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European SMEs and Resource Efficiency Measures: Firm Characteristics and Contextual Factors

Abstract

This paper investigates how access to finance and skilled workforce endowments affect the propensity of European small and medium sized enterprises (SMEs) to adopt different types of resource efficiency measures (REMs), possibly simultaneously. For this purpose, a Multinomial Logit model is estimated using data from the 2017 Flash Eurobarometer survey covering a large sample of European firms. The analysis is carried out first for the whole sample and then for clusters based on two contextual factors measured by the Ease of Access to Loans Index (EAL) and the European Skill Index (ESI). The findings suggest that the two firm characteristics considered lead to the adoption of more than one REM simultaneously. Moreover, the propensity to implement them is stronger in the case of firms located in countries with easier access to financial resources, whilst the workforce skill-set appears to be a less important factor in this context.

JEL-Codes: G320, O160, Q400.

Keywords: resource efficiency measures, financing, SMEs, workforce skills.

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1. Introduction

Recent years have witnessed an increasing governmental and societal awareness of the environmental degradation caused by the use of exhaustible resources. This is a particularly severe problem in the case of Europe, given the fact that since 2013 the European Union (EU) member states have all been energy net importers. [1] The EU has therefore developed a new growth strategy, known as the European Green Deal (EGD), whose aim is "to transform the EU into a fair and prosperous society with […] a competitive economy", at the same time preserving the environment.[2] It is also a crucial part of the EU's plan to achieve the 2030 Agenda for Sustainable Development. The main goals of the EGD are a net carbon-neutral European Union by 2050 and a decoupling of economic growth and resource use. This ambitious programme requires reducing greenhouse gas emissions by at least 55% by 2030 as well as greater energy efficiency and higher shares of renewable energy. [3] It also highlights the strong synergies between climate actions and the circular economy, especially in energy and carbon intensive industries, promoting the creation of a more supportive environment for deploying the clean tech manufacturing capacity required to meet Europe's ambitious green target.

It is noteworthy that in the European context the industrial sector, which globally accounts for about 38% of final energy consumption (IEA, 2018), mainly comprises small and medium sized enterprises (SMEs). These are expected to play a key role in achieving the shift to a low carbon economy by adopting resource efficiency measures (REMs; Hrovatin et al., 2021), despite not benefiting from the same competitive advantages as large enterprises (economies of scale, cheaper credit and direct access to global value chains - OECD, 2015). In order to deliver on the Green Deal and reach climate neutrality by 2050, SMEs are expected to green their processes and activities by changing their industrial processes as well as organisational structure to intensify the adoption of resource efficiency measures. During the transition phase the main challenge for the EU industrial sector is to maintain and improve its competitiveness while implementing the green technologies necessary to meet the Green Deal objectives. However, many REMs are not adopted due to financial constraints, lack of information, and limited in-house skills (Fresner et al., 2017). Thus, not surprisingly, the four pillars

[1] https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_id/default/table?lang=en

[2] European Commission, 2020. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions - The European Green Deal.

[3] The European Commission presented the EGD to the EU institutions and the public on 11 December 2019. After a parliamentary debate in January 2020, the European Parliament decided to support the EGD, but pointed out that more needed to be done to achieve a fair transition that would leave no one behind. It also called for higher interim targets, most recently concerning carbon emissions.

of the Green Deal industrial plan include faster access to funding and enhanced skills in addition to a predictable and simplified regulatory environment and open trade for resilient supply chains.

The present study aims to investigate to what extent firm specific characteristics as well as contextual factors determine the adoption of resource efficiency measures by exploiting the extensive information provided by the 456 Flash Eurobarometer survey released in 2017 (European Commission, 2018). We focus exclusively on SMEs and consider three categories of REMs: i) energy saving measures (ES); ii) the adoption of renewable energy (RE); and iii) the implementation of circular economy measures (CE). Firms have the following options: i) not to adopt any measures; ii) to adopt only one; or iii) to adopt two resource efficiency measures simultaneously.[4] In particular, we examine first how access to finance and the availability of a skilled workforce help firms adopt one or more of those measures (with the latter case being described as high adoption intensity). As mentioned above, these are two of the four pillars specified in the Green Industrial Plan; we investigate their impact separately first and then also allow them to interact. Second, we rank EU firms according to two contextual factors, namely the Ease of Access to Loans Index (EAL) and the European Skill Index (ESI), and cluster firms accordingly. Third, following the recent literature (Cagno and Trianni, 2012; Henriques and Catarino, 2016) we investigate whether the intensity of the adoption of REMs varies across industrial sectors. The remainder of the paper is organised as follows: Section 2 reviews the relevant literature; Section 3 describes the data and the variables used for the analysis; Section 4 introduces the model and the hypotheses tested; Section 5 discusses the empirical results; Section 6 offers some concluding remarks.

2. Literature Review

The issue of the efficient use of energy and specifically physical exhaustible resources has interested scholars for some time (Dasgupta and Heal, 1980). Over the years a theoretical framework has been developed to understand the strategic decisions made by firms to increase the sustainability of their production processes, namely the natural-resource-based view (NRBV) (Hart, 1995; Shivastava, 1995). This is based on the idea that firms are organisations expected to develop their specific competitive advantages by dealing with the increasingly binding constraints imposed by the natural environment. The ensuing empirical studies found that firm specific resources and its organisational capabilities produce better economic and social outcomes (Judge and Douglas, 1998; Russo and Fouts, 1997). In this area of the literature, only a few papers have focused on the relationship between

[4] We chose to focus on these three alternatives since in our sample the share of firms investing simultaneously in all three categories is very small.

firm resource endowments and the adoption of cleaner technologies (Chan, 2005). Some studies, following Grant (1991), consider the resources used by firms as inputs into the production process, where the former include different types of resources such as capital equipment, finance, skills of employees, patents and so on, and try to establish which resources are crucial to increase firms' propensity to adopt resource efficiency measures (Cagno and Farné, 2016; Bodas-Freitas and Corrocher, 2019; Hrovatin et al., 2021; Kalantzis and Revoltella, 2019; Kalar et al., 2021; Trianni et al., 2016). As Fresner et al. (2017) pointed out, many of these measures are not implemented owing to financial reasons, lack of information, and limited in-house skills. For smaller firms the crucial role of internal finance emerges, as they extensively rely on internal earnings to finance investments in cleaner technologies (Ghisetti et al., 2017; Bodas-Freitas and Corrocher, 2019; Caporale et al., 2023). However, Kalantzis and Revoltella (2019) find that firms depending only on internal funds to finance their projects exhibit a lower propensity to invest in energy efficiency measures. In fact in the last decade banks, institutional investors, and policymakers have focused on providing more external funding for environmental projects (EEA, 2014) and enhancing the financial resources available to SMEs that want to adopt resource efficiency measures. Recent studies have shown the positive impact of external finance, public and/or private, on the propensity to adopt REMs (Trianni et al., 2016; Bodas-Freitas and Corrocher, 2019; Kalantzis and Revoltella, 2019). Further, the role of private finance in firms' decision to invest in more resource efficiency technologies has been found to be affected by the country level of environmental awareness (Cariola et al., 2020). In particular, recent studies suggest that the effectiveness of financial institutions (private and public) in providing credit for REMs can vary significantly across countries according to the institutional context (Ghisetti et al., 2017; Bahn-Walkowiak and Wilts, 2017).

One way to reduce the constraints faced by SMEs to adopt new technologies or production processes is to develop skills (Mayer, 1992), since insufficient expertise often accounts for the failure to introduce green practices (Cassells and Lewis, 2011). Often SMEs' employees are given the opportunity to organise their learning processes (Thollander and Palm, 2015). Workforce skills are also crucial for more effective audit programmes aimed at overcoming information barriers often encountered by smaller firms (Palm and Backam, 2020). [5] As for the factors improving a firm's access to external sources of finance, Nemet (2012) argues that subsidising the development of environmental energy technologies can be an effective tool only if knowledge externalities exist. The

[5] Palm and Backam (2020) also outline that such energy audits are often performed by professionals with a background in engineering while the SMEs' workforce may lack similar background knowledge, making it difficult for smaller firms to exploit all the information acquired through the audits.

rationale is that the endowment of technical expertise improves a firm's ability to use the additional funds obtained through external sources of finance.

Finally, a few studies address the issue of the factors affecting a firm's decision to adopt more REMs simultaneously, though they are typically based on small samples not exceeding 500 observations. In particular, Arvanitis and Lay (2013) consider the adoption decisions regarding a broad spectrum of energy-saving technologies and find that the previous experience of other companies connected to the firm plays an important role. Also, Delmas and Pechovich (2015) conclude that the propensity to adopt more REMs is notably lower during economic downturns, but it is bigger for firms that focus on cost leadership strategies, have adopted environmental standards, conduct their research internally and are vertically integrated.

3. Data and Variables Description

The 456 Flash Eurobarometer survey, carried out in 2017, and released by the European Commission in 2018, provides detailed information about financial (internal/external, private/public) as well as non-financial (the technical skillset of the workforce, non-financial assistance from private consulting and audit companies or from business associations, etc.) factors potentially improving efficiency in the use of resources.[6] For our purposes, we restrict the original sample to European Small and Medium sized firms only (the percentage of the large firms dropped from the sample is less than 8%) in order to consider a more homogenous set of firms. Table 1 describes the variables included in the analysis, while Table 2 shows their correlation matrix.

(Please insert Tables 1-2 here)

On the basis of the information included in the survey, we distinguish between three types of REMs, namely energy saving measures (ES), the use of renewable energy (RE), and the implementation of circular economy practices (CE), the latter including saving water, 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. The most frequently adopted measures in the sample are ES, with 63% of firms implementing them. [7] We classify firms according to whether they

[6] The full name of the survey is: "Small and Medium Enterprises, Resource Efficiency and Green Markets". This survey is the only one explicitly asking about resource efficiency measures as well as the role and impact of different types of external financing used by SMEs.

[7] The survey asks firms about the action undertaken to be more resource efficient distinguishing between the following measures: saving energy, 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. The use of renewable energy requires the use of a specific kind of energy which is inexhaustible, therefore energy

declared not to adopt any resource efficiency measure, to adopt only one or two or more types of measures simultaneously. In our dataset firms adopting only one measure usually invest in energy saving measures, whilst very few firms invest simultaneously in all three types of REMs. Therefore the dependent variables in the model are defined in terms of the choice between the following three options for firms: (1) not adopting any measures; (2) implementing only energy saving measures; (3) adopting simultaneously two types of REMs. [8] All data refer to 2017, except for the investment ones which refer to two years before the survey was released (see Table 1).

We consider two sets of independent variables corresponding respectively to sources of financing and endowment in terms of workforce technical skills. More specifically, the first group of covariates includes internal finance (*Int_fin)* and external finance (*Ext_fin).* The former is equal to one if firms, to be more efficient, rely on their own financial resources, and to zero otherwise, whereas the latter is equal to one if firms rely on external sources of finance such as private funding (from a bank, investment company or venture capital) or public funding to invest in REMs, and to zero otherwise. The second set of covariates includes the variable *Int_tech_skills*, which is equal to one if firms rely on their own technical expertise to be more resource efficient, and to zero otherwise. A set of control variables is also included. *Size* and *Positive_turnover* are both dichotomous variables respectively equal to one when a firm has less than 50 employees and if it has invested over the previous two years, on average, a positive share of the annual turnover, and to zero otherwise. The former variable captures the fact that smaller enterprises tend to have less resources to invest in the adoption of REMs (Kesidou and Demirel, 2012; Trianni et al., 2016; Bodas-Freitas and Corrocher, 2019); the latter reflects the fact that it is reasonable to expect a positive relationship between the share of turnover invested in the adoption of more resource efficient technologies and the adoption of REMs. The variable *Age* indicates the years of activity of the firm, while the variables *Green_products* and *Non_Ec_support* are equal to one if the firm offers green product or services and when it receives external support from public rather than private organizations (i.e. public administration, private consulting, audit companies or business associations), and to zero otherwise. As for *Age*, we expect a positive effect since the implementation of green practices tends to increase with a firm's age (Yin et al., 2022). Firms selling green products create their green image that represents a driver for energy

efficiency measures differ from the use of renewable energy. However, ES and RE work in synergy: when pursued together, they result in higher shares of renewable energy, a faster reduction in energy intensity, and a lower cost for the energy system. This synergy also has important environmental and societal benefits, such as lower levels of air pollution (IRENA, 2017).

[8] In our sample, out of 9143 companies 58 firms declared to invest only in RE measures, 604 only in CE measures while 2483 adopted ES measures. Fewer firms adopted simultaneously all the three measures (1385) than those adopting at least two measures (5249).

efficiency measures (Trianni et al., 2016), so we also expect a positive effect of this variable as well as for the variable *Non_Ec_support* on the basis of the recent literature (Kalantzis and Revoltella, 2019; Schleich and Fleiter, 2019). The variables *Consumers* and *PA* indicate respectively if the company offers product and services directly to consumers or, in the latter case, directly to public administration. The variable *West* is a geographical dummy indicating if a firm belongs to a Western European Country; in this case a positive relationship is expected as a more developed socio-economic context can affect SMEs performance in terms of REM adoption (Caporale, et al. 2023). Sectoral dummies are also included but are not reported for lack of space and are available upon request. [9] Table 3 shows descriptive statistics for the full sample as well as for the clusters obtained on the basis of the two indices discussed in the previous section. [10] In all sectors considered firms adopt mainly energy saving measures, especially in Manufacturing, Construction and Wholesale, and Retail.

(Please insert Table 3 here)

4. Model Specification and Hypothesis Testing

As previously mentioned, our dependent variables measure different degree of adoption of REMs, which allows us to consider three mutually exclusive groups of firms characterised by: 1) no adoption; 2) low intensity adoption (i.e., adopting only ES measures); 3) high intensity adoption (i.e., implementing simultaneously two of the three REMs considered). In this way, we can investigate the factors affecting the adoption of REMs for different degrees of intensity. We follow McFadden (1974), who argues that the Multinomial Logit model is more appropriate in cases where the alternatives can plausibly be assumed to be distinct and weighted independently in the eyes of each decision maker, and thus estimate the following Multinomial Logit model:

$$\text{Prob}\{Y_i = \text{j} \mid \text{x}_i)\} = \frac{e^{\beta_j x_i}}{1+\Sigma_{k=1}^{j} e^{\beta_k x_i}} \qquad for\ j = 0, 2, \ldots., j;\ \beta_0 = 0, \qquad (1)$$

[9] The shares of firms in the sample by sector are the following: Mining (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).

[10] First, we cluster our sample according to whether a firm belongs to a country with an EAL index above or below the EU median value, and then to whether it is located in a country with an ESI index above or below a similarly defined threshold to the previous case.

where Y_i stands for the dependent variables with index *j* (*j=1* being the baseline category), x_i is a vector of independent variables (including both financial and non-financial drivers as described in the previous section) with index *i,* which refers to firm *i* in the sample, and βj is a vector of coefficients. As discussed in Section 2, various recent studies have analysed the impact of internal and external sources of financing on a firm's choice to adopt energy as well as other resource efficiency measures (Trianni et al., 2016; Bodas-Freitas and Corrocher, 2019; Hrovatin et al., 2021; Kalantzis and Revoltella, 2019; Cariola et al., 2020; and Kalar et al., 2021). However, those studies focus on the effects on individual types of REMs. By contrast, the present one allows for the possibility of a range of such measures being adopted simultaneously and thus extends previous works by testing the set of hypotheses specified below.

Hypothesis 1. *The availability of internal and external sources of finance affects the SMEs' adoption intensity (i.e., their propensity to adopt simultaneously more than one type of resource efficiency measures).*

The recent literature has examined whether the SMEs' ability to adopt REMs may be related to an inadequate endowment of resources and expertise (Cassells and Lewis, 2011). In the case of smaller firms, the lack of technical skills has been recognised as a major barrier to the adoption of resource efficiency measures (Backman, 2017). Technical expertise suited to the implementation of REMs is the result of a learning processes that firms are expected to develop. These processes, if coupled with a technically skilled workforce, allow SMEs to process actively information internally and to exploit it for the purpose of REM adoption (Thollander and Palm, 2015; Palm and Backman, 2020). This leads us to formulate the following hypothesis:
Hypothesis 2: *The availability of a technically skilled workforce affects the SMEs' adoption intensity*.

Moreover, extending the analysis of Nemet (2012), we test whether the use of internal as well as external sources of finance can be more effective for the adoption of REMs when firms can rely on a skilled workforce. Therefore, our third hypothesis is the following:

Hypothesis 3. *SMEs that can rely on both financial resources and a skilled workforce have a higher propensity to invest in more than one resource efficiency measure*.

Finally, the seminal work of North (1990) highlighted the importance of country-wise contextual factors for economic outcomes. Therefore, as stressed by Bahn-Walkowiak and Wilts (2017) and Domneck and Bahn-Walkowiak (2019), when analysing the determinants of REMs it is crucial to take into account the possible impact of different national institutional settings and policy frameworks. This important issue has been relatively little explored in the literature (Ghisetti et al., 2017; La Rocca and Cariola, 2020). We address it here by using two appropriate indices measuring how differences between the European countries in terms of the ease of access to finance and the availability of a technically skilled workforce (two contextual factors considered crucial in the EGD strategy) affect the adoption of REMs by firms. Therefore, the last hypothesis we test is the following:

Hypothesis 4: *Contextual factors affect the impact of financial and non-financial drivers on the SMEs' adoption intensity.*

5. Empirical Analysis

Table 4 presents the results from the Multinomial Logit model (relative risk ratios and standard errors are reported in brackets) with category 2 (low intensity adoption) being taken as the reference category.

(Please insert Table 4 here)

Multinomial Logit models assume the independence of irrelevant alternatives (IIA), which implies that adding or deleting them does not affect the odds (Freese and Long, 2006). Violation of this assumption leads to biased estimates. Therefore, before proceeding further, we conduct a Small-Hsiao test confirming that the IIA assumption holds also when we change the reference category. [11]

The outcomes reveal that for category 1 (column one, Table 3), i.e. non-adopting firms, as expected, the coefficients on financial drivers as well as on other drivers are not statistically significant at the standard 5% conventional level. By contrast, as reported in column two of Table 3, the relative risk of adopting more intensively REMs (category 3), compared to a low level of adoption (category 2, our reference category), is always significant and greater than one for all parameters of interest. For instance, the relative risk of choosing category 3, compared to choosing category 2, is 1.30 for firms

[11] Moreover, to check the robustness of our findings, we compare the results obtained with the Multinomial Logit with those found by estimating an Ordered model. These results are qualitatively similar and therefore are not reported, but are available upon request.

relying on internal resources to be more resource efficient compared to those not relying on them. The same relative risk is 1.615 for firms relying on external financial resources relative to those not relying on them, and it is 1.548 for firms relying on internal technical skills relative to those not relying on internal technical skills. Regarding the non-financial drivers, all coefficients are significant and greater than one (the higher relative risk ratio is associated to the variable *Green_products*). Therefore, the positive role of the financial and non-financial drivers examined is confirmed for firms combining two different REMs. Concerning the control variables, the dummy West associated to the Western European countries, as expected, has a positive and significant coefficient (2.64).

Following Williams (2012), in order to capture the interdependence between two variables in a non-linear model, we compute the adjusted predictions for each combination of the values of the drivers considered, i.e. workforce skills and the two kinds of financial resources (internal and external) analysed. Therefore, using Multinomial Logit model previously estimated, we calculate the adjusted predictions for each combination of the values related to *Int_fin* (0,1) and *Int_tech_skills* (0,1) as well as for each combination of the values related to *Ext_fin* (0,1) and *Int_tech_skills* (0,1). Table 5 shows the predicted probabilities for category 2 and 3. [12]

(Please insert Table 5 here)

As previously discussed, we are interested in investigating whether firms relying on financial resources (distinguishing between internal and external ones) as well as on a skilled workforce exhibit a higher propensity to adopt simultaneously two kinds of REMs. The first column of Table 5 shows that internal and external sources of finance reduce a firm's propensity to invest only for one type of measures, i.e. energy saving ones. This result is not surprising given the fact that category 1 includes firms investing only in one type of efficiency measures and excludes those implementing simultaneously ES and other resource efficiency measures (such as CE or RE). [13] The second column of Table 5 instead shows that financial resources as well as the endowment of a skilled workforce significantly improve a firm's propensity to adopt REMs. Moreover, the gain in terms of a higher propensity to adopt two types of measures simultaneously is particularly marked for firms combining internal sources of finance with internal technical skills (+ 15%) as well as for firms combining external sources of finance and internal technical skills (+18).

[12] We do not report the results for firms belonging to the first category. In this case, as expected, all coefficients are close to zero and always not statistically significant.

[13] Firms investing in ES measures are, in most of the cases, also involved in the adoption of an additional REM.

5.2 Contextual Factors and REM Adoption

The second part of our empirical analysis focuses on two contextual factors possibly influencing a firm's adoption intensity. Specifically, we cluster firms according to two indices, namely the Ease of Access to Loans (EAL) Index and the European Skill Index (ESI), which rank European countries on the basis of these two factors identified as pillars in the European Industrial Plan for the implementation of the Green Deal. The former index measures how easy it is to obtain bank loans with only a good business plan and no collateral. The source is The World Economic Forum's Global Competitiveness Report (2017), which collects data through executive opinion surveys providing information on individuals' views on access to bank loans in different countries. Countries are ranked on a scale from one to seven (1 = impossible, 7 = extremely easy). The latter index instead measures the performance of the EU 28 countries in terms of skill creation. It is constructed by Cedefop (European Centre for Development of Vocational Training), which supports the promotion and implementation of EU policies in the field of skills and qualifications policies by working together with the European Commission and EU member states. The ESI final report uses normalised scores with values ranging between 0 and 100. Table 6 shows the EAL and ESI per country as well as the median EU values of the two indices.

(Please insert Table 6 here)

We use them to cluster firms into more homogeneous groups including those belonging to European countries reporting an EAL (ESI) below or above the median European value respectively. Table 7 shows the estimates for the two clusters obtained on the basis of the EAL median value. The first two columns show the predicted probabilities associated to the combination of internal and external sources of finance with internal technical skills, for low (category 2) and high intensity adoption firms (category 3); those for firms belonging to category 1 are always statistically insignificant, with estimated coefficients close to zero, and are not reported. The last two columns provide instead the same information for firms belonging to countries where the EAL index is above the EU 28 median value.

(Please insert Table 7 here)

In both clusters, for firms with low adoption intensity both types of financing, a skilled workforce endowment as well as the combination of the two, reduce the propensity to adopt energy saving measures only. The highest negative value is estimated for firms simultaneously relying on external

financial instruments and internal technical skills (-0.21) that are located in countries with a low EAL index. For firms belonging to category 3 there is positive effect on the propensity to adopt two types of measures simultaneously regardless of the cluster firms they belong to (below or above the EAL median value). Firms located in a country with a greater value of the Ease of Access to Loans Index exhibit the highest predicted probability associated with the use of external sources of finance (0.76 against 0.69 in the other cluster) as well as the highest gain arising from their use (0.16 instead of 0.09). However, the combined use of financial resources and technical skilled workforce produces greater gains (in terms of a higher propensity to adopt two types of measures) for firms belonging to countries where the EAL is lower than the median value; this suggests that such firms are more efficient and/or productive and thus find it easier to gain access to external financing.

(Please insert Table 8 here)

Table 8 shows the results for firms clustered according to the ESI index (those for category 1 are again insignificant and are not included). Consistently with the previous results, firms located in countries with a greater ESI Index exhibit a higher increase in the propensity to adopt two types of REMs and greater associated predicted probabilities (0.77) when they have access to external financial resources (+ 21%). Further, combining financial resources and technical skills leads to an even greater increase in adoption intensity in both clusters, with the greatest predicted probabilities being estimated for firms located in countries with an ESI Index below the median value.

5.3 Robustness Check – Contextual Factors

To shed more light on this apparently counterintuitive result, and as a robustness check, we create four different clusters defined as follows: Low EAL - Low ESI, Low EAL - High ESI, High EAL - Low ESI and High EAL - High ESI, where “Low” and “High” stand for below and above the median value respectively (see Table 9).

(Please insert Table 9 here)

Tables A1 and A2 in the Appendix report the complete set of predicted probabilities for each of the four clusters. For firms belonging to the cluster Low EAL - Low ESI, these are not significant and exhibit the lowest gain from the use of external finance as well as internal skills (0.06 and 0.03, respectively). Therefore, firms located in these countries are penalized and unable to use those for adopting resource efficiency measures. Firms located in the High EAL - High ESI cluster exhibit the

highest predicted probabilities (always highly significant) associated to the use of external finance (0.79), whilst those belonging to the Low ESI - High EAL cluster exhibit the highest ones associated to the simultaneous use of two sources of finance (internal and external) and to workforce skills (0.81 and 0.84). Finally, firms belonging to the High ESI - Low EAL cluster exhibit the highest predicted probabilities related to the use of external finance (0.78), all other predicted probabilities being insignificant.

5.4 Robustness Check - Sectoral Analysis

As an additional robustness check, we replicate the analysis clustering firms according to the two most relevant sectors included in our sample, i.e. manufacturing and wholesale and retail trade. [14] The results are reported in Table 10 and are consistent with the main ones. The simultaneous use of financing and technical skills increases the intensity of REM adoption, while it decreases a firm's propensity to invest only in energy saving measures, in both sectors. Firms belonging to the manufacturing sector benefit more than those belonging to the wholesale and retail trade sector from access to external financing (0.82 being the predicted probability to invest in more than one REM) as well as from combining financing activities and technical skills (0.86 and 0.91 being the estimated values for the combination with technical skills of internal and external finance, respectively, compared to 0.74 and 0.78 for the wholesale and retail trade sector).

6. Conclusions

Global warming has become a serious threat to the future of the planet Earth. Reducing CO_2 emissions with the aim of limiting the increase in the average temperature is therefore essential. Firms can contribute to achieving this objective by adopting resources efficiency measures resulting in (i) a reduction in the use of conventional energy sources (Andrews-Speed et al., 2017; Bahn-Walkowiak and Wilts, 2017) and (ii) the diffusion of cleaner technologies with positive environmental and economic spillovers (Farghali et al., 2023; IRENA, 2017). An inefficient use of resources raises sustainability issues which can only be addressed through global governance (Milligan and O'Keeffe, 2019) and by taking into account the economic, ecological, and social factors driving the green transformation of the industrial sector (Ekins et al., 2019). However, it is still at "the national level that the great majority of policies that use or seek to manage resources are formulated and implemented" (Wilts and O' Brien, 2019).

[14] The sample includes 1928 observations for manufacturing firms and 2838 firms belonging to the wholesale and retail trade sector.

The present study provides new evidence on the factors affecting the propensity to adopt resource efficiency measures (REMs) in the case of the European SMEs by using data from 2017 Flash Eurobarometer survey and estimating a Multinomial Logit model. European firms operate in different economic and institutional contexts, especially in terms of environmental policies and performance (Domneck and Bahn-Walkowiak 2019). Therefore it is crucial to consider not only firm specific characteristics but also country-wide factors, labelled as contextual factors, affecting a firm's decision to adopt resource efficiency measures. For this reason, we investigate the role of some contextual factors, specifically the differences between European countries in terms of the ease of access to finance (measured by the EAL index) and the ability to create/employ a skilled workforce (measured by the ESI index), by clustering firms accordingly. In the European case two of the four pillars specified in the industrial plan for the implementation of the European Green Deal are access to finance and the workforce skillset. Our results show that both increase the propensity to adopt more than one REM, which supports our hypotheses H1 and H2. Moreover, the simultaneous use of financial resources and technical skills further increases the European SMEs' adoption intensity, which is consistent with our hypothesis H3. These results can be summarised as follows. In all clusters the propensity to invest in two types of REMs increases when firms simultaneously use financial tools (internal/external) and a technically skilled workforce. Firms located in countries where EAL or ESI are above the EU median values exhibit a greater adoption intensity, driven by successful external financing. However, the highest gains are observed for SMEs located in countries with a low EAL and ESI. This finding would seem counterintuitive at first sight, but can be rationalised in terms of the greater efficiency of firms investing in two types of REMs and belonging to the two latter clusters. We extend the analysis further by creating four clusters based on all possible combinations of the "High" and "Low" values for the two indices considered. The estimated predicted probabilities indicate that firms belonging to the cluster with low values of both indices experience the lowest gain from the use of external financing. The highest gain, when combining external financing and technical skills, is detected for firms belonging to the cluster High EAL - Low ESI. Therefore, it appears that the main contextual factor affecting a firm's propensity to adopt more than one REM is access to finance, consistently with our hypothesis H4. Finally, our sectoral analysis implies that the manufacturing sector benefits the most from both access to finance and a skilled workforce.

On the whole, our evidence suggests that the propensity of European SMEs to adopt REMs is affected by both firm specific characteristics, specifically the ability to attract financial resources and a skilled workforce, and country-wide contextual factors, namely country-wide ease of access to loans and skills, structural economic and financial conditions having previously been found to matter (North, 1990; Van de Bergh et al., 2011). Contextual factors are particularly important in the case of the

European SMEs, which are subject to national as well as supranational laws and regulations (Bahn-Walkowiak and Wilts, 2017), with the effectiveness of the latter depending on the specific policy mix adopted at country level (Flanagan et al., 2017).

Our findings have important implications. Specifically, they confirm the importance of appropriate policies aimed at increasing incentives for banks, investment companies and venture capitalists to finance SMEs in order to promote the adoption of resources efficiency measures. They also suggest that policies aimed specifically at firms adopting more than one REMs might be more effective. Further, policy intervention appears to be especially important in countries where access to finance is more difficult for firms since, owing to path dependencies, inertia and other biases against change, improvements are not likely to result from the operation of markets alone (Milligan and O'Keeffe, 2019). On the whole, our study confirms that, as argued by Ekins et al. (2019), the speed at which environmental targets can be met varies across countries depending on their contextual factors as well as firm characteristics, and thus policies should be designed to improve resource efficiency across the board and to minimise the risk of leaving behind entire economic sectors and/or countries.

Finally, it should be acknowledged that the present study has some limitations. Specifically, the nature of the dataset used (which is survey-based), while providing detailed information about the role of financing along with workforce skills, does not allow us to control for other firm specific characteristics, 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. By using additional data sources future work could explore the role of those factors and also investigate the determinants (including contextual ones) of adoption intensity at the regional level.

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Table 1. List of variables

Variables	Description
Dependent variable	
REMs choices	REMs = 0 = *not adopting*, if firm does not adopt any measure REMs = 1 = *low intensity of adoption*, if firm adopts only one kind of measure (ES) ; REMs = 2 = *high intensity of adoption*, if firm adopts two different kinds of measures
Indipendent variables	
Int_tech_skill	Takes value 1 if the company, to be more resource efficient, relies on its own technical expertise
Internal_fin	Takes value 1 if the company, to be more resource efficient, relies on its own financial resources, 0 otherwise
External_fin	Takes value 1 if the company, to be more resource efficient, relies on external (private or public) financial resources, 0 otherwise
Size	Takes the value 1 if the number of employees is ≤ 50, 0 otherwise
Age	Indicates years of activity
Pos_turnover	Takes value 1 if the company, over the past two years, has invested on average, per year, to be more resource efficient a positive share of the annual turnover, 0 otherwise
Green_products	Takes value 1 if the company offers green products or services, 0 otherwise
No_Ec_support	Takes value 1 if the company receives external support from public administration, private consulting and audit companies, or business associations, 0 otherwise
Consumer	Takes value 1 if the company offers products and services directly to consumers, 0 otherwise
PA	Takes value 1 if the company sells its products or services directly to public administration, 0 otherwise
West	Takes value 1 if the company is located in a Western European Country, 0 otherwise

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

Table 2. Correlation matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1 REMs_choice	1.000											
2 Internal_fin	0.411	1.000										
3 External_fin	0.177	0.035	1.000									
4 Int_tech_skill	0.392	0.155	0.041	1.000								
5 Size	-0.010	-0.069	-0.088	-0.066	1.000							
6 Age	0.143	0.062	0.084	0.075	-0.167	1.000						
7 Pos_turn	0.072	0.029	0.030	0.030	-0.031	-0.012	1.000					
8 Green_products	0.166	0.092	0.041	0.101	-0.028	0.060	0.044	1.000				
9 No_ec_support	0.215	0.030	0.048	0.055	-0.125	0.156	0.057	0.068	1.000			
10 Cons	0.005	0.024	0.012	-0.023	0.130	-0.011	-0.037	0.056	-0.012	1.000		
11 PA	0.089	0.048	0.063	0.106	-0.018	0.088	0.024	0.085	0.081	0.192	1.000	
12 West	0.254	0.001	0.067	0.051	0.030	0.237	0.029	0.106	0.188	-0.068	0.051	1.000

Note: The variables are described in Table 1.

Table 3. Descriptive statistics

Variables	Full sample		EAL > Median Value		EAL < Median Value		ESI > Median Value		ESI < Median Value	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
REMs_choice	2.420	0.743	2.430	0.727	2.437	0.737	2.397	0.750	2.437	0.736
Internal_fin	0.589	0.491	0.637	0.481	0.574	0.494	0.610	0.488	0.798	0.401
External_fin	0.118	0.323	0.130	0.336	0.111	0.315	0.126	0.332	0.111	0.315
Int_tech_skill	0.516	0.500	0.560	0.496	0.487	0.499	0.552	0.497	0.487	0.499
Size	0.798	0.401	0.799	0.400	0.798	0.401	0.798	0.402	0.798	0.401
Age	25.452	23.550	26.332	24.939	24.130	21.488	27.097	25.839	24.130	24.488
Pos_turn	0.516	0.500	0.800	0.399	0.762	0.426	0.818	0.386	0.762	0.426
Green_products	0.286	0.452	0.301	0.459	0.265	0.441	0.311	0.463	0.265	0.441
No_ec_support	0.161	0.368	0.174	0.379	0.155	0.362	0.169	0.374	0.155	0.362
Consumers	0.621	0.485	0.624	0.484	0.616	0.486	0.627	0.483	0.617	0.486
PA	0.319	0.466	0.352	0.477	0.259	0.438	0.395	0.488	0.259	0.438
West	0.583	0.493	0.567	0.495	0.657	0.474	0.490	0.499	0.658	0.474
Obs.	9143		4663		4480		4010		5133	

Note: The variables are described in Table 1.

Table 4. Multinomial Logit model results (Relative risk ratio)

	Category 1 (Not adopting firms)		Category 3 (High intensity firms)	
Financial drivers and skills				
Int_fin	0.001		1.300	***
	(0.001)		(0.072)	
Ext_fin	0.001		1.615	***
	(0.001)		(0.158)	
Int_tech_skill	0.001		1.548	***
	(0.001)		(0.082)	
Other drivers				
Pos_turnover	0.895		1.213	***
	(0.123)		(0.075)	
Non_ec_support	0.001		1.465	***
	(0.001)		(0.125)	
Green_products	1.197		1.648	***
	(0.195)		(0.102)	
Control variables				
Consumer	0.685	***	0.978	
	(0.091)		(0.056)	
PA	0.992		1.138	**
	(0.141)		(0.067)	
West	0.341	***	2.637	***
	(0.045)		(0.146)	
Size_small	0.891		0.765	***
	(0.167)		(0.054)	
Age	0.992	***	1.001	
	(0.003)		(0.001)	
Constant	23.593	***	0.421	***
	(6.636)		(0.057)	
Obs.	9143			
Chi-squared	6949.88	***		
Pseudo R squared	0.395			

Note: The reference category (Category 2) refers to firms adopting only one measure, labelled as low intensity category. Sectorial dummies are included but not reported for lack of space and are available upon request. ***, **and * correspond to significance levels at the 1%, 5% and 10%, respectively.

Table 5. Multinomial Logit model (Predicted probabilities)

	Int_fin * Int_skills			Δ	Ext_fin * Int_skills		Δ
Category 2 (Low Intensity Firms)	00	0.406			0.395	***	
		(0.331)			(0.011)		
	01	0.322	***	-0.08	0.309	***	-0.09
		(0.012)			(0.293)		
	10	0.359	***	-0.04	0.273	***	-0.12
		(0.011)			(0.024)		
	11	0.258	***	-0.14	0.218	***	-0.18
		(0.008)			(0.022)		
Category 3 (High Intensity Firms)	00	0.593			0.604	***	
		(0.487)			(0.011)		
	01	0.677	***	0.08	0.706	***	0.08
		(0.012)			(0.007)		
	10	0.644	***	0.05	0.726	***	0.09
		(0.016)			(0.024)		
	11	0.741	***	0.15	0.781	***	0.21
		(0.008)			(0.022)		

Note: ***, **and * correspond to significance levels at the 1%, 5% and 10%, respectively.

Table 6. Ease of Access to Loans Index (EAL) and European Skill Index (ESI)

EU Countries	EAL 2016	ESI 2016
France	4.26	0.48
Belgium	4.96	0.53
Netherlands	4.19	0.58
Germany	5.05	0.62
Italy	2.98	0.25
Luxembourg	5.20	0.71
Denmark	4.13	0.67
Ireland (Republic)	3.50	0.36
United Kingdom	4.27	0.52
Greece	1.75	0.23
Spain	3.57	0.23
Portugal	3.66	0.45
Finland	5.19	0.72
Sweden	5.38	0.72
Austria	4.84	0.62
Cyprus (Republic)	2.55	0.32
Czech Republic	4.40	0.75
Estonia	4.57	0.68
Hungary	4.61	0.55
Latvia	3.51	0.59
Lithuania	4.20	0.61
Malta	4.51	0.56
Poland	4.34	0.62
Slovakia	4.75	0.59
Slovenia	3.18	0.69
Bulgaria	4.08	0.33
Romania	3.13	0.31
Croatia	3.41	0.60
Median Value	4.2	0.59

Note: Ease of Access to Loans Index (EAL) and European Skill Index Technical Report (2017) for ESI.

Table 7. Multinomial Logit model (Predicted probabilities) - Contextual Factor - Ease of Access to Loans Index

		Subsample < Median Value						Subsample > Median Value					
	Int_fin * Int_skills			Δ	Ext_fin * Int_skills		Δ	Int_fin * Int_skills		Δ	Ext_fin * Int_skills		Δ
Category 2 (Low Intensity Firms)	00	0.404			0.395	***		0.389	***		0.394	***	
		(5.856)			(0.014)			(0.066)			(0.015)		
	01	0.339	***	-0.06	0.319	***	-0.08	0.308	***	-0.08	0.267	***	-0.13
		(0.016)			(0.015)			(0.018)			(0.015)		
	10	0.363	***	-0.04	0.306	***	-0.09	0.361	***	-0.03	0.237	***	-0.16
		(0.141)			(0.034)			(0.162)			(0.033)		
	11	0.277	***	-0.13	0.185	***	-0.21	0.238	***	-0.15	0.238	***	-0.16
		(0.014)			(0.034)			(0.019)			(0.031)		
Category 3 (High Intensity Firms)	00	0.569	***		0.604	***		0.611	***		0.606	***	
		(8.256)			(0.014)			(0.099)			(0.015)		
	01	0.667	***	0.09	0.682	***	0.08	0.691	***	0.08	0.732	***	0.13
		(0.016)			(0.011)			(0.018)			(0.015)		
	10	0.639	***	0.07	0.697	***	0.09	0.639	***	0.03	0.762	***	0.16
		(0.014)			(0.034)			(0.016)			(0.033)		
	11	0.722	***	0.15	0.814	***	0.21	0.761	***	0.15	0.767	***	0.16
		(0.014)			(0.034)			(0.014)			(0.031)		

Note: Please see notes in Table 5. Firms are clustered according to the EAL Index being below or above the median EU value.

Table 8. Multinomial Logit model (Predicted probabilities) - Contextual Factor - European Skill Index

		Subsample < Median Value						Subsample > Median Value					
	Int_fin *Int_skills			Δ	Ext_fin *Int_skills		Δ	Int_fin *Int_skills		Δ			Δ
Category 2 (Low Intensity Firms)	00	0.387			0.376	***		0.427	*		0.424	***	
		(0.469)			(0.012)			(0.237)			(0.016)		
	01	0.327	***	-0.06	0.287	***	-0.10	0.313	***	-0.11	0.306	***	-0.12
		(0.016)			(0.015)			(0.019)			(0.011)		
	10	0.344	***	-0.04	0.311	***	-0.06	0.383	***	-0.05	0.226	***	-0.2
		(0.136)			(0.033)			(0.017)			(0.035)		
	11	0.231	***	-0.16	0.198	***	-0.19	0.287	***	-0.14	0.243	***	-0.18
		(0.019)			(0.029)			(0.018)			(0.033)		
Category 3 (High Intensity Firms)	00	0.607	***		0.623	***		0.574	***		0.575	***	
		(0.736)			(0.012)			(0.306)			(0.016)		
	01	0.672	***	0.06	0.719	***	0.10	0.686	***	0.12	0.693	***	0.12
		-0.016			(0.015)			(0.016)			-0.016		
	10	0.655	***	0.05	0.688	***	0.06	0.619	***	0.05	0.773	***	0.20
		(0.016)			(0.033)			(0.017)			(0.035)		
	11	0.768	***	0.16	0.809	***	0.19	0.712	***	0.14	0.756	***	0.18
		(0.011)			(0.029)			(0.012)			(0.033)		

Note: Please see notes in Table 5. Firms are clustered according to the European Skill Index (ESI) being below or above the median EU value.

Table 9. Ease of Access to Loans Index and European Skill Index Clusters

	Low EAL	**High EAL**
Low ESI	Bulgaria; Cyprus; Greece; Italy; Latvia; Portugal; Romania; Spain	Belgium; France; Hungary; Ireland; Malta; Netherlands; Slovakia; UK
High ESI	Croatia; Lithuania; Slovenia	Austria; Czech Republic; Denmark; Estonia; Finland; Germany; Luxemburg; Poland; Sweden

Table 10. Multinomial Logit model (Predicted probabilities) by Sector (Manufacturing and Wholesale Retail Trade)

		Manufacturing						Wholesale Retail Trade					
		Int_fin * Int_skills			Ext_fin* Int_skills			Int_fin * Int_skills			Ext_fin* Int_skills		
Category 2 (Low Intensity Firms)	00	0.308			0.271	***		0.439			0.418	***	
		(0.303)			(0.023)			(2.727)			(0.017)		
	01	0.198	***		0.178	***		0.337	***		0.295	***	
		(0.035)			(0.013)			(0.046)			(0.014)		
	10	0.229	***		0.182	***		0.365	***		0.261	***	
		(0.017)			(0.037)			(0.015)			(0.042)		
	11	0.141	***	-0.17	0.082	***	-0.19	0.258	***	-0.18	0.221	***	-0.20
		(0.028)			(0.025)			(0.044)			(0.046)		
Category 3 (High Intensity Firms)	00	0.687			0.728	***		0.537			0.583	***	
		(0.676)			(0.023)			(3.336)			(0.017)		
	01	0.802	***		0.824	***		0.669	***		0.704	***	
		(0.035)			(0.013)			(0.046)			(0.014)		
	10	0.777	***		0.818	***		0.634	***		0.738	***	
		(0.017)			(0.037)			(0.015)			(0.029)		
	11	0.858	***	0.17	0.917	***	0.19	0.742	***	0.20	0.782	***	0.20
		(0.028)			(0.025)			(0.043)			(0.046)		

Note: Please see notes in Table 5.

Appendix

Table A1. Multinomial Logit model (Predicted probabilities) - Contextual Factors – EAL and ESI

		High EAL - High ESI						Low EAL - Low ESI					
		Int_fin *Int_skills		Δ	Ext_fin *Int_skills		Δ	Int_fin *Int_skills	Δ		Ext_fin *Int_skills		Δ
Category 2 (Low Intensity Firms)	00	0.416	*		0.393	***		0.331		00	0.409		
		(0.229)			(0.019)			(16.323)			(18.046)		
	01	0.277	***	-0.14	0.263	***	-0.14	0.389	0.06	01	0.346		-0.06
		(0.021)			(0.012)			(10.406)			(16.904)		
	10	0.347	***	-0.07	0.212	***	-0.19	0.395	0.06	10	0.379		-0.03
		(0.022)			(0.043)			(10.462)			(17.566)		
	11	0.247	***	-0.17	0.231	***	-0.17	0.291	-0.04	11	0.234		-0.18
		(0.014)			(0.036)			(9.038)			(13.234)		
Category 3 (High Intensity Firms)	00	0.582	*		0.608	***		0.541		00	0.594		
		(0.319)			(0.019)			(25.802)			(18.046)		
	01	0.722	***	0.14	0.736	***	0.14	0.611	0.07	01	0.653		0.06
		(0.021)			(0.012)			(10.406)			(16.904)		
	10	0.652	***	0.07	0.787	***	0.19	0.604	0.06	10	0.629		0.03
		(0.022)			(0.043)			(10.462)			(17.566)		
	11	0.757	***	0.17	0.769	***	0.17	0.708	0.17	11	0.769		0.18
		(0.013)			(0.036)			(9.038)			(13.234)		

Note: see notes in Table 5.

Table A2. Multinomial Logit model (Predicted probabilities) - Contextual Factors – EAL and ESI

		High EAL - Low ESI						Low EAL - High ESI					
		Int_fin *Int_skills		Δ	Ext_fin *Int_skills		Δ	Int_fin *Int_skills	Δ		Ext_fin *Int_skills		Δ
Category 2 (Low Intensity Firms)	00	0.379	***		0.341	***		0.362		00	0.519		
		(0.038)			(0.017)			(55.633)			(35.669)		
	01	0.279	***	-0.10	0.238	***	-0.11	0.453	0.09	01	0.471		-0.05
		(0.029)			(0.013)			(26.343)			(35.611)		
	10	0.304	***	-0.08	0.263	***	-0.08	0.495	0.14	10	0.311		-0.21
		(0.019)			(0.041)			(26.575)			(30.572)		
	11	0.185	***	-0.19	0.161	***	-0.18	0.449	0.09	11	0.284		-0.24
		(0.014)			(0.034)			(26.306)			(28.835)		
Category 3 (High Intensity Firms)	00	0.627	***		0.658	***		0.357		00	0.482		
		(0.035)			(0.017)			(58.763)			(35.669)		
	01	0.724	***	0.10	0.769	***	0.11	0.546	0.19	01	0.528		0.05
		(0.022)			(0.013)			(26.342)			(35.611)		
	10	0.699	***	0.08	0.736	***	0.08	0.504	0.15	10	0.689		0.21
		(0.019)			(0.041)			(26.575)			(30.572)		
	11	0.815	***	0.19	0.838	***	0.18	0.554	0.19	11	0.719		0.24
		(0.014)			(0.034)			(26.306)			(28.836)		

Note: see notes in Table 5.