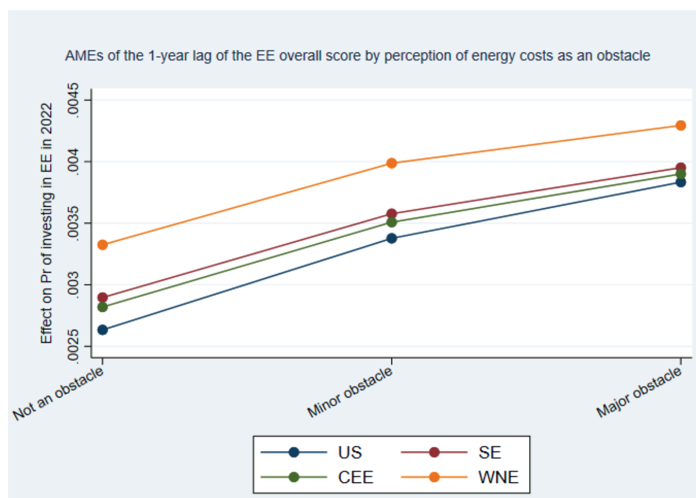
Note: Displayed Conditional average marginal effects (CAMEs) of the impact of the Overall Policy Score for energy efficiency on the probability of SMEs investing in energy efficiency are calculated at different levels of profit and the type of finance that the business predominantly relies on over the region variable. Results are statistically significant at the 1% or 5% level in both Models.
Source: EIBIS (2023)

Figure 18 – CAME of the Overall Energy Efficiency Policy Score at different levels of perception of energy costs as a barrier to investment.

Model 1

Model 2



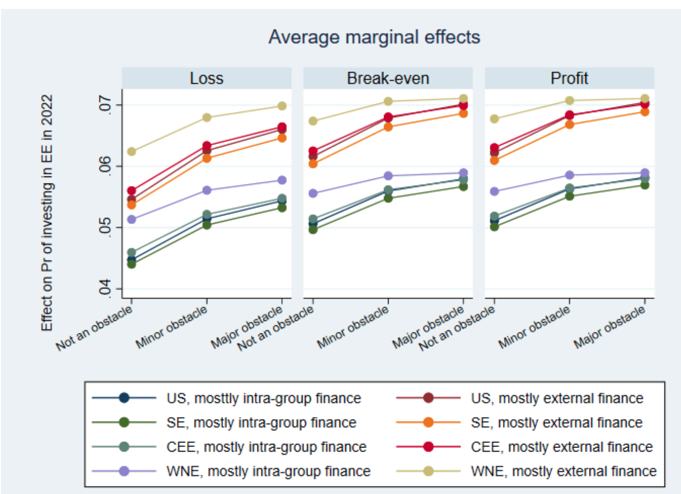


Note: Displayed Conditional average marginal effects (CAMEs) of the impact of the Overall Policy Score for energy efficiency on the probability of SMEs investing in energy efficiency are calculated at different levels of profit and the type of finance that the business predominantly relies on over the region variable. Results are statistically significant at the 1% level in both Models.
Source: EIBIS (2023).

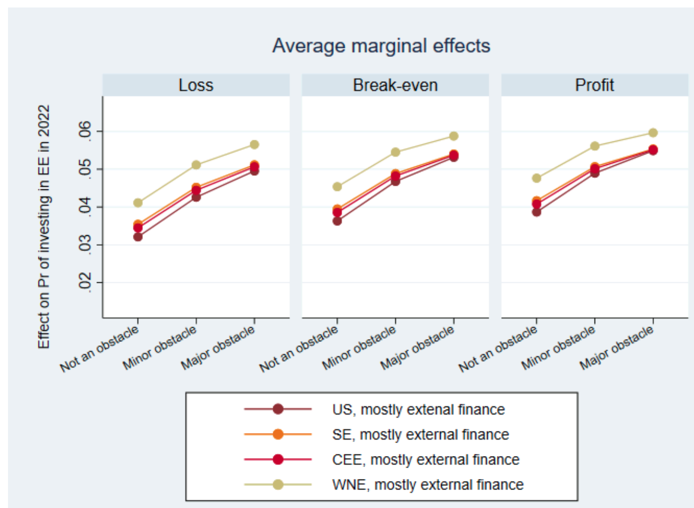
We also analyse how the marginal effect of the type of finance that businesses mostly rely on varies across levels of the profit variable and the energy costs as an obstacle to investments variables in **Figure 19**. In the right-hand panel displaying the average marginal effects for Model 2, we exclude the average marginal effects for intragroup funding as they are not statistically significant. In Model 1, businesses relying on external finance exhibit a stronger impact on the average marginal probability of investing in energy efficiency compared to those relying on internal funds. We further observe that gaps between regions converge in the case of SMEs considering that energy costs are a major obstacle to investment. In Model 2 however, average marginal effects remain slightly higher for SMEs in WNE. Finally, we look at variations of the marginal effect of mainly relying on external finance or intragroup funding compared to internal funds at different levels of the RISE policy score. We find that the marginal effect of relying mainly on external finance increases with the overall policy score across Models 1 and 2 (**Figure 20**). This suggests that relying mostly on external finance is most effective in the presence of a robust regulatory environment.

Figure 19 – CAMEs of the type of finance SMEs predominantly rely on across levels of the profit and perception of energy costs as an obstacle to investments variables.

Model 1

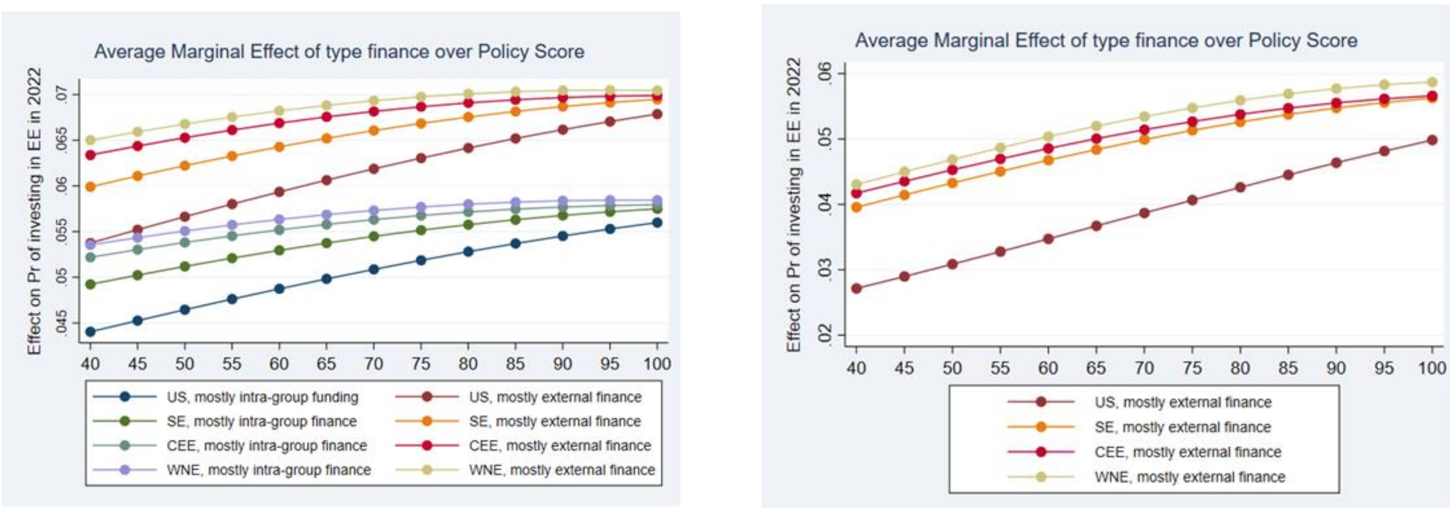


Model 2



Note: Displayed Conditional average marginal effects (CAMEs) of the impact of the type of finance SMEs predominantly rely on are calculated with respect to the baseline category of relying mostly on internal funds and at different levels of profit and perception of energy costs as an obstacle to investment over the region variable and are statistically significant at the 1% level in both Models.
Source: EIBIS (2023)

Figure 20 – CAMEs of type finance over different RISE overall policy scores for energy efficiency.
Model 1 Model 2



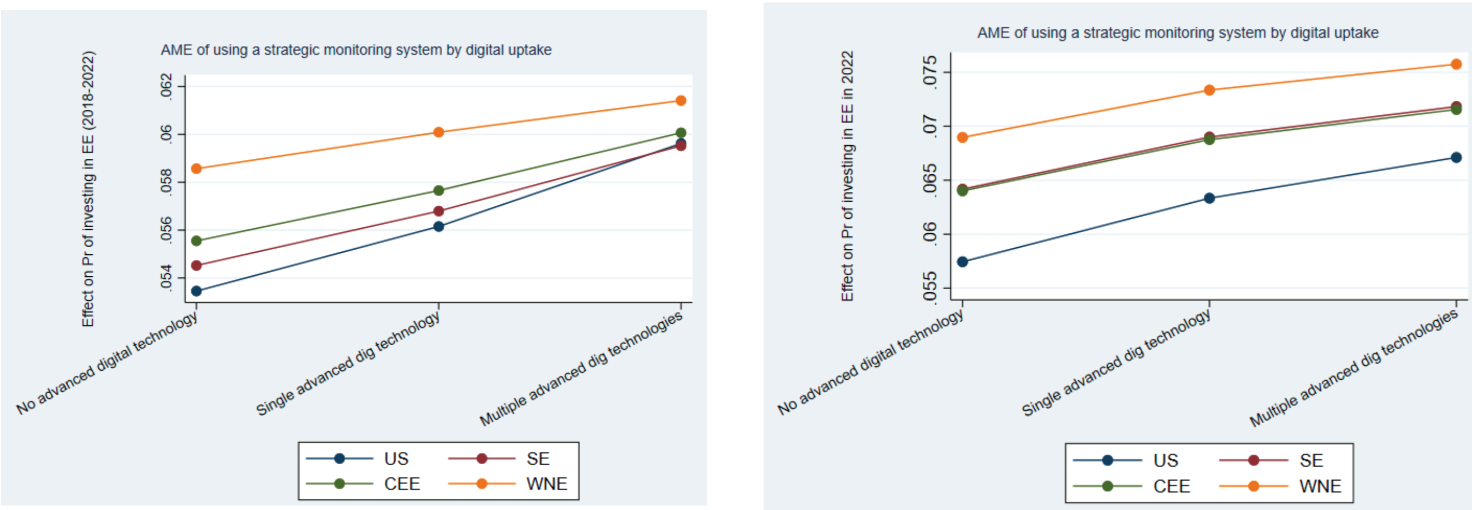
Note: The x-axis are different levels of the RISE overall policy. Displayed Conditional average marginal effects (CAMEs) of the impact of the type of finance SMEs predominantly rely on at different levels of RISE overall energy efficiency scores were calculated over the region variable and are statistically significant at the 1% level in both Models.
Source: EIBIS (2023)

We finally analysed the impact of an SME implementing a strategic monitoring system across different levels of the digital uptake variable, to see whether the average marginal effect was stronger for SMEs implementing advanced digital technologies within their business. In line with expectations, we find that the average marginal effect of implementing a strategic monitoring system is higher for businesses with a higher level of digital uptake. We note a stronger linear relationship in the case of Model 1 with differences in average marginal probabilities across regions converging in the case where SMEs implementing multiple advanced digital technologies within their business (

Figure *21*).

Figure 21 – CAMEs of implementing a strategic monitoring system across levels of digital uptake.

Model 1 Model 2



Note: Displayed Conditional average marginal effects (CAMEs) of the impact of implementing a strategic business monitoring system at different levels of digital implementation were calculated over the region variable and are statistically significant at the 1% level in both Models.
Source: EIBIS (2023)

It is important to note that while the results from the conditional average marginal effects suggest interesting interactions between independent variables of interest, the introduction of several interaction terms in the regression model itself was discarded as they were found to have no statistical significance. Future research could focus on analysing in more depth interactions between financial determinants like the perception of energy costs as an obstacle to investment or the type of finance the business predominantly relies on and more qualitative aspects like the organisational, strategic planning skills of businesses.

Validation

To determine the best fit for Model 1 (**Equation 1** and **Equation 2**), we started by specifying pooled and random effects logit models (see **Table 31**, **Table 32**, **Table 33** and **Table 34**). The coefficients of the pooled model are consistent if the error term isn't correlated with the explanatory variables (is exogenous) and individual (within) effects are either equal across individuals or equal to zero (Longhi and Nandi, 2015). In the presence of unobserved heterogeneity (within effects are Random effects models are efficient if the error term is exogenous, otherwise a fixed effects specification is preferred to control for the impact of unobserved entity-specific effects (Longhi and Nandi, 2015; Oscar, 2007). In line with expectations, a Likelihood Ratio test rejects the null hypothesis of constant variance of the errors (no unobserved heterogeneity) meaning the pooled model coefficients are inconsistent (Longhi and Nandi, 2015; StataCorp, 2023).

We then perform a fixed effects logit model[21] and a Hausman test, which rejects the hypothesis of no endogeneity, indicating that a fixed effects or a Mundlak approach is preferred to control for the impact of unobserved entity specific effects on regressors (Longhi and Nandi, 2015; Oscar, 2007). We settle on the Mundlak specification, which allows for the inclusion of time-invariant (entity-specific) regressors that would be dropped from a fixed effects regression (Longhi and Nandi, 2015). Finally, a Wald test rejects the null hypothesis that the Mundlak terms are jointly equal to zero, thereby supporting their inclusion to capture the impact of unobserved entity-specific effects (Perales, 2013; Wooldridge, 2010b). As previously mentioned, standard errors clustered at the firm level are applied to all model specifications to allow for correlation between the errors of panel observations and correct for heteroskedasticity (Wooldridge, 2021).

As may be seen in **Table 31**, **Table 32**, **Table 33** and **Table 34**, the results of the fixed effects logit regression closely align with those of the Mundlak specification. We note however, that the number of observations in the fixed effects logit specification is much lower, as observations for which the dependent variable does not vary across time (businesses either always invest in energy efficiency or do not throughout the analysed period) are not used in the estimation of the model (Longhi and Nandi, 2015). As explained in the methodology, the results of a Mundlak regression should converge with those of a fixed effects regression in the linear case (Mundlak, 1978). To verify the accurate implementation of the Mundlak methodology, we also performed a fixed effects Linear Probability Model and a random effects Linear Probability Model with Mundlak terms and, as shown in **Table 27** and **Table 28** (Annex 2) in the case of Model 1, **Equation 1** with the overall policy scores and Tables **Table 29** and **Table 30** (Annex 2) in the case of Model 1, **Equation 2** with the policy sub-sores, the Fixed Effects and Mundlak linear probability model coefficients converge for time-varying covariates.

To verify the robustness of the results to an alternative model specification, we further performed the Mundlak specification using a probit link function instead of a logit link function. The use of the probit model, which, like logistic regression, models binary outcomes but assumes

[21] In line with the terminology adopted in the literature for social sciences, by fixed-effects panel logit model, we refer to the conditional fixed effects logit model (Chamberlain, 1980).

a normal distribution of the error terms (instead of a logistic distribution in the case of logit), did not alter the inferred relationships between policy scores and firms' likelihood of investing in energy efficiency, suggesting that the observed effects are not model-specific outcomes[22].

The use of different time lags for the overall and sub-policy components in Models 1 and 2 allows us test for the sensitivity of the results to different implementation lags as previously discussed and enables us to correct for potential reverse causality biases. This is because changes in policy for energy efficiency may be influenced by past of current business investment behaviour or in reaction to economic shocks. The use of lagged policy scores enables us to address this as the policy framework one or two years back cannot be influenced by the current firm's investment behaviour.

Finally, to test the sensitivity of the results to the weighting methodology used to calculate the overall and sub-policy scores, all models are also estimated using the original RISE scores without altering the weighting methodology[23]. Starting with Model 1 as specified in **Equation 1** using the overall policy score, we find that the one-year lag of the overall score has an even smaller positive effect on the odds of investing in energy efficiency and is furthermore statistically insignificant. Using the two-year lag, however, the odds ratio is close to that obtained when using the summation methodology and is significant at the 1% level. Specifically, using the RISE weighting methodology, a one-point increase in the overall score increases the odds of investing in energy efficiency by a factor of 1.023 against 1.027 using the summation methodology implemented in the framework of this study. Everything else equal, the average marginal effect of a one-point increase in the two-year lag of the policy score leads to an increase of 0.3 percentage points in the probability of investing in energy efficiency over the analysed period (2018-2022) using the RISE weighting methodology and 0.4 percentage points when using the equal-weighting methodology.

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[22] To maintain brevity in the Annexes, the results of the probit specification are not included, but are available upon request.

[23] To maintain brevity, regression results from validation processes are not included in the paper but are available from the author on request.

4. Discussion

Hypothesis testing

- **Hypothesis 1:** Business characteristics as predictors of energy efficiency investments.

Based on literature findings, we posited that SMEs would be found to be less likely to invest in energy efficiency than large businesses, which was confirmed in the descriptive statistics and by both Models even if the in second model specification the coefficient for SMEs was not statistically significant.

We also anticipated that businesses in more energy intensive sectors would exhibit a higher probability of investing in energy efficiency which was first confirmed by descriptive statistics showing that businesses operating in the manufacturing and infrastructure sectors were the most numerous to invest in energy efficiency (**Figure 6**). However, we found that businesses in construction, which should be more energy intensive than businesses in services (see section **ANNEX 1 – Definitions** of energy intensity), were generally the least likely to invest in energy efficiency. In Model 1, in the case where only the overall policy score was included (**Equation 1**), we found that businesses operating in Manufacturing were the most likely to invest in energy efficiency. When including the policy sub-scores (**Equation 2**) the sector categorical variable lost its statistical significance, but we could see that businesses in Manufacturing and Infrastructure were the most likely to invest in energy efficiency, both having a positive impact on the probability of investing in energy efficiency in the analysed period. The analysis revealed that service sector businesses seemed more inclined to invest in energy efficiency than their counterparts in the construction sector, as evidenced by the Average Marginal Effects detailed in **Table 17**.

However, the odds ratio of investing in energy efficiency for businesses in the Services sector was below 1 in **Table 15** and **Table 16 –** typically suggesting a negative impact on the likelihood of investment. This discrepancy can be explained by the inclusion of the interaction term between the policy score for Incentives and Mandates for energy efficiency in the Industrial and Commercial sectors and the sector categorical variable. As can be seen when looking at the coefficients of the interaction term in **Table 15** and **Table 16**, although the odds ratios aren't statistically significant, they are both greater than 1. This indicates a positive effect of incentives and mandates on the likelihood of service sector businesses investing in energy efficiency compared to those in the construction sector, which serves as the reference group, and which affects the AMEs displayed in **Table 17**.

Based on findings by Beck et al. (2006) who found that younger businesses were more likely to be financially constrained, we expected younger businesses to exhibit a lower probability of investing in energy efficiency. The relationship between age and the probability of investing in energy efficiency wasn't however as straightforward. Coefficients for business age were statistically insignificant across models but suggested, contrary to expectations, that younger businesses were more prone to invest in energy efficiency. Mature and old businesses, respectively in operation for 10 to 20 years and over 20 years were found to be less likely to invest in energy efficiency than start-ups in the analysed period. Young businesses, in operation between 5 and 10 years, had, however, higher odds of investing in energy efficiency in Model 1 (**Table 14**) but not in Model 2 (**Table 20**). A possible explanation for this might stem from the specificity of energy efficiency investments as compared investment in general as analysed by Beck et al. (2006). Energy efficiency investments might be perceived by younger businesses as a means to cut costs, which would explain their stronger propensity to invest in this area in line with findings indicating that young businesses tend to have more limited financial resources.

- **Hypothesis 2:** Financing sources and energy efficiency investments

In the theoretical framework and based on previous literature findings, we posited that businesses relying mainly on internal finance would be less likely to invest in energy efficiency than businesses predominantly financing their investments with external finance. This hypothesis was based on findings in the literature suggesting that businesses experiencing financing constraints as a result of their limited access to external finance are less likely to engage in investment activities and particularly research by Beatriz, Coffinet and Nicolas (2022) highlighting the importance of the diversification of sources of finance or by Fazzari, Hubbard, and Petersen (1988) and N. Berger and F. Udell (1998) investigating the effects of SMEs' stronger reliance on internal funds or relationship lending as a result of their limited access to external finance.

A first look at the data confirmed that businesses relying either on intra-group funding or external finance were more numerous to invest in energy efficiency than businesses relying on internal funds (**Figure 8**) and results from Model 1 and 2 confirmed this as well. In the first specification of Model 1 using the lag of the overall energy efficiency policy score, we saw those businesses relying mainly on intragroup funding (subsidiaries) were actually slightly more likely to invest in energy efficiency than firms relying on external finance (**Table 14**). This is interesting as it suggests easier access to capital for investments in energy efficiency by subsidiaries from their parent companies or common strategic goals between them which may favourably affect the probability of investing in energy efficiency. Nevertheless, it must be noted that the coefficient for external finance had a higher level of statistical significance and that there were comparatively fewer businesses relying on intragroup funding in the dataset.

Within the framework of Model 2, focusing on investment activities in 2022 by businesses who did not previously invest in energy efficiency, we also find that firms relying mainly on external finance are the most likely to start investing in energy efficiency that year. Remaining financial controls including profitability and total fixed assets also have effects in line with expectations, with profitable businesses being more likely to invest in energy efficiency than businesses experiencing losses – even though in Model 2 the profit categorical variable has no statistical significance –and the log of total fixed assets having a positive impact on the probability of investing.

- **Hypothesis 3:** Organisational capabilities and digitalisation as predictors of higher energy efficiency investments

Across model specifications and beyond financial factors, we found that organisational capabilities and firm development in other areas also positively influence the likelihood of investing in energy efficiency. These include the ability to integrate advanced digital tools into business operations and the implementation of formal strategic monitoring systems, such as Key Performance Indicators, to track and evaluate progress toward established business goals. Specifically, the probability of investing in energy efficiency increases by about 2 percentage points with the use of a strategic business monitoring system across model specifications in Model 1 and 6 percentage points in Model 2, suggesting the heightened importance of these practices in the context of the energy crisis.

Implementing either one or multiple advanced digital technologies within the businesses was also associated with an increase in the probability of investing with businesses implementing multiple digital technologies being more likely to do so. Furthermore, within the framework of Model 2 we were able to analyse the effect of additional business practices on the probability of taking up investment in energy efficiency in 2022. Businesses that had a strategy to face the energy shock, whether this was directly passing the cost to consumers, focusing on energy savings, renegotiating the energy contract changing the energy mix or stopping the production of certain goods and services were more likely to invest in energy efficiency. This was also the case for businesses that had undergone an energy audit in the past three years, which is in line with findings in the literature and with our hypothesis according to which businesses with more developed managerial practices, seeking information about their energy consumption are more likely to invest in energy efficiency.

- **Hypothesis 4:** Sensitivity of energy efficiency investments to rising energy costs in 2022.

Within the framework of Model 2 we were able to analyse the factors influencing firm decisions to start investing in energy efficiency in 2022 when they previously didn't invest in this area. Our fourth hypothesis posited that different economic shocks were likely to impact investments into energy efficiency differently and that a shock like that experienced in 2022 with rising energy costs was likely to favour investments in energy efficiency to cut energy costs. A first analysis of the data confirmed that while the share of firms investing in energy efficiency dropped in 2020 (**Table 3**), the year of the outbreak of the Covid-19 pandemic, this did not seem to be the case in 2022. Further analysis revealed that the share of businesses that started to invest in energy efficiency in 2022 after no investment in this area in 2021 was at 18.9% in the EU and 15.7% in the US, the highest figures for this category (transition from no investment the previous year to investment in the current year) observed throughout the analytical period (2018-2020).

Model 2 focused on analysing the determinants of transitioning into investment in energy efficiency in 2022 and enabled us to analyse the impact of new variables as previously discussed albeit from a cross-sectional perspective. One of them was whether businesses that were already investing in sustainability area in 2021 (waste management, renewable energy, sustainable transport or investing in less polluting areas) were more likely to start investing in energy efficiency in 2022. Results from Model 2 revealed this was the case, increasing the probability of investing in energy efficiency by close to 15 percentage points. This was one of the strongest predictors of investment in the model along with considering energy costs as a major barrier to investment and could reflect the presence of a positive feed-back loop of investments in sustainability areas beyond practical cost-saving aspects. However, to thoroughly investigate this hypothesis, additional analysis is warranted. Future studies, incorporating additional data collected post-energy crisis, could employ panel analyses to explore the dynamic impact of incremental sustainability investments.

- **Hypothesis 5:** the RISE Energy Efficiency policy scores and energy efficiency investments

Finally, in developing the theoretical framework for the analysis, we anticipated that a higher RISE energy efficiency policy score – reflecting the strength of a country's regulatory environment – would have a positive influence on the likelihood of firms investing in energy efficiency. We also expected policy sub-scores composing the RISE overall score to positively impact the probability of investing in energy efficiency at varying levels as some of these policy scores were only expected to influence firm level investments indirectly if at all, through general equilibrium effects.

While the impact of the country-level overall score was positive throughout the analysed models, results where more difficult to interpret when including the policy sub-scores as independent variables in Model 1 as specified in **Equation 2**. The analysis revealed that the effect of the RISE policy-scores was limited with average marginal effects remaining below a one percentage point change in the probability of investing in energy efficiency and only two policy scores being statistically significant in the model specification including the 1- and the 2-year lags of the policy sub-scores. The coefficient of the policy component that was positive and significant in both specifications was "National Planning for energy efficiency". The score of this policy component was based on three policy packages: legislation and action planning for energy efficiency, the presence of sub-sectoral targets for the residential, commercial, industrial, transport and power sectors and their scope (whether targets are defined based on publicly available analyses, requirements for regular progress reports etc.) (World Bank, 2021) and its evolution in the EU and the US throughout the analysed period can be found in **Figure 25** in **ANNEX 1 – Definitions**.

This suggests that comprehensive national planning for energy efficiency with sectoral targets as well as clear goals established and updates in a transparent and evidenced-based way have a positive albeit small impact on the probability of investing in energy efficiency. The fact that businesses are responsive to improvements in the robustness of national plans and regulatory frameworks for energy efficiency highlights the key role that national governments can play by mitigating uncertainty and providing clear signals supporting private-sector investments in energy efficiency by establishing sector-specific targets. While the effect measured is small, it suggests that incremental improvements in the robustness of national strategies (by expanding the specificity and scope of national targets for example) could also have incremental impact on the probability of investing in energy efficiency.

In the specification including the 1-year lag of the policy sub-scores, an improvement in the score for incentives and mandates for energy utility programmes was found to negatively impact the probability of firm-level investment in energy efficiency. This policy component was scored based on the presence of enforceable regulations requiring energy utility companies (providing electricity, natural gas etc.) to engage in energy efficiency activities across generation, transmission, distribution, and demand-side management sectors, along with associated penalties for non-compliance. It also was based on the presence of mechanisms like public budget financing, consumer surcharges, or decoupling for utilities to recuperate costs or lost revenue from mandated energy efficiency initiatives in addition to the implementation of Time of Use metering (TOU) across different sectors to evaluate whether electricity prices are cost reflective (World Bank, 2021). However, in the second model specification, an increase in the score for this policy component no longer had a statistically significant impact. We cannot infer the reasons behind this observed negative effect which could be interpreted in a variety of ways. It could be related, for example, to distortions associated with the effective reduction of energy consumption by energy utility programmes, which could act as a disincentive to invest in energy efficiency measures or to other unobservable effects in the context of this analysis. This highlights the limitations of examining the effect of policy frameworks at such a high level of aggregation.

In the specification including the 2-year lag of policy sub-components, the score for the policy component “Financing Schemes for Energy Efficiency” was also statistically significant. This component was evaluated based on the extent of the coverage and variety of financing mechanisms across sectors. Some examples include the presence of discounted "green" mortgages, on-bill financing, credit lines with banks, green bonds, leasing, or partial risk guarantees. Another aspect factored in the evaluation of this policy score was the proportion of financial or non-financial institutions offering credit lines for energy efficiency investments within each sector (World Bank, 2021). Its positive albeit small impact on the probability of investing in energy efficiency is intuitive, in the sense that a greater availability of financing mechanisms for energy efficiency should foster investments by businesses in this area. However, several factors need to be considered, particularly the ease of access to these financial instruments. As discussed in the literature, SMEs tend to have a more limited access to sources of external finance and might therefore be also less likely to be able to benefit from these financing mechanisms.

Finally, the interaction term for the policy score “Incentives and Mandates for the Industrial and Commercial sectors” and the Sector categorical variable is positive and significant in the case of businesses operating in the infrastructure sector. When calculating average marginal effects for the interaction term, we find that a one-point increase in the policy score induces a 0.2 percentage point increase in the probability of investing in energy efficiency for businesses in infrastructure. This policy component was evaluated based on the presence of policies such as reporting requirements, measurement and verification programmes, public recognition initiatives and awareness programmes, technical assistance, and incentive programmes for both large energy users and SMEs (World Bank, 2021). The interaction term is however no longer significant when using the 2-year lag of the policy score. The positive effect observed when using the 1-year lag could be interpreted as the heightened sensibility of businesses in the infrastructure to policy changes in this area due to their high energy intensity, meaning they stand to gain more from energy efficiency improvements. However, once again, we can only emit hypotheses as to the nature of the underlying mechanisms.

The low statistical significance of policy sub-scores and the fact that some policy packages even appeared to have a negative effect on the probability of investing in energy efficiency highlights the complexity of the mechanisms through which policies may impact firm-level investment decisions. These results are in fact in line with findings by Galeazzi et *al.* (2023) in their analysis of the impact of the RISE policy scores for the renewable energy component on the emissions in developing countries. Indeed, the authors also found that certain policy packages had a negative effect on the level of emissions.

Limitations

This study aimed to analyse the influence of the overall policy environment on the likelihood of firms investing in energy efficiency. However, it is important to note the limitations of this approach, which have in part already been highlighted in the analysis of the Results and Discussion sections.

The observation that the results are more statistically significant when including the overall policy score, compared to the analysis of the eleven individual policy packages that constitute the final score, suggests that the overall quality of a country's policy framework for energy efficiency might capture synergies between policies implemented under different policy sub-components and that appear to have a positive impact on the probability of firms investing in energy efficiency.

This effect might, however, be less apparent when policy packages are examined individually. Indeed, the variability in results and the generally lower levels of statistical significance of individual policy sub-scores suggest that examining policies at an intermediate level of granularity — through the lens of the RISE policy sub-scores — may not be as accurate. Indeed, it is unlikely that the complex mechanisms through which policies impact firm-level investments in energy efficiency can be fully captured by these eleven policy sub-scores, as their impact is likely to depend on the specific characteristics and circumstances of different businesses with sector-specific dynamics at play. In other words, all policies – and thus all policy packages – are unlikely to exert a uniform effect across different businesses with varying capacities or incentives to comply with or benefit from specific regulations.

When evaluating the policy environment as a whole by using the overall score for energy efficiency, however, seems to provide insight into the impact of the policy framework's robustness. The findings suggest that a stronger and more comprehensive policy framework generally fosters firm-level investments in energy efficiency. Results are furthermore robust to different weighting methodologies and other robustness checks including fixed effects and probit specifications. To analyse the impact of the policy framework at a higher level of granularity, it might therefore be better to analyse the impact of specific schemes instead of focusing on an intermediate level as the RISE policy categories composing the overall score. As previously mentioned, Galeazzi *et al.* (2023) also find that very few policy packages have any statistical significance on the outcome of interest with only one sixth of the analysed policy packages under the Renewable Energy Policy Component having any statistical significance. Focusing on the overall policy framework however has the merit of confirming that improvements measured with respect to the implementation of certain standardised policy measures does appear to favourably impact firm investments in energy efficiency.

While incorporating the lag of the energy efficiency policy score in our regression model enables us to account for the lag between policy implementation and their impact on firm level investment activities, it's essential to acknowledge a limitation associated with the non-inclusion of emergency policy packages in the context of the 2022 energy shock. The exclusion of these measures represents a gap in the analysis, as emergency policies might exert a distinct and immediate influence on firms' decisions to invest in energy efficiency beyond pre-existing policy frameworks (established 1 or 2 years ago). The model's ability to capture the effects of changes in the policy framework in the context of the energy crisis is therefore likely to be constrained by the non-inclusion of these emergency measures and highlights the need for future research on the impacts of emergency policy responses on firms' energy efficiency investment behaviours.

Implementing a hybrid model like the random effects logit model with Mundlak terms offers non-negligeable advantages as highlighted in the methodology. It allows for the estimation of both time-varying and entity-specific covariates at a point in time by including the period averages of entity specific covariates. However, the model specification presented several challenges related to the unbalanced character of the panel and the choice of independent variables. Defining separate models to analyse the impact of different policy sub-scores on the probability of investing in energy efficiency at the country level was not possible given that the longitudinal component of the EIBIS dataset consists of the random sampling of 40% of the businesses present in the previous wave of the survey. Limiting the analysis to the country-level would have therefore considerably limited the number of observations. Furthermore, and given that one of the main independent variables of interest, the RISE policy scores, are country-level variables, this excluded the possibility of integrating country fixed effects in the analysis as they would have introduced a high level of collinearity. Other challenges were related to the databases themselves, for instance with 7 EU countries being excluded from the analysis as they were not included in the RISE database. Finally, within the framework of this study, we have jointly analysed determinants of investments by EU and US businesses. All model specifications included a "region", the baseline of which was the US and that enabled us to compare trends in investment across EU macro regions compared to the US. It must however be noted that the EU and the US have different policy frameworks and that determinants of investment in energy efficiency are also different across EU and US businesses. Further analysis focusing solely of the drivers and barriers of investments in energy efficiency at the country level in the US and across EU countries is therefore likely to yield more concrete insights.

Future research

This study has focused on the analysis of the binary outcome of investing or not on energy efficiency. However, as introduced at the beginning of the Methodology section, the EIBIS variable on which our dependent variable is based is the percentage of total investment allocated to energy efficiency by businesses. In order to expand understanding of the determinants of firm level investments in energy efficiency, it would be interesting to develop a two-part model, that would not only analyse the determinants of investing in energy efficiency but also the likelihood of allocating a larger proportion of total investment towards energy efficiency. By modelling both the decision to invest and the level of investment, a Heckman model could for instance offer a comprehensive approach to understanding firm-level behaviour in allocating resources to energy efficiency initiatives. Another alternative would be a quantile regression, in order to gain further insights on the prediction strength of the determinants analysed within the framework of this study for businesses at different levels of investment in energy efficiency.

About the analysis of the impact of the energy crisis on firm-level investments in energy efficiency, conducting longitudinal studies would provide valuable insights into how this shock might have lastingly impacted – or not – investment practices in the field of energy efficiency. Collection of data on newly introduced determinants of investments in the latest wave of the EIBIS survey, including investment practices in other sustainability areas or having recently undergone an energy audit would enable a more detailed analysis of how these factors might lastingly impact or not the propensity of businesses to invest in energy efficiency. It would further be interesting to analyse in more detail whether cost related determinants including spending in energy or perception of energy costs as a barrier to investment prevail over or interact with more qualitative aspects like strategic planning and monitoring, the ability to abide with more stringent energy efficiency regulations or to benefit from policy incentives encouraging investments in energy efficiency. This would be particularly interesting in light of the heightened policy attention directed towards energy efficiency in order to meet climate targets in both the European Union and the United States.

5. Conclusion

This study has explored the impact of the overall policy framework for energy efficiency and other least explored determinants of investments on the probability of corporate investments in energy efficiency. This was made possible through the analysis of data collected by the European Investment Bank Investment Survey. This study employed a hybrid model approach, using a logit random effects regression with Mundlak terms, to analyse the determinants influencing firm-level investments in energy efficiency by EU and US businesses. Key factors examined included the overall energy efficiency policy framework, as measured by the RISE scores developed by the World Bank and ESMAP, which reflect the robustness of national energy efficiency policies. Additionally, the study explored the role of organisational development, measured by businesses' implementation of strategic monitoring systems and adoption of digital tools, in driving these investments. The methodology drew on frameworks from Pouliakas and Wruuck (2022), which focused on firm-level investments in skills training, as well as from Galeazzi et al. (2023), who analysed the impact of the RISE Renewable Energy scores on GHG emissions in developing countries.

Findings suggest that improvements in the overall policy framework for energy efficiency have positive and statistically significant albeit modest effects on the probability of investing in energy efficiency. However, the analysis of the impact of policy sub-scores on the probability of investment was less straightforward, in line with previous literature findings measuring the impact RISE scores on the level of greenhouse gas emissions in developing countries (Galeazzi et al., 2023). Rather than to analyse these specific mechanisms, the purpose of this study was to examine how the overall policy framework for energy efficiency – both at a high (overall score) and intermediate (policy sub-scores) level of aggregation – affects the probability of businesses investing in energy efficiency. However, it is crucial to emphasise that understanding the underlying mechanisms is key to identifying how targeted policy improvements can encourage energy efficiency investments among firms with varying characteristics, across different sectors and regions. For this reason, research that focuses on the impact of policies within specific sectors and countries is essential. Such research helps foster continuous, targeted improvements in energy efficiency policy frameworks, not only at the national level, but also at the local and wider regional levels, in the case of the European Union.

The study also finds that businesses with strategic competencies, proactively tracking business performance and integrating advanced digital technologies in their business are more likely to invest in energy efficiency. However, the impact of financial determinants must not be disregarded either. Perception of energy costs as a major barrier to investments appears to be an important predictor of energy efficiency investments – particularly in 2022 – and so does the type of finance that the business is mainly reliant on, with businesses relying more strongly on internal finance appearing to be less likely to invest in energy efficiency. The analysis of the factors influencing the decision to start investing in energy efficiency in 2022 allowed us to examine the impact of additional determinants, such as having conducted an energy audit within the past three years or having already made investments in sustainability initiatives in 2021. This last aspect was found to be a particularly strong predictor of firm-level investments in energy efficiency in 2022.

Overall, the findings underscore the importance of adopting a multifaceted approach when analysing the determinants of firm-level investments in energy efficiency. This approach should extend beyond financial factors to also consider indicators of managerial capacity and strategic planning within the firm, particularly in relation to compliance with energy efficiency regulations and the ability to leverage policy incentives for energy efficiency. It further suggests that supporting the development of organisational capacities at the firm level has the potential to channel firm-level investments in energy efficiency. Actively promoting the adoption strategic performance monitoring and the take up of digital technologies to enhance efficiency, alongside other critical strategic planning activities like conducting energy audits, could effectively incentivise businesses to invest in this area. This approach could be especially important for SMEs, as they are often less inclined – or, in the case of energy audits in the EU, legally constrained – to adopt these advanced practices.

6. Annexes

ANNEX 1 – Definitions, summary statistics and representativeness of the EIBIS database

- **Business size**

The EIBIS classifies businesses according to size and value-added in line with the EU categorisation (see table below), excluding micro-businesses with less than 4 employees. This definition is based on the EU recommendation 2003/361[24].

Table 21 – Definition of SMEs by number of employees and turnover

Company category	Number of employees	Turnover or	Balance sheet total
Medium-sized	<250	≤ EUR 50 million	≤ EUR 43 million
Small	<50	≤ EUR 10 million	≤ EUR 10 million
Micro	<10	≤ EUR 2 million	≤ EUR 2 million

Source: Table directly extracted from (European Commission, n.d.) and based on (*Directive 2003/361/EC of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (Text with EEA relevance) (notified under document number C(2003) 1422)*, 2003)

- **Business sector**

The EIBIS database is sampled in order to be representative of the business population of EU and US businesses across countries, business size and sector (EIB, 2024, 2020). The EIBIS collects data on NACE sectors C to J and classifies them into 4 overarching categories – manufacturing, construction, services and infrastructure – as shown in the table below. We use the same classification in the context of this analysis.

Table 22 – Sector categorization EIBIS database.

Company sector	**Construction**	**Services**	**Manufacturing**	**Infrastructure**

[24] Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (Text with EEA relevance) (notified under document number C(2003) 1422). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32003H0361

C. Manufacturing			178 369	
D. Electricity, gas				11 446
E. Water supply, sewage				20 982
F. Construction	136 168			
G. Wholesale and retail		133 244		
H. Transportation and Storage				76 439
I. Accomodation and food service activities		27 768		
J. Information and Communication				35844
Total	178 369	136 168	161 012	144 711

Note: This table reflects the sector composition of observations in the EIBIS database from years 2010 to 2022, excluding the United Kingdom from 2021 onwards and EU countries not covered by the RISE index (CY, EE, LT, LU, LV, MT and SI).

Source: EIBIS (2023)

- *Energy intensity*

Energy intensity is defined as a ratio between the units of energy and economic output (Eurostat, 2020a).

In the EU, the construction sector accounts for 5.44% of Value Added in the EU, manufacturing for 16.69%, the infrastructure sector for about 28%[25] and the service sector composed in the EIBIS dataset by the wholesale and retail sector and the accommodation sector 19%[26]. In the US,

[25] Industry including energy accounts for 18.45%, information and communication for 5.5% (OECD, 2024) and transport and storage for 2.7% based on (Eurostat, 2020b).
[26] 18.45% for the wholesale and retail sector and 0.6% for the accommodation sector based on (Eurostat, 2020b).

the construction sector represents 4.19% of value added, manufacturing 11.11%, infrastructure 22%[27] and the service sector including the wholesale and retail sector for 16.46%.

As can be inferred from the table below, manufacturing accounts for 23.3% of the total energy use of production activities, services for 2.5%, infrastructure for 28.3% and construction for 2.1%. While the share of net energy use in the service sector is much lower than the share of value added (2.5% of net energy use against 18.45% of value added), infrastructure, manufacturing and construction appear as more energy intensive (in that order). In the US, sectors are compounded in wider categories that do not overlap with the sector categorisation made by the EIBIS. We can however infer from **Figure 22** that the commercial sector is also the least energy consuming and therefore energy intensive.

Table 23 - Net domestic energy use by economic activities in the EU

[27] Industry including energy accounts for 20.17%, information and communication for 7.5% (OECD, 2024). No information was found for transport and storage.

Net domestic energy use by economic activities

European Union (EU-27), 2020

Economic activities			
label	code (NACE)	Terajoules	%
All activities		57 618 275	100
Production activities (NACE)		42 035 728	73.0
Electricity, gas, steam and air conditioning supply	D	11 400 787	19.8
Manufacture of chemicals and chemical products	C20	4 999 783	8.7
Land transport and transport via pipelines	H49	2 449 195	4.3
Manufacture of coke and refined petroleum products	C19	2 296 627	4.0
Manufacture of basic metals	C24	2 091 885	3.6
Water transport	H50	1 499 294	2.6
Manufacture of other non-metallic mineral products	C23	1 465 965	2.5
Manufacture of paper and paper products	C17	1 308 845	2.3
Manufacture of food products; beverages and tobacco products	C10-C12	1 243 710	2.2
Crop and animal production, hunting and related service activities	A01	1 235 482	2.1
Construction	F	1 198 565	2.1
Air transport	H51	917 002	1.6
Wholesale trade, except of motor vehicles and motorcycles	G46	756 425	1.3
Retail trade, except of motor vehicles and motorcycles	G47	710 238	1.2
Public administration and defence; compulsory social security	O	691 812	1.2
Other NACE production activities		7 770 112	13
Households' consumption activities		15 582 547	27.0
Heating/cooling activities by households		8 748 793	15.2
Transport activities by households		5 281 440	9.2
Other activities by households		1 552 314	2.7

Source: Physical Energy Flow Accounts (PEFA) - Key indicators by NACE Rev. 2 activity (online data code: env_ac_pefa04)

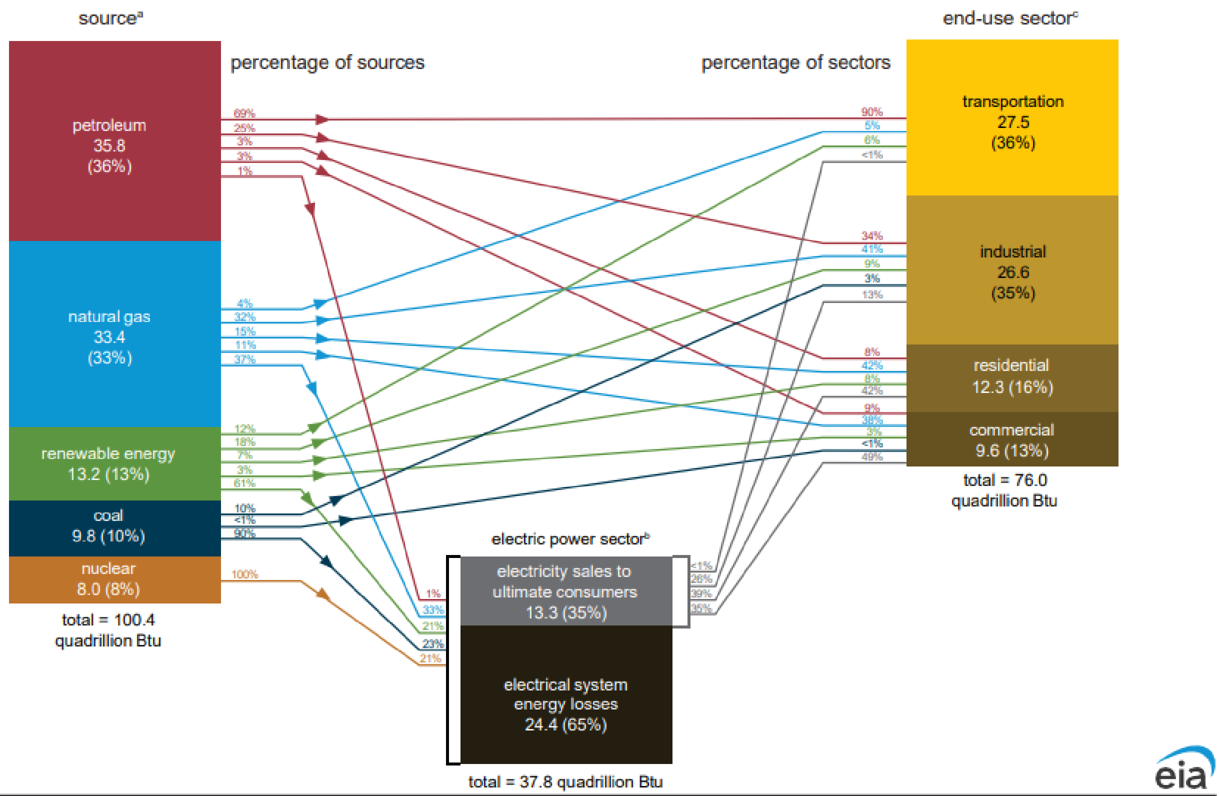
eurostat

Source: (Eurostat, 2022).

Figure 22 – US energy consumption by source and sector (in Btu)

U.S. energy consumption by source and sector, 2022

quadrillion British thermal units (Btu)



Source: (EIA, 2022)

Table 24. Summary Statistics Model 1 (2018-2022)[28]

Varibale	Observations	Mean	Standard deviation	Min.	Max.
Invested EE	44 269	0.42	0.49	0	1
SME	206 385	0.85	0.36	0	1
Sector	206 554	2.54	1.07	1	4
Age	53 776	3.51	0.79	1	4
Region	206 639	2.19	0.89	0	3
Profit	52 397	1.65	0.69	0	2
Log of Total Fixed Assets	48 194	14.12	2.56	-1.26	32.07
Type of Finance the firm is mainly reliant on	45 157	1.33	0.99	0	3
Energy Obstacle as a barrier to investment	53 336	1.01	0.82	0	2
Use of Key Performance Indicators	52 516	0.44	0.5	0	1
Level of Digital Uptake	53 490	0.83	0.83	0	2

[28] Table reflects summary statistics of dependent and independent variables from financial years 2018 to 2022 (waves 2019 – 2023) for the entire EIBIS – Orbis Bvd sample, excluding the RISE Scores. To see Summary Statistics for the RISE Scores (2018-2021) please refer to **Table 26**.

Table 25. Summary statistics additional variables introduced in Model 2 (2022)

Variable	Observations	Mean	Standard deviation	Min.	Max.
Log of Total Spending in energy	9 686	11.44	2.25	-5.98	20.95
Energy audit in the past 3 years	9 959	0.34	0.47	0	1
Any concern about the energy crisis	10 385	0.93	0.25	0	1
Any strategy for the energy crisis	10 371	0.91	0.28	0	1
Investment in a sustainability area in 2021	4 342	0.81	0.39	0	1

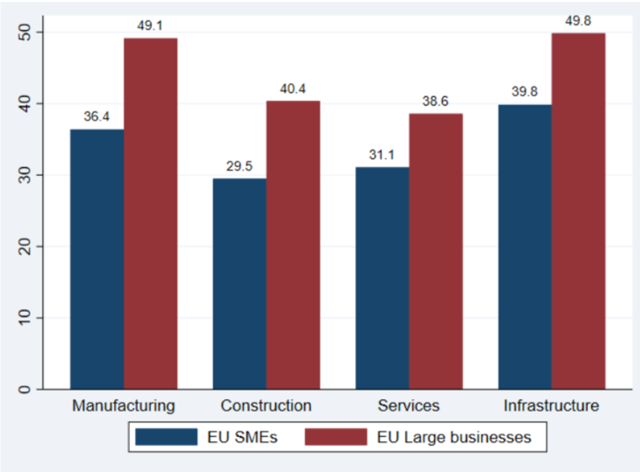
Table 26 – Summary Statistics for the Rise Energy Efficiency Policy Scores (2018-2022)

Variable	Observations	Mean	Standard deviation	Min.	Max.
EE Overall Score	196 253	70.43	11.08	32.41	89.39
National Planning Score	196 253	79.26	23.08	10	100
EE Entities Score	196 253	82.7	16.48	0	100
Incentives and Mandates for the Public Sector Score	196 253	66.3	19.55	30	100
Incentives and Mandates for the Industrial and Commercial Sectors Score	196 253	68.03	25.1	0	100
Incentives and Mandates for the EE Utility Programmes Score	196 253	53.28	16.84	5.71	80
Minimum EE Standards Score	196 253	80.24	17.98	0	100
EE Labelling System Score	196 253	73.56	21.08	33.33	100
EE Building Code Score	196 253	83.63	10.64	38.9	100

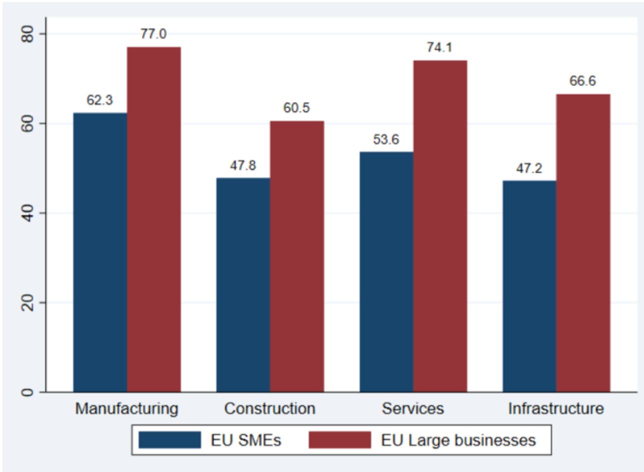
EE Financing Schemes Score	196 253	39.34	24.97	3.7	96.3
Transport Sector Score	196 253	51.83	21.69	5.26	94.74
Carbon Pricing Mechanism Score	196 253	96.51	17.64	0	100

Figure 23 – Percent of EU businesses investing in sustainability areas in 2021 by size and sector

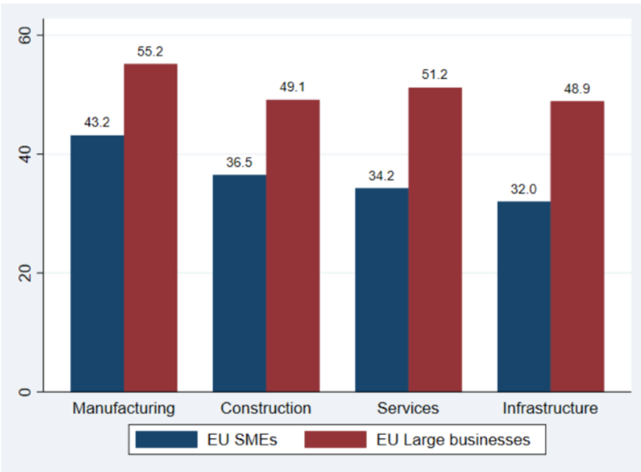
Investing in less polluting areas



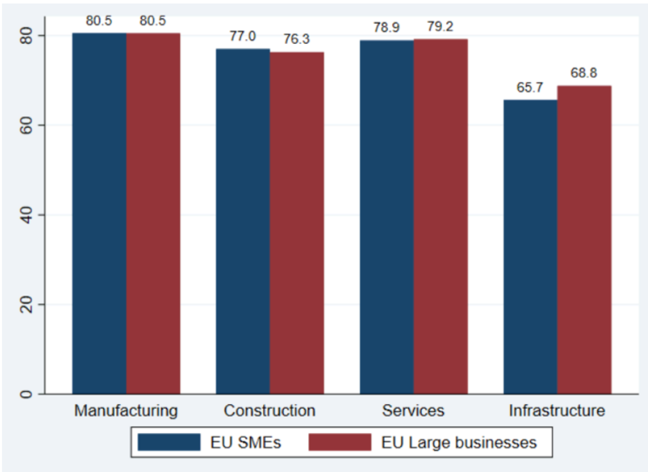
Investing in energy efficiency



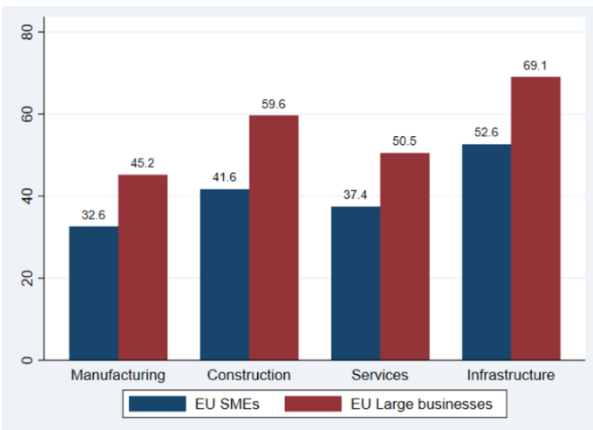
Investing in renewable energy



Investing in waste management



Investing in sustainable transport

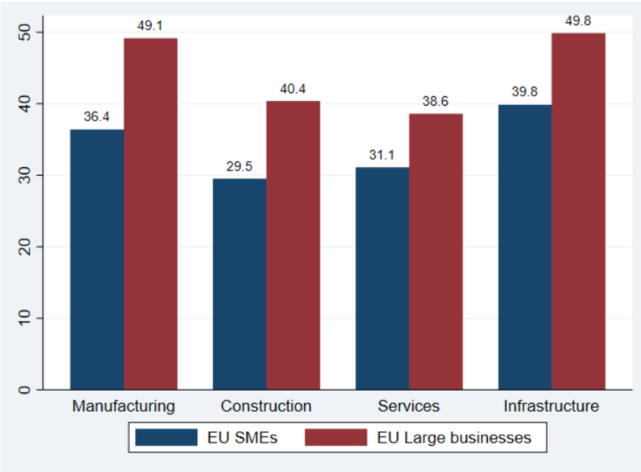


Note: The total number of respondent businesses is 9 594.

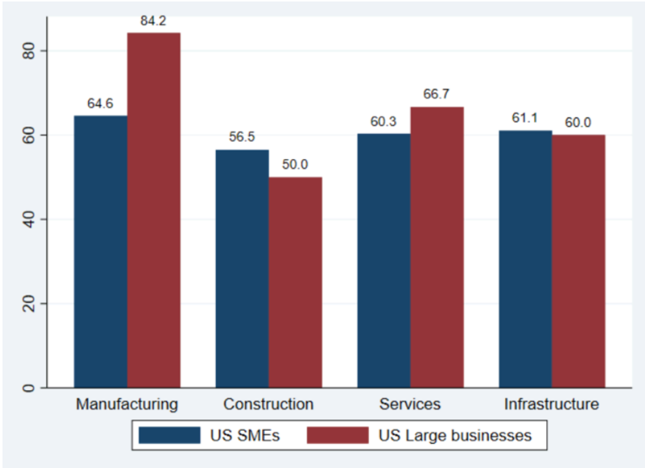
Source: EIBIS (2023)

Figure 24 – Percentage of US businesses investing in sustainability areas in 2021 by size and *sector.*

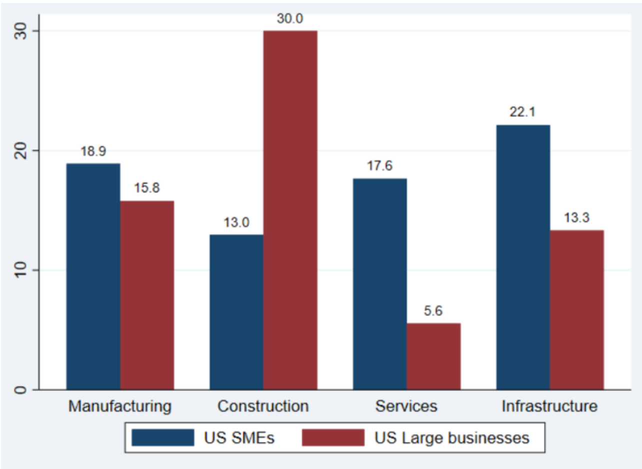
Investing in less polluting areas



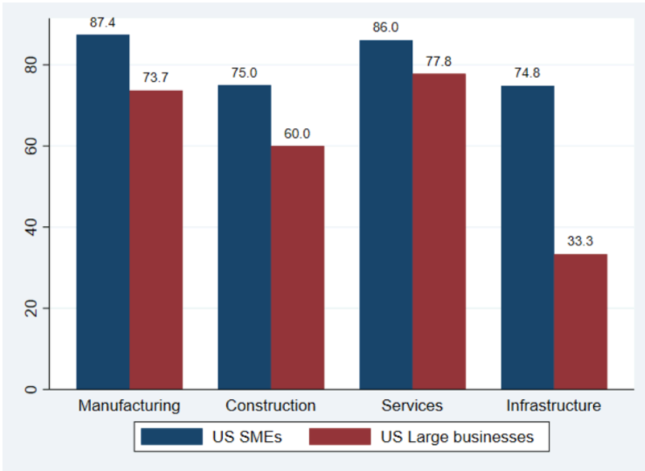
Investing in energy efficiency



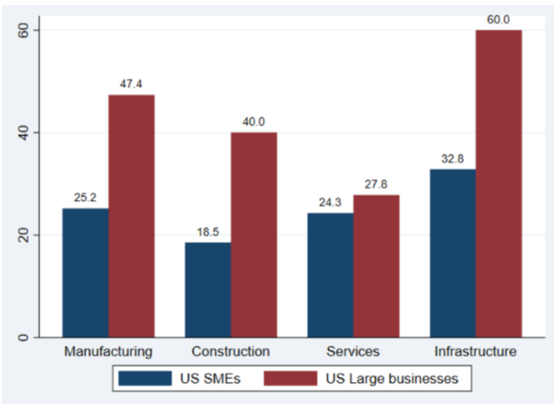
Investing in renewable energy



Investing in waste management



Investing in sustainable transport



Note: The total number of respondent businesses is 759.

Source: EIBIS (2023)

Figure 25 – Breakdown of RISE subscores in the EU and the US

Source: (World Bank, 2021).

ANNEX 2 – Stepwise specification Model 1

Table 27 – Linear Probability Models with the 1-year lag of the overall energy efficiency policy score

VARIABLES	(1) Pooled LPM	(2) Random Effects LPM	(3) Fixed Effects LPM	(4) Mundlak Correction LPM
1-year lag of overall EE policy score	0.003***	0.003***	0.003*	0.003*
	(0.000)	(0.000)	(0.001)	(0.001)
Energy cost = 1, Minor obstacle to investment	0.089***	0.074***	0.033***	0.033***
	(0.008)	(0.008)	(0.011)	(0.011)
Energy cost = 2, Majorobstacle to investment	0.141***	0.116***	0.041***	0.041***
	(0.009)	(0.009)	(0.013)	(0.013)
Using a formal strategic business monitoring system	0.067***	0.059***	0.020**	0.020**
	(0.008)	(0.007)	(0.010)	(0.010)
Implemented at one advanced digital technology	0.037***	0.035***	0.023**	0.023**
	(0.008)	(0.008)	(0.011)	(0.011)
Implemented multiple advanced digital technologies	0.101***	0.095***	0.062***	0.062***
	(0.009)	(0.009)	(0.014)	(0.014)
SME	-0.112***	-0.121***	-0.139***	-0.139***
	(0.012)	(0.012)	(0.040)	(0.040)
Sector = 2, services	-0.003	-0.002		-0.011
	(0.012)	(0.011)		(0.011)
Sector = 3, manufacturing	0.035***	0.038***		0.023**
	(0.011)	(0.011)		(0.011)

Sector = 4, infrastructure	0.007	0.006		-0.003
	(0.012)	(0.011)		(0.011)
Age is 5-10 years	0.012	0.012	0.004	0.004
	(0.023)	(0.022)	(0.035)	(0.035)
Age is 10-20 years	-0.005	0.003	-0.002	-0.002
	(0.022)	(0.021)	(0.040)	(0.040)
Age is >20 years	0.027	0.027	-0.028	-0.028
	(0.021)	(0.021)	(0.041)	(0.041)
Log of Total Fixed Assets	0.033***	0.032***	0.009**	0.009**
	(0.002)	(0.002)	(0.004)	(0.004)
profit = Break-even	0.073***	0.065***	0.036*	0.036*
	(0.015)	(0.014)	(0.020)	(0.020)
profit = Profit (positive)	0.076***	0.072***	0.054***	0.054***
	(0.011)	(0.010)	(0.015)	(0.015)
Type finance = Mostly intragroup finance	0.044**	0.056**	0.067*	0.067*
	(0.022)	(0.022)	(0.035)	(0.035)
Type finance = Mostly external finance	0.065***	0.068***	0.062***	0.062***
	(0.008)	(0.008)	(0.013)	(0.013)
region = SE	0.018	0.021		0.008
	(0.018)	(0.017)		(0.018)
region = CEE	0.124***	0.122***		0.124***
	(0.019)	(0.019)		(0.019)
region = WNE	0.132***	0.131***		0.134***
	(0.017)	(0.016)		(0.016)
d2019	-0.019*	-0.021**	-0.026**	-0.026**
	(0.010)	(0.010)	(0.011)	(0.011)

d2020	-0.078***	-0.081***	-0.089***	-0.089***
	(0.011)	(0.011)	(0.014)	(0.014)
d2021	-0.112***	-0.106***	-0.087***	-0.087***
	(0.011)	(0.011)	(0.016)	(0.016)
d2022	-0.031***	-0.030**	-0.022	-0.022
	(0.012)	(0.012)	(0.017)	(0.017)
				0.000
Mundlak terms	-	-	-	YES
Constant	-0.485***	-0.428***	0.153	-0.576***
	(0.053)	(0.052)	(0.123)	(0.059)
Observations	20,266	20,266	20,266	20,266
R-squared	0.127		0.019	
Number of idn		9,950	9,950	9,950

Robust standard errors clustered at the firm level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 28 – Linear Probability Models with the 2-year lag of the overall energy efficiency policy score

VARIABLES	(1) Pooled LPM	(2) Random Effects LPM	(3) Fixed Effects LPM	(4) Mundlak correction LPM
2-year lag of overall EE policy score	0.003***	0.003***	0.004***	0.004***
	(0.000)	(0.000)	(0.001)	(0.001)
Energy cost = 1, Minor obstacle	0.089***	0.074***	0.032***	0.032***

to investment				
	(0.008)	(0.008)	(0.011)	(0.011)
Energy cost = 2, Majorobstacle to investment	0.141***	0.116***	0.041***	0.041***
	(0.009)	(0.009)	(0.013)	(0.013)
Using a formal strategic business monitoring system	0.067***	0.058***	0.021**	0.021**
	(0.008)	(0.007)	(0.010)	(0.010)
Implemented at one advanced digital technology	0.037***	0.035***	0.023**	0.023**
	(0.008)	(0.008)	(0.011)	(0.011)
Implemented multiple advanced digital technologies	0.101***	0.095***	0.061***	0.061***
	(0.009)	(0.009)	(0.014)	(0.014)
SME	-0.111***	-0.121***	-0.138***	-0.138***
	(0.012)	(0.012)	(0.040)	(0.040)
Age is 5-10 years	0.012	0.012	0.003	0.003
	(0.023)	(0.022)	(0.035)	(0.035)
Age is 10-20 years	-0.004	0.003	-0.004	-0.004
	(0.022)	(0.021)	(0.040)	(0.040)
Age is >20 years	0.027	0.028	-0.031	-0.031
	(0.021)	(0.021)	(0.041)	(0.041)
Sector = 2, services	-0.003	-0.001		-0.010
	(0.012)	(0.011)		(0.011)
Sector = 3, manufacturing	0.036***	0.039***		0.024**
	(0.011)	(0.011)		(0.011)
Sector = 4, infrastructure	0.008	0.007		-0.002
	(0.012)	(0.011)		(0.011)
Log of Total Fixed Assets	0.033***	0.032***	0.009**	0.009**

	(0.002)	(0.002)	(0.004)	(0.004)
profit = Break-even	0.073***	0.065***	0.036*	0.036*
	(0.015)	(0.014)	(0.019)	(0.020)
profit = Profit (positive)	0.076***	0.072***	0.053***	0.053***
	(0.011)	(0.010)	(0.015)	(0.015)
Type finance = Mostly intragroup finance	0.045**	0.056***	0.067*	0.067*
	(0.022)	(0.022)	(0.035)	(0.035)
Type finance = Mostly external finance	0.065***	0.068***	0.062***	0.062***
	(0.008)	(0.008)	(0.013)	(0.013)
region = SE	0.017	0.022		0.005
	(0.018)	(0.017)		(0.018)
region = CEE	0.122***	0.123***		0.119***
	(0.019)	(0.019)		(0.019)
region = WNE	0.131***	0.132***		0.131***
	(0.017)	(0.016)		(0.016)
d2019	-0.024**	-0.026***	-0.034***	-0.034***
	(0.010)	(0.010)	(0.012)	(0.012)
d2020	-0.074***	-0.076***	-0.089***	-0.089***
	(0.011)	(0.011)	(0.014)	(0.014)
d2021	-0.114***	-0.108***	-0.100***	-0.100***
	(0.011)	(0.011)	(0.017)	(0.017)
d2022	-0.035***	-0.034***	-0.039**	-0.039**
	(0.012)	(0.012)	(0.018)	(0.018)
Mundlak terms	-	-	-	YES

Constant	-0.462***	-0.413***	0.061	-0.540***
	(0.052)	(0.051)	(0.119)	(0.058)
Observations	20,229	20,229	20,229	20,229
R-squared	0.127		0.020	
Number of idn		9,927	9,927	9,927

Robust standard errors clustered at the firm level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 29 – Linear Probability Models with the 1-year lag of the energy efficiency policy sub-scores

	(1)	(2)	(3)	(4)
VARIABLES	Pooled LPM	Random Effects LPM	Fixed Effects LPM	Mundlak correction LPM
All Policy Scores are lagged by 1 year				
National Planning	0.000	0.000*	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
Energy Efficiency Entities	-0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
Incentives and Mandates for the Public Sector	0.001***	0.001***	-0.000	-0.000
	(0.000)	(0.000)	(0.002)	(0.002)
Incentives and Mandates for the Industrial and Commercial Sectors	0.000	0.000	-0.001	-0.001
	(0.000)	(0.000)	(0.002)	(0.002)
Incentives and Mandates for Energy Utility Programmes	0.001***	0.001***	-0.006**	-0.006**
	(0.000)	(0.000)	(0.003)	(0.003)

Labelling System	0.002***	0.002***	-0.002	-0.002
	(0.000)	(0.000)	(0.002)	(0.002)
Minimum EE Standard	-0.000	0.000	0.001	0.001
	(0.000)	(0.000)	(0.001)	(0.001)
Building Codes	-0.002***	-0.002***	-0.001	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)
Transport Sector	-0.001**	-0.001**	0.001	0.001
	(0.000)	(0.000)	(0.002)	(0.002)
Carbon Pricing Mechanism	0.000	0.000	-0.001	-0.001
	(0.000)	(0.000)	(0.001)	(0.001)
Financing Schemes for EE	-0.000	-0.000	0.001	0.001
	(0.000)	(0.000)	(0.002)	(0.002)
Construction Sector # Incentives and Mandates for the Industrial and Commercial Sectors	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Services Sector # Incentives and Mandates for the Industrial and Commercial Sectors	0.001	0.001	0.002	0.002
	(0.000)	(0.000)	(0.002)	(0.002)
Manufacturing Sector # Incentives and Mandates for the Industrial and Commercial Sectors	0.001*	0.001**	0.003	0.003
	(0.000)	(0.000)	(0.002)	(0.002)
Infrastructure Sector # Incentives and Mandates for the Industrial and Commercial Sectors	-0.000	-0.000	0.004*	0.004*
	(0.000)	(0.000)	(0.002)	(0.002)
Energy cost = 1, Minor obstacle to investment	0.089***	0.075***	0.033***	0.033***
	(0.008)	(0.008)	(0.011)	(0.011)

Energy cost = 2, Minor obstacle to investment	0.139***	0.115***	0.040***	0.040***
	(0.009)	(0.009)	(0.013)	(0.013)
Using a formal strategic business monitoring system	0.064***	0.055***	0.020*	0.020*
	(0.008)	(0.007)	(0.010)	(0.010)
Implemented at one advanced digital technology	0.038***	0.036***	0.024**	0.024**
	(0.008)	(0.008)	(0.011)	(0.011)
Implemented multiple advanced digital technologies	0.101***	0.095***	0.061***	0.061***
	(0.009)	(0.009)	(0.014)	(0.014)
SME	-0.111***	-0.121***	-0.136***	-0.136***
	(0.012)	(0.012)	(0.039)	(0.039)
Sector = 2, services	-0.044	-0.047		-0.046
	(0.034)	(0.033)		(0.034)
Sector = 3, manufacturing	-0.021	-0.019		-0.025
	(0.032)	(0.031)		(0.032)
Sector = 4, infrastructure	0.007	0.004		0.009
	(0.033)	(0.032)		(0.032)
Age is 5-10 years	0.006	0.007	0.003	0.003
	(0.023)	(0.022)	(0.035)	(0.035)
Age is 10-20 years	-0.009	-0.000	-0.002	-0.002
	(0.022)	(0.021)	(0.040)	(0.040)
Age is >20 years	0.021	0.022	-0.029	-0.029
	(0.021)	(0.021)	(0.041)	(0.041)
Log of Total Fixed Assets	0.033***	0.031***	0.011***	0.011***
	(0.002)	(0.002)	(0.004)	(0.004)

profit = Break-even	0.077***	0.068***	0.034*	0.034*
	(0.015)	(0.014)	(0.020)	(0.020)
profit = Profit (positive)	0.079***	0.074***	0.053***	0.053***
	(0.011)	(0.010)	(0.015)	(0.015)
Type finance = Mostly intragroup finance	0.045**	0.056**	0.066*	0.066*
	(0.022)	(0.022)	(0.035)	(0.035)
Type finance = Mostly external finance	0.067***	0.069***	0.062***	0.062***
	(0.008)	(0.008)	(0.013)	(0.013)
region = SE	0.020	0.024		-0.002
	(0.026)	(0.025)		(0.027)
region = CEE	0.107***	0.108***		0.100***
	(0.029)	(0.028)		(0.030)
region = WNE	0.104***	0.101***		0.103***
	(0.021)	(0.020)		(0.022)
d2019	-0.016	-0.018*	-0.026**	-0.026**
	(0.010)	(0.010)	(0.012)	(0.012)
d2020	-0.065***	-0.072***	-0.091***	-0.091***
	(0.012)	(0.012)	(0.017)	(0.017)
d2021	-0.100***	-0.098***	-0.079***	-0.079***
	(0.013)	(0.013)	(0.020)	(0.020)
d2022	-0.020	-0.021	-0.010	-0.010
	(0.014)	(0.014)	(0.021)	(0.021)
Constant	-0.357***	-0.298***	0.694***	-0.464***
	(0.070)	(0.068)	(0.268)	(0.083)
Observations	20,266	20,266	20,266	20,266

R-squared	0.133		0.022	
Number of idn		9,950	9,950	9,950

Robust standard errors clustered at the firm level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 30 – Linear Probability Models with the 2-year lag of the energy efficiency policy sub-scores

	(1)	(2)	(3)	(4)
VARIABLES	Pooled LPM	Random Effects LPM	Fixed Effects LPM	Mundlak correction LPM
All policy variables are lagged by 2 years				
National Planning	0.001**	0.001***	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
Energy Efficiency Entities	-0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
Incentives and Mandates for the Public Sector	0.001***	0.001***	0.000	0.000
	(0.000)	(0.000)	(0.002)	(0.002)
Incentives and Mandates for the Industrial and Commercial Sectors	0.000	0.000	-0.002	-0.002
	(0.000)	(0.000)	(0.002)	(0.002)
Incentives and Mandates for Energy Utility Programmes	0.001***	0.001***	-0.000	-0.000
	(0.000)	(0.000)	(0.001)	(0.001)
Labelling System	0.001***	0.001***	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
Minimum EE Standard	-0.000	-0.000	0.000	0.000

	(0.000)	(0.000)	(0.001)	(0.001)
Building Codes	-0.001**	-0.002***	-0.001	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)
Transport Sector	-0.001**	-0.001**	-0.001	-0.001
	(0.000)	(0.000)	(0.001)	(0.001)
Carbon Pricing Mechanism	0.000	0.000		0.000
	(0.000)	(0.000)		(0.000)
Financing Schemes for EE	-0.000	-0.000	0.003*	0.003*
	(0.000)	(0.000)	(0.002)	(0.002)
Construction Sector # Incentives and Mandates for the Industrial and Commercial Sectors	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Services Sector # Incentives and Mandates for the Industrial and Commercial Sectors	0.000	0.001	0.002	0.002
	(0.000)	(0.000)	(0.002)	(0.002)
Manufacturing Sector # Incentives and Mandates for the Industrial and Commercial Sectors	0.001*	0.001*	0.003	0.003
	(0.000)	(0.000)	(0.002)	(0.002)
Infrastructure Sector # Incentives and Mandates for the Industrial and Commercial Sectors	-0.000	-0.000	0.003	0.003
	(0.000)	(0.000)	(0.002)	(0.002)
Energy cost = 1, Minor obstacle to investment	0.089***	0.074***	0.032***	0.032***
	(0.008)	(0.008)	(0.011)	(0.011)
Energy cost = 2, Minor obstacle to investment	0.138***	0.114***	0.040***	0.040***
	(0.009)	(0.009)	(0.013)	(0.013)

Using a formal strategic business monitoring system	0.064***	0.056***	0.022**	0.022**
	(0.008)	(0.007)	(0.010)	(0.010)
Implemented at one advanced digital technology	0.038***	0.036***	0.023**	0.023**
	(0.008)	(0.008)	(0.011)	(0.011)
Implemented multiple advanced digital technologies	0.101***	0.094***	0.061***	0.061***
	(0.009)	(0.009)	(0.014)	(0.014)
SME	-0.109***	-0.119***	-0.135***	-0.135***
	(0.012)	(0.012)	(0.040)	(0.040)
Sector = 2, services	-0.034	-0.036		-0.036
	(0.032)	(0.031)		(0.032)
Sector = 3, manufacturing	-0.014	-0.011		-0.018
	(0.030)	(0.030)		(0.030)
Sector = 4, infrastructure	0.008	0.006		0.009
	(0.031)	(0.031)		(0.031)
Age is 5-10 years	0.008	0.010	0.002	0.002
	(0.023)	(0.022)	(0.035)	(0.035)
Age is 10-20 years	-0.006	0.002	-0.004	-0.004
	(0.022)	(0.021)	(0.040)	(0.040)
Age is >20 years	0.024	0.025	-0.031	-0.031
	(0.021)	(0.021)	(0.041)	(0.041)
Log of Total Fixed Assets	0.033***	0.032***	0.009**	0.009**
	(0.002)	(0.002)	(0.004)	(0.004)
profit = Break-even	0.077***	0.067***	0.035*	0.035*
	(0.015)	(0.014)	(0.020)	(0.020)
profit = Profit (positive)	0.079***	0.074***	0.053***	0.053***

	(0.011)	(0.010)	(0.015)	(0.015)
Type finance = Mostly intragroup finance	0.046**	0.056***	0.067*	0.067*
	(0.022)	(0.022)	(0.035)	(0.035)
Type finance = Mostly external finance	0.067***	0.069***	0.062***	0.062***
	(0.008)	(0.008)	(0.013)	(0.013)
region = SE	0.025	0.026		0.004
	(0.025)	(0.025)		(0.027)
region = CEE	0.123***	0.118***		0.123***
	(0.028)	(0.027)		(0.030)
region = WNE	0.119***	0.115***		0.124***
	(0.020)	(0.020)		(0.021)
d2019	-0.035***	-0.036***	-0.028**	-0.028**
	(0.011)	(0.010)	(0.014)	(0.014)
d2020	-0.080***	-0.084***	-0.084***	-0.084***
	(0.012)	(0.011)	(0.015)	(0.015)
d2021	-0.118***	-0.115***	-0.096***	-0.096***
	(0.013)	(0.013)	(0.020)	(0.020)
d2022	-0.043***	-0.044***	-0.033	-0.033
	(0.014)	(0.014)	(0.022)	(0.022)
Constant	-0.397***	-0.348***	0.191	-0.483***
	(0.066)	(0.064)	(0.198)	(0.075)
Observations	20,229	20,229	20,229	20,229
R-squared	0.133		0.021	
Number of idn		9,927	9,927	9,927

Robust standard errors clustered at the firm level in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 31 – Robustness Checks for Model 1, **Equation 1** using the 1-year lag of the Overall Policy Score.

Results are expressed in odds ratios.

VARIABLES	(1) Pooled logit	(2) Random Effects logit	(4) Fixed Effects logit	(5) Mundlak correction logit
1-year lag of overall EE policy score	1.014***	1.018***	1.016*	1.017*
	(0.002)	(0.003)	(0.009)	(0.010)
Energy cost = 1, Minor obstacle to investment	1.548***	1.636***	1.217***	1.240***
	(0.063)	(0.087)	(0.087)	(0.088)
Energy cost = 2, Majorobstacle to investment	1.966***	2.120***	1.276***	1.299***
	(0.088)	(0.124)	(0.106)	(0.112)
Using a formal strategic business monitoring system	1.364***	1.446***	1.122*	1.136*
	(0.048)	(0.066)	(0.074)	(0.074)
Implemented at one advanced digital technology	1.190***	1.250***	1.147*	1.158**
	(0.047)	(0.064)	(0.083)	(0.084)
Implemented multiple advanced digital technologies	1.582***	1.806***	1.464***	1.474***
	(0.068)	(0.102)	(0.130)	(0.131)
SME	0.631***	0.494***	0.515***	0.442***
	(0.035)	(0.037)	(0.127)	(0.107)
Age is 5-10 years	1.090	1.105	1.038	1.040
	(0.133)	(0.173)	(0.238)	(0.248)
Age is 10-20 years	1.010	1.041	0.959	0.994
	(0.117)	(0.156)	(0.245)	(0.269)

Age is >20 years	1.171	1.214	0.796	0.831
	(0.131)	(0.176)	(0.211)	(0.231)
Sector = 2, services	0.988	0.998		0.943
	(0.056)	(0.075)		(0.072)
Sector = 3, manufacturing	1.176***	1.281***		1.161**
	(0.064)	(0.092)		(0.086)
Sector = 4, infrastructure	1.035	1.041		0.979
	(0.059)	(0.078)		(0.075)
Log of Total Fixed Assets	1.173***	1.229***	1.053**	1.059**
	(0.011)	(0.015)	(0.027)	(0.028)
profit = Break-even	1.431***	1.532***	1.226	1.265*
	(0.107)	(0.148)	(0.165)	(0.165)
profit = Profit (positive)	1.444***	1.594***	1.417***	1.428***
	(0.077)	(0.110)	(0.141)	(0.141)
Type finance = Mostly intragroup finance	1.226**	1.415**	1.654**	1.559*
	(0.127)	(0.197)	(0.408)	(0.354)
Type finance = Mostly external finance	1.348***	1.525***	1.450***	1.481***
	(0.051)	(0.076)	(0.112)	(0.119)
region = SE	1.079	1.141		1.042
	(0.093)	(0.130)		(0.122)
region = CEE	1.785***	2.205***		2.263***
	(0.168)	(0.274)		(0.293)
region = WNE	1.869***	2.347***		2.424***
	(0.150)	(0.250)		(0.266)
d2019	0.918*	0.878**	0.847**	0.849**
	(0.044)	(0.056)	(0.063)	(0.062)

d2020	0.693***	0.593***	0.569***	0.563***
	(0.036)	(0.042)	(0.051)	(0.053)
d2021	0.591***	0.507***	0.578***	0.572***
	(0.031)	(0.036)	(0.057)	(0.060)
d2022	0.860***	0.824***	0.885	0.870
	(0.048)	(0.061)	(0.094)	(0.097)
Mundlak terms	-	-	-	YES
Constant	0.008***	0.002***		0.001***
	(0.002)	(0.001)		(0.000)
Observations	20,266	20,266	7,117	20,266
Number of idn		9,950	2,584	9,950

Robust standard errors clustered at the firm level in parentheses

*** p<0.01, ** p<0.05, * p<0.1[29]

Table 32 – Robustness Checks for Model 1, **Equation 1** using the 2-year lag of the Overall Policy Score.

Results are expressed in odds ratios.

	(1)	(2)	(4)	(5)
VARIABLES	Pooled logit	Random Effects logit	Fixed Effects logit	Mundlak correction logit
2-year lag of overall EE policy score	1.013***	1.017***	1.025***	1.027***
	(0.002)	(0.003)	(0.009)	(0.009)

[29] Except for fixed effects logit model which does not admit clustered standard errors.

Energy cost = 1, Minor obstacle to investment	1.545***	1.634***	1.215***	1.237***
	(0.063)	(0.087)	(0.087)	(0.088)
Energy cost = 2, Majorobstacle to investment	1.962***	2.118***	1.278***	1.301***
	(0.088)	(0.124)	(0.106)	(0.112)
Using a formal strategic business monitoring system	1.361***	1.444***	1.127*	1.142**
	(0.048)	(0.066)	(0.074)	(0.075)
Implemented at one advanced digital technology	1.190***	1.252***	1.154**	1.163**
	(0.047)	(0.064)	(0.084)	(0.085)
Implemented multiple advanced digital technologies	1.580***	1.803***	1.464***	1.472***
	(0.068)	(0.102)	(0.131)	(0.131)
SME	0.632***	0.494***	0.514***	0.443***
	(0.035)	(0.037)	(0.127)	(0.108)
Age is 5-10 years	1.093	1.107	1.031	1.031
	(0.134)	(0.174)	(0.236)	(0.247)
Age is 10-20 years	1.013	1.044	0.948	0.983
	(0.117)	(0.157)	(0.243)	(0.266)
Age is >20 years	1.175	1.216	0.787	0.819
	(0.131)	(0.177)	(0.209)	(0.228)
Sector = 2, services	0.992	1.004		0.949
	(0.057)	(0.075)		(0.073)
Sector = 3, manufacturing	1.181***	1.290***		1.171**
	(0.065)	(0.093)		(0.087)
Sector = 4, infrastructure	1.039	1.049		0.986
	(0.059)	(0.079)		(0.076)

Log of Total Fixed Assets	1.173***	1.229***	1.054**	1.061**
	(0.011)	(0.015)	(0.027)	(0.028)
profit = Break-even	1.431***	1.532***	1.231	1.268*
	(0.107)	(0.148)	(0.166)	(0.165)
profit = Profit (positive)	1.444***	1.593***	1.414***	1.423***
	(0.078)	(0.110)	(0.141)	(0.141)
Type finance = Mostly intragroup finance	1.229**	1.421**	1.646**	1.565**
	(0.127)	(0.197)	(0.406)	(0.355)
Type finance = Mostly external finance	1.349***	1.528***	1.452***	1.483***
	(0.051)	(0.076)	(0.112)	(0.120)
region = SE	1.075	1.147		1.022
	(0.093)	(0.131)		(0.121)
region = CEE	1.772***	2.224***		2.186***
	(0.167)	(0.278)		(0.284)
region = WNE	1.862***	2.362***		2.383***
	(0.149)	(0.253)		(0.262)
d2019	0.895**	0.849**	0.805***	0.803***
	(0.043)	(0.055)	(0.063)	(0.062)
d2020	0.706***	0.609***	0.568***	0.560***
	(0.037)	(0.042)	(0.049)	(0.050)
d2021	0.583***	0.497***	0.536***	0.526***
	(0.031)	(0.036)	(0.057)	(0.058)
d2022	0.845***	0.802***	0.797*	0.777**
	(0.048)	(0.061)	(0.093)	(0.093)
Constant	0.009***	0.002***		0.001***
	(0.002)	(0.001)		(0.000)

Mundlak terms	-	-	-	YES
Observations	20,229	20,229	7,102	20,229
Number of idn		9,927	2,577	9,927

Robust standard errors clustered at the firm level in parentheses

*** p<0.01, ** p<0.05, * p<0.1[30]

Table 33 – Robustness checks Model 1 **Equation 2** with the 1-year lag of policy sub-components

Results are expressed in odds ratios.

	(1)	(2)	(4)	(5)
VARIABLES	Pooled Logit	Random Effects Logit	Fixed Effects Logit	Mundlak correction
All Policy Scores are lagged by 1 year				
National Planning	1.002	1.003*	1.006**	1.006**
	(0.001)	(0.002)	(0.003)	(0.003)
Energy Efficiency Entities	0.999	0.999	1.000	1.000
	(0.002)	(0.002)	(0.003)	(0.004)
Incentives and Mandates for the Public Sector	1.007***	1.010***	1.000	0.998
	(0.002)	(0.003)	(0.013)	(0.014)
Incentives and Mandates for the Industrial and Commercial Sectors	1.002	1.001	0.990	0.990
	(0.002)	(0.003)	(0.013)	(0.014)

[30] Except for fixed effects logit model which does not admit clustered standard errors.

Incentives and Mandates for Energy Utility Programmes	1.006***	1.008***	0.961**	0.961**
	(0.002)	(0.002)	(0.015)	(0.016)
Labelling System	1.008***	1.010***	0.986	0.984
	(0.001)	(0.002)	(0.012)	(0.013)
Minimum EE Standard	1.000	1.001	1.004	1.004
	(0.001)	(0.002)	(0.004)	(0.004)
Building Codes	0.990***	0.986***	0.996	0.994
	(0.003)	(0.004)	(0.011)	(0.011)
Transport Sector	0.995**	0.993**	1.008	1.008
	(0.002)	(0.003)	(0.013)	(0.013)
Carbon Pricing Mechanism	1.001	1.000	0.994	0.994
	(0.002)	(0.002)	(0.007)	(0.005)
Financing Schemes for EE	0.999	0.999	1.007	1.006
	(0.002)	(0.002)	(0.012)	(0.013)
Construction Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)
Services Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.003	1.004	1.016	1.017
	(0.002)	(0.003)	(0.015)	(0.016)
Manufacturing Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.004*	1.005*	1.018	1.020
	(0.002)	(0.003)	(0.014)	(0.015)
Infrastructure Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.000	1.000	1.025*	1.026*
	(0.002)	(0.003)	(0.015)	(0.015)
		(0.003)		

Energy cost = 1, Minor obstacle to investment	1.552***	1.640***	1.215***	1.243***
	(0.064)	(0.087)	(0.088)	(0.089)
Energy cost = 2, Major obstacle to investment	1.954***	2.106***	1.268***	1.298***
	(0.089)	(0.124)	(0.106)	(0.112)
Using a formal strategic business monitoring system	1.341***	1.411***	1.111	1.131*
	(0.047)	(0.065)	(0.074)	(0.074)
Implemented at one advanced digital technology	1.201***	1.262***	1.149*	1.167**
	(0.048)	(0.065)	(0.084)	(0.085)
Implemented multiple advanced digital technologies	1.587***	1.807***	1.457***	1.474***
	(0.069)	(0.102)	(0.131)	(0.131)
SME	0.628***	0.493***	0.536**	0.450***
	(0.035)	(0.037)	(0.134)	(0.109)
Sector = 2, services	0.814	0.742		0.745
	(0.138)	(0.166)		(0.173)
Sector = 3, manufacturing	0.923	0.913		0.881
	(0.143)	(0.187)		(0.187)
Sector = 4, infrastructure	1.045	1.030		1.068
	(0.166)	(0.217)		(0.234)
Age is 5-10 years	1.059	1.073	1.023	1.029
	(0.130)	(0.169)	(0.235)	(0.245)
Age is 10-20 years	0.989	1.021	0.930	0.985
	(0.115)	(0.153)	(0.238)	(0.267)
Age is >20 years	1.141	1.176	0.768	0.818

	(0.128)	(0.171)	(0.204)	(0.227)
Log of Total Fixed Assets	1.173***	1.227***	1.062**	1.071**
	(0.011)	(0.015)	(0.027)	(0.029)
profit = Break-even	1.464***	1.567***	1.229	1.257*
	(0.110)	(0.151)	(0.166)	(0.165)
profit = Profit (positive)	1.468***	1.620***	1.422***	1.422***
	(0.079)	(0.112)	(0.142)	(0.141)
Type finance = Mostly intragroup finance	1.231**	1.413**	1.636**	1.561*
	(0.128)	(0.197)	(0.407)	(0.355)
Type finance = Mostly external finance	1.359***	1.534***	1.450***	1.484***
	(0.052)	(0.077)	(0.112)	(0.120)
region = SE	1.068	1.134		0.966
	(0.132)	(0.185)		(0.175)
region = CEE	1.647***	2.001***		1.931***
	(0.228)	(0.364)		(0.390)
region = WNE	1.632***	1.935***		1.996***
	(0.163)	(0.255)		(0.288)
d2019	0.928	0.893*	0.837**	0.843**
	(0.045)	(0.058)	(0.066)	(0.064)
d2020	0.733***	0.628***	0.552***	0.550***
	(0.043)	(0.049)	(0.061)	(0.062)
d2021	0.621***	0.531***	0.593***	0.596***
	(0.038)	(0.043)	(0.075)	(0.077)
d2022	0.906	0.870	0.928	0.934
	(0.059)	(0.075)	(0.127)	(0.129)
Constant	0.015***	0.005***		0.002***
	(0.005)	(0.002)		(0.001)

Mundlak terms	-	-	-	YES
Observations	20,266	20,266	7,117	20,266
Number of idn		9,950	2,584	9,950

Robust standard errors clustered at the firm level in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$[31]

Table 34 – Robustness checks Model 1 **Equation 2** with the 2-year lag of policy sub-components

Results are expressed in odds ratios.

VARIABLES	(1) Pooled Logit	(2) Random Effects Logit	(4) Fixed Effects Logit	(5) Mundlak correction
All Policy Scores are lagged by 2 years				
National Planning	1.003**	1.005***	1.005**	1.006**
	(0.001)	(0.001)	(0.003)	(0.003)
Energy Efficiency Entities	0.998	0.998	1.001	1.001
	(0.001)	(0.002)	(0.003)	(0.003)
Incentives and Mandates for the Public Sector	1.007***	1.009***	1.004	1.004
	(0.002)	(0.003)	(0.012)	(0.013)
Incentives and Mandates for the Industrial and Commercial Sectors	1.001	1.001	0.990	0.987
	(0.002)	(0.003)	(0.011)	(0.013)

[31] Except for fixed effects logit model which does not admit clustered standard errors.

Incentives and Mandates for Energy Utility Programmes	1.005***	1.006***	0.997	0.998
	(0.002)	(0.002)	(0.007)	(0.007)
Labelling System	1.006***	1.008***	1.002	1.002
	(0.001)	(0.001)	(0.004)	(0.004)
Minimum EE Standard	1.000	0.999	1.002	1.002
	(0.001)	(0.002)	(0.004)	(0.004)
Building Codes	0.993**	0.991***	0.995	0.994
	(0.003)	(0.004)	(0.010)	(0.010)
Transport Sector	0.995**	0.994**	0.996	0.996
	(0.002)	(0.003)	(0.009)	(0.009)
Carbon Pricing Mechanism	1.002	1.003		1.001
	(0.002)	(0.002)		(0.003)
Financing Schemes for EE	1.000	1.000	1.017	1.018*
	(0.002)	(0.002)	(0.011)	(0.011)
Construction Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)
Services Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.002	1.003	1.010	1.014
	(0.002)	(0.003)	(0.013)	(0.015)
Manufacturing Sector # Incentives and Mandates for the Industrial and Commercial Sectors	1.003	1.004	1.016	1.020
	(0.002)	(0.003)	(0.013)	(0.014)
Infrastructure Sector # Incentives and Mandates for the Industrial and Commercial Sectors	0.999	1.000	1.021	1.021
	(0.002)	(0.003)	(0.015)	(0.016)

Energy cost = 1, Minor obstacle to investment	1.547***	1.634***	1.212***	1.234***
	(0.064)	(0.087)	(0.087)	(0.088)
Energy cost = 2, Majorobstacle to investment	1.944***	2.095***	1.269***	1.295***
	(0.088)	(0.124)	(0.106)	(0.112)
Using a formal strategic business monitoring system	1.344***	1.420***	1.127*	1.144**
	(0.048)	(0.065)	(0.075)	(0.075)
Implemented at one advanced digital technology	1.201***	1.262***	1.155**	1.166**
	(0.048)	(0.065)	(0.084)	(0.085)
Implemented multiple advanced digital technologies	1.588***	1.806***	1.458***	1.470***
	(0.069)	(0.102)	(0.131)	(0.131)
SME	0.634***	0.499***	0.528***	0.451***
	(0.036)	(0.037)	(0.131)	(0.110)
Sector = 2, services	0.858	0.805		0.800
	(0.140)	(0.173)		(0.177)
Sector = 3, manufacturing	0.956	0.965		0.922
	(0.143)	(0.190)		(0.187)
Sector = 4, infrastructure	1.055	1.055		1.071
	(0.162)	(0.216)		(0.225)
Age is 5-10 years	1.069	1.086	1.030	1.024
	(0.131)	(0.171)	(0.236)	(0.245)
Age is 10-20 years	0.999	1.036	0.949	0.976
	(0.116)	(0.156)	(0.243)	(0.265)
Age is >20 years	1.153	1.196	0.785	0.815

	(0.130)	(0.174)	(0.208)	(0.227)
Log of Total Fixed Assets	1.174***	1.229***	1.051**	1.059**
	(0.011)	(0.015)	(0.027)	(0.028)
profit = Break-even	1.463***	1.563***	1.216	1.260*
	(0.110)	(0.151)	(0.165)	(0.165)
profit = Profit (positive)	1.467***	1.615***	1.410***	1.421***
	(0.079)	(0.111)	(0.141)	(0.141)
Type finance = Mostly intragroup finance	1.235**	1.419**	1.607*	1.566**
	(0.128)	(0.197)	(0.399)	(0.356)
Type finance = Mostly external finance	1.358***	1.533***	1.450***	1.485***
	(0.052)	(0.077)	(0.112)	(0.120)
region = SE	1.105	1.169		1.014
	(0.135)	(0.188)		(0.180)
region = CEE	1.784***	2.156***		2.239***
	(0.239)	(0.379)		(0.441)
region = WNE	1.765***	2.114***		2.282***
	(0.172)	(0.270)		(0.315)
d2019	0.851***	0.794***	0.827**	0.833**
	(0.043)	(0.054)	(0.076)	(0.075)
d2020	0.682***	0.582***	0.578***	0.576***
	(0.038)	(0.043)	(0.058)	(0.059)
d2021	0.571***	0.476***	0.536***	0.535***
	(0.037)	(0.041)	(0.070)	(0.071)
d2022	0.813***	0.752***	0.805	0.804
	(0.055)	(0.068)	(0.118)	(0.117)
Mundlak terms	-	-	-	YES

Constant	0.012***	0.004***		0.001***
	(0.004)	(0.002)		(0.001)
Observations	20,229	20,229	7,102	20,229
Number of idn		9,927	2,577	9,927

Robust standard errors clustered at the firm level in parentheses
*** p<0.01, ** p<0.05, * p<0.1[32]

[32] Except for fixed effects logit model which does not admit clustered standard errors.

7. Declaration on the usage of AI

I declare that the artificial intelligence ChatGPT was used to proofread parts of this Master Thesis.

References

Abadie, L.M., Ortiz, R.A., Galarraga, I., 2012. Determinants of energy efficiency investments in the US. Energy Policy 45, 551–566. https://doi.org/10.1016/j.enpol.2012.03.002

Agrawal, R., De Tommasi, L., Lyons, P., Zanoni, S., Papagiannis, G.K., Karakosta, C., Papapostolou, A., Durand, A., Martinez, L., Fragidis, G., Corbella, M., Sileni, L., Neusel, L., Repetto, M., Mariuzzo, I., Kakardakos, T., Güemes, E.L., 2023. Challenges and opportunities for improving energy efficiency in SMEs: learnings from seven European projects. Energy Effic. 16, 17. https://doi.org/10.1007/s12053-023-10090-z

Allcott, H., 2011. Consumers' Perceptions and Misperceptions of Energy Costs. Am. Econ. Rev. 101, 98–104. https://doi.org/10.1257/aer.101.3.98

Bailey, E.E., Coleman, R.D., 1971. The Effect of Lagged Regulation in an Averch-Johnson Model. Bell J. Econ. Manag. Sci. 2, 278–292. https://doi.org/10.2307/3003168

Bansal, S., Filippini, M., Srinivasan, S., 2023. How regulation might fail to reduce energy consumption while still stimulating total factor productivity growth. Economics Working Paper Series.

Beatriz, M., Coffinet, J., Nicolas, T., 2022. Relationship lending and SMEs' funding costs over the cycle: Why diversification of borrowing matters. J. Bank. Finance 138, 105471. https://doi.org/10.1016/j.jbankfin.2018.12.007

Beaver, G., 2003. Small business: success and failure. Strateg. Change 12, 115–122. https://doi.org/10.1002/jsc.624

Beck, T., Demirgüç-Kunt, A., Laeven, L., Maksimovic, V., 2006. The determinants of financing obstacles. J. Int. Money Finance 25, 932–952. https://doi.org/10.1016/j.jimonfin.2006.07.005

Beck, T., Demirgüç-Kunt, A., Maksimovic, V., 2005. Financial and Legal Constraints to Growth: Does Firm Size Matter? J. Finance 60, 137–177. https://doi.org/10.1111/j.1540-6261.2005.00727.x

Bertoldi, P., 2022. Policies for energy conservation and sufficiency: Review of existing policies and recommendations for new and effective policies in OECD countries. Energy Build. 264, 112075. https://doi.org/10.1016/j.enbuild.2022.112075

Blundel, R., Hampton, S., 2021. How Can SMEs Contribute to Net Zero?: An Evidence Review. State Art Rev. Ser.

Brunke, J.-C., Johansson, M., Thollander, P., 2014. Empirical investigation of barriers and drivers to the adoption of energy conservation measures, energy management practices and energy services in the Swedish iron and steel industry. Spec. Vol. Sustain. Agenda Miner. Energy Supply Demand Netw. Integr. Anal. Ecol. Ethical Econ. Technol. Dimens. 84, 509–525. https://doi.org/10.1016/j.jclepro.2014.04.078

Brutscher, P.-B., Coali, A., Delanote, J., Harasztosi, P., 2020. EIB Group Survey on Investment and Investment Finance: A technical note on data quality (EIB Working Papers No. 2020/08). European Investment Bank (EIB), Luxembourg. https://doi.org/10.2867/772584

Cagno, E., Ramirez-Portilla, A., Trianni, A., 2015. Linking energy efficiency and innovation practices: Empirical evidence from the foundry sector. Energy Policy 83, 240–256. https://doi.org/10.1016/j.enpol.2015.02.023

Caporale, G.M., Donati, C., Spagnolo, N., 2023. Small and medium sized European firms and energy saving measures: The role of financing. Energy Policy 179, 113613. https://doi.org/10.1016/j.enpol.2023.113613

CDP, We Mean Business, New Climate Institute, 2023. Annual report 2023. We Mean Bus. Coalit. URL https://www.wemeanbusinesscoalition.org/about/ (accessed 11.6.24).

CDP, We Mean Business, New Climate Institute, 2016. The Business End of Climate Change [WWW Document]. Bus. End Clim. Change. URL

https://static1.squarespace.com/static/575ecca7b654f9dd886dec23/t/576c39fdd2b857d28be73608/1466710526653/The+Business+End+of+Climate+Change.pdf (accessed 1.18.24).
Chamberlain, G., 1980. Analysis of Covariance with Qualitative Data. Rev. Econ. Stud. 47, 225–238. https://doi.org/10.2307/2297110
Choi, H., Anadón, L.D., 2014. The role of the complementary sector and its relationship with network formation and government policies in emerging sectors: The case of solar photovoltaics between 2001 and 2009. Technol. Forecast. Soc. Change 82, 80–94. https://doi.org/10.1016/j.techfore.2013.06.002
Climate Action Tracker, 2022. USA [WWW Document]. URL https://climateactiontracker.org/countries/usa/ (accessed 1.18.24).
Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - “Think Small First” - A “Small Business Act” for Europe {SEC(2008) 2101} {SEC(2008) 2102}, 2008.
Cubbin, J., Stern, J., 2006. The Impact of Regulatory Governance and Privatization on Electricity Industry Generation Capacity in Developing Economies. World Bank Econ. Rev. 20, 115–141.
DeCanio, S.J., Watkins, W.E., 1998. Investment in Energy Efficiency: Do the Characteristics of Firms Matter? Rev. Econ. Stat. 80, 95–107.
Directive 2003/361/EC of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (Text with EEA relevance) (notified under document number C(2003) 1422), 2003. , OJ L.
Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast) (Text with EEA relevance), 2009.
Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), 2010.
Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance, 2012.
Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (Text with EEA relevance), 2023. , OJ L.
Directorate-Generral for Climate Action, E.C., 2020. Financing the energy transition: Commission puts €14 billion fund to modernise energy sectors in 10 Member States into action - European Commission [WWW Document]. Clim. Action. URL https://climate.ec.europa.eu/news-your-voice/news/financing-energy-transition-commission-puts-eu14-billion-fund-modernise-energy-sectors-10-member-2020-07-09_en (accessed 2.13.24).
EIA, 2022. U.S. energy facts explained - consumption and production - U.S. Energy Information Administration (EIA) [WWW Document]. URL https://www.eia.gov/energyexplained/us-energy-facts/ (accessed 2.11.24).
EIB, 2024. EIB Investment Survey (EIBIS) - Details [WWW Document]. EIB.org. URL https://www.eib.org/en/publications-research/economics/surveys-data/eibis/about/index.htm (accessed 2.14.24).
EIB, 2021. Building a smart and green Europe in the COVID-19 era, Investment report 202/2021.
EIB, 2020. EIB Group Survey of Investment and Investment Finance Technical Report.
European Climate, Infrastructure and Environment Executive Agency, E.C., 2024. Horizon 2020 Energy Efficiency - European Commission [WWW Document]. URL https://cinea.ec.europa.eu/programmes/horizon-europe/energy-use-horizon-europe/horizon-2020-energy-efficiency_en (accessed 2.13.24).

European Climate, Infrastructure and Environment Executive Agency, E.C., 2023. Innovation Fund - European Commission [WWW Document]. URL https://cinea.ec.europa.eu/programmes/innovation-fund_en (accessed 2.13.24).
European Commission, 2024. Recovery and Resilience Facility for clean energy - European Commission [WWW Document]. URL https://energy.ec.europa.eu/topics/funding-and-financing/recovery-and-resilience-facility-clean-energy_en (accessed 11.23.24).
European Commission, 2023. Championing Europe's SMEs [WWW Document]. Eur. Comm. - Eur. Comm. URL https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4409 (accessed 2.13.24).
European Commission, 2022a. Eurobarometer: EU SMEs working towards sustainability - European Commission [WWW Document]. URL https://single-market-economy.ec.europa.eu/news/eurobarometer-eu-smes-working-towards-sustainability-2022-03-28_en (accessed 1.29.24).
European Commission, 2022b. EU action to address the energy crisis - European Commission [WWW Document]. URL https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/eu-action-address-energy-crisis_en (accessed 1.29.24).
European Commission, 2021a. Current funding [WWW Document]. URL https://energy.ec.europa.eu/topics/energy-efficiency/financing/eu-programmes/current-funding_en (accessed 1.29.24).
European Commission, 2021b. Recovery and Resilience Facility - European Commission [WWW Document]. URL https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en (accessed 2.13.24).
European Commission, 2021c. Inforegio - European Regional Development Fund [WWW Document]. URL https://ec.europa.eu/regional_policy/funding/erdf_en (accessed 2.13.24).
European Commission, 2021d. Just Transition Fund [WWW Document]. URL https://ec.europa.eu/regional_policy/funding/just-transition-fund_en (accessed 2.13.24).
European Commission, 2021e. Clean Energy Transition - European Commission [WWW Document]. URL https://cinea.ec.europa.eu/programmes/life/clean-energy-transition_en (accessed 2.13.24).
European Commission, 2020a. NUDging consumers towards Energy Efficiency through behavioral science | NUDGE Project | Fact Sheet | H2020 [WWW Document]. CORDIS Eur. Comm. URL https://cordis.europa.eu/project/id/957012 (accessed 2.13.24).
European Commission, 2020b. Behavioral Insgihts and Effective Energy policy Actions| EVIDENT Project | Fact Sheet | H2020 [WWW Document]. CORDIS Eur. Comm. URL https://cordis.europa.eu/project/id/957117 (accessed 2.13.24).
European Commission, 2020c. The potential for investment in energy efficiency through financial instruments in the European Union.
European Commission, n.d. SME definition - European Commission [WWW Document]. URL https://single-market-economy.ec.europa.eu/smes/sme-definition_en (accessed 2.7.24).
European Commission Directorate-General for Internal Market Industry, DIW econ, PwC, Gorgels, S., Priem, M., Blagoeva, T., Martinelle, A., Milanesi, G., 2022. Annual report on European SMEs 2021/2022: SMEs and environmental sustainability : background document. Publications Office of the European Union, LU.
European Court of auditors, 2020. Special Report 02/2022: Energy efficiency in enterprises - Some energy savings but weaknesses in planning and project selection.
Eurostat, 2022. Energy use by businesses and households - statistics [WWW Document]. URL https://ec.europa.eu/eurostat/statistics-

explained/index.php?title=Energy_use_by_businesses_and_households_-_statistics (accessed 10.5.23).
Eurostat, 2020a. Glossary:Energy intensity [WWW Document]. URL https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Energy_intensity (accessed 2.10.24).
Eurostat, 2020b. Annual detailed enterprise statistics for services (NACE Rev. 2 H-N and S95). https://doi.org/10.2908/SBS_NA_1A_SE_R2
Fawcett, T., Hampton, S., 2020. Why & how energy efficiency policy should address SMEs. Energy Policy 140, 111337. https://doi.org/10.1016/j.enpol.2020.111337
Fazzari, S.M., Hubbard, R.G., Petersen, B.C., Blinder, A.S., Poterba, J.M., 1988. Financing Constraints and Corporate Investment. Brook. Pap. Econ. Act. 1988, 141–206. https://doi.org/10.2307/2534426
Fischer, A., 2021. How Energy Efficiency Will Power Net Zero Climate Goals – Analysis [WWW Document]. IEA. URL https://www.iea.org/commentaries/how-energy-efficiency-will-power-net-zero-climate-goals (accessed 1.18.24).
Fleiter, T., Schleich, J., Ravivanpong, P., 2012. Adoption of energy-efficiency measures in SMEs—An empirical analysis based on energy audit data from Germany. Energy Policy, Renewable Energy in China 51, 863–875. https://doi.org/10.1016/j.enpol.2012.09.041
Fresner, J., Morea, F., Krenn, C., Uson, J.A., Tomasi, F., 2017. Energy efficiency in small and medium enterprises: Lessons learned from 280 energy audits across Europe. J. Clean. Prod. 142, 1650–1660.
Galeazzi, C., Steinbuks, J., Anadón, L.D., 2023. Assessing the Impact of Renewable Energy Policies on Decarbonization in Developing Countries, Policy Research Working Papers. The World Bank. https://doi.org/10.1596/1813-9450-10329
Gao, K., Cevik, S., 2023. Reaching (Beyond) the Frontier: Energy Efficiency in Europe.
Goldschlag, N., Tabarrok, A., 2018. Is regulation to blame for the decline in American entrepreneurship? Econ. Policy 33, 5–44. https://doi.org/10.1093/epolic/eix019
Gruber, E., Fleiter, T., 2011. Efficiency of an energy audit programme for SMEs in Germany – results of an evaluation study, ECEEE Summer Study 2011.
Hill, D., 2014. Small Business: The “Neglected Middle” of Climate Change | HuffPost Impact [WWW Document]. URL https://www.huffpost.com/entry/small-business-the-neglec_b_6289210?guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS91cmw_c2E9dCZ (accessed 11.6.24).
Hirst, E., Brown, M., 1990. Closing the efficiency gap: barriers to the efficient use of energy. Resour. Conserv. Recycl. 3, 267–281.
IEA, 2023a. Decade for Action Highlights – Energy Efficiency: The Decade for Action – Analysis [WWW Document]. IEA. URL https://www.iea.org/reports/energy-efficiency-the-decade-for-action/decade-for-action-highlights (accessed 1.18.24).
IEA, 2023b. Energy Efficiency - Energy System - IEA [WWW Document]. URL https://www.iea.org/energy-system/energy-efficiency-and-demand/energy-efficiency#tracking (accessed 1.18.24).
IEA, 2022a. Energy Efficiency 2022. Energy Effic.
IEA, 2022b. Coping with the Crisis: Increasing Resilience in Small Businesses in Europe through Energy Efficiency.
IEA, 2021. Security of Clean Energy Transitions – Analysis [WWW Document]. IEA. URL https://www.iea.org/reports/security-of-clean-energy-transitions-2 (accessed 1.18.24).
IEA, 2020a. Energy Efficiency 2020. Paris.
IEA, 2020b. European Union 2020.
IEA, 2019a. Energy Policies of IEA Countries: United States 2019 Review. IEA, Paris.
IEA, 2019b. Energy efficiency and digitalisation – Analysis [WWW Document]. IEA. URL https://www.iea.org/articles/energy-efficiency-and-digitalisation (accessed 1.29.24).
IEA, 2015. Policy Pathway - Accelerating Energy Efficiency in Small and Medium-sized Enterprises 2015 – Analysis [WWW Document]. IEA. URL

https://www.iea.org/reports/policy-pathway-accelerating-energy-efficiency-in-small-and-medium-sized-enterprises-2015 (accessed 1.23.24).
IEA, 2011. Saving Electricity in a Hurry 2011 – Analysis.
Jaffe, A.B., Stavins, R.N., 1994. The energy-efficiency gap What does it mean? Energy Policy, Markets for energy efficiency 22, 804–810. https://doi.org/10.1016/0301-4215(94)90138-4
Johansen, F., 1994. Investment and Financial Constraints An Empirical Analysis of Norwegian Firms (Working Paper No. 109). Discussion Papers.
Johansson, I., Johnsson, S., Thollander, P., 2022. Impact evaluation of an energy efficiency network policy programme for industrial SMEs in Sweden. Resour. Environ. Sustain. 9, 100065. https://doi.org/10.1016/j.resenv.2022.100065
Joskow, P.L., Rose, N.L., 1989. Chapter 25. The effects of economic regulation, in: Handbook of Industrial Organization, Volume II. Elsevier Science Publishers.
Kalantzis, F., Nakaris, K., 2020. Going green: Who is investing in energy efficiency, and why it matters. EIB. https://doi.org/10.2867/28919
Kalantzis, F., Niczyporuk, H., 2021. Can European businesses achieve productivity gains from investments in energy efficiency?, ECONOMICS - WORKING PAPERS 2021/07. EIB.
Kalantzis, F., Revoltella, D., 2019. Do energy audits help SMEs to realize energy-efficiency opportunities? Energy Econ. 83, 229–239. https://doi.org/10.1016/j.eneco.2019.07.005
Kammerer, D., 2009. The effects of customer benefit and regulation on environmental product innovation.: Empirical evidence from appliance manufacturers in Germany. Ecol. Econ. 68, 2285–2295.
Kerr, N., Gouldson, A., Barrett, J., 2017. The rationale for energy efficiency policy: Assessing the recognition of the multiple benefits of energy efficiency retrofit policy. Energy Policy 106, 212–221. https://doi.org/10.1016/j.enpol.2017.03.053
Koirala, S., 2018. SMEs: Key Drivers of Green and Inclusive Growth. OECD, Environment Directorate.
Lanoie, P., Patry, M., Lajeunesse, R., 2008. Environmental regulation and productivity: testing the porter hypothesis. J. Product. Anal. 30, 121–128.
Larsen, J., King, B., Kolus, H., Dasari, N., Bower, G., Jones, W., 2022. A Turning Point for US Climate Progress: Assessing the Climate and Clean Energy Provisions in the Inflation Reduction Act. Rhodium Group. URL https://rhg.com/research/climate-clean-energy-inflation-reduction-act/ (accessed 1.18.24).
Lasheras Sancho, M., Tueske, A., Forthcoming. Regulatory and economic drivers of firms' energy efficiency investments.
Longhi, S., Nandi, A., 2015. Analysis of panel data for discrete dependent variables, in: A Practical Guide to Using Panel Data. SAGE Publications, Inc., pp. 97–211.
Maçãs Nunes, P., Mendes, S., Serrasqueiro, Z., 2012. SMEs' investment determinants: empirical evidence using quantile approach. J. Bus. Econ. Manag. 13, 866–894. https://doi.org/10.3846/16111699.2011.620172
Markandya, A., Labandeira, X., Ramos, A., 2014. Policy Instruments to Foster Energy Efficiency, in: Green Energy and Efficiency: An Economic Perspective.
Mason, C., Kwork, J., n.d. Discussion Paper on Investment Readiness Programmes. OECD.
Ministère du Travail, de l'Emploi et de l'Insertion, France Travail, Association des Mécènes Les Entreprises s'engagent, 2018. Les entreprises s'engagent - Pour une société inclusive et un monde durable [WWW Document]. URL https://lesentreprises-sengagent.gouv.fr/ (accessed 2.13.24).
Mundlak, Y., 1978. On the Pooling of Time Series and Cross Section Data. Econometrica 46, 69–85. https://doi.org/10.2307/1913646
Mushafiq, M., Arisar, M.M.K., Tariq, H., Czapp, S., 2023. Energy Efficiency and Economic Policy: Comprehensive Theoretical, Empirical, and Policy Review. Energies 16, 2381. https://doi.org/10.3390/en16052381

N. Berger, A., F. Udell, G., 1998. The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle. J. Bank. Finance 22, 613–673. https://doi.org/10.1016/S0378-4266(98)00038-7
Neri, A., Cagno, E., Trianni, A., 2021. Barriers and drivers for the adoption of industrial sustainability measures in European SMEs: Empirical evidence from chemical and metalworking sectors. Sustain. Prod. Consum. 28, 1433–1464. https://doi.org/10.1016/j.spc.2021.08.018
OECD, 2024. National income - Value added by activity - OECD Data [WWW Document]. theOECD. URL http://data.oecd.org/natincome/value-added-by-activity.htm (accessed 2.10.24).
OECD, 2023a. SME policy responses to the 2022/2023 energy crisis: Policy highlights and country experiences (OECD SME and Entrepreneurship Papers No. 43), OECD SME and Entrepreneurship Papers. https://doi.org/10.1787/80012fbd-en
OECD, 2023b. Managing Shocks and Transitions: Future-Proofing SME and Entrepreneurship Policies Key Issues Paper.
OECD, 2022a. Financing SMEs for sustainability.
OECD, 2022b. Financing SMEs and Entrepreneurs 2022: An OECD Scoreboard | en | OECD.
OECD, 2021a. OECD SME and Entrepreneurship Outlook 2021.
OECD, 2021b. No net zero without SMEs [WWW Document]. OECD. URL https://www.oecd.org/en/publications/no-net-zero-without-smes_bab63915-en.html (accessed 11.6.24).
OECD, 2021c. The Digital Transformation of SMEs.
OECD, 2017. Enhancing the contributions of SMEs in a global and digitalised economy, Meeting of the OECD Council at Ministerial Level.
OECD, n.d. Small businesses, job creation and growth: Facts, obstacles and best practices. Paris.
Oscar, T.-R., 2007. Panel Data Analysis: Fixed and Random Effects using Stata (v.6.0).
Parag, Y., Fawcett, T., Hampton, S., Eyre, N., 2023. Energy saving in a hurry: A research agenda and guidelines to study European responses to the 2022–2023 energy crisis. Energy Res. Soc. Sci. 97, 102999. https://doi.org/10.1016/j.erss.2023.102999
Peñasco, C., Anadón, L.D., Verdolini, E., 2021. Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments. Nat. Clim. Change 11, 257–265.
Perales, F., 2013. MUNDLAK: Stata module to estimate random-effects regressions adding group-means of independent variables to the model. Stat. Softw. Compon.
Poderys, D., 2015. Does Access to External Finance Affect Development of Small and Medium Enterprises and Economic Growth? Eur. J. Bus. Sci. Technol. 1, 43–53. https://doi.org/10.11118/ejobsat.v1i1.37
Pouliakas, K., Wruuck, P., 2022. EIB Working Paper 2022/07 - Corporate training and skill gaps Did Covid-19 stem EU convergence in training investments? European Investment Bank. https://doi.org/10.2867/89269
Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU (Text with EEA relevance.), 2017. , OJ L.
Reuter, S., Lackener, P., Brandl, G., 2021. Mapping SMEs in Europe: Data collection, analysis and methodologies for estimating energy consumptions at Country levels.
Ringel, M., Laidi, R., Djenouri, D., 2019. Multiple Benefits through Smart Home Energy Management Solutions—A Simulation-Based Case Study of a Single-Family-House in Algeria and Germany. Energies 12, 1537. https://doi.org/10.3390/en12081537
Robinson Jr, R.B., Pearce II, J.A., Vozikis, G.S., Mescon, T.S., 1984. The relationship between stage of development and small firm planning and performance. J. Small Bus. Manag. Pre-1986 22, 45.

Rosenow, J., Eyre, N., 2022. Reinventing energy efficiency for net zero. Energy Res. Soc. Sci. 90, 102602. https://doi.org/10.1016/j.erss.2022.102602

Saunders, H.D., Roy, J., Azevedo, I.M.L., Chakravarty, D., Dasgupta, S., De La Rue Du Can, S., Druckman, A., Fouquet, R., Grubb, M., Lin, B., Lowe, R., Madlener, R., McCoy, D.M., Mundaca, L., Oreszczyn, T., Sorrell, S., Stern, D., Tanaka, K., Wei, T., 2021. Energy Efficiency: What Has Research Delivered in the Last 40 Years? Annu. Rev. Environ. Resour. 46, 135–165. https://doi.org/10.1146/annurev-environ-012320-084937

SBA, 2023. You Don’t Need to be a Big Business to Make a Big Difference This Earth Day | U.S. Small Business Administration [WWW Document]. URL https://www.sba.gov/blog/2023/2023-03/you-dont-need-be-big-business-make-big-difference-earth-day (accessed 1.29.24).

Segarra-Blasco, A., Jove-Llopis, E., 2019. Determinants of energy efficiency and renewable energy in european smes. Econ. Energy Environ. Policy 8, 117–140.

SME Climate Hub, 2020. Home [WWW Document]. SME Clim. Hub. URL https://smeclimatehub.org/ (accessed 1.18.24).

Solnørdal, M.T., Foss, L., 2018. Closing the energy efficiency gap—A systematic review of empirical articles on drivers to energy efficiency in manufacturing firms. Energies 11, 518.

StataCorp, 2023. xtlogit — Fixed-effects, random-effects, and population-averaged logit models, in: Stata 18 Longitudinal-Data/Panel-Data Reference Manual. Stata Press, pp. 294–312.

The White House, 2023. FACT SHEET: Biden-Harris Administration Leverages Historic U.S. Climate Leadership at Home and Abroad to Urge Countries to Accelerate Global Climate Action at U.N. Climate Conference (COP28) [WWW Document]. White House. URL https://www.whitehouse.gov/briefing-room/statements-releases/2023/12/02/fact-sheet-biden-harris-administration-leverages-historic-u-s-climate-leadership-at-home-and-abroad-to-urge-countries-to-accelerate-global-climate-action-at-u-n-climate-conference-cop28/ (accessed 1.18.24).

The White House, 2022. FACT SHEET: How the Inflation Reduction Act Will Help Small Businesses [WWW Document]. White House. URL https://www.whitehouse.gov/briefing-room/statements-releases/2022/09/12/fact-sheet-how-the-inflation-reduction-act-will-help-small-businesses/ (accessed 11.23.24).

The White House, 2021. UPDATED FACT SHEET: Bipartisan Infrastructure Investment and Jobs Act [WWW Document]. White House. URL https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/02/updated-fact-sheet-bipartisan-infrastructure-investment-and-jobs-act/ (accessed 1.19.24).

Thollander, P., Palm, J., 2013a. Improving Energy Efficiency in Industrial SMEs, in: Thollander, P., Palm, J. (Eds.), Improving Energy Efficiency in Industrial Energy Systems: An Interdisciplinary Perspective on Barriers, Energy Audits, Energy Management, Policies, and Programs. Springer, London, pp. 15–34. https://doi.org/10.1007/978-1-4471-4162-4_2

Thollander, P., Palm, J., 2013b. Setting the Agenda, in: Thollander, P., Palm, J. (Eds.), Improving Energy Efficiency in Industrial Energy Systems: An Interdisciplinary Perspective on Barriers, Energy Audits, Energy Management, Policies, and Programs. Springer, London, pp. 1–14. https://doi.org/10.1007/978-1-4471-4162-4_1

United States International Trade Commission, 2010. Small and Medium-Sized Enterprises: Overview of Participation in U.S. Exports (No. 4125).

Verdolini, E., Bosetti, V., Jockers, P., 2015. The impact of policy uncertainty on innovation in the wind industry: evidence from EU countries.

Veugelers, R., 2012. Which policy instruments to induce clean innovating? Res. Policy 41, 1770–1778.

Walsh, C., Thornley, P., 2012. Barriers to improving energy efficiency within the process industries with a focus on low grade heat utilisation. J. Clean. Prod. 23, 138–146. https://doi.org/10.1016/j.jclepro.2011.10.038
Wang, C., Walker, E., Redmond, J., 2007. Explaining the lack of strategic planning in SMEs: The importance of owner motivation.
Wooldridge, J.M., 2021. Two-Way Fixed Effects, the Two-Way Mundlak Regression, and Difference-in-Differences Estimators. https://doi.org/10.2139/ssrn.3906345
Wooldridge, J.M., 2019. Correlated random effects models with unbalanced panels. J. Econom., Annals Issue in Honor of Jerry A. Hausman 211, 137–150. https://doi.org/10.1016/j.jeconom.2018.12.010
Wooldridge, J.M., 2010a. Nonlinear models and related topics, in: Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge, UNITED STATES.
Wooldridge, J.M., 2010b. Basic Linear Unobserved Effects Panel Data Models, in: Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge, UNITED STATES.
World Bank, 2021. Indicators | RISE [WWW Document]. URL https://rise.esmap.org/indicators (accessed 2.12.24).
World Bank SME Finance [WWW Document], 2024. . World Bank. URL https://www.worldbank.org/en/topic/smefinance (accessed 2.14.24).