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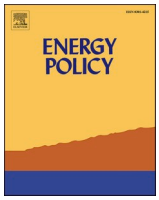

Small and medium sized European firms and energy saving measures: The role of financing☆

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ABSTRACT

This paper investigates the factors (such as different sources of financing, energy audits and internal monitoring activities) affecting the propensity of European small and medium sized enterprises (SMEs) to adopt energy saving measures (ES). For this purpose, a Probit model is estimated using data from the 2017 Flash Eurobarometer survey covering a large sample of European firms. The analysis is carried out for the full sample as well as for clusters based on an environmental performance index (EPI) and on the level of economic development in turn. The results indicate that internal financing always has a positive effect on a firm's propensity to adopt ES. Private external sources of financing appear to be more important for Western European firms as well as for those located in countries with a greater level of environmental awareness; in the latter, when firms combine private financing with energy audits or internal monitoring activities the propensity to adopt ES increases further. By contrast, in the Eastern Countries this occurs when firms simultaneously rely on public funds and monitoring activities.

1. Introduction

Since 2013, the European Union (EU) member states have all been energy net importers. EU import dependency[1] since 1990 (50.0%) has grown steadily, reaching its highest value in 2019 (60.5%) before declining in 2020 (57.5%) as a result of the COVID-19 economic crisis (Eurostat 2022). Reducing it would decrease the energy efficiency gap,[2] thus boosting economic and social development (Allcott and Greenstone, 2012). The International Energy Agency (IEA) estimates that more than 40% of the planned reduction by 2040 in global CO2 emissions relative to baseline could be achieved through improved energy efficiency (IEA, 2018). Therefore, national governments and international organisations have set ambitious environmental targets [3]; in particular, Europe's Green Deal, put forward by the EU Commission, aims for a carbon-neutral continent by 2050 (European Commission, 2019).

Globally, the industrial sector accounts for about 38% of final energy consumption (IEA, 2018); in the European context it includes mainly small and medium sized enterprises (SMEs); although these do not share the same competitive advantages as larger ones (such as economies of scale, cheaper credit and direct access to global value chains - OECD, 2015), they could nevertheless play a key role in achieving the shift to a low carbon economy by adopting energy efficiency measures (EEMs), a fact that has been overlooked by previous studies (Hrovatin et al., 2021). Before the COVID-19 pandemic and the current global energy crisis, the EU liquidity trap situation, characterized by very low real interest rates

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[1] Import dependency is the ratio of net imports (imports minus exports) to gross available energy, the latter being the overall supply of energy for all activities on the territory of a country, which also includes energy transformation, losses and use of fossil fuel products for non-energy purposes.

[2] The energy-efficiency gap is the difference between actual and optimal energy use; according to Jaffe and Stavins (1994) there are "five separate and distinct notions of optimality: the economists' economic potential, the technologists' economic potential, hypothetical potential, the narrow social optimum and the true social optimum. Each of these has associated with it a corresponding definition of the energy-efficiency gap."

[3] For example, energy efficiency targets are part of the "Getting to Zero" US policy agenda as well as representing important tools for China's transition to a carbon neutral society by 2060 (Chen et al., 2020).

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and structural excess of savings, represented an opportunity for firms to implement low carbon investments (Ghisetti et al., 2017) in accordance with the Lisbon Treaty (Vedder, 2010). However, there are a number of obstacles preventing SMEs from adopting more efficient technologies; these include limited capital access and information regarding energy efficiency opportunities, and lack of environmental awareness on the part of the firm's management and of organizational skills of the workforce (Southernwood et al. 2021; Trianni et al., 2016; Sorrell et al., 2004).

Understanding the drivers of cleaner production choices in SMEs can enable policymakers to provide more effective incentives to such firms to adopt them (Merli et al., 2018; Kalar et al., 2021). The present study aims to contribute to this area of the literature by analysing a dataset still largely unexplored (Kalar et al., 2021, being the only previous study using it), namely the Flash Eurobarometer survey from 2017 that provides information about a set of potential determinants of the EEMs adopted by European SMEs. More precisely, in our analysis we focus on some specific drivers of energy saving measures. [4] Since firms adopting energy efficiency measures have more financial needs compared to those that do not (Jensen et al., 2019), we investigate if and how different sources of financing, internal as well as external, can be effective in promoting the adoption of these measures. In fact, although there exist several studies analysing capital constraints to the adoption of EEMs (Cagno and Trianni, 2012; Bodas-Freitas and Corrocher, 2019; Kalantzis and Revoltella, 2019; Cariola et al., 2020), none of them distinguish between internal and external sources of finance as the present one does, this being its first contribution to the literature. The investment decisions of SMEs can be strongly related to the availability of internal funds since the problem of information asymmetry is particularly severe for this type of firms (see, among all, Fazzari et al., 1988); moreover, the access to external funding for small firms may be limited, especially in a context characterized by technological and market uncertainties and regulatory changes (Rennings, 2000). Therefore, some authors have recognized the crucial role of internal funds in promoting the adoption of EEMs (Ghisetti et al., 2017; Bodas-Freitas and Corrocher, 2019). However, in the last decade, banks, institutional investors and policy-makers have also provided some external funding for environmental projects (EEA, 2014), thereby increasing the financial resources available to SMEs to finance energy efficiency measures.

In our analysis we also distinguish between private and public sources of external financing. Both of them can be crucial since, as shown by Kalantzis and Revoltella (2019), firms depending only on internal funds to finance their projects exhibit a lower propensity to invest in EEMs. Therefore, the availability of additional, public funds has a positive effect on the adoption of energy saving measures. In the present study, we investigate in depth the role of various external sources of public financing, analyzing separately the role of subsidies, whose use is controversial because it can generate free-rider problems (Allcott et al., 2015) as this form of financing is not directly linked to specific investments. To promote the adoption of EEMs, grants and subsidies are provided to firms interested in specific policy programmes (Johansson et al., 2019). Hence, our second contribution consists in examining whether subsidies can become more effective tools to improve the firm adoption of ES when firms rely on their own technical expertise.

Our study also aims to assess what makes financial instruments most effective in promoting the adoption of energy saving measures by SMEs and the removal of obstacles to their implementation, especially in the case of small firms. The recent literature suggests that SMEs are more likely to adopt cleaner technologies when they are better informed about the costs and the benefits of these measures (Schaech, 2004; and Bodas-Freitas and Corrocher, 2019), or when they introduce internal organisational changes (Thollander and Ottosson, 2008; and Trianni et al., 2016). We focus in particular on the role of energy audits in providing the necessary information for the adoption of EEMs (Moya et al., 2016; Kalantzis and Revoltella, 2019; Schleich and Fleiter, 2019), and on that of internal monitoring activities of the EEMs introduced (Trianni et al., 2016; Hrovatin et al., 2021). Specifically, we examine how they interact with three different sources of external funding (private and public, considering the role of subsidies separately) affecting the adoption of EEMs, this being the third contribution of our study. Finally, it is a well-established fact that the effectiveness of financial institutions (private and public) in providing credit for energy efficiency investments can vary across countries and it is normally influenced by the institutional context (Ghisetti et al., 2017) as well as by national environmental awareness (Ghisetti et al., 2017, Cariola et al., 2020); therefore, our fourth contribution is to provide evidence for clusters of firms based on two indicators: a country's level of environmental awareness, measured by the EPI index, [5] and its economic development measured by their GDP per capita. In addition, as a robustness check we also carry out the analysis for the quartile distribution of our sample of firms according to the EPI index.

The rest of the paper is organised as follows. Section 2 reviews the relevant literature; Section 3 describes the data and the variables; Section 4 introduces the model and the hypotheses to be tested; Section 5 discusses the empirical results; Section 6 offers some concluding remarks.

2. Literature review

According to the pecking order theory firms (especially smaller ones such as SMEs) tend to finance new projects with internal cash flows and to seek external finance only when internal funds have been exhausted, external equity being their least preferred form of finance (Myers, 1984). Larger firms are instead more likely to obtain finance owing to their greater informational transparency and the consequent reduction of information asymmetries (Berger and Udell, 1998).

Several studies have analyzed the role of debt in the presence of financial constraints and obtained mixed results (Molinari, 2013), even though according to the capital structure literature there should be a negative relationship between debt and firm performance, with the cost of debt offsetting its potential benefits, especially in the case of SMEs (Booth et al.,2001; Tong and Green, 2005). In most European countries, the low development of capital markets and asymmetric information problems affect a firm's choice between the use of internal or external finance to promote growth. For firms facing constraints in their ability to raise funds externally, internal cash flows are almost the only way to achieve this objective (Fazzari et al., 1988; Carpenter and Guariglia, 2008). Other studies argue that more debt (i.e. external finance) allows firms to expand their production and profits, thus increasing the available resources and their ability to invest and grow (Molinari, 2013), and also facilitating the adoption of EEMs (Fleiter et al., 2012; Trianni et al., 2016).

External financial support may also be offered by governments to improve the ability of SMEs to use cleaner production technologies

[4] Energy saving is one of the energy efficiency measures that a firm can decide to adopt. It is particularly relevant in the current scenario since, for European SMEs, the transition to a greater use of renewables has not appeared to be easily achievable in the short run, and this type of measure can help reduce their severe energy import dependency. As discussed in the literature review section, energy saving is in fact the energy efficiency measure (EEM) most used by European firms.

[5] The Environmental Performance Index ranks 180 countries on twenty performance indicators belonging to the following nine policy categories: health impacts, air quality, water and sanitation, water resources, agriculture, forests, fisheries, biodiversity and habitat, and climate and energy. These categories track performance and progress on two broad objectives, environmental health and ecosystem vitality. The EPI's proximity-to-target methodology facilitates cross-country comparisons among economic and regional peer groups.

(Fleiter et al., 2012; Trianni et al., 2016). In particular, below we investigate the role of public subsidies to ease financial restrictions to the introduction of environmental measures despite the associated free-rider issues (Allcott et al., 2015).

However, facilitating access to finance might be not sufficient to guarantee the introduction of EEMs by SMEs. Other strategical measures could be necessary to deal with the lack of information about technological risks and transactions costs (Sorrell et al., 2004 and Thollander and Ottosson, 2008) as well as the absence of internal energy monitoring activities when energy does not represent a management priority (Trianni et al., 2016; Hrovatin et al., 2021). As pointed out by Mickovic and Wouters (2020), the untapped potential for energy savings can be traced back to the lack of resources for energy monitoring and energy efficiency projects. Yet, access to capital remains a crucial factor for the implementation of EEMs (Trianni et al., 2016; Kalantzis and Revoltella, 2019). It is noteworthy that the use of external sources of finance such as debt can have a negative impact on the performance of European SMEs operating in the energy sector, though this effect positive becomes when there is a strong environmental commitment at country level (Cariola et al., 2020). Hence, SMEs' environmental awareness and behavioural issues (related to managerial priorities) emerge as critical factors affecting the adoption of EEMs by firms (Trianni et al., 2016; Kalantzis and Revoltella, 2019; Cariola et al., 2020). .[6]

3. Data and variables description

As outlined in the previous section, a large number of energy efficiency measures are not implemented owing to financial reasons, lack of information, and limited in-house skills (Fresner et al., 2017). The 456 Flash Eurobarometer survey from 2017 (European Commission, 2018) [7] provides detailed information about several types of financial (internal/external, private/public) as well as non-financial resources available to firms and is used for our purposes. We restrict the original sample to focus only on Small and Medium sized firms (the percentage of large firms, which are dropped from the sample is in fact less than 8%).

Table 1 describes the variables included in the analysis while Table 2 shows the correlation matrix.

The dependent variable is energy saving (ES), a dichotomous variable which is equal to one when a firm implements this action to become more resource efficient and to zero otherwise.[8] In the cross-sectional survey used all data refer to 2017, with the exception of the investment ones which refer to two years before the survey was released (see Table 1).

Table 1
List of variables.

Variable	Description
ES	Takes value 1 if the company is involved in saving energy to be more resource efficient
Inv1	Takes value 1 if the company over the past two years have invested on average per year to be more resource efficient less than 1% of annual turnover, 0 otherwise
Inv2	Takes value 1 if the company over the past two years have invested on average per year to be more resource efficient between 1 and 5% of annual turnover, 0 otherwise
Inv3	Takes value 1 if the company over the past two years have invested on average per year to be more resource efficient between 6 and 10% of annual turnover, 0 otherwise
Inv4	Takes value 1 if the company over the past two years have invested on average per year to be more resource efficient more than 10% of annual turnover, 0 otherwise
Size	Takes the value 1 if the number of employees is≤50, 0 otherwise
Int_skills	Takes value 1 if the company to be more resource efficient rely on its own technical expertise
Internal_fin	Takes value 1 if the company to be more resource efficient rely on its own financial resources, 0 otherwise
Private_fin	Takes value 1 if the company to be more resource efficient rely on private funding from a bank, investment company or venture capital fund, 0 otherwise
Pub_fin	Takes value 1 if the company to be more resource efficient rely on public funding such as grants, guarantees or loans, 0 otherwise
Subs	Takes value 1 if the company believes that what helps it most (3 answers possible) to be resource efficient are the subsidies/grants, 0 otherwise
Audits	Takes value 1 if the company to be more resource efficient relies on financial assistance from private consulting and audit companies or from business associations, 0 otherwise
Int_monitoring	Takes value 1 if the company believes that what helps it most (3 answers possible) to be resource efficient is a tool to self-assess how resource efficient the company is with respect to other companies, 0 otherwise
Dim_new_tech	Takes value 1 if the company believes that what helps it most (3 answers possible) to be resource efficient is the demonstration of new technologies or processes to improve resource efficiency
Better_coop	Takes value 1 if the company believes that what helps it most (3 answers possible) to be resource efficient is better cooperation between companies across sectors

Note: Data is sourced by the Flash Eurobarometer survey 2017, commissioned by the European Commission. This survey follows up on previous Eurobarometer surveys (FL342 in 2012, FL381 in 2013 and FL426 in 2015) in reviewing the current levels of resource efficiency actions and the state of the green market amongst Europe's SMEs,.

The first set of independent variables of interest corresponds to the firms' sources of financing and investment choices. Specifically, this group of covariates includes *Int_fin*, *Private_fin,* and *Pub_fin,* which are equal to one if firms, to be more efficient, rely on their own financial resources, private funding (from a bank, investment company or venture capital) and/or public funding respectively, and zero otherwise. All these variables account for financial resources (internal or external) that can enhance a firm's ability to invest in more efficient production technologies. Finally, we consider subsidies (*Subs*) as a possible additional source of financing leading companies to a more resource efficient allocation. The survey also provides information about the amount invested by firms to be more resource efficient; in particular, it specifies whether a firm has invested on average over the previous two years less than 1%, between 1 and 5%, between 6 and 10%, or more than 10% of its annual turnover.

Other covariates included in the model take into account some crucial activities that firms may undertake, such as vocational training, audits and monitoring activities. In particular, the variable *Int_skills* is equal to one if firms rely on internal technical skills to be more resource efficient and zero otherwise; we expect this variable, representing a vocational training activity, to have a positive and significant impact on the dependent variable (Trianni et al., 2016). *Audits* indicates if firms rely on non-financial assistance from private consulting and audit

[6] Sectoral evidence has also been investigated in the recent literature. For example, Henriques and Catarino (2016) report that the perception of barriers in Portuguese SMEs varies according to the sector; the metal sector is the most frequently examined in studies only considering a single sector (Trianni et al., 2013; Johansson et al., 2019). Since this is not the main focus of the present paper in our analysis we simply control for different sectors using dummy variables.

[7] The full name of the survey is: "Small and Medium Enterprises, Resource Efficiency and Green Markets". This survey follows up from the past Euro barometer surveys (FL342 in 2012, FL381 in 2013 and FL426 in 2015) in reviewing the current levels of resource efficiency actions and the state of the green market amongst Europe's SMEs, as well as in neighbouring countries and in the US. The topics covered include current and planned resource efficiency actions, barriers when implementing resource efficiency actions, the role and impact of different types of external support used by SMEs for the production of green products or services and the current state of the green markets.

[8] The survey considers other measures that a firm can adopt to be more resource efficient, such as: saving water, using renewable energy, saving materials, minimising waste, selling scrap material to another company, recycling material or waste within the company and designing products that are easier to repair or reuse. Energy saving is the most adopted measure in the sample (63% of firms implementing this type of action).

Table 2
Correlation matrix.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 EE	1														
2 Inv1	0.11	1													
3 Inv2	0.19	−0.32	1												
4 Inv3	0.08	−0.14	−0.15	1											
5 Inv4	0.03	−0.10	−0.10	−0.04	1										
6 Size	−0.09	−0.03	−0.08	0.00	−0.01	1									
7 Internal_fin	0.27	0.12	0.17	0.09	0.07	−0.08	1								
8 Subs	0.12	0.04	0.09	0.05	0.04	−0.03	0.10	1							
9 Private_fin	0.09	−0.01	0.08	0.08	0.06	−0.06	0.03	0.05	1						
10 Pub_fin	0.11	0.00	0.08	0.07	0.08	−0.11	0.06	0.11	0.32	1					
11 Int_skills	0.26	0.08	0.13	0.06	0.03	−0.07	0.14	0.09	0.03	0.06	1				
12 Int_monitoring	0.09	0.05	0.07	0.00	−0.02	−0.05	0.07	−0.03	0.03	0.04	0.08	1			
13 Audits	0.17	0.05	0.13	0.05	0.02	−0.14	0.03	0.05	0.33	0.37	0.06	0.11	1		
14 Dim_new_tech	0.11	0.04	0.09	0.02	0.02	−0.03	0.09	0.01	0.07	0.07	0.10	0.01	0.10	1	
15 Better_coop	0.09	0.03	0.07	0.03	0.02	−0.04	0.07	−0.02	0.04	0.04	−0.04	−0.06.	0.07	0.01	1

Note: The variables are described in Table 1.

companies or from business associations. As previously mentioned, firms can also introduce internal activities to facilitate the adoption of energy saving measures. Therefore we include the variable *Int_monitoring* for an internal monitoring activity indicating if the firm believes that it is important to have a system in place to self-assess how resource efficient it is relative to others. We also control for other activities that firms carry out to improve the adoption of more efficient technologies such as *Dim_new_tech,* that is equal to one if a firm uses new technologies or processes and zero otherwise, and *Better_coop*, which is equal to one if a firm considers better cooperation between companies across sectors as an important driver of the adoption of more efficient technologies and zero otherwise.

Finally, we control for firm size through the variable *Size*, which takes value one if a firm has a number of employees that does not exceed 50 units and zero otherwise – it accounts for the fact that larger enterprises may have more resources to invest in energy saving measures and are likely to have better monitoring activities and a better trained workforce (Kesidou and Demirel, 2012; Trianni et al., 2016; Bodas-Freitas and Corrocher, 2019).

After a cleaning process, our final sample consists of 12,087 SMEs located in the 28 EU member countries. [9] A firm's decision to invest in EEMs is also driven by its characteristics and by national policies (Kalantzis and Revoltella, 2019 and Cariola et al., 2020). Therefore, in addition to the entire sample of firms from all EU member states (EU28 including the UK), we also consider four clusters of firms. The first two are based on the Environmental Performance Index (EPI), which ranks countries according to how close they are to established environmental policy targets; it is a scorecard that highlights leaders and laggards in environmental performance. Specifically, we split the sample in two clusters including firms located in countries with an EPI above or below the European average respectively. The other two clusters include firms from Western and Eastern European countries respectively, since these two sets of countries differ significantly in terms of their real GDP per capita [10], as well as the quality of their institutions. [11]

Table 3 shows the level of EPI Index in 2016 for each of the EU countries as well as the EU28 average (85.85). It can be seen, that, as expected, the index is generally higher than the average for the Western European countries (EPI = 86.39), with the exceptions of Belgium, Cyprus, Germany, Italy and the Netherlands. By contrast, it is lower (85.30) than the EU28 average for the Eastern European countries, with the noticeable exceptions of Croatia, Estonia and Slovenia.

Table 3
EPI 2016 Index, Western and Eastern European countries.

Western Countries	*EPI16*	*Obs. per country*	*Eastern Countries*	*EPI16*	*Obs. per country*
France	88.20	467	*Czech Republic*	84.67	466
Belgium	80.15	464	*Estonia*	88.59	479
The Netherlands	82.03	466	*Hungary*	84.60	481
Germany	84.26	462	*Latvia*	85.71	482
Italy	84.48	465	*Lithuania*	85.49	468
Luxembourg	86.58	170	*Poland*	81.26	469
Denmark	89.21	468	*Slovakia*	85.42	466
Ireland	86.60	467	*Slovenia*	88.98	472
United Kingdom	87.38	466	*Bulgaria*	83.40	469
Greece	85.81	470	*Romania*	83.24	465
Spain	88.91	466	*Croatia*	86.98	465
Portugal	88.63	478	**μ**	85.30	
Finland	90.68	471			
Sweden	90.43	465			
Austria	86.64	483			
Cyprus (Republic)	80.24	177			
μ	86.39				

Note: The EPI index ranks 180 countries according to twenty performance indicators belonging to the following nine policy categories: health impacts, air quality, water and sanitation, water resources, agriculture, forests, fisheries, biodiversity and habitat, and climate and energy. These categories track performance and progress on two broad objectives, environmental health and ecosystem vitality. The EPI's proximity-to-target methodology facilitates cross-country comparisons among economic and regional peer groups. We use the 2016 EPI Index as it was the latest released before 2017. μ refers to the average value.

Table 4 presents the descriptive statistics for all variables used in the analysis and for all clusters of firms previously defined. On average, firms located in Western Europe perform, in terms of the adoption of energy saving measures, better than those from Eastern Europe; similarly, firms located in countries with an EPI index above the EU28 average outperform those from countries with an environmental performance below average. The share of firms using financial internal resources is quite stable (around 58% for all clusters of firms analyzed). The variable *Subs* has similar values for all firms, whereas for the other two types of external financing sources, *Private_fin* and *Pub_fin*, there is a clear difference between Western and Eastern European firms: in the

[9] The cleaning process consisted in restricting our sample only to SMEs located in the EU28 as well as discarding observations with missing values for the relevant variables.

[10] Real GDP per capita, USD constant price, 2015 PPs; data source: https://stats.oecd.org/index.aspx?DataSetCode=PDB_lV.

[11] As outlined in Alfano et al. (2020), the EU Historical Members (the core group being the Western European countries) belong to the "high club" and have achieved convergence in terms of all six World Government Indicators (WGIs), whereas the new members (Eastern European countries) have not caught up, especially in terms of Control of Corruption and EU authorities and institutions.

Table 4
Descriptive statistics.

Variable	Full sample		EPI < μ		EPI > μ		Western		Eastern	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
EE	0.629	0.483	0.596	0.491	0.665	0.472	0.695	0.460	0.541	0.498
Internal_fin	0.585	0.493	0.585	0.493	0.584	0.493	0.585	0.493	0.584	0.493
Private_fin	0.066	0.249	0.066	0.248	0.067	0.250	0.078	0.269	0.051	0.220
Pub_fin	0.068	0.252	0.062	0.242	0.074	0.262	0.081	0.273	0.049	0.218
Subs	0.358	0.479	0.363	0.481	0.353	0.478	0.353	0.478	0.364	0.481
Int_skills	0.512	0.500	0.501	0.500	0.523	0.500	0.537	0.499	0.478	0.500
Inv_1	0.236	0.425	0.227	0.419	0.246	0.431	0.247	0.431	0.221	0.415
Inv_2	0.253	0.435	0.236	0.425	0.272	0.445	0.282	0.450	0.215	0.411
Inv_3	0.061	0.239	0.062	0.241	0.059	0.236	0.066	0.248	0.054	0.225
Inv_4	0.029	0.168	0.031	0.172	0.027	0.163	0.027	0.163	0.031	0.175
Size	0.794	0.404	0.795	0.403	0.793	0.405	0.801	0.400	0.786	0.410
Int_monitoring	0.152	0.359	0.123	0.329	0.183	0.387	0.199	0.399	0.089	0.285
Audits	0.142	0.349	0.113	0.317	0.173	0.379	0.201	0.401	0.063	0.244
Dim_new_tech	0.240	0.427	0.223	0.223	0.257	0.437	0.252	0.434	0.223	0.416
Better_coop	0.225	0.418	0.201	0.201	0.251	0.433	0.247	0.431	0.195	0.396
Obs.	12,087		6270		5817		6905		5182	

Note: The variables are described in Table 1.

case of the former the share relying on private and public external sources of finance is nearly twice as big as that of the latter. There is a significant difference between these two sets of firms also in terms of the variables *Int_monitoring* and *Audits*.

4. The empirical model and the hypotheses tested

In general, dichotomous choice models can be interpreted in terms of an underlying latent variable process. In our case, we assume the existence of a latent propensity to invest in SME, indicated by f^*, generated by the following process: $f_i^* = X_i'\beta + u_i$, where u_i is the error term and the vector X includes the potential determinants of firms' ES. When $f^* > 0$ one observes the phenomenon under study. If δ is an indicator function such that $\delta = 1$ if $f^* > 0$ and $\delta = 0$ if $f^* \leq 0$, the probability of observing firms' ES is $P(\delta_i = 1|X_i) = P(f_i^* > 0) = P(u_i > -X_i'\beta) = F(X_i'\beta)$ where F is the standard normal distribution density function. The possible factors affecting the energy saving (ES) choices of a firm are examined using a Probit model specified as follows:

$$P(\boldsymbol{ES}_i = \mathbf{1}|\boldsymbol{X}_i) = \boldsymbol{F}\left(\boldsymbol{\alpha} + \boldsymbol{\beta_1 Int}_{fin_i} + \boldsymbol{\beta_2 Private}_{fin_i} + \boldsymbol{\beta_3 Pub}_{fin_i} + \boldsymbol{\beta_4 Subs}_i + \boldsymbol{\beta_5 Int}_{skills\,i} + \boldsymbol{\beta_6 Audits} + \boldsymbol{\beta_7 Int}_{monitoring_i} + \boldsymbol{\beta_8 Z}_i + \sum_s \boldsymbol{\delta}_s \boldsymbol{S}_s + + \boldsymbol{\mu}_i\right) \quad (1)$$

Our analysis aims to explore in greater depth the role of financing in enhancing a firm's ability to adopt energy saving measures (Kalantzis and Revoltella, 2019). Finance has been recognized as an important driver of energy saving in various recent studies, which argue that public funding helps firms overcome financial barriers to cleaner production choices (Ghisetti et al., 2017; Bodas-Freitas and Corrocher, 2019); moreover, external sources of finance in general increase the likelihood that firms will invest in EEMs, especially after an energy audit (Kalantzis and Revoltella, 2019). These previous findings motivate our focus on the interactions between private and public financing with the external and internal activities described in the previous section. In particular, the variables *Audit* and *Int_monitoring* can be considered potential strategic non-economic drivers as stressed by the recent literature.

Therefore, coefficients $\beta_1 - \beta_4$ provide information about the role of the different sources of financing. The coefficient β_5 , instead, considers the role of the workforce skillset accounting for the effect related to the competence building process (learning by doing). Indeed, this kind of investment shows the firm involvement in reducing the cost of the adoption of energy efficiency projects (Hrovatin et al., 2021). The β_6 and β_7 coefficients shed light on the possible impact of energy audits and monitoring activities on the adoption of energy saving measures. In particular, the first coefficient is associated to the *Audit* variable that represents a crucial activity since help SMEs to overcome information-related barriers preventing firm from the adoption of energy efficiency measures; while the second coefficient, associated to the *Int_monitoring* activity reflects the fact that firm is involved in changing its organizational structure to become more resource efficient.

The Z vector contains the control variables identified according to the information included in our dataset such as *Dim_new_tech*, *Better_coop* and *Size* (see Table 1). [12] Sectoral (δs) and *West* dummy, indicating if firm belong to Western European Country, are also included. [13]

The literature discussed above leads us to formulate a set of hypotheses to be tested. The first, based on the Pecking Order Theory, is the following:

H1. *The propensity to adopt energy saving measures is positively related to the availability of internal financial resources.*

As previously mentioned, the role of external sources of financing, such as debt, is controversial, especially for SMEs. The ability to access

[12] For example, the control variables Better_coop and Dim_new_tech capture a firm's willingness to become more resource efficient by exploiting better the cooperation between companies across sectors or using new technologies or processes to implement ES.

[13] The share of firms in the sample by sector are the following: Mining and quarrying (0.56%); Manufacturing (21.75); Electricity and gas (0.67); Water supply, sewerage, waste management (1.73); Construction (15.59); Wholesale and retail trade (30.55); Transportation and storage (5.51); Accommodation and food service activities (5.87); Information and communication technologies (3.57); Financial and insurance activities (2.52); Real estate activities (2.13); Professional, scientific and technical activities (9.56), corresponding to sections B-M of NACE classification of Sector activity (B-M). In all sectors considered firms adopt ES. Manufacturing, Construction and Wholesale, and Retail are more involved in ES compared to other sectors.

Table 5
Probit model estimates.

	Full sample		EPI16<μ		EPI16>μ		WEST		EAST	
	Internal Finance (Hypothesis 1)									
	0.501	***	0.579	***	0.414	***	0.346	***	0.686	***
	(0 .0262)		(0.0376)		(0.0400)		(0.0363)		(0.0417)	
	External Finance (Hypothesis 2-3)									
	0.115	*	−0.042		0.207	**	0.098		0.076	
	(0.0596)		(0 .0811)		(0.0896)		(0.0760)		(0.0966)	
Pub_fin	0.1920	***	0.19	**	0 .166	*	0.157	**	0.243	**
	(0.0661)		(0.0888)		(0.0882)		(0.0802)		(0.0993)	
Subs	0.170	***	0.176	***	0.131	***	0.127	***	0.2225	***
	(0 .0271)		(0.0378)		(0 .0406)		(0.0369)		(0.0411)	
	Other drivers									
Int_skills	0 .502	***	0.496	***	0.407	***	0.375	***	0.592	***
	(0.0259)		(0.0371)		(0 .0388)		(0.0354)		(0.0405)	
Int_monitoring	0 .0967	**	0.0210		0.1831	***	0.0738	*	0.1410	**
	(0.03764)		(0.05545)		(0.05094)		(0.04439)		(0.04439)	
Audits	0.322	***	0.276	***	0 .297	***	0.315		0.274	***
	(0.0469)		(0.0670)		(0.0603)		(0.0521)		(0.0883)	
Dim_new_tech	0.150	***	0.160	***	0 .106	**	0.064	***	0.239	***
	(0 .0308)		(0.0436)		(0.0439)		(0.0405)		(0.0472)	
Better_coop	0.091	***	0.095	**	0.096	**	0.120	***	0.087	*
	(0.0314)		(0.0447)		(0 .0445)		(0.0410)		(0.0488)	
Size	−0.137	***	−0.117	***	−0.220	***	−0.192	***	−0.09	*
	(0.0305)		(0 .0456)		(0.0500)		(0.0460)		(0.0491)	
Inv1	0 .407	***	0.497	***	0.332	***	0.430	***	0.396	***
	(0.0335)		(0 .0470)		(0.0485)		(0.0446)		(0.0512)	
Inv2	0.527	***	0.510	***	0.569	***	0.627	***	0.405	***
	(0.0344)		(0.0485)		(0 .0513)		(0.0464)		(0.0537)	
Inv3	0 .468	***	0.59	***	0 .406	***	0.61	***	0.35	***
	(0.0585)		(0.0801)		(0.0865)		(0.0777)		(0.0777)	
Inv4	0.309	***	0.484	***	0.230	**	0.371	***	0.207	***
	(0.0790)		(0.0401)		(0.1611)		(0.1104)		(0.1210)	
West	0.316	***								
	(0.0278)									
Above_EPI16	0.023									
	(0.0272)									
Obs	12.087		6.270		5.817		6905		5.182	
Chi-squared	2223.07	***	1647.03	***	1428.62	***	1260.89	***	1481.55	***
Pseudo R_squared	0.1690		0.1947		0.1927		0.1485		0.2073	

Note: Sectorial dummies are included but not reported for lack of space and available upon request. ***, ** and * correspond to significance at the 1%, 5% and 10%, respectively.

finance is an important determinant of firms' growth (Beck and Demirguc-Kunt, 2006). As pointed out by Brutscher et al. (2020), the debate on how to improve firms' energy efficiency has overlooked the key role of external financing. In theory more energy efficient firms, being more cost-competitive, should be – *coeteris paribus* – more creditworthy. However, firms appear to adopt EEMs sluggishly and mainly because of market failures (Allcott and Greenstone, 2012; Jaffe and Stavins, 1994). Such firms cannot exploit the ability to signal to credit markets the competitive advantage connected to the systematic adoption of EEMs and thus experience difficulties in accessing external sources of financing. Moreover, Cariola et al. (2020) find that the use of private external finance reduces the energy performance of European SMEs, but this effect turns from negative to positive when there is strong environmental awareness at country level. Other studies find that the access to private external sources of finance may facilitate the adoption of EEMs by SMEs (Trianni et al., 2016; Bodas-Freitas and Corrocher, 2019; Kalantzis and Revoltella, 2019). Given the fact that the available empirical evidence is mixed, we do not specify a prior about the relationship between the dependent variable and the variable *Private_fin* for the private sources of external financing. Therefore, our second hypothesis is formulated as follows:

H2. *The propensity to adopt energy saving measures is affected by the availability of private external finance.*

The literature has also emphasised the role of public financing to increase firms' financial resources for the adoption of EEMs (Fleiter et al., 2012); hence, we formulate our third hypothesis as follows:

H3. *The propensity to adopt energy saving measures is affected by the availability of public external finance.*

Subsidies represent a controversial form of public financing since, as already mentioned, they can give rise to free-rider issues (Allcott et al., 2015). However, there is evidence that an experienced workforce improves a firm's performance by retaining the knowledge concerning the adoption of new measures or technologies, thereby increasing the profitability of investment (Nemet, 2012). Consequently, subsidies when supported by internal technical skills should be an effective tool to promote the adoption of energy saving measures, otherwise firms rely on "rules of thumb" to make such decisions (Trianni and Cagno, 2012). The lack of technical skills has been recognized as a major barrier to the adoption of energy efficiency measures in the case of small firms (Backman, 2017). As Nemet (2012) argues, subsidizing the development of environmental energy technology can be effective if knowledge externalities exist. The reason is that the accumulation of technical expertise improves a firm's ability to use the additional funds obtained through subsidies. Hence, at least in the short run, firms relying on the technical skills of their workforce can exploit the benefits from the additional funds obtained through subsidies, thereby increasing their propensity to adopt energy saving measures. Therefore, our fourth hypothesis is the following:

H4. *The propensity to adopt energy saving measures increases when firms*

can simultaneously rely on subsidies and internal technical skills.

As discussed before, external financial resources have an important role to play but are not sufficient to guarantee that the energy saving measures will be implemented by SMEs. On the basis of the recent literature, summarized in Section 2, we argue that a key determinant of a firm's adoption of energy saving measures is its ability to overcome barriers such as the lack of information about the costs and benefits of EEMs (see, e.g., Moya et al., 2016; Bodas-Freitas and Corrocher, 2019; Kalantzis and Revoltella, 2019; Schleich and Fleiter, 2019), as well as to change its internal organization through ad hoc monitoring activities (Thollander and Ottosson, 2008; Trianni et al., 2016; Hrovatin et al., 2021). As for energy audits, their crucial role for SMEs has been recognized by the first European directive introduced in 2006. [14] Therefore, when considering our sample of European SMEs, we investigate whether external audit activities (by increasing the quality of information about the costs and benefits of energy saving measures), and internal monitoring activities (aimed at supervising the implementation of these measures) significantly increase a firm's ability to save energy in the production process. Consequently, we formulate our fifth hypothesis as follows:

H5. *The probability of adopting energy saving measures increases for firms combining external sources of financing (private or public) with energy audits or internal monitoring activities*.

The above hypotheses are all tested for the whole sample as well as for the sub-samples of firms previously described. In particular, the first subsample analyses clusters of firms based on the level of the EPI index in the country to which firms declare to belong, while the second one groups countries by geographical location given the fact that average income is typically higher in Western Europe compared to Eastern Europe. Table 3 shows that in Western Europe twelve out of seventeen countries have an EPI index above the EU28 average, while in Eastern Europe only this is the case for only three out of the eleven countries.

4.1. Empirical analysis

The Probit model given by Eq. (1) was used to investigate the effects of the set of independent dichotomous variables described in the previous section on the adoption of energy saving measures. These estimation results are presented in Table 5. The first column of Table 5 reports the point estimates for the full sample while the second and the third ones show the corresponding coefficients for the two subgroups of firms with an EPI below or above the EU28 average, and the last two columns those for firms from Western and Eastern Europe, respectively. In the full sample estimation, we include the dummies *West*, that is equal to one if a firm belongs to a Western European country and zero otherwise ,[15] and the dummy Above _EPI16, that is equal to 1 if the EPI index is above the EU average and zero otherwise. The former is significant and has the expected sign while the latter, though positive as expected, is insignificant. The evidence of a country effect motivates our additional analysis based on firm clusters as previously mentioned.

Regarding the firms' financial resources, the coefficient of the variable *Internal_fin* is positive and highly significant in all cases confirming that the role of a firm's internal earnings is crucial for European SMEs. By contrast, *Private_fin* is not always positive and it is significant only for the subsample of firms from the countries with a higher EPI. These results point to the critical role of external private financing but also to the presence of obstacles that make this instrument ineffective in countries with a low institutional level of environmental awareness.

In all clusters considered *Subs* and *Pub_fin* have a positive and significant effect on a firm's propensity to save energy, and the same holds for *Int_skills*. Therefore, access to subsidies and to public financing increases the probability to adopt ES with respect to firms that do not benefit from these additional sources of finance. Firms that invested in technical skills of their workforce outperform those that did not.

Investment in internal monitoring activities also plays a positive and significant role, except for firms located in countries where the EPI index is below the EU average. The effect of the variable *Audits* is always positive and highly significant, which shows that this practice is crucial to overcome information barriers limiting a firm's ability to invest in ES.[16] Finally, both the use of new technologies, *Dim_new_tech*, and the presence of better cooperation between companies across sectors, *Better_coop*, enhance a firm's ability to implement energy saving with respect to firms that are not engaged in these activities.

As for the coefficients on the control variables Inv1-Inv4, the reference category corresponds to the case of companies which, over the past two years, declared not to have invested with the aim to become more resource efficient. As expected, all these coefficients are positive and significant.[17] For the variable *Size* the reference group is medium size firms. In line with the previous literature, the coefficient of this variable is negative and significant, which indicates that smaller firms encounter more obstacles when they try to implement energy saving measures.[18]

Next, we examine how the simultaneous use of external sources of finance (*Subs, Internal_fin, and Pub_fin*) and some crucial investments/measures that a firm can choose to adopt (*Int_skills; Audits and Int_monitoring*) affect its propensity to save energy (Tables 6a and 6b).

Following Williams (2012), to capture the interdependence between two variables in a non-linear model, in this case subsidies and internal technical skills, we calculate the adjusted predictions for each combination of the values of *Subs* (0,1) and *Int_skills* (0,1) on the basis of the model shown in Table 5 (the same is done in all other cases, e.g. for the interdependence between the different sources of external finance and the firm's activities captured by the variables *Audits* and *Int_monitoring*). Table 6a reports the results concerning the role of subsidies and internal technical skills. Both variables increase the probability of implementing ES compared to firms without them when the full sample is considered; this effect is bigger for firms located in countries with a low level of the EPI index (second column of Table 6a) and in the Eastern European ones

[14] European Commission. Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy End-use Efficiency and Energy Services and Repealing Council Directive 93/76/EEC. Off. J. Eur. Union 2006, 4.

[15] Alternatively, we included all the country dummies, which produced very similar results (these are not reported in Table 5 for reasons of space, but are available upon request).

[16] Bodas-Freitas and Corrocher (2019) and Kalantzis and Revoltella (2019) focus on the role of audits in promoting the adoption of EEMs. In particular, the latter follow the methodology developed by Roy (1951) and Rubin (1974) by taking into account the participation in an audit programme as a way to reduce the bias in the estimation of treatment effects with observational data sets. The standard problem of treatment evaluation concerns inference about the causal connection between the treatment and the outcome. In the case of cross-sectional data such as the ones we analyze, correlations rather than causal connections are detected.

[17] Concerning the sectoral dummies mentioned in footnote 13, the reference category is "Professional, scientific and technical activities" (NACE classification). The main industries in terms of observations (close to 52%) as well as economical relevance are "Wholesale and Retail trade" and "Manufacturing". Both coefficients are significant and positive as expected.

[18] Note that we have carried out a number of robustness checks. Specifically, we have also estimated equation (1) using the Logit model, which confirmed the previous results; we then obtained additional estimates by excluding in turn the smaller economies, such as Cyprus and Luxembourg, and then the four largest European economies belonging to the G7, i.e. the United Kingdom, France, Italy and Germany. Reassuringly, the results for the predicted probabilities (the focus of our analysis) are qualitatively similar in both cases (these results are available upon request). As reported in the main text, the other robustness checks consisting in clustering firms according to either the EPI index or real GDP per capita and re-estimating the model by quantiles also confirm the main results.

Table 6a
Adjusted predictions (Probit model).

	Full sample			Δ	EPI < μ		Δ	EPI > μ		Δ	Western		Δ	Eastern		Δ
Subs	0	0.630	***		0.587	***		0.675	***		0.708	***		0.511	***	
Subs	1	0.690	***		0.654	***		0.721	***		0.750	***		0.590	***	
Int_skills	0	0.552	***		0.514	***		0.613	***		0.652	***		0.436	***	
Int_skills	1	0.736	***		0.702	***		0.756	***		0.778	***		0.650	***	
Subs_Int_skills (H4)	0 0	0.517	***		0.482	***		0.580	***		0.628	***		0.394	***	
	0 1	0.724	***	21%	0.685	***	20%	0.752	***	17%	0.770	***	14%	0.637	***	24%
	1 0	0.612	***	9%	0.570	***	9%	0.672	***	9%	0.696	***	7%	0.510	***	12%
	1 1	0.757	***	24%	0.731	***	25%	0.763	***	18%	0.792	***	16%	0.673	***	28%
												***				
Private_fin	0	0.647	***		0.613	***		0.692	***		0.720	***		0.538	***	
Private_fin	1	0.701	***		0.622	***		0.764	***		0.758	***		0.576	***	
															***	
Audits	0	0.633	***		0.601	***		0.675	***		0.701	***		0.534	***	
Audits	1	0.749	***		0.712	***		0.771	***		0.801	***		0.626	***	
															***	
Private_fin_Audits	0 0	0.629	***		0.600	***		0.667	***		0.698	***		0.532	***	
(H5)	0 1	0.749	***	12%	0.716	***	12%	0.767	***	10%	0.800	***	10%	0.628	***	10%
	1 0	0.691	***	6%	0.617	***	2%	0.739	***	7%	0.742	***	4%	0.575	***	4%
	1 1	0.762	***	13%	0.651	***	5%	0.825	***	16%	0.819	***	12%	0.591	***	6%
															***	
Pub_fin	0	0.645	***		0.612	***		0.694	***		0.719	***		0.534	***	
Pub_fin	1	0.753	***		0.715	***		0.761	***		0.800	***		0.642	***	
Audits	0	0.634	***		0.602	***		0.672	***		0.704	***		0.534	***	
Audits	1	0.751	***		0.713	***		0.781	***		0.805	***		0.619	***	
Pub_fin_Audits	0 0	0.626	***		0.593	***		0.667	***		0.695	***		0.528	***	
(H5)	0 1	0.751	***	12%	0.712	***	12%	0.767	***	10%	0.804	***	11%	0.615	***	9%
	1 0	0.733	***	11%	0.710	***	12%	0.739	***	7%	0.796	***	10%	0.639	***	11%
	1 1	0.774	***	15%	0.725	***	13%	0.825	***	16%	0.819	***	12%	0.685	***	16%

Note: Δ measures the probability to increase/decrease EE. This is a measure of what firms gain if any of the potential drivers considered, or their combination, are adopted. ***, ** and * correspond to significance at the 1%, 5% and 10%, respectively.

Table 6b
Adjusted predictions (Probit model).

	Full sample			Δ	EPI < μ		Δ	EPI > μ		Δ	Western		Δ	Eastern		Δ
Private_fin	0	0.647	***		0.612	***		0.685	***		0.720	***		0.537	***	
Private_fin	1	0.688	***		0.595	***		0.755	***		0.752	***		0.557	***	
Int_monitoring	0	0.644	***		0.612	***		0.678	***		0.718	***		0.534	***	
Int_monitoring	1	0.679	***		0.604	***		0.741	***		0.743	***		0.580	***	
	0 0	0.642	***		0.613	***		0.674	***		0.716	***		0.534	***	
	0 1	0.674	***	3%	0.604	***	−1%	0.733	***	6%	0.738	***	2%	0.578	***	4%
	1 0	0.675	***	3%	0.594	***	−2%	0.733	***	6%	0.743	***	3%	0.541	***	1%
Private_fin _Int_mon (H5)	1 1	0.754	***	11%	0.608	***	−1%	0.841	***	17%	0.780	***	6%	0.711	***	18%
Pub_fin	0	0.645	***		0.606	***		0.686	***		0.718	***		0.534	***	
Pub_fin	1	0.715	***		0.680	***		0.742	***		0.770	***		0.633	***	
			***			***			***			***			***	
Int_monitoring	0	0.645	***		0.612	***		0.678	***		0.718	***		0.534	***	
Int_monitoring	1	0.679	***		0.605	***		0.740	***		0.742	***		0.585	***	
	0 0	0.640	***		0.607	***		0.674	***		0.713	***		0.529	***	
	0 1	0.676	***	4%	0.602	***	−1%	0.737	***	6%	0.740	***	3%	0.580	***	5%
	1 0	0.713	***	7%	0.686	***	8%	0.733	***	6%	0.773	***	6%	0.628	***	10%
Pub_fin_Int_monitoring (H5)	1 1	0.724	***	8%	0.639	***	3%	0.781	***	11%	0.760	***	5%	0.682	***	15%

Note: See the notes in Table 6a.

(last column of Table 6a).

As mentioned in the literature section, energy audits (*Audits*) can enhance a firm's adoption of ES. The second block of Table 6a shows the adjusted predictions of a firm's propensity to adopt ES, when energy audits, *Audits* (0,1) are carried out and private external sources of finance, *Private_fin* (0,1) are used, whilst the third block presents the corresponding results for *Audits* (0,1) and *Pub_fin* (0,1) respectively. One can see that the variable *Audits* (0,1) significantly increases the propensity to implement ES in all clusters of firms. In the case of Western European firms, as well as firms located in countries with a high EPI index, combining private financial support with energy audits (*Private_fin_Audits*) results in a higher propensity, whilst in the case of the two other clusters this remains below that estimated when firms simply rely on private non-financial assistance (*Private_fin_Audits*) (see columns 2 and 5 in Table 6a).

For all clusters of firms considered public funding (*Pub_fin*) increases the propensity to adopt ES (by more than 10 percentage points with respect to firms which do not receive this kind of support). The biggest increases from combining public funding with private non-financial assistance are detected in the case of firms located in countries with an EPI above the EU28 average and for Eastern European firms. The use of private sources of finance and the adoption of internal monitoring activities, *Private_fin_Int_monitoring*, reduces (increases) the propensity to adopt ES for firms located in countries with a low (high) level of EPI

(Table 6b, first block). The simultaneous use of private sources of financing and monitoring internal activity generally increases this propensity, except for the cluster of firms located in countries with a low level of the EPI index (Table 6b, column 2). Finally, the role of public funding is particularly beneficial, significantly increasing the propensity to adopt ES for Eastern European firms that invest in internal monitoring activities (*Pub_fin_Int_monitoring*).

4.2. Quantile regressions

It is well known that the conditional expectation or any other measure of conditional central tendency only provides limited information about a statistical relationship among variables (Koenker and Bassett, 1982). For this reason, as a robustness check we also consider the quartile distribution of our sample of firms according to the EPI index.

The first block of Table 7a shows that both subsidies and internal technical skills increase a firm's propensity to adopt ES in all four quartiles (columns Q1-Q4). This effect is even bigger for firms in the last quartile that rely on both subsidies and technical skills. Moreover, for firms in the first quartile access to private sources of finance slightly decreases the propensity to adopt ES compared to those not relying on banks and/or private equity (from 0.61 to 0.59), whereas the opposite holds for firms in the last two quartiles. The results of the first two columns (Q1 and Q2) show that the probability of implementing ES increases when firms are involved in regulatory external activities; however, combining these activities with the search for external finance from the private sector reduces the probability of adopting ES. The opposite holds for firms in the third and the fourth quartile.

As for firms that simultaneously use *Pub_fin* and *Audits (Pub_fin_Audits)*, the predicted probability to implement ES decreases in the first quartile while it substantially increases in the last one. Concerning *Private_fin_Int_monitoring* and *Pub_fin_Int_monitoring*, the results reported in the last two blocks of Table 7b show that they both decrease they propensity to adopt ES relative to firms only using private or public finance. Therefore, for a firm located in a country with a low level of EPI Index the beneficial effect of introducing internal monitoring activities is not apparent.

5. Conclusion and policy implications

Energy technology investments require significant changes in financing tools, social preferences, policies, regulations and the overall institutional context (Ghisetti et al., 2017). The aim of this paper is to investigate to what extent these factors affect the decision of the EU28 SMEs to save energy. The concept of "environmental awareness" can be defined in terms of how close a country is to established environmental policy targets, but also on the basis of the extent to which firms are engaged in changing their strategies to improve the energy efficiency of their production. Following a resource-based view (Hart, 1995), a firm that wants to adopt a resource efficient scheme of production must mobilize an adequate set of financial and non-financial resources. To analyze the former, we have focused on the relevance of internal and external ones and also distinguished, in the latter case, between private and public financing. As for non-financial resources, we have assessed the role of two activities that are considered relevant by the recent literature, namely audits and internal monitoring. The empirical exercise has been carried out using the full set of firms available as well as different clusters based on the EPI index and real GDP per capita; as a robustness check we also consider the quartile distribution of our sample of firms according to the EPI index.

The results suggest that in all cases the main financial resources used by European SMEs to adopt ES are the internal ones (which supports H1). However, Cooremans (2011) noted that investments in EEMs are not considered as strategic by firms depending on internal funds for whom they are not a priority. Therefore, the role of external finance, although supplemental, is also crucial.

The firm cluster analysis provides further insights. In particular, our results show that Eastern firms are generally more financially constrained and relatively less supported by public funding with respect to Western ones. However, public funding improves the propensity to adopt ES for all European firms. By contrast, private funding has a significant positive impact only in countries with a strong environmental awareness and well-developed institutions (thus H2 is only partially supported), whereas public sources of financing exert, in all clusters, a significant and positive effect on the dependent variable (H3 holds).

A significant percentage of European SMEs also considers subsidies as one of the most useful instruments to support the introduction of

Table 7a
Adjusted predictions (Quartile estimation).

		Q1		Δ	Q2		Δ	Q3		Δ	Q4		Δ
Subs	0	0.587	***		0.588	***		0.646	***		0.706	***	
Subs	1	0.633	***		0.673	***		0.703	***		0.742	***	
Int_skills	0	0.527	***		0.504	***		0.578			0.650	***	
Int_skills	1	0.675	***		0.727	***		0.743	***		0.773	***	
Subs_Int_skills (H4)	0 0	0.504	***		0.463	***		0.545	***		0.623	***	
	0 1	0.664	***	16%	0.705	***	24%	0.732	***	19%	0.782	***	16%
	1 0	0.567	***	6%	0.573	***	11%	0.632	***	9%	0.711	***	10%
	1 1	0.694	***	19%	0.762	***	30%	0.762	***	22%	0.775	***	15%
Private_fin	0	0.606	***		0.620	***		0.661	***		0.713	***	
Private_fin	1	0.592	***		0.652	***		0.783	***		0.744	***	
Audits	0	0.591	***		0.609	***		0.656	***		0.697	***	
Audits	1	0.685	***		0.746	***		0.729	***		0.818	***	
Private_fin_Audits (H5)	0 0	0.591	***		0.607	***		0.648	***		0.691	***	
	0 1	0.690	***	10%	0.749	***	14%	0.726	***	8%	0.803	***	11%
	1 0	0.584	***	−1%	0.649	***	4%	0.783	***	14%	0.712	***	2%
	1 1	0.634	***	4%	0.691	***	8%	0.783	***	14%	0.851	***	16%
Pub_fin	0	0.599	***		0.616	***		0.665	***		0.714	***	
Pub_fin	1	0.730	***		0.686	***		0.729	***		0.801	***	
Audits	0	0.595	***		0.608	***		0.657	***		0.693	***	
Audits	1	0.700	***		0.732	***		0.734	***		0.812	***	
Pub_fin_Audits (H5)	0 0	0.581	***		0.605	***		0.650	***		0.691	***	
	0 1	0.702	***	12%	0.728	***	12%	0.735	***	9%	0.805	***	12%
	1 0	0.743	***	16%	0.672	***	7%	0.730	***	8%	0.782	***	10%
	1 1	0.691	***	11%	0.809	***	20%	0.720	***	7%	0.884	***	19%

Note: See the notes in Table 6a.

Table 7b
Adjusted predictions (Quartile estimation.

		Q1		Δ	Q2		Δ	Q3		Δ	Q4		Δ
Private_fin	0	0.605	***		0.619	***		0.661	***		0.713	***	
Private_fin	1	0.576	***		0.625	***		0.761	***		0.757	***	
Int_monitoring	0	0.603	***		0.621	***		0.659	***		0.700	***	
Int_monitoring	1	0.601	***		0.607	***		0.706	***		0.780	***	
Private_fin	0 0	0.605	***		0.621	***		0.652	***		0.699	***	
Private_fin	0 1	0.606	***	0%	0.600	***	−2%	0.704	***	5%	0.766	***	7%
Int_monitoring	1 0	0.582	***	−2%	0.614	***	−0.7%	0.764	***	11%	0.706	***	1%
Private_fin_Int_mon	1 1	0.542	***	−6%	0.725	***	10%	0.750	***	9%	0.906	***	21%
Pub_fin	0	0.597	***		0.616	***		0.664	***		0.710	***	
Pub_fin	1	0.676	***		0.684	***		0.696	***		0.804	***	
Int_monitoring	0	0.604	***		0.620	***		0.658	***		0.700	***	
Int_monitoring	1	0.602	***		0.604	***		0.706	***		0.778	***	
Pub_fin	0 0	0.595	***		0.619	***		0.656	***		0.694	***	
Pub_fin	0 1	0.605	***	1%	0.596	***	−2%	0.704	***	5%	0.770	***	8%
Int_monitoring	1 0	0.693	***	10%	0.674	***	6%	0.688	***	3%	0.786	***	9%
Pub_fin_Int_mon	1 1	0.575	***	−2%	0.777	***	16%	0.733	***	8%	0.870	***	18%

Note: See the notes in Table 6a.

cleaner production strategies. Especially in the case of Eastern European firms, their effectiveness significantly increases if firm can rely on internal technical skills. In other words, the accumulation of technical expertise improves firms' ability to use additional funds obtained through a source of financing, such as subsidies, which is not directly related to specific investments driven by energy saving measures. As for the effect of energy audits, these are found to increase considerably a firm's propensity to adopt ES in all clusters considered. A beneficial role is also detected for monitoring internal activities, but mainly in the case of countries with a strong environmental awareness.

The results by clusters also suggest that in the case of Western European SMEs the simultaneous use of private funding and energy audits, or private funding and internal monitoring measures, increases a firm's propensity to adopt ES. This means that, in these countries, banks and venture capitalists are able to improve the energy efficiency propensity of SMEs that simultaneously adopt these strategic measures, consistently with the findings of Kalantzis and Revoltella (2019). Energy audits also play a role for Eastern European SMEs, although the role of private funding in their case is not as important as in the case of Western Europe. In fact, in the former Soviet countries it is mainly the simultaneous use of public funding and energy audits or that of public funding and monitoring activities that boosts the propensity to adopt ES (thus H5 is only partially supported). This confirms the findings of Staikouras et al. (2008) and Brown et al. (2012), namely that in Eastern Europe the efficiency of the banking sector is generally low compared to Western Europe owing to often complicated loan application procedures. The quartile analysis broadly confirms these conclusions.

Our findings have some important implications. In particular, they suggest that policy-makers should increase incentives for banks, investment companies and venture capitalists to finance SMEs that are implementing energy audits or/and internal monitoring activities. In the Eastern European countries, the role of the private financial sector is still quite marginal and the presence of public funding should be enhanced to complement the limited supply of private credit. Eastern European firms appear to be constrained also by limited organizational skills and by managers' attitudes and propensity towards implementing ES.

In line with other studies (Moya et al., 2016; Kalantzis and Revoltella, 2019, among others) we show that energy audits improve the energy efficiency choices of SMEs and thus policy makers should introduce more regulations aimed at increasing the quality standards for such audits (Fleiter et al., 2012). At the same time, the environmental awareness of firms' managers should be enhanced; in particular, policymakers should provide assistance and information to SMEs' managers regarding the benefits of energy saving and give incentives to firms to implement the internal organisational changes needed for the adoption of cleaner production technologies.

Finally, it should be acknowledged that the present study has some limitations arising from the nature of the data examined. Specifically, the survey used provides detailed information concerning the role of financing (internal, external private and external public) along with workforce energy-related skills, but it does not allow us to control for firm specific characteristics affecting the adoption of energy saving measures, such as a firm's energy-intensity, profitability, export status, competition in the market, R&D activity, expectations about future energy prices, uncertain demand, etc. This type of analysis, using firm level data, will be carried out in follow-up studies.

Credit author statement

All three authors have contributed to the various aspects of this research equally.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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