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Does energy efficiency of UK SMEs affect their access to finance?

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ABSTRACT

To effectively mitigate climate change, a crucial focus area is enhancing energy efficiency in firms and industries. This objective becomes even more imperative in light of the recent escalation in energy prices caused by the Russo-Ukrainian war. Given the limited financial resources of Small and Medium Enterprises (SMEs), facilitating their access to finance becomes a potential avenue for reducing carbon emissions. Based on our knowledge, this is the first study that analyses the potential impact of energy efficiency on access to finance for SMEs in the UK. We consider a dataset of 2855 UK firms from 2015 to 2021 collected from the Longitudinal Small Business Survey. We find that energy efficient companies and firms that show energy saving behaviours are facing fewer credit constraints. These results are robust if we control for several company characteristics, including age, size, turnover, industry, location, and legal status.

1. Introduction

To address the adverse effects of climate change, both the UK and the EU governments have committed to the ambitious goal of achieving net-zero greenhouse gas (GHG) emissions by the year 2050. A notable example of the UK's dedication to transitioning towards a low-carbon economy is the establishment of the UK Infrastructure Bank, which boasts an impressive capital allocation of £22 billion.[1] Similarly, the European Union has proposed significant initiatives, including the EU Green Deal and the NextGeneration EU recovery package, to accelerate the transition towards a more sustainable and environmentally friendly future. Recent geopolitical tensions and substantial supply disruptions have contributed to an unprecedented energy crisis, imposing considerable financial burdens on Small and Medium-sized Enterprises (SMEs) in the UK (UK Parliament, 2023).[2] These SMEs are now grappling with escalating energy costs, making the transition to energy efficiency a matter of utmost urgency. In light of soaring energy prices and the UK's commitment to a net-zero emissions target, SMEs are increasingly in need of investment capital to facilitate their transition towards energy-efficient practices. This situation raises a fundamental question: Do financiers really take account of the company' s energy-efficient behaviour when allocating credit to SMEs?

There is a strand of literature investigating the potential problems that SMEs face when seeking to raise capital from banks. In uncertainty times, SMEs may find it increasingly difficult to secure external additional funding, despite the pressing demand (Freel et al., 2012; Harrison et al., 2022; Mac an Bhaird et al., 2016). These challenges primarily stem from the lack of transparent information surrounding SMEs, which hampers their access to financial resources. Much of the modern literature takes as its departure point the classic theoretical models of credit rationing (Jaffee and Modigliani, 1969), which are underpinned by information-based problems and the difficulties banks have when assessing the underlying quality of funding propositions from smaller, informationally opaque, businesses. However, while previous literature has documented abundant evidence of credit rationing for SMEs in general, there is little known on the energy-efficient behaviours of SMEs' impact on access to external finance.

Recent literature focus on the climate-oriented regulatory polices impact on the reallocation of credit to green firms. Many institutional investors believe climate risks have financial implications for their portfolio firms and that there risks, particularly regulatory risks, that have already have begun to materialize (Krueger et al., 2020). In EU, after the Paris Agreement (COP21) signed in December 2015, European banks decrease the flow of credit towards polluting firms with high GHG emissions and reallocate credit to green firms in the EU (Reghezza et al., 2022). In developing economies, green credit policy substantially

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[1] https://www.gov.uk/government/publications/green-finance-strategy/mobilising-green-investment-2023-green-finance-strategy

[2] https://commonslibrary.parliament.uk/research-briefings/cbp-9523/

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decreases heavily polluting firms' performance by increasing firm financing constraints and decreasing investment levels (Yao et al., 2021). In contrast to previous literature on regulatory impacts on credit allocation from the supply side, our study focuses on both the demand side and supply side using unique measures of energy efficient behaviours of SMEs.

Energy-efficient SMEs may experience lower capital constraints through several channels. First, energy efficient measures reduce direct costs and bolster liquidity. Form an internal cost-saving perspective, effective environmental management leads to cost advantages (Christmann, 2000). Numerous industry reports indicate that firms can directly reduce utility bills by implementing energy-efficient measures. This cost reduction increases their ability to service debt, and the information is inexpensive for banks to gather (Bougheas et al., 2006). Second, with increasing legislation on green requirements, energy-efficient firms gain competitive advantages. In the UK, SMEs play a pivotal role in driving the necessary changes for the country's transition to a net zero economy, accounting 50% of all UK business-driven emissions (British Business Bank, 2021). The UK's clean growth strategy has the main target of reducing industry energy intensity by 20% by 2030 (BEIS, 2017). Initiatives and regulations are proposed to stimulate green investments, and banks also incorporate firms' environmental consciousness in their corporate lending decisions (Nandy and Lodh, 2012). Based on these factors, energy-efficient firms are at the forefront of the game. Third, green investments, such as energy-efficient measures, may increase the future value of a firm by enhancing the value of collateral. For SMEs, information asymmetry is severe for lenders. Collateral becomes a crucial tool for banks to offset informational asymmetries and help resolve credit rationing. Assets with energy-efficient measures carry a price premium (Fuerst et al., 2015), and are more protected against "asset stranding" (Muldoon-Smith and Greenhalgh, 2019).

In this study, we aim to examine the impact of SME's energy-efficient behaviour on their demand and ability to access external financing. These SMEs are embracing energy-efficient measures and behaviours to monitor energy consumption, such as utilising smart meters for gas and electricity[3]; adopting sustainable and renewable energy sources like biomass or solar energy; and taking advantage of government financial incentives and schemes, such as Energy Savings Opportunity Scheme (ESOS)[4] and Domestic Renewable Heat Incentive (RHI),[5] as well as claiming capital allowances to tax relief on purchase of energy-efficient products.[6] To investigate the impacts of these energy-efficient measures and behaviours on accessing external financing, we utilise panel data from 2015 to 2021 in the UK from the Longitudinal Small Business Survey (LSBS), which conducted by the Department for Business Energy and Industrial Strategy (BEIS). The LSBS is a large-scale representative annual survey of UK SME owners and managers with annual sample sizes ranging from 6619 to 15,015 UK SMEs and wirghting used. To address sample selection bias, we employ a Heckman type probit selection model and employ the two-stage maximum likelihood method (Heckman, 1979; Van de Ven and Van Praag, 1981). Our results suggest that SMEs engaging in energy-efficient policy activities have a higher demand for external capital, especially SMEs that are seeking to increase their investment in energy-efficient and eco-friendly measures (e.g., plans to install a low carbon heating system). Meanwhile, on the supply side, our findings reveal that SMEs exhibiting energy-efficient and energy-saving behaviours and who have plans for energy-introducing efficient measures face less credit constraints. Additionally, we account for various company characteristics, including age, size, turnover, industry, location, and legal status.

[3] https://www.gov.uk/guidance/smart-meters-how-they-work

[4] https://www.gov.uk/guidance/energy-savings-opportunity-scheme-esos#about-esos

[5] https://www.gov.uk/domestic-renewable-heat-incentive

[6] https://www.gov.uk/capital-allowances/first-year-allowances

This article makes a number of contributions both to literature on access to finance for SMEs and green investments. First, to our knowledge, our study is among the first to empirically examine the determinants of external finance demand and supply for SME by considering energy efficient behaviours. We use unique energy-efficient schemes and measures in the UK, which add novel empirical evidence to estimate green initiative by governments impacts on credits. Second, our results contribute to literature on energy efficiency. Previous literature focus on the energy efficiency impacts on firms' innovation (Ferreira et al., 2010) and financial performance (Guenster et al., 2011), and energy-efficient labels enhance the value of assets (Fuerst et al., 2015). Our research indicates energy efficient SMEs gain competitive advantages in obtaining external finance. Furthermore, our study contributes to government and policymakers by suggesting that supporting firms to go green by governments is an indirect way of enhancing access to capital.

The rest of the paper is organized as follows. In the second section, we review the literature on SME credit constraints and difficulties, environmental management impacts on financial performance and operational risks, debt capability and risk management for credit allocation. In the third section, we discuss our sample data and descriptive statistics. The fourth section is the results of loan apply and approval. The fifth section is discussions and conclusions.

2. Literature review

We begin by reviewing the theoretical literature around small business finance. We then consider the body of research associated with the energy efficiency impacts on firms' financial performance, competitive advantages, and future value.

2.1. Access to finance for SMEs

Access to external finance for SMEs is a well-explored topic in the literature, with various studies emphasising the potential challenges they face (Cowling et al., 2016; Freel et al., 2012; Harrison et al., 2022). These challenges often stem from the lack of transparent information surrounding SMEs. Berger and Udell (1998) underscore the presence of information asymmetry in the lending process, where lenders encounter difficulties in distinguishing between 'good' and 'bad' borrowers in the initial stage of credit application evaluation, leading to issues to adverse selection. Subsequently, in the monitoring stage, moral hazard can arise as borrowers may follow riskier approaches. The concept of credit rationing for the SMEs and banking sector context is closely related to asymmetric information (Berger and Udell, 1992). Notably, asymmetric information issues tend to be more pronounced for SMEs with higher levels of intangible assets (Mina et al., 2013). Furthermore, there is a distinction between large firms, for which banks can determine a specific lending amount based on their credit rating, and SMEs, where the absence of comparable ratings makes this process challenging (Yoshino and Taghizadeh-Hesary, 2015). Consequently, banks face heightened uncertainty and risk when evaluating the creditworthiness of SMEs, which may results in a reduced willingness to provide loans (Bruns and Fletcher, 2008; Kautonen et al., 2020).

To mitigate these risks, banks tend to allocate loans to firms with higher repayment capabilities and lower risk (Berger et al., 2001). This strategy aligns with the debt capacity theory, where small and high-growth firms typically face the most restrictive debt capacity constraints (Lemmon and Zender, 2010). Therefore, banks increasingly consider a borrower's ability to repay loans, as reflected in their balance sheets, which is consistent with signaling theory (Connelly et al., 2011). Some banks adopt an income-based approach, taking into account factors such as cash flow, business plans, and future prospects (Mason and Stark, 2004; Wilson, 2016). However, in cases where information asymmetry persists, a capital-based approach that emphasises the use of collateral as a signaling and bonding mechanism to counteract the

adverse effects caused by information asymmetry is adopted (Binks and Ennew, 1996). The credit guarantee scheme serves as a crucial tool in facilitating SMEs' access to lending, especially during times of crises and uncertainty. A increased credit guarantee ratio will help SMEs survive in a crisis and recover after the crisis (Taghizadeh-Hesary et al., 2022). Consequently, banks exercise greater caution by considering a borrower's ability to service the debt and the value of collateral when allocating credits to SMEs.

2.2. The links between energy efficiency and access to finance

2.2.1. Energy efficiency and debt servicing capacity

Previous literature presents evidence that more energy-efficient firms tend to be more cost-competitive, as energy efficiency measures reduce operational costs and bolster liquidity. The existing body of research on environmental performance and carbon responsibility has demonstrated the potential for companies to achieve higher financial value and enhanced corporate performance through these practices. Notably, previous studies have predominantly focused on the environmental and carbon responsibility of publicly listed firms (Al-Tuwaijri et al., 2004; Guenster et al., 2011; Horváthová, 2010), with fewer investigations into privately-owned firms (Qian and Xing, 2018). From an internal cost-saving perspective, previous research suggests that effective environmental management can lead to cost advantages (Christmann, 2000), improved product pricing (De Beer and Friend, 2006), and increased product innovation (Ferreira et al., 2010). These factors collectively contribute to the development of a competitive advantage, ultimately creating financial value (Guenster et al., 2011; López-Gamero et al., 2009).

The direct cost reduction is evident through the adoption of energy-efficient measures within firms. For instance, in the UK, the SMEs have the potential to reduce their energy bills by 18%–25% through the implementation of energy efficiency measures and behavioural changes (Department of Energy & Climate Change, 2014). Recently, Tyl by NatWest commissioned a survey of 500 SME Business Owners to find out how much small businesses are paying out per year on utility bills, as well as how many SMEs are making changes to create a more sustainable work environment. Businesses are saving money – almost a fifth (19%) are saving between £2000 and £3000 a year through energy efficiency measures.[7] Especially, with the recent intensification of Eastern Europe conflict, energy costs in the UK are expected to rise sharply. Lowering energy costs becomes a key factor in increasing the liquidity of firms, thereby compelling SMEs to consider investing in greater energy efficiency on their premises as a way of reducing their energy expenses.[8]

In accordance with the debt servicing capacity theory, banks select firms with the ability to service the debt, which necessitates having adequate liquidity or the capacity to generate it. In the absence of perfect information about the project, banks reply on certain firm characteristics that can be cheaply obtained, such as information from a firm's balance sheet (Bougheas et al., 2006). Energy efficiency measures assist firms in reducing costs and enhancing liquidity, and this information readily available for lenders. Especially times of rising energy prices caused by geopolitical conflicts and energy supply disruptions, SMEs that have adopted energy-efficient practices not only become more cost-competitive but also potentially more creditworthy, making it easier for them to access external financing.

2.2.2. Energy efficiency and risk management

In addition to the cost reduction and improved financial performance associated with energy-saving and energy-efficient behaviour, there are also risk management benefits for SMEs. SMEs are particularly vulnerable to changes in socio-economic conditions over which they have limited control (Smallbone et al., 2012), and they are highly exposed to energy price volatility (Varga et al., 2022). Unstable energy supplies pose a significant threat to the survival of SMEs, particularly when businesses lack prior knowledge or preparedness (Von Ketelhodt and Wöcke, 2008). The disruption of the energy supply chain can have a severe impact on SMEs. For instance, the interruption of energy trade resulting from the Russia-Ukraine war severely affected SMEs in the UK. According to the Federation of Small Businesses (FSB) (2023), SMEs have experienced a 424% increase in gas costs and a 349% increase in electricity costs since February 2021, leading to the potential closure, downsizing, or radical restructuring of 93,000 small firms. Implementing renewable energy and sustainable energy strategies can enhance a company's resilience to supply chain disruptions and mitigate the impact of energy price shocks (Tian et al., 2022). Furthermore, renewable energy and related technologies also contribute to decreased operational risks in the face of other types of shocks. Based on the decentralized nature of most renewable energy technologies, renewable energy plays a vital role by involving communities and harnessing remote control capabilities during the COVID-19 crisis (Hosseini, 2020). Energy-efficiency decreases exposure of energy price volatility, and provides more resilience against supply chain risks, thereby increase their attractiveness to risk-averse lenders.

Further, energy-efficiency and energy-saving behaviour also contribute to the mitigation of environmental and climate risks for SMEs. These behaviours lead to a reduction in greenhouse gas emissions and overall energy consumption (Hasanbeigi et al., 2014). By implementing measures such as equipment upgrades, process optimization, and the adoption of renewable energy sources, companies can minimize their carbon footprint and environmental impact. Climate risks have become a significant consideration for institutional investors, particularly following the Paris Agreement, as they incorporate climate risk assessments into their investment decisions (Krueger et al., 2020). Firms with higher climate risk tend to have lower leverage, reducing their demand for debt, while lenders become more cautious in providing loans to firms with higher risk (Ginglinger and Moreau, 2019). Banks have also started factoring carbon risk into their lending decisions following the Paris Agreement (Delis et al., 2019). Risk-averse banks may reduce credit allocation to high-emission firms and redirect funds to low-emission firms, recognizing the financial risks associated with high emission activities. Such actions by banks reflect their prudent approach to lending (Kacperczyk and Peydró, 2022). In line with risk management theory, energy-efficiency can help reduce SMEs' climate and operational risks, making them more attractive borrowers for banks.

2.2.3. Energy efficient and collateral value

Firms adopting energy efficient measures may also have better collateral. A strand of hedonic analyses found evidence of capitalisation of energy efficiency into commercial buildings, and the topic has attracted interest in the last decade with the advent energy performance certificates such as that promoted by the European Energy Performance Certificates (EU-EPCs). For example, Fuerst and McAllister (2011) found that energy-efficiency labelled buildings carry a price premium in the United States. Similarly, the price premium is also found in Europe after EU-EPCs, such as in the Netherlands (Brounen and Kok, 2011) and England (Fuerst et al., 2015). Furthermore, energy efficient assets are more protected against "asset stranding". One example is their buildings that are more likely to comply with increasingly stringent efficiency regulations, whereas climate change policy could induce the stranding of some conventional property assets (Muldoon-Smith and Greenhalgh, 2019).

Collateral is an important tool for banks to offset informational asymmetries and help resolve credit-rationing. It acts as a security against the failure of the firm to pay its debt back on time, which comes in the form of assets. If the collateral comes in the form of commercial building stock that meets high or higher energy efficiency standards, it is

[7] https://www.tylbynatwest.com/card-machines/no-time-to-waste

[8] https://www.britishchambers.org.uk/news/2022/03/the-conflict-in-eastern-europe-and-what-it-means-for-uk-energy-supply/

worth more than the same stock that has low energy efficiency standards. It is preferable for banks to request collateral that is "cleaner" and not at the risk of becoming "stranded assets" that are likely to lose value in the coming years (Semieniuk et al., 2021).

In summary, in response to the challenges of accessing bank loans, SMEs seek ways to position themselves as appealing borrowers by increasing their cost-competitive, risk management, and valuable collateral. While there is some research on the implications of climate change for banking, there is limited literature focusing specifically on the energy efficient behaviours of SMEs and its impact on financial constraints. A recent study have examined the relationship between environmental and carbon responsibility and debt, highlighting the importance of lower carbon emissions in reducing financial constraints (Kacperczyk and Peydró, 2022). However, there is a gap in research concerning the impact of energy consumption behaviour on financial constraints. Therefore, the main objective of this paper is to address this gap in the literature.

3. Data description

The panel data used in this study are from the Longitudinal Small Business Survey (LSBS), covering the period from 2015 to 2021, which conducted by the Department for Business Energy and Industrial Strategy (BEIS). The survey uses computer-assisted telephone interviews (CATI) and a stratifies random sample selection method. The LSBS is a large-scale representative annual survey of UK SME owners and managers with annual sample sizes ranging from 6619 to 15,015 UK SMEs. To ensure representation of the SME population in the UK, the survey employs a weighting system. This unique survey includes information on the energy-saving and energy-efficiency behaviour of the firms, encompassing indicators such as the utilization of smart or advanced meters, adoption of low-carbon heating systems, and participation in energy-efficiency schemes and activities. These energy-efficiency indicators are employed to address our primary research question. Accordingly, 12,062 observations remain in our sample after eliminating missing values.

The key dependent variables related to our research question are as follows: (i) *Apply finance* - coded as 1 if the firm applied for finance in the last 12 months, and 0 if not; (ii) *Obtain finance* - coded as 1 if the firm received finance in the last 12 months, and 0 if not. The independent variables of interest related to the environment and energy are as follows: *Smart meter* - coded as 1 if the main premises have any smart or advanced meters for gas or electricity, and 0 if not; *Energy activity*[9] - coded as 1 if the firm has engaged in energy-related activities, and 0 if not; *Low carbon heating system* - coded as 1 if the firm plans to install a low carbon heating system (such as heat pumps, biomass, or solar thermal) in any of its premises in the next 12 months, and 0 if not. Additionally, we include firm-level control variables to capture common business characteristics and firm orientation. The company characteristic variables include the organisation's premise description, number of employees, firm age, location (urban or not), whether it is women-led, industry, UK region, and legal status. Firm orientation is proxied by *Expgrow* - coded as 1 if the firm expects growth in the next year, and 0 if not. The definitions and summary statistics of all dependent and independent variables are reported in Table 1.

In our study, the total number of firm-year level observations amounts to 12,062, considered the 2855 SMEs (businesses with fewer than 250 employees) in the UK. It is also possible that a firm was defined as an SME in earlier surveys but grew to a larger firm with >250 employees, and so we have removed these firms to restrict our analysis to SMEs only. The main variables, descriptive statistics and pairwise correlations are shown in Table 1, we use the weighted data. The definitions and descriptive statistics of all variables (including control variables) are in the Appendix Table A.1.

In addition, we conducted two sets of univariate mean-comparison tests for finance applicants and non-applicants, as shown in Appendices Table A.1. The results indicate that firms with attendance in energy-related activities, and a preference for installing a low carbon heating system are more likely to apply for finance. On average, non-applicants were older in terms of firm establishment and led by women. Firms with expectations for growth and those perceiving finance as a major obstacle to growth are also more inclined to seek finance. Additionally, industries that typically rely more on physical assets, such as the Primary, Manufacturing, Construction, Wholesale/Retail industries, exhibit a higher likelihood of seeking external finance. At the regional level, firms located in more deprived regions appear less likely to seek external finance. Furthermore, incorporated legal status such as private limited companies (LTD) and limited liability partnerships are more likely to apply for external finance, whereas sole proprietorships/traders and partnerships are less likely to do so.

4. Models

We are particularly interested in how demand-side (apply for external finance) and supply-side (approval of finance application) changes if consider the energy-efficient characteristics of companies. We have two binary dependent variables, which are applied finance and finance application outcome. As both dependent variables are expressed in binary (0,1) form, we estimate with probit model. Inherently, finance application outcomes are only observable for applicants. To correct for potential sample selection bias, the two-stage maximum likelihood method is used. We use the Heckprobit model was employed to correct for sample selection bias (Heckman, 1979; Van de Ven and Van Praag, 1981). Furthermore, for the identification to be valid, a vector of exclusion restrictions is only included in the first-stage selection equation, which is not included in the second-stage outcome equation.

The two exclusion restrictions we used in the first-stage selection equation are growth expectation (*expgrow*) and consideration of finance problem as the main growth obstacle (*finobstacle*). The two exclusion restrictions we used is similar to previous literature to explain the SMEs loans application and outcomes during COVID-19 (Calabrese et al., 2022). Indeed, expect growth is a key factor to explain finance-seeking behaviours but is unobservable by lenders (Michaelas et al., 1999; Psillaki and Daskalakis, 2009). And the second exclusion restriction-finance obstacle-used to explain the relationship between internal finance constraints and seeking external finance behaviours, due to the pecking-order theory.

5. Empirical results

Table 2 presents the results of our analysis on finance applications and finance application outcomes, which address our key question. To investigate these relationships, we use a probit model with sample selection adjustment as mentioned in the Methodology section. We use weighted data to ensure the sample is representative for UK SME population. The coefficient estimates as well as the marginal effects shown in the result table represent their economic significance. In this section, we discuss the effects of energy-efficiency and energy-saving behaviour, along with various categories of explanatory variables, on the dependent variables.

In Table 2, column (1) represents the selection equation, indicating whether the firm applies for external finance or not. Column (2)

[9] The independent variable *Energy activity* includes: e.g., 1)Used The Energy Technology List to purchase a product 2)Claimed Enhanced Capital Allowance to get tax relief for energy efficient products 3)Made or experienced changes to buildings as a result of The Private Rented Sector Energy Efficiency Regulations; 4)Received payments under The Renewable Heat Incentive; 5)Installed a low carbon heating system e.g. heat pumps, biomass, solar thermal 6) Installed an electric vehicle chargepoint 7)Made or experienced changes to buildings as a result of the Energy Savings Opportunity scheme.

Table 1
Main variables, descriptive statistics and pairwise correlations (Weighted; $N = 12{,}062$).

Variables	Mean	Std. Dev.	Apply	Obtain	Smart meter	Energy activity	Low carbon of heating system
Apply	0.0657	0.248	1.000				
Obtain	0.870	0.337	0.021	1.000			
Smart meter	0.295	0.456	0.015*	0.033*	1.000		
Energy activity	0.0705	0.256	0.034***	0.073***	0.110***	1.000	
Low carbon of heating system	0.888	0.316	0.027***	0.031	−0.006	−0.061****	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; weight applied.

Table 2
Accessing finance applications and outcomes (weighted).

	(1) apply	(2) obtain	
Variable name	Coeff.	Coeff.	dy/dx
Smart meter	−0.0522	0.311*	0.0729
	(0.0681)	(0.173)	
Energy activity	0.214*	0.520*	0.122
	(0.113)	(0.309)	
Low carbon of heating system	0.223**	1.185***	0.278
	(0.103)	(0.266)	
Exclusion Restrictions			
expgrow	0.210***		
	(0.0622)		
finobstacle	0.717***		
	(0.0718)		
Control variables	*Yes*	*Yes*	
athrho	0.416*		
	(0.249)		
Constant	−1.937***	2.152**	
	(0.223)	(0.937)	
Observations	12,062		
Selected N	1298		
Wald χ2	292.64***		
Log pseudolikelihood	-1832.893		
χ2 (ρ = 0)	2.80*		

Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * $p < 0.1$.
Weighted data used in regressions.
Control variables includes: age; number of employees; turnover; urban; women-led; organisation's main premises description; industry; UK region; legal status.

corresponds to the outcome equation, showing whether the firm receives external finance or not. In column (1), the results indicate that the exclusion restrictions (*expgrow* and *finobstacle*) are statistically significant in relation to the selection equation at a significance level of 1%. Moreover, the coefficient of athrho and the Wald test of independent equations support the rejection of the null hypothesis of no correlation between the error terms of the main equation (*Obtain finance*) and the selection equation (*Apply finance*) at a significance level of 10%. These findings suggest that the probit model with sample selection adjustment used in our analysis is appropriate. We also control for various company characteristics, such as company age, number of employees, turnover, if located in urban, whether lead by women, organisation's main premises description, industry, UK region, and legal status. The full results include controls are shown in Appendices Table A.2.

5.1. Sought finance

In Table 2, column (1) shows the coefficient of our interest independent variable *Energy Activity* is positive and statistically significant at a 10% level, which represents the probability of seeking external finance increased if the SME has attended energy-efficient and energy-saving schemes. Furthermore, the coefficient of interest independent variable *Low carbon heating system* is also positive and statistically significant at the 5% level, which represents the probability of seeking external finance will be increased if the SME planning to install a low carbon heating system in the following year. We find the coefficient of independent variable *Smart meter* not statistically significant, which represents the probability of seeking external finance not influenced by if SME has smart or advanced meters for gas or electricity in any premises. The instalments and investments of low carbon heating system may cause financial constraints, which may increase their demand for external finance. The high investment cost is a key factor impeding the adoption of energy-efficiency measures (Fleiter et al., 2012), which is consistent with the literature on financial barriers as a bottleneck inhibiting energy efficiency improvements for SMEs (Giraudet, 2020; Kostka et al., 2013). Besides, attending energy activities and schemes also impact the propensity of SMEs' perception of seeking external finance. Indeed, if a firm purchased a product using The Energy Technology List or made/experience changes to buildings as a result of the Energy Savings Opportunity scheme, they are facing finance obstacles as investments in energy-efficient measures may be expensive and SMEs usually have cash constraints, which increases their demand for extra external financing. This finding is consistent with prior study that Energy Audit scheme in European Union inspires SMEs to seek external finance to investment in energy-efficiency measures (Kalantzis and Revoltella, 2019).

In terms of firm demographics, our findings indicate companies are reluctant to apply external finance if their main premises are owned. The result also indicates a positive association between the demand for finance and the number of employees. Furthermore, our results show more mature companies are reluctant to seek external financing. Younger firms, experiencing rapid growth, have less time to generate internal funds and, therefore, prefer to seek external funding in line with the pecking-order theory (Watson, 2006).

Consistent with previous literature, our results indicate that incorporated companies and partnerships, such as private limited companies and limited liability partnerships, have a higher demand for seeking external financing. Whereas unlimited liability is associated with a reluctance for seeking external finance, due to higher risks. This finding aligns with studies that have demonstrated a positive association between debt financing and the formation of limited liability (Fatoki and Asah, 2011; Kira and He, 2012). Regarding industry effects, based on the magnitude of the coefficients, we observe that firms in sectors such as education, accommodation/food, and health/ social work are the least likely to apply for external finance. On the other hand, at the regional level, we find that companies located in the East of England, London, West Midlands, Yorkshire & the Humber, exhibit a positive inclination towards seeking external finance.

5.2. Application outcomes

In Table 2, column (2) shows lenders' decisions on whether the application for financing is approved or not approved, conditional on SMEs seeking external financing. In column (2), we find three of our interest independent variables on energy-efficiency and energy-saving behaviours are positive and statistically significant. Respectively, the coefficient of *Smart meter* is positive and statistically significant at a 10% level, which represents the proportion of receiving external finance increased by 7.29 percentage points if an SME has smart or advanced

Table 3
Lagged effects on apply and obtain external finance.

	(1)	(2)	(3)	(4)	(5)	(6)
	apply	apply	apply	obtain	obtain	obtain
L. apply	1.285***					
	(0.119)					
D2. apply			0.928***			
			(0.063)			
L. obtain				4.711		
				(23.616)		
D2. obtain						0.406*
						(0.233)
L. Smart meter	0.004			−0.079		
	(0.05)			(0.372)		
D. Smart meter		−0.154			−0.124	
		(0.103)			(0.553)	
D2. Smart meter			−0.122*			−0.391
			(0.07)			(0.28)
L. *Energy activity*	0.078			−0.112		
	(0.079)			(2.83)		
D. *Energy activity*		0.072			−0.303	
		(0.222)			(1.035)	
D2. *Energy activity*			0.185			−0.117
			(0.18)			(0.313)
L. *Low carbon of heating system*	0.092			−0.428		
	(0.084)			(0.895)		
D. *Low carbon of heating system*		0.940***			0.110	
		(0.203)			(2.986)	
D2. *Low carbon of heating system*			1.251***			0.155
			(0.255)			(0.625)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−1.985***	−2.704***	−2.297***	−0.835	8.800	11.252
	(0.218)	(0.364)	(0.426)	(6.447)	(4.009)	(31.312)
/lnsig2u	−1.813***	0.691***	0.682***	−13.854	3.514	3.696***
	(0.526)	(0.098)	(0.13)	(1.42e+07)	(0)	(0.873)
Observations	8405	8405	5585	1907	1907	1333

Robust standard errors are in parentheses
*** p < 0.01, ** p < 0.05, * p < 0.1
Control variables includes: age; number of employees; turnover; urban; women-led; organisation's main premises description; industry; UK region; legal status.

Table 4
Probit model with sample selection using predicted interest independent variables (weight applied).

	(2) apply	(2) outcome
Variable name	Coeff.	Coeff.
p. Smart meter	−5.368	55.53***
	(6.019)	(19.91)
p. Energy activity	−0.616	−2.302
	(1.737)	(4.761)
p. Low carbon of heating system	2.831	−10.78
	(2.988)	(11.88)
expgrow	0.210***	
	(0.0624)	
finobstacle	0.716***	
	(0.0713)	
Control variables	Yes	Yes
athrho	0.443*	
	(0.250)	
Constant	−3.388	3.433
	(2.878)	(12.01)
Observations	12,062	
Selected N	1298	
Wald χ2	518.06***	
Log pseudolikelihood	−1844.508	
χ2 (ρ = 0)	3.12*	

Robust standard errors are in parentheses. Weight applied.
*** p < 0.01, ** p < 0.05, * p < 0.1
Control variables includes: age; number of employees; turnover; urban; women-led; organisation's main premises description; industry; UK region; legal status.

meters for gas or electricity in any premises. The coefficient of *Energy activity* is positive and statistically significant at a 10% level, which indicates SMEs are easier to access external finance if attended energy-saving activities or energy-efficiency schemes. In this condition, the proportion of SMEs receiving external finance increased by 12.2 percentage points. Furthermore, the coefficient of *Low carbon of heating system* is also positive and statistically significant at a 1% level, which represents the proportion of approval for external finance increased by 27.8 percentage points if the SME planning to install a low carbon heating system in the following year.

These results imply that energy-saving and energy-efficient behaviours play a significant role in helping SMEs access external financing more effectively. From a debt capacity perspective, energy-efficiency measures lead to lower operational costs and increased long-term profitability for companies. Additionally, investments in energy-efficient technologies, such as smart or advanced meters and low carbon heating systems, along with properties conforming to energy-efficiency regulations, can enhance the value of collateral, making SMEs more attractive to lenders (Wilkinson and Sayce, 2020). Moreover, energy-efficiency practices also contribute to effective risk management. By reducing operational risks and climate-related risks, SMEs can demonstrate greater resilience, which further enhances their creditworthiness. This is consistent with empirical evidence on residential housing price that energy-inefficient properties decrease compared with their energy-efficient counterparts after the introduction of the minimum energy efficiency standard in the UK (Ferentinos et al., 2023). Additionally, participation in energy-efficiency schemes, can serve as a positive signal for the creditworthiness of borrowers.

Regarding the control variables, our findings reveal that larger SMEs

find it easier to access external finance. This is likely because larger-sized and more established firms have a stronger track record, which helps reduce information asymmetries and achieve economies of scale in lending, thereby decreasing transaction costs (Berger and Udell, 1998; Cassar, 2004; Cowling et al., 2016). This finding aligns with risk management theory, as banks are generally less inclined to provide finance to seed or start-up firms due to their higher inherent risks. While smaller companies are worse credit risks, the fixed costs of lending are higher and lending generates lower profit margins (Levenson and Willard, 2000).

Legal status is indeed a significant factor in accessing external finance, as we find that finance applications from Private limited company, limited by shares (LTD) and partnership are less likely to be approved. At the industry level, we observe that the education and transport/storage sectors have a higher likelihood of accessing external finance, while the information and communication arts/ entertainment sector are least likely to secure external financing. This could be attributed to the substantial capital expenditures typically associated with the education sector in the UK, leading to the adoption of a range of funding sources for major capital projects (McCann et al., 2019). The significance of the macroeconomic environment in influencing the availability and accessibility of external financing opportunities (Brown et al., 2019). In terms of regional distribution, it appears that external finance offers are less likely to be funded in the West Midlands and South West, but positive associations were identified for firms located in the North West.

6. Robustness check

We also run different specifications to test the robustness of our primary results. We introduce the lag of dependent variables (*L.apply; L. obtain*) and independent variables (*L. Smart meter; L. Energy activity; L. Low carbon of heating system*) to capture the lagged effects. Furthermore, we employ the difference of interest independent variables between the lag year and the focal year to estimate the impacts on changes. We also include specifications with the changes of lagged year and the year before lagged year.

In column (1) Table 3, we find the coefficient of lagged apply (*L. apply*) is positive and statistically significant at 1% level ($p < 0.01$), which indicates if a SME sought external finance in the last year, it more likely to seek external finance in this year. In column (2), the coefficient of on energy-efficiency awareness changes (*D. Low carbon of heating system*) are positive and statistically significant at 1% level ($p < 0.01$), which indicates if a SME plan to install the low carbon of heating system in the last year, it more likely to seek external finance in this year. Furthermore, in column (3), the coefficient of the growth in the probability of seeking finance in the last year (*D2.apply*) is positive and statistically significant at 1% level ($p < 0.01$), which indicates the growth in the probability to seek finance in the last year increase the probability of seeking finance in the focal year.

Furthermore, we predict our independent variables using a broad set of control variables, then use the predicted values to replace original values. The results showed in Table 4. The results show that the coefficient of the predicted value of original interest independent variable (*p. Smart meter*) is positive and statistically significant (*p* value<0.01).

7. Conclusions and policy recommendations

Even if energy efficiency receives a lot of attention due to climate change and the rise of energy prices due to the Russo-Ukrainian war, based on our knowledge, there are no empirical analyses related to a potential relationship between SMEs' energy efficiency and the lending assessment performed by financial institutions in providing credit to SMEs. This study pioneers an analysis of the impact of energy efficiency on SMEs' access to finance in the UK, offering unique insights. Our research employs a comprehensive dataset from the Longitudinal Small Business Survey, encompassing 2855 UK firms spanning the period from 2015 to 2021. The findings highlight that energy efficient companies and those demonstrating energy-saving practices encounter fewer credit constraints in the UK. These results remain robust even after controlling for various company characteristics, such as age, size, turnover, industry, location, and legal status and sample selection. Our results indicate that green firms can get privileged access to external finance.

Due to the recognition of the impact of energy efficiency on credit assessment by financial institutions, SMEs in the UK now have a strong incentive to enhance their energy efficiency practices. This shift in the lending landscape provides SMEs with a compelling reason to prioritize energy efficiency improvements within their operations. By actively seeking to reduce their energy consumption and adopting sustainable practices, SMEs can potentially improve their creditworthiness and increase their chances of obtaining favourable financing terms. This alignment of financial incentives with environmental goals not only benefits individual SMEs but also contributes to the broader objective of mitigating climate change and reducing carbon emissions. Therefore, it is in the best interests of SMEs in the UK to embrace and invest in energy efficiency measures to leverage this newfound incentive and enhance their financial prospects.

Furthermore, supporting firms to go green by governments is an indirect way of improving access to capital. Government supports and initiatives on encouraging SMEs to go green not only aids in reducing their environmental impact but also indirectly addresses the credit constraints they face. This support opens avenues for improved access to capital and ultimately contributes to the overall economic development and sustainability of these SMEs.

CRediT authorship contribution statement

Jingyuan Chen: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Raffaella Calabrese:** Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Marc Cowling:** Funding acquisition, Project administration, Supervision, Writing – review & editing, Methodology, Resources.

Declaration of Competing Interest

None.

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Appendix A. Appendices

Table A.1
Variable definition and descriptive statistics (Weighted; $N = 12{,}062$).

		Full sample		(1) Apply = 0	(2) Apply = 1	*t*-Test (1) = (2)
Variables		Mean	Std. Dev.	Mean	Mean	
Dependent variables						
Apply finance	= 1 if firm tried to obtain external finance in the past 12 months; 0 otherwise	0.0657	0.248			
Obtain finance (conditional)	=1 if firm offered the finance applied for; 0 otherwise	0.870	0.337			
Independent variables						
Environmental & energy variables						
Smart meter	=1 if main premises have any smart or advanced meters for gas or electricity; 0 otherwise	0.295	0.456	0.296	0.287	
Energy activity	= 1 if firm have done energy-related activities; 0 otherwise	0.0705	0.256	0.0679	0.107	***
Low carbon of heating system	= 1 if firm planning to install a low carbon heating system, e.g. heat pumps, biomass or solar thermal, in any of premises in the next 12 months; 0 otherwise	0.888	0.316	0.886	0.918	***
Company characteristic variables						
Organisation's main premises discerption	Dummy variables: descriptions for organisation's main premises					
Rented from a private or commercial landlord		0.422	0.494	0.417	0.482	***
Owned by you or your business		0.434	0.496	0.440	0.340	***
Leased		0.109	0.311	0.106	0.150	***
Other		0.0360	0.186	0.0365	0.0281	*
Expgrow	=1 if firm expected growth in the next year; 0 otherwise	0.372	0.483	0.362	0.519	***
Finobstacle	=1 if firm say obtaining finance is the major obstacles to the success of business; 0 otherwise	0.139	0.346	0.122	0.374	***
Age	Age of business from year when it was established	18.028	13.865	18.095	17.080	**
Number of employees	Dummy variable: The number of employees is currently on firm's payroll in the UK, excluding owners and partners, across all sites					
zero		0.594	0.491	0.606	0.430	***
Micro 1–4		0.240	0.427	0.237	0.292	***
Micro 5–9		0.0841	0.278	0.0822	0.112	***
Small 10–19		0.0385	0.193	0.0373	0.0566	***
Small 20–49		0.0322	0.177	0.0286	0.0842	***
Medium 50–99		0.00655	0.0807	0.00582	0.0169	***
Medium 100–249		0.00382	0.0617	0.00348	0.00859	*
Turnover (million £)	Turnover of business in the past 12 months across all UK sites	0.818	14.022	0.763	1.605	
Urban	= 1 if postcode of firm belongs to broad urban categorisation; 0 otherwise	0.715	0.451	0.716	0.717	
Women-led	=1 if business is women-led; 0 otherwise	0.181	0.385	0.184	0.144	***
Industry	Sector (SIC 2007 1 digit)					
Primary		0.0297	0.170	0.0280	0.0543	***
Manufacturing		0.0898	0.286	0.0868	0.134	***
Construction		0.0815	0.274	0.0800	0.103	**
Wholesale/ Retail		0.172	0.378	0.169	0.214	***
Transport/ Storage		0.0445	0.206	0.0445	0.0447	
Accommodation/Food		0.0390	0.194	0.0404	0.0193	***
Information/ Communication		0.0644	0.245	0.0653	0.0515	**
Financial/ Real estate		0.0509	0.220	0.0517	0.0388	**
Professional/ Scientific		0.168	0.374	0.172	0.100	***
Administrative/ Support		0.0842	0.278	0.0853	0.0697	**
Education		0.0175	0.131	0.0183	0.00577	***
Health/ Social Work		0.0490	0.216	0.0507	0.0251	***
Arts/ Entertainment		0.0529	0.224	0.0513	0.0749	***
Other service		0.0567	0.231	0.0560	0.0661	
UK region	Dummy variable: UK regions					
East Midlands		0.0634	0.244	0.0643	0.0496	**
East of England		0.0887	0.284	0.0860	0.128	***
London		0.0900	0.286	0.0878	0.121	***
North East		0.0271	0.162	0.0281	0.0131	***
North West		0.100	0.300	0.101	0.0913	
South East		0.216	0.411	0.221	0.142	***
South West		0.164	0.371	0.165	0.154	
West Midlands		0.0794	0.270	0.0786	0.0900	
Yorkshire & the Humber		0.0705	0.256	0.0687	0.0964	***
Scotland		0.0643	0.245	0.0629	0.0836	**
Wales		0.0368	0.188	0.0373	0.0305	

(*continued on next page*)

Table A.1 (*continued*)

Variables		Full sample Mean	Std. Dev.	(1) Apply = 0 Mean	(2) Apply = 1 Mean	*t*-Test (1) = (2)
Legal status	Dummy variables: legal form of the firm					
Sole proprietorship/trader		0.322	0.467	0.332	0.179	***
Private limited company, limited by shares (LTD.)		0.504	0.500	0.497	0.605	***
Partnership		0.0866	0.281	0.0879	0.0684	***
Limited liability partnership		0.0164	0.127	0.0158	0.0239	*
Other		0.0710	0.257	0.0673	0.123	***

Weighted data applied. The sample observation N = 12,062, except for *Obtain finance* (*N* = 1298 and only observed if Apply finance =1). The independent variable *Energy activity* includes: e.g., 1)Used The Energy Technology List to purchase a product 2)Claimed Enhanced Capital Allowance to get tax relief for energy efficient products 3)Made or experienced changes to buildings as a result of The Private Rented Sector Energy Efficiency Regulations; 4)Received payments under The Renewable Heat Incentive; 5)Installed a low carbon heating system e.g. heat pumps, biomass, solar thermal 6) Installed an electric vehicle chargepoint 7)Made or experienced changes to buildings as a result of the Energy Savings Opportunity scheme.

Table A.2
Accessing finance applications and outcomes (weighted).

	(1) apply	(2) outcome	
Variable name	Coeff.	Coeff.	dy/dx
Smart meter	−0.0522	0.311*	0.0729
	(0.0681)	(0.173)	
Energy activity	0.214*	0.520*	0.122
	(0.113)	(0.309)	
Low carbon of heating system	0.223**	1.185***	0.278
	(0.103)	(0.266)	
Age	−0.00477**	−0.00281	−0.000659
	(0.00216)	(0.00675)	
Turnover (million)	0.000424	−0.0107	−0.00251
	(0.000994)	(0.0209)	
Urban	0.0420	−0.159	−0.0372
	(0.0737)	(0.174)	
Women-led	−0.0658	−0.00456	−0.00107
	(0.0899)	(0.225)	
Organisation's main premises discerption			
Owned by you or your business	−0.132*	−0.258	−0.0597
	(0.0776)	(0.163)	
Leased	0.0426	−0.322	-0.0754
	(0.113)	(0.207)	
Other	−0.202	−1.166**	−0.299
	(0.162)	(0.461)	
Number of Employees			
Micro 1–4	0.169**	−0.161	−0.0395
	(0.0756)	(0.205)	
Micro 5–9	0.188**	0.426*	0.0928
	(0.0846)	(0.255)	
Small 10–19	0.233***	0.200	0.0459
	(0.0835)	(0.232)	
Small 20–49	0.586***	0.378	0.0833
	(0.0824)	(0.249)	
Medium 50–99	0.593***	1.070***	0.194
	(0.0893)	(0.379)	
Medium 100–249	0.564***	1.069**	0.194
	(0.108)	(0.445)	
Industry			
Manufacturing	−0.221	−1.648***	−0.287
	(0.165)	(0.522)	
Construction	−0.304*	−0.390	−0.0364
	(0.178)	(0.625)	
Wholesale/ Retail	−0.318**	−1.680***	−0.296
	(0.143)	(0.525)	
Transport/ Storage	−0.245	4.897***	0.0468
	(0.228)	(0.794)	

(*continued on next page*)

Table A.2 (*continued*)

	(1) apply	(2) outcome	
Variable name	Coeff.	Coeff.	dy/dx
Accommodation/ Food	−0.903***	−1.785***	−0.326
	(0.175)	(0.637)	
Information/ Communication	−0.635***	−2.071***	−0.412
	(0.166)	(0.571)	
Financial/ Real Estate	−0.612***	−1.724**	−0.309
	(0.176)	(0.672)	
Professional/ Scientific	−0.665***	−1.388**	−0.218
	(0.145)	(0.558)	
Administrative/ Support	−0.531***	−1.139*	−0.160
	(0.178)	(0.598)	
Education	−0.963***	3.512***	0.0467
	(0.218)	(1.005)	
Health/ Social Work	−0.877***	−0.855	−0.104
	(0.169)	(0.679)	
Arts/ Entertainment	−0.0905	−2.054***	−0.407
	(0.238)	(0.630)	
Other service	−0.390**	−2.121***	−0.427
	(0.179)	(0.668)	
UK regions			
East of England	0.375***	−0.245	−0.0575
	(0.124)	(0.332)	
London	0.312***	−0.0890	−0.0201
	(0.118)	(0.355)	
North East	−0.244	−0.697	−0.179
	(0.179)	(0.614)	
North West	0.105	0.881**	0.142
	(0.130)	(0.391)	
South East	−0.0309	−0.271	−0.0641
	(0.105)	(0.318)	
South West	0.191	−0.656**	−0.167
	(0.130)	(0.326)	
West Midlands	0.267*	−1.276***	−0.345
	(0.142)	(0.364)	
Yorkshire & the Humber	0.387**	−0.191	−0.0442
	(0.153)	(0.378)	
Scotland	0.201	0.336	0.0665
	(0.133)	(0.447)	
Wales	0.0397	−0.385	−0.0935
	(0.169)	(0.446)	
Legal status			
Private limited company, limited by shares (LTD)	0.306***	−0.912**	−0.205
	(0.117)	(0.425)	
Partnership	0.185	−0.804*	−0.0176
	(0.134)	(0.462)	
Limited liability partnership	0.465***	−0.641	−0.135
	(0.165)	(0.598)	
others	0.473***	−0.483	−0.0979
	(0.161)	(0.568)	
expgrow	0.210***		
	(0.0622)		
finobstacle	0.717***		
	(0.0718)		
athrho	0.416*		
	(0.249)		
Constant	−1.937***	2.152**	
	(0.223)	(0.937)	
Observations	12,062		
Selected N	1298		
Wald χ2	292.64***		
Log pseudolikelihood	-1832.893		
χ2 (ρ = 0)	2.80*		

Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.
Weighted data used in regressions. Base categories: *Organisation's main premises discerption* = Rented from a private or commercial landlord; *Age of business* = 0–5 years; *Industry* = Primary; *UK region* = East Midlands; *Legal status* = Sole proprietorship.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2023.107251.

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