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The Role of External Support on the Implementation of Resource Efficiency Actions: Evidence from European Manufacturing Firms

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Abstract: This paper contributes to analyze the relationship between firms' recourse to different types of external support and adoption of environmental sustainability practices. To this aim, we consider both direct financial support and indirect support, in the form of advice and consulting services, upon which the firm relies on in its efforts to be more resource efficient. The empirical analysis uses data on 6595 manufacturing firms from 35 European countries, taken from the third and fourth waves of the Flash Eurobarometer survey "Small and Medium Enterprises, Resource Efficiency and Green Markets". Our empirical findings suggest that firms using external financing and external advice are more likely to implement greening investments and practices. Moreover, we provide strong empirical evidence that external support significantly contributes to increase the benefits from the adoption of resource efficiency actions in terms of production cost reduction. This study further contributes to the existing literature by highlighting the heterogenous effects of direct and indirect external support on the environmental sustainability actions of both SMEs and large firms.

Keywords: external support; environmental practices; resource efficiency; sustainable entrepreneurship; firm size

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1. Introduction

In recent years, increasing attention has been paid to the adoption of resource and energy efficiency practices by firms, also as a result of government policies aimed at supporting the implementation of environmental technologies and eco-innovations. Energy and resource efficiency is a key pillar of the European Union's long-term strategic vision and it is part of the Sustainable Development Goals approved by the United Nations in the Agenda 2030, with the aim to encourage a profound systemic shift to a more sustainable economy.

Firms' adoption of measures for a more responsible and efficient use of natural resources is important both for overcoming the problem of resource scarcity and waste management, and for incentivizing sustainable development and innovation towards a circular economy [1]. The increase in energy consumption, the need to reduce emission of greenhouse gases, the progressive depletion of natural resources and the dependence on energy from countries characterized by unstable political regimes have generated the need for eco-innovative solutions. It follows that firms are called upon to change their business model, taking into greater account the environmental and social values.

Firms' ability to integrate and align multiple forms of value (commercial, economic and financial values and environmental and social values) within their business models is a timely and important issue that affects not only firms' development but even the economic system as a whole. The challenges in this field are numerous, especially for small and medium enterprises (SMEs). This new development model is based on the resource efficiency in a logic of circularity, and on innovation in terms of eco-design, with the aim to reduce negative externalities on the environment since the design and development phases.

The general benefits deriving from eco-sustainable practices are diversified according to the characteristics of the intervention, the degree of circularity of production processes, the external environment in which the company operates, and the role of the company in the value chain. Currently, the most common resource efficiency measures among firms include: the environmental management systems aimed at saving water, energy and greenhouse gas emissions; the prevalent use of energy from renewable sources; the minimization of waste and sale of waste materials to another company; the reuse of materials.

Environmental investments require a strategic long-term vision: they do not represent exclusively a cost item for companies, but a central factor in acquiring a competitive advantage in the medium and long term, a better reputation and different strategic positioning. The European Commission has repeatedly stressed that in order to support firms in developing new resource-efficient technologies and solutions, it is crucial for access to financing; nevertheless, the context of technological and market uncertainties related to the eco-innovations may contribute to increase the difficulty in access to external funding by firms. Moreover, to attract investment in eco-innovations can be difficult, as they are often characterized by high risk and long-term returns [2–4].

There are several factors that may hamper or delay the adoption of resource and energy efficiency measures [5]. The literature has documented the existence of direct negative effects of financial barriers on the adoption of resource and energy efficiency practices [6,7]. For this reason, many targeted public financing programs have been proposed by both EU and non-EU countries, and a large set of financial instruments and services have been designed by financial intermediaries to support firms' investments. However, only in a few cases has the link between different types of external support and the adoption of resource efficiency practices been analyzed [8].

In this paper, we shed light on the relationship between the use of different types of external support and the adoption of eco-innovative practices by small and medium enterprises. To this aim, extending the analysis of Bodas-Freitas and Corrocher [8], we consider both direct financial support and indirect support in the form of advice and consulting services related to the adoption of resource efficiency practices. Furthermore, as a novel contribution to the literature, in this study, we assess the presence of firm-size heterogeneities in the effects of direct and indirect support on firms' engagement in the greening process. In fact, while the environmental behavior of small- and medium-sized enterprises has been extensively analyzed, that of large firms is still broadly unexplored. Our analysis relies on cross-sectional data from the third and fourth waves of the Flash Eurobarometer surveys "Small and Medium Enterprises, Resource Efficiency and Green Markets" [9,10]. In particular, our estimation sample consists of 6595 manufacturing firms from 35 European countries. The empirical analysis is carried out by means of a propensity score matching approach, which compares the effect of the treatment (in our case, the use of external support) between the subsamples of treated and untreated firms with similar observable characteristics. This methodology allows us to produce an estimate of the average additional effect of external support on the probability of adopting resource efficiency practices and on the benefits from the adoption, the so-called average treatment effect on the treated (ATET).

Our main results suggest that firms using external financial advice are more likely to implement greening investments and practices, including re-engineering and waste management actions. Moreover, we provide strong empirical evidence that external support significantly contributes to increase the benefits from the adoption of resource efficiency measures in terms of production cost reduction. This study further contributes to the existing literature by providing strong empirical evidence of the heterogeneous effects exerted by direct and indirect external support on different types of environmental practices of both SMEs and large firms. In this latter respect, our findings suggest that while SMEs' implementation of environmental practices strongly depends on both external financing and indirect support, large firms tend to rely more on internal financial resources and

mainly benefit from the recourse to external advice and consulting services to support their efforts to be more resource efficient.

The paper is structured as follows. Section 2 provides an overview of the background literature. Section 3 describes the data, while Section 4 illustrates the methodology. Section 5 presents and discusses the main results and Section 6 offers some concluding remarks and policy implications.

2. Literature Review

In the literature, there are many attempts to develop a taxonomy of the barriers to investments in energy and resource efficiency practices. Sorrell et al. [11] classify these barriers according to economic, organizational, or behavioral categories, observing that they may co-exist and overlap each other. Rentschler et al. [12] propose a taxonomy consisting in the following five categories: scarce information, low capacity, financial constraints, uncompetitive market structures and fiscal mismanagement. In particular, they observe how the theoretical assumptions of perfect and efficient markets are violated in practice, and how this results in investment barriers. Analogously, Jordan et al. [13] demonstrate that deficits in innovation culture, inter-firm cooperation along the value chain, finance, awareness and take-up of government funds limit the adoption of resource efficiency measures. They propose a policy mix, comprising government funding schemes, innovation agents and innovation laboratories, to support firms in implementing resource efficiency procedures.

Previous empirical studies have also focused attention on the role of external support on the adoption of different environmental practices. Bodas-Freitas and Corrocher [8] assess the impact of both direct financial support and indirect external support, in term of advice and consultancy, on the adoption of resource efficiency practices. They find that both types of external support positively affect the firm's implementation of resource efficiency measures and the cost-reduction benefits of adopting resource efficiency practices. They also point out that financial support has a direct effect on the benefits from the adoption, while the recourse to advice and consultancy support affects them indirectly, by supporting the implementation of complementary technological and managerial solutions. Accordingly, Hoogendoorn et al. [14] show that companies that receive external financial support are not only more likely to invest in practices related to production processes (greening processes), but they are also more likely to offer green products and services.

Firms recognize limited access to capital as one of the most common barriers to resource efficiency [12,15]. In particular, small and medium-sized enterprises experience greater difficulties in access to financing. These firms are typically characterized by scarce own funds and usually rely on bank loans than equity to finance their activity; moreover, the lack of collateral and the dependence by few clients may contribute to the perception of vulnerability and risk by financial intermediaries and limit the probability of advantageous funding conditions [16]. Furthermore, investments in eco-innovations and resource efficiency are characterized by high technical risks and longer-term returns, hence financial constraints are particularly relevant for these kinds of investments and may further contribute to affect firms' probability of experiencing liquidity constraints [2,17]. The adoption of energy and resource efficiency measures, even when it represents a profitable investment, has a crucial barrier in the lack of access to capital. Anderson and Newell [18] and Thollander et al. [19], among others, conclude that the initial investment costs negatively affect the adoption rate, especially for larger investments. Moreover, during periods of banking sector instability, as, for example, financial and economic crises, the restricted access to credit may further contribute to limit firms' resource efficiency investments [12].

To overcome financial constraints and capital–market imperfections, many public policy measures have been introduced with the aim to complement inefficient credit markets and provide SMEs with financial incentives and assistance supporting the innovation process [13,20]. Investment subsidies or soft loans can contribute to the dissemination of energy-efficiency measures in SMEs [7] and can increase access to finance for eco-innovative

activities. Access to public funds and incentives is considered effective for improving a firm's ability to introduce eco-innovations. In this respect, Ghisetti [21] shows the crucial role of governmental demand in shaping the direction and speed of environmental innovations in the manufacturing sector. Accordingly, Özbuğday et al. [22] provide evidence of a positive and statistically significant effect of resource efficiency investments on SMEs' growth performances and suggest that an effective policy that governments could adopt to boost green growth is to give public subsidies to support resource efficiency investments of SMEs operating in energy-intensive sectors.

According with the previous remarks, we thus posit our first research hypothesis:

Hypothesis 1 (H1). *Access to private and public external financing enhances firms' engagement in different types of environmental practices and improves the benefits from the adoption of greening processes.*

Both banks and institutional investors, as well as policy makers, thus exert a crucial role in mobilizing a large amount of funds and allocating them to long-term environmental or eco-innovative projects that are often characterized by immature technologies or complex technological systems [23]. On the other hand, it is worth remarking that the extent to which banks appreciate the potential profitability of resource efficiency projects also depend on a firm's ability to report efficiency practices and communicate the related opportunities [24]. In this sense, the lack of information on these technologies or the lack of specific expertise by firms are further important obstacles that may hamper their access to financial resources. Previous studies point out that more than half of the European SMEs recognize information constraints as an obstacle to improving resource efficiency [9,10,25] and that smaller enterprises have a greater perception of the barriers to energy efficiency than larger ones, discouraging them from adopting energy-efficient technologies and practices [26]. In addition to the knowledge gaps, SMEs' capabilities to implement new measures of resource and energy efficiency may be constrained by the lack of time, human capital, managerial/organizational factors, and informal management of sustainability issues [16,27]. Thus, external advice and consultancy may provide firms with the competencies necessary to implement resource efficiency actions, enhance the efficiency of these measures and allow sustainable innovations [28]. Accordingly, Horbach et al. [29] show that eco-innovative activities require more external sources of knowledge and information compared to other types of innovations; moreover, they confirm the central role of regulation and cost savings as motivations for eco-innovations. In addition to these knowledge gaps, SMEs are typically characterized by organizational rigidity that act as barriers to firm performance and have a significant impact on innovation capability [30]. Moreover, firms with strong business networks and easy access to knowledge and technology are more likely to conduct eco-innovation activities [23].

The pursuit of green growth requires direct financial investments and indirect forms of external support, involving both private and public actors. In particular, consultancy or other advice are aimed at filling organizational, knowledge and technical gaps, that can be provided by suppliers, consulting firms or public research institutions. Thus, while financial barriers result into low capital availability and low access to external funding opportunities and contribute to hamper firms' innovation and growth, the difficulty of identifying cost-effective resource efficiency projects represents an additional limit to the implementation of resource efficiency practices by firms. Thus, the recourse to both external funding and advice may significantly mitigate issues related to the scarcity of financial resources and the lack of expertise and knowledge, enhancing SMEs' ability to implement technologies and practices that can achieve savings in resources and production costs [8,29]. As observed by Ghisetti et al. [2], small firms face major difficulties in getting credit for their eco-innovation investments compared to large enterprises, which may have direct access to capital markets and have more developed skills and competencies to engage in environmental practices [14].

While the role of different types of external support on the environmental behavior of small and medium firms has been extensively analyzed, the effect on the greening processes of large enterprises still remains largely unexplored. Smaller firms are usually considered as lacking skills, knowledge and financial resources to implement environmental management systems [31,32], while larger enterprises are assumed to be more resourceful and proactive and so are more capable of enjoying the benefits deriving from the implementation of resource efficiency practices [33]. In this respect, openness to external sources of knowledge which could help small and medium firms to overcome the lack of internal capabilities and resources for the adoption of environmental activities [2]. Differences in strategic resource allocation patterns between small and large firms are also found to be related to firms' characteristics and organizational costs [34]. Moreover, Kalar et al. [35] pointed out that firms in the innovative stage of their organizational life-cycle are not only characterized by different resource efficiency strategies, but also have different external support needs than firms in the conservative stage. A further input for the environmental behavior of SMEs can derive from the "stakeholder perspective", according to which smaller firms are much more responsive to external pressure by stakeholders than large firms [14]. The relationship between stakeholder pressures and environmental strategy is found to vary with firm size [36]. In particular, SMEs pay more attention to achieve and maintain a good reputation, while large firms are better able to manage external pressures. On the other hand, as highlighted by Wong et al. [33], in many countries, large firms are often state-owned or subsidized by the government, so they could face governmental pressures for their involvement in environmental management.

Based on the discussion above, we posit and test the following two hypotheses:

Hypothesis 2 (H2). *Indirect external support, in the form of advice and consulting, facilitates the adoption of resource efficiency measures and increases the cost-reduction benefits from the adoption of such actions.*

Hypothesis 3 (H3). *The impact of alternative forms of external support on the extent and types of environmental practices is characterized by significant heterogeneity with respect to firm size.*

3. Data and Descriptive Analysis

3.1. Data Sources

To investigate firms' engagement in environmental practices, we rely on data from the Flash Eurobarometer survey "SMEs, resource efficiency and green markets" [9,10]. This survey is focused on SMEs and large firms operating in the Manufacturing, Retail, Services and Industry sectors in the 28 European Union Member States and other European and non-European countries. The survey provides detailed information on firms' investment and implementation of resource efficiency practices and use of different types of external support to introduce these measures, together with data on several firm-level characteristics. For the aims of our study, we combine cross-sectional data from two independent waves of the survey (the third and the fourth, referred, respectively, to years 2015 and 2017) and focus on manufacturing firms from 35 European countries (including both EU and non-EU states). The final estimation sample consists of a total of 6595 enterprises.

3.2. Outcome Variables

To assess firms' adoption of green processes, we consider several alternative measures. We first define a set of binary variables indicating which actions the firm is undertaking to be more resource efficient. In particular, we define 9 dummies equal to 1 if the firm has adopted actions to save water, save energy, use predominantly renewable energy, save materials, minimize waste, sell scrap material, recycle by reusing material or waste, design products that are easier to maintain or repair, and other resource efficiency measures. As in Bodas-Freitas and Corrocher [8], we sum these dummies to define alternative variables that count the number of resource efficiency practices implemented by the enterprise. We

first define a variable (*Resource Efficiency Actions*) counting the number of any resource efficiency measure adopted and taking values from 0 to 9. Then, we build two variables accounting for the different type of practices and define the variable *Re-engineering Actions* that counts the number of practices requiring process re-engineering (i.e., saving water, saving energy, using renewable energy, saving materials, and designing products easier to maintain/repair) and the variable *Waste Management Actions* that counts the number of practices related to waste management (i.e., minimizing waste, selling scrap material, recycling). As it can be noticed form Table 1, the number of resource efficiency actions implemented by the enterprises increases with firm size, according to the consideration that large firms have more resources to invest in greening processes. In particular, the number of re-engineering actions is equal to 2.459 in the subsample of SMEs, rising to 3.030 in that of large firms; analogously, the number of waste management actions varies from 1.693 for small and medium enterprises to 2.103 for large ones.

Table 1. Descriptive statistics.

	(1)	(2)	(3)
	Whole Sample	**SMEs**	**Large Firms**
(a) Outcome variables			
Resource Efficiency Actions	4.284	4.166	5.149
Re-engineering Actions	2.528	2.459	3.030
- Saving Water	0.500	0.477	0.682
- Saving Energy	0.699	0.680	0.851
- Using Renewable Energies	0.168	0.158	0.244
- Saving Materials	0.665	0.649	0.788
- Re-designing Products	0.330	0.319	0.417
Waste Management Actions	1.742	1.693	2.103
- Reducing Waste	0.679	0.664	0.800
- Selling Scrap Materials	0.494	0.471	0.679
- Recycling Materials	0.454	0.437	0.590
Other RE Actions	0.013	0.013	0.016
RE Investment	0.464	0.461	0.486
Production Costs Decreased	0.550	0.530	0.704
(b) Treatment variables			
Any External Support	0.276	0.253	0.445
External Funding	0.125	0.117	0.187
External Advice	0.192	0.173	0.331
External Funding and Advice	0.070	0.064	0.119
(c) Independent variables			
Age	30.694	28.924	44.470
Small	0.333	0.376	0.000
Medium	0.282	0.318	0.000
Large	0.114	0.000	1.000
Low turnover	0.471	0.522	0.077
Own financial resources	0.709	0.701	0.771
Own technical competencies	0.638	0.627	0.719
B2C Market	0.476	0.489	0.372
B2B Market	0.833	0.828	0.875
PA Market	0.243	0.246	0.218
2017	0.496	0.492	0.529

Notes: The table reports average values of the outcome, treatment and independent variables computed on the whole sample and on the subsamples of SMEs and large firms. Descriptive statistics are computed sample weights. **Source**: Own elaboration on Eurobarometer data.

We also consider firms' investment in resource efficiency as an additional proxy of involvement in greening processes and define a binary indicator (*Resource Efficiency Investment*) identifying firms that, over the last two years, invested at least 1% of their annual turnover to be more resource efficient. Even in this case, larger firms show a higher

average value of the *Resource Efficiency Investment* indicator (0.486) with respect to small and medium ones (0.461), demonstrating that large firms have a greater propensity to invest part of their turnover in greening processes.

Finally, in order to assess the benefits from the adoption of resource efficiency practices, we define the dummy variable *Production Costs Decreased*, which is equal to 1 if the undertaken resource efficiency actions have contributed to decrease production costs over the past two years. This variable highlights that those firms that have higher environmental awareness also experience higher cost savings. Coherently with previous results, large firms experience larger savings in production costs (0.704), while SMEs have a slightly lower value (0.530). In any case, it is evident how the adoption of energy efficiency practices produce significant benefits in terms of reduction of production costs.

3.3. Treatment Variables

In our empirical analysis, we aim at investigating the role of the external support in the form of financial funding and business/technology advice on different types of external support on firms' implementation of resource efficiency practices and on the benefits derived from the adoption of greening processes. Following Hoogendorm et al. [14] and Bodas-Freitas and Corrocher [8], we consider alternative proxies for a firm's recourse to external support for implementing resource efficiency measures. First, we define a dichotomous variable (*Any External Support*) indicating whether the firm has relied on any form of external support in its efforts to be more resource efficient. Then, we define two additional dummies to distinguish between the use of (public and private) external financial support (*External Funding*) and the use of (public and private) advice and consultancy (*External Advice*). Finally, we define a binary variable (*External Funding and Advice*) identifying those firms that use both types of external supports, in order to assess the presence of possible complementarities on the effect of external funding and consultancy on the adoption of resource efficiency measures.

From Table 1, we notice that 27% of the firms in our sample use any form of external support; this percentage is equal to 25% for SMEs and increases to about 45% for large enterprises. External advice is the type of support mainly used by both SMEs and large firms, while only 6% of SMEs and nearly 12% of large firms rely on the combined use of funding and advice. The differences in average values of the resource efficiency indicators by support type are presented in Table 2. These values are always positive and statistically significant, with the only exception of the residual category *Other RE Actions*, demonstrating that the positive impact of external support on the implementation of greening actions. The practices requiring process re-engineering present the highest values: they range from 43%, when we consider any type of external support to 73% when the firm uses both external funding and advice. In particular, the combined use of direct and indirect external support (column 4) highlights the greatest effect on all the types of resource efficiency actions. When we consider investments in resource efficiency practices, we highlight that the highest impact is exerted by access to external funding, demonstrating that this type of external support significantly contributes to boost firm investments in greening practices. Finally, the effect of the different types of external support on the reduction of production costs varies from 7.7 to 15.1%, with the highest impact exerted by the combined use of external financing and advice. These results demonstrate that the use of any type of external support contributes to the increasing benefits for firms and could represent an incentive for the adoption of greening actions.

Table 2. Differences in average values of resource efficiency indicators by external support.

	(1)	(2)	(3)	(4)
	Any External Support	**External Funding**	**External Advice**	**External Funding and Advice**
(a) Resource Efficiency Actions	0.762 ***	0.783 ***	1.027 ***	1.209 ***
(a1) Re-engineering Actions	0.434 ***	0.471 ***	0.577 ***	0.732 ***
- Saving Water	0.082 ***	0.090 ***	0.118 ***	0.175 ***
- Saving Energy	0.113 ***	0.110 ***	0.140 ***	0.213 ***
- Using Renewable Energies	0.091 ***	0.118 ***	0.102 ***	0.166 ***
- Saving Materials	0.063 ***	0.064 ***	0.106 ***	0.183 ***
- Re-designing Products	0.085 ***	0.089 ***	0.113 ***	0.169 ***
(a2) Waste Management Actions	0.329 ***	0.311 ***	0.456 ***	0.489 ***
- Reducing Waste	0.122 ***	0.103 ***	0.161 ***	0.221 ***
- Selling Scrap Materials	0.140 ***	0.150 ***	0.178 ***	0.246 ***
- Recycling Materials	0.067 ***	0.058 ***	0.116 ***	0.142 ***
(a3) Other RE Actions	−0.002	−0.001	−0.006	−0.010
(b) RE Investment	0.112 ***	0.143 ***	0.109 ***	0.147 ***
(c) Production Costs Decreased	0.077 ***	0.090 ***	0.098 ***	0.151 ***

Notes: The table reports (unconditional) differences in the means/proportions of the outcome variables between the subsamples of firms recurring and not recurring to the different types of external support measures considered. ***, ** and * denote significance of the differences in means/proportions at the 1, 5 and 10% levels, respectively. **Source**: Own elaboration on Eurobarometer data.

3.4. Independent Variables

As in Hoogendorm et al. [14] and Bodas-Freitas and Corrocher [8], we control for observable firm-level characteristics that might affect firms' decision to adopt environmental practices and to recur to external support. First, we control for firm age (in years) and size using binary indicators for *Small* (with 10–49 employees), *Medium* (with 50–249 employees) and *Large* (with 250 or more employees) enterprises (considering *Micro* firms with less than 10 employees as reference group). We also control for firm turnover by means of a dummy indicating firms with a turnover lower than 2 million Euro (*Low turnover*). Second, as a firm's decision to adopt resource efficiency measures depends not only on the external support received, but also on internal funds and competencies, we define two dummies (*Own financial resources* and *Own technical competencies*) to control whether the firm relies on its own financial resources and its own technical expertise to implement greening processes. Third, we control for the firm's market segment by means of three non-exclusive binary variables indicating whether the firm sells products or services directly to consumers (*B2C Market*), to other companies (*B2B Market*) and to public administrations (*PA Market*). Finally, we include survey year and country fixed effects, to control for heterogeneities in environmental practices and recourse to external support over time and across countries. Table A1 in the Appendix A reports complete variable definitions.

4. Methods

To assess the impact of external support on the firm's implementation of greening processes, we use a propensity score matching approach, which compares the effect of the treatment (i.e., the recourse to external support) in the subsamples of treated and untreated firms with similar observable characteristics. In particular, following previous literature [8,21,22], we focus on the additional effect of the external support on the adoption

of resource efficiency actions and use Kernel matching algorithms to estimate the average treatment effect on the treated (ATET). Formally, the ATET can be written as:

$$ATET = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1) \quad (1)$$

where $D = 1$ indicates a firm's recourse to external funding and/or advice in its effort to be more resource efficient (treatment variable) and Y_1 and Y_0 represent the potential outcomes with and without treatment, i.e., the greening processes adopted by those firms that have recurred or have not recurred to external support, respectively. The ATET is the average treatment effect ($ATE = E(Y_1 - Y_0) = E(Y_1) - E(Y_0)$) computed on the subsample of treated units. The last equality in Equation (1) highlights the counterfactual nature of a causal effect. The first term, $E(Y_1|D = 1)$, is the average outcome of treated units, which is an observable quantity. The second term, $E(Y_0|D = 1)$, refers instead to the average outcome of treated units had they not been treated; this quantity cannot be observed and a proper substitute for it has to be chosen in order to estimate the ATET.

When selection to treatment is not random (as it is in the case of a firm's decision to recur to external support), the treatment D is not probabilistically independent from Y_1 and Y_0, giving rise to a selection bias and preventing proper identification of treatment effects. However, it is still possible to identify causal effects from observational data by assuming that the non-random assignment to treatment is driven by individual observable factors $\mathbf{x}$. Under selection on observables, the knowledge of $\mathbf{x}$ may be sufficient to identify the causal parameters, even in a case of non-random assignment. In particular, as discussed in Rosenbaum and Rubin [37], the condition of randomization is restored by means of the so-called *Conditional Independence Assumption* (CIA), stating that, conditional on $\mathbf{x}$, Y_1 and Y_0 are probabilistically independent of D: $(Y_1; Y_0) \perp D|\mathbf{x}$. When the interest is in measuring average effects, it is possible to rely on a weaker assumption, the so-called *Conditional Mean Independence* (CMI), assuming that $E(Y_1|D, \mathbf{x}) = E(Y_1|\mathbf{x})$ and $E(Y_0|\mathbf{x}, D) = E(Y_0|\mathbf{x})$. Assuming CMI, we obtain that:

$$ATET(\mathbf{x}) = E(Y_1|\mathbf{x}, D = 1) - E(Y_0|\mathbf{x}, D = 1,) = E(Y|\mathbf{x}, D = 1) - E(Y|\mathbf{x}, D = 0) \quad (2)$$

which shows that, by conditioning on $\mathbf{x}$, the $ATET(\mathbf{x})$ depends on observable quantities and it is thus correctly identified and no bias emerges. By averaging $ATET(\mathbf{x})$ over the support of $\mathbf{x}$, we can then obtain the global effect:

$$ATET = E_{\mathbf{x}}\{ATET(\mathbf{x})\} \quad (3)$$

implying that an estimation of the ATET can be obtained by the sample equivalent:

$$\hat{ATET} = \frac{1}{\sum_{i=1}^{N} D_i} \left\{ \sum_{i=1}^{N} D_i [\hat{m}_1(\mathbf{x}_i) - \hat{m}_0(\mathbf{x}_i)] \right\} \quad (4)$$

where $\hat{m}_1(\mathbf{x}_i)$ and $\hat{m}_0(\mathbf{x}_i)$ are consistent estimators of $E(Y|\mathbf{x}, D = 1)$ and $E(Y|\mathbf{x}, D = 0)$, respectively. Besides CMI, identification of average treatment effects (ATEs) also requires the *Overlap Assumption* (OA), which states that, for each unit, the probability to get treated given $\mathbf{x}$ (i.e., the *propensity score*) must be $0 < P(D = 1|\mathbf{x}_i) < 1$ (i.e., units with a given set of observable characteristics $\mathbf{x}$ have to belong to both the treated and untreated groups).

One of the most frequently used approaches to estimate average treatment effects under the assumption of selection on observables is Propensity Score Matching (PSM) [38,39]. In general, the basic idea of matching approaches is to determine a group of untreated units (*control group*) with similar values of the observable characteristics in $\mathbf{x}$ compared to those

of the treated units. Then, an estimate of the ATET can be obtained as the mean of the differences between the observed outcomes and the counterfactual values:

$$\hat{ATET}_M = \frac{1}{N_1} \sum_{i \in D_i = 1} (Y_{1i} - \hat{Y}_{0i}) = \frac{1}{N_1} \sum_{i=1}^{N} D_i (Y_{1i} - \hat{Y}_{0i}) \quad (5)$$

where $D_i = 1$ identifies the set of treated units and the counterfactual outcome $\hat{Y}_{0i}$ is equal to Y_i if $D_i = 0$ and to a weighted average of the observed outcomes for the untreated units j chosen as matches for the treated unit i, $\sum_{j|D=0} w_{ij} Y_j$, if $D_i = 0$.

Rosenbaum and Rubin [37] suggested to match units according to the propensity score $\pi(\mathbf{x}_i) = P(D = 1|\mathbf{x}_i)$, which is the conditional probability of receiving the treatment given the confounding variables $\mathbf{x}$. In fact, if the CIA holds, it follows that $(Y_1; Y_0) \perp D|\pi(\mathbf{x})$ and average causal effects can be thus estimated by conditioning on the propensity score $\pi(\mathbf{x})$ instead of $\mathbf{x}$ (*Unconfoundedness Property*), reducing the multidimensionality of $\mathbf{x}$ to a single scalar dimension. The propensity score also entails that $D \perp \mathbf{x}|\pi(\mathbf{x})$, which implies that, conditionally on $\pi(\mathbf{x})$, the treatment D and the observables covariates $\mathbf{x}$ are independent (*Balancing Property*). This property states that if $\pi(\mathbf{x})$ is correctly specified, then units stratified according to the propensity score should be indistinguishable in terms of their observable characteristics $\mathbf{x}$. Testing empirically the balancing property thus allows to assess whether the correct propensity score is being used.

The typical PSM procedure to compute ATEs consists of the following steps [40]:

(1) estimate a probit or logit model for the probability of receiving the treatment and compute the propensity score for each unit in the sample;
(2) choose an appropriate matching algorithm, using a specific distance metric based on the estimated propensity score, and then match treated units with untreated units;
(3) test the balancing property by comparing, for each covariate in $\mathbf{x}$, the mean of the treated with the mean of the controls selected by the matching algorithm used;
(4) if the balancing is satisfied, calculate average treatment effects, otherwise modify the probit/logit specification until the balancing is satisfied.

In our empirical analysis, we use a probit specification to model a firm's probability to recur to alternative types of external support, as a function of the independent variables presented in Section 3.4, and estimate the propensity score. Then, following Heckman et al. [41], we use an Epanechnikov Kernel matching algorithm with automatic bandwidth selection [42], which matches every treated unit with a weighted average of all control units with weights that are inversely proportional to the distance between treated and control units. After testing for balancing, we estimate the ATET using Equation (5) to assess the impact of external support on a firm's adoption of resource efficiency measures.

5. Results and Discussion

5.1. The Effect of External Support on Firms' Implementation of Resource Efficiency Practices

To calculate propensity scores, we estimate alternative probit models to evaluate a firm's probability to recur to different types of external support, as a function of the observable characteristics discussed in Section 3.4. Probit estimation results are reported in Table 3. Estimated coefficients show that firm size has a positive and statistically significant effect on the recourse to external support, while firm age has a positive and significant impact only for the recourse to external advice, but it is not statistically significant for the other types of support. Firms with a turnover lower than 2 million Euro have a lower probability to recur to external support, whereas the availability of own internal financial resources and technical competencies tend to foster the combined use of external funding and advice, rather than single forms of support. Furthermore, we find that the firm's market segment significantly affects its propensity to recur to the different types of external support. Finally, we provide evidence of significant heterogeneity in the recourse to external support both across countries and over time.

Table 3. Probit estimates of the propensity to recur to external support.

	(1)	(2)	(3)	(4)
	Any External Support	**External Funding**	**External Advice**	**External Funding and Advice**
Age	0.0008	0.0004	0.0017 **	0.0006
	(0.0008)	(0.0008)	(0.0008)	(0.0009)
Small	0.3095 ***	0.2388 ***	0.3110 ***	0.2595 ***
	(0.0530)	(0.0637)	(0.0610)	(0.0824)
Medium	0.5280 ***	0.4253 ***	0.5563 ***	0.5194 ***
	(0.0617)	(0.0723)	(0.0695)	(0.0900)
Large	0.8147 ***	0.5384 ***	0.7865 ***	0.5425 ***
	(0.0753)	(0.0869)	(0.0826)	(0.1070)
Low turnover	−0.1598 ***	−0.0637	−0.1687 ***	−0.1341 **
	(0.0457)	(0.0540)	(0.0505)	(0.0666)
Own financial resources	−0.1739 ***	−0.0406	−0.0430	0.1112 *
	(0.0399)	(0.0476)	(0.0437)	(0.0589)
Own technical competencies	−0.1881 ***	−0.0958 **	−0.0350	0.1452 **
	(0.0382)	(0.0449)	(0.0423)	(0.0572)
B2C Market	0.0551	0.1388 ***	0.0017	0.1551 ***
	(0.0426)	(0.0502)	(0.0470)	(0.0597)
B2B Market	0.1993 ***	0.1621**	0.1534 **	0.1604 *
	(0.0566)	(0.0673)	(0.0642)	(0.0836)
PA Market	0.0788*	0.1191 **	0.1123 **	0.1309 **
	(0.0457)	(0.0534)	(0.0496)	(0.0617)
2017	0.1513***	−0.0788*	0.1416 ***	−0.0035
	(0.0359)	(0.0425)	(0.0394)	(0.0507)
Intercept	−0.7398 ***	−1.2527 ***	−1.2111 ***	−1.9315 ***
	(0.1257)	(0.1441)	(0.1381)	(0.1789)
Country FE [*p*-value]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
N	6137	6137	6137	5955
Log-Likelihood	−3274.88	−2164.45	−2627.13	−1451.93
Pseudo R^2	0.0947	0.0646	0.1238	0.1063
Wald c^2 [*p*-value]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
% of Correctly Predicted	73.37	87.49	80.80	92.24

Notes: The table reports results obtained from probit estimation of the conditional treatment probability on all the covariates for the different types of external support measures considered. Bootstrapped (200 replications) standard errors are reported in parentheses. ***, ** and * denote significance of the parameters at the 1, 5 and 10% levels, respectively. **Source**: Own elaboration on Eurobarometer data.

Based on these probit estimations, we estimate propensity scores for each unit in the sample and we use an Epanechnikov Kernel matching algorithm, with automatic bandwidth selection and imposing common support, to match treated and untreated units and estimate average treatment effects. Table 4 presents the main results of the propensity score matching for the effect of the different types of external support on a firm's resource efficiency actions and investment behavior and on the benefits from the adoption of such actions (in terms of reduction in production costs) for the whole sample.

Table 4. Impact of external support on resource efficiency actions: ATETs for the whole sample of firms.

	(1)		(2)		(3)		(4)	
	Any External Support		**External Funding**		**External Advice**		**External Funding and Advice**	
	ATET		**ATET**		**ATET**		**ATET**	
(a) Resource Efficiency Actions	0.426	***	0.468	***	0.552	***	0.653	***
	(0.057)		(0.076)		(0.060)		(0.080)	
(a1) Re-engineering Actions	0.262	***	0.298	***	0.325	***	0.422	***
	(0.039)		(0.053)		(0.044)		(0.056)	
- Saving Water	0.067	***	0.068	***	0.093	***	0.091	***
	(0.015)		(0.022)		(0.019)		(0.025)	
- Saving Energy	0.073	***	0.070	***	0.079	***	0.086	***
	(0.012)		(0.015)		(0.013)		(0.016)	
- Using Renewable Energies	0.049	***	0.084	***	0.043	**	0.107	***
	(0.012)		(0.018)		(0.017)		(0.024)	
- Saving Materials	0.033	**	0.026	*	0.057	***	0.063	***
	(0.015)		(0.015)		(0.014)		(0.019)	
- Re-designing Products	0.039	***	0.051	***	0.053	***	0.075	***
	(0.015)		(0.019)		(0.019)		(0.025)	
(a2) Waste Management Actions	0.164	***	0.167	***	0.230	***	0.233	***
	(0.027)		(0.038)		(0.030)		(0.043)	
- Reducing Waste	0.069	***	0.057	***	0.080	***	0.080	***
	(0.012)		(0.018)		(0.013)		(0.017)	
- Selling Scrap Materials	0.071	***	0.084	***	0.088	***	0.106	***
	(0.014)		(0.021)		(0.016)		(0.023)	
- Recycling Materials	0.025		0.026		0.061	***	0.047	*
	(0.016)		(0.019)		(0.019)		(0.026)	
(a3) Other RE Actions	0.000		0.003		−0.002		−0.002	
	(0.003)		(0.004)		(0.003)		(0.003)	
(b) Resource Efficiency Investment	0.108	***	0.133	***	0.099	***	0.124	***
	(0.016)		(0.021)		(0.018)		(0.027)	
(c) Production Costs Decreased	0.060	***	0.068	***	0.070	***	0.076	***
	(0.016)		(0.020)		(0.017)		(0.024)	
Bandwidth	0.011		0.013		0.006		0.004	
Matched sample:								
N. treated	1695		766		1172		459	
N. controls	4441		5369		4961		5493	
Region of common support	[0.022, 0.777]		[0.015, 0.427]		[0.012, 0.699]		[0.005, 0.383]	
Matching quality indicators:	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
Pseudo-R2	0.095	0.001	0.065	0.001	0.124	0.001	0.106	0.002
Mean bias	9.9	0.8	8.6	0.8	12.8	0.8	13.5	1.1
Median bias	8.1	0.6	8.1	0.6	11.4	0.7	12.0	0.8
B	77.9	7.0	69.7	7.0	93.2	7.8	94.7	10.6
R	0.79	0.84	0.68	0.97	0.74	0.85	0.72	0.90

Notes: The table reports the ATETs of different types of external support measures on alternative indicators of resource efficiency actions and on the benefit from the implementation of RE actions (in terms of reductions in production costs), estimated on the whole sample of firms. The ATETs are computed using Epanechnikov kernel matching, with automatic bandwidth selection and imposing common support, performed using the Stata module *kmatch* by Jann [42]. Bootstrapped (200 replications) standard errors are reported in parentheses. Pseudo-R^2 is obtained from probit estimation of the conditional treatment probability on all the covariates on the matched sample. Mean bias and median bias are summary indicators of the distribution of the absolute standardized percentage bias for each covariate after matching. B and R are the standardized difference in the means and the ratio of the variances of the propensity scores between treated and untreated firms after matching, respectively. ***, ** and * denote significance of the ATETs at the 1, 5 and 10% levels, respectively. **Source**: Own elaboration on Eurobarometer data.

Before discussing the estimated treatment effects, we focus on assessing the quality of the matching. The indicators reported in the bottom part of Table 4 provide support to the effectiveness of the matching procedure in restoring balancing in the covariates. In particular, the values of pseudo-R^2 decrease substantially after matching and almost approach zero for all the models. Similarly, the mean and median values of the absolute standardized percentage bias are remarkably lower after matching. Additionally, the values of both the standardized difference in the means (Rubin's *B*) and the ratio of the variances (Rubin's *R*) of the propensity scores between treated and untreated firms after matching are always within the ranges suggested by Rubin [43] for a balanced distribution of covariates (i.e., less than 25 for *B* and between 0.5 and 2 for *R*), providing support to post-matching balancing. Finally, Figure 1 reports kernel density plots for the estimated propensity scores of treated and untreated units before and after matching. For the matched sample, the plots are almost indistinguishable, confirming that matching on the estimated propensity score has balanced the covariates. Overall, the evidence obtained suggests that there are no systematic differences in the distribution of observable characteristics between treated and untreated firms after matching.

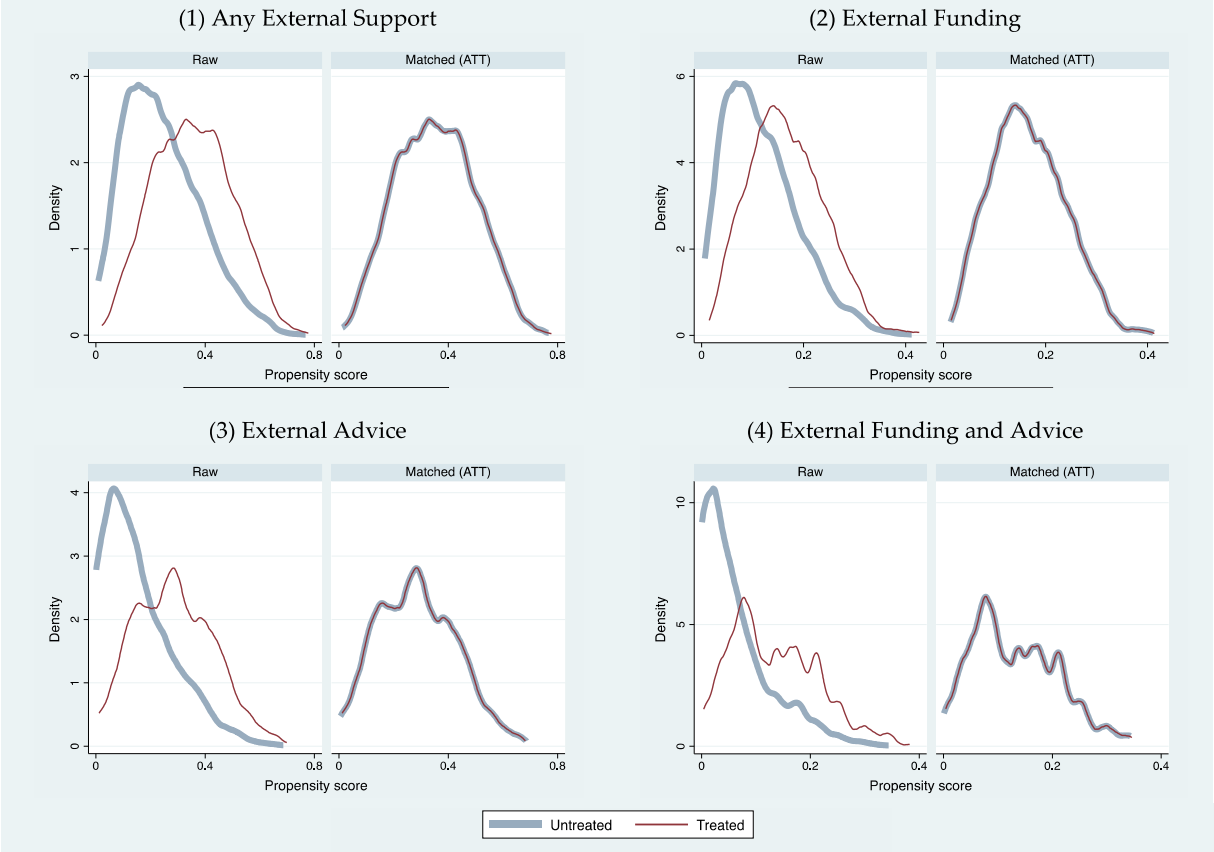

Figure 1. Propensity score distribution for treated and untreated groups before and after matching. **Source**: Own elaboration on Eurobarometer data.

Once we have ensured that the balancing property is satisfied, we estimate the average treatment effects on the treated (ATETs), measuring the additional effect of external support on the firm's engagement in greening processes (in terms of adoption and investment in resource efficiency practices) and on the benefits from the adoption of these processes (in terms of production cost reduction).

Coherently with the findings of Bodas-Freitas and Corrocher [8] and in line with our first hypothesis, empirical results show that the overall effect of external support is positive and statistically significant both on the adoption and on the benefits from the adoption of

green practices. The additional effect of external support observed among treated firms is always statistically significant at the 1 and 5% level, with the only exception of the effect on the residual category *Other RE actions* and on the *Recycling Materials* process, which is significantly affected only by the recourse to external advice and by the combined use of both direct and indirect external support. The estimated ATETs show that firms recurring to any type of external support adopt, on average, a number of resource efficiency actions 0.426 higher than those in the control group. This value further rises to 0.65 when we consider the combined use of external funding and advice. The effect of external support is higher for the adoption of re-engineering practices (0.262 and 0.653, respectively, for any external support and for the combined use of external funding and advice) than for the adoption of waste management practices (0.164 and 0.233). Moreover, the additional impact of indirect support in the form of advice and consulting on the number of practices implemented by the firm is always slightly higher than that of direct financial support. Focusing on the ATET of external support on the different resource efficiency practices, we notice that firms relying on any form of external support are about 7% more likely to implement actions to save water and energy (the ATETs are equal to 0.067 and 0.073, respectively), to reduce waste (0.069) and to sell scrap materials (0.071); these effects further increase to about 9–10% when we consider the combined use of external financing and advice. It is also worth remarking that for these four resource efficiency practices, indirect support has a significantly higher additional effect than direct financing support. Interestingly, the use of renewable energies emerges as the only practice for the implementation of which external financial support exerts a much larger effect than external consulting: firms relying on direct (public or private) financing are, on average, 8.4% more likely to use renewable energies than firms that do not use this type of external support.

As in Hoogendorm et al. [14], we also assess the impact of external support on firms' investment in resource efficiency practices. The estimated ATETs point out that, on average, firms that rely on any type of external support, are 10.8% more likely to invest at least 1% of their annual turnover in resource efficiency activities than firms in the control group. The estimated treatment effect rises to 13.3% for the recourse to direct financial support, pointing out the key role played by access to external support in boosting a firm's investment in greening processes.

With respect to the impact of external support on firms' performance, in line with the previous literature [7,8,26], firms using external support are from 6.0 to 7.6% more likely to experience cost savings in comparison to firms with similar characteristics that do not rely on external support. This evidence confirms our second hypothesis, providing strong empirical support to the significant role of both direct and indirect support not only in fostering firm adoption of resource efficiency actions and investment, but also in increasing the cost-related benefits of implementing resource efficiency practices.

5.2. Sensitivity Analysis: Firm Size and the Role of External Support on Greening Processes

In this section, we explore the presence of heterogeneous effects of external support on firms' engagement in greening processes according to firm size. Tables 5 and 6 show the results of the propensity score matching for the subsamples of SMEs and large firms, respectively. Empirical results fully confirm our third research hypothesis, according to which the role of alternative forms of external support on the implementation of different types of environmental practices significantly differs according to firm size.

Table 5. Impact of external support on resource efficiency actions: ATETs for the subsample of SMEs.

	(1)		(2)		(3)		(4)	
	Any External Support		**External Funding**		**External Advice**		**External Funding and Advice**	
	ATET		**ATET**		**ATET**		**ATET**	
(a) Resource Efficiency Actions	0.496	***	0.529	***	0.645	***	0.702	***
	(0.051)		(0.078)		(0.062)		(0.091)	
(a1) Re-engineering Actions	0.319	***	0.342	***	0.391	***	0.454	***
	(0.038)		(0.053)		(0.046)		(0.062)	
- Saving Water	0.074	***	0.068	***	0.098	***	0.095	***
	(0.017)		(0.021)		(0.020)		(0.028)	
- Saving Energy	0.084	***	0.077	***	0.092	***	0.083	***
	(0.013)		(0.018)		(0.014)		(0.021)	
- Using Renewable Energies	0.065	***	0.100	***	0.061	***	0.124	***
	(0.013)		(0.019)		(0.017)		(0.026)	
- Saving Materials	0.029	**	0.031	***	0.054	***	0.060	***
	(0.014)		(0.019)		(0.018)		(0.021)	
- Re-designing Products	0.067	***	0.066	***	0.086	***	0.093	***
	(0.016)		(0.022)		(0.020)		(0.028)	
(a2) Waste Management Actions	0.176	***	0.184	***	0.257	***	0.249	***
	(0.027)		(0.041)		(0.032)		(0.048)	
- Reducing Waste	0.067	***	0.054	***	0.077	***	0.077	***
	(0.014)		(0.019)		(0.014)		(0.019)	
- Selling Scrap Materials	0.083	***	0.088	***	0.112	***	0.104	***
	(0.016)		(0.022)		(0.018)		(0.027)	
- Recycling Materials	0.027	*	0.041	*	0.067	***	0.068	**
	(0.017)		(0.023)		(0.019)		(0.029)	
(a3) Other RE Actions	0.001		0.004		−0.002		−0.001	
	(0.003)		(0.004)		(0.003)		(0.004)	
(b) Resource Efficiency Investment	0.138	***	0.166	***	0.118	***	0.147	***
	(0.017)		(0.021)		(0.019)		(0.030)	
(c) Production Costs Decreased	0.068	***	0.060	***	0.087	***	0.054	**
	(0.018)		(0.023)		(0.018)		(0.027)	
Bandwidth	0.007		0.003		0.006		0.007	
Matched sample:								
N. treated	1368		630		927		373	
N. controls	4032		4770		4468		4860	
Region of common support	[0.016, 0.701]		[0.009, 0.380]		[0.012, 0.636]		[0.007, 0.345]	
Matching quality indicators:	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
Pseudo-R2	0.088	0.001	0.065	0.001	0.117	0.001	0.106	0.001
Mean bias	9.6	0.9	8.7	0.9	12.7	0.8	13.6	0.9
Median bias	8.1	0.5	7.6	0.7	11.9	0.6	11.8	0.6
B	75.3	8.5	70.3	7.4	91.5	7.6	95.4	7.7
R	0.78	0.99	0.63	0.97	0.74	1.02	0.76	0.89

Notes: The table reports the ATETs of different types of external support measures on alternative indicators of resource efficiency actions and on the benefit from the implementation of RE actions (in terms of reductions in production costs), estimated on the subsamples of SMEs. The ATETs are computed using Epanechnikov kernel matching, with automatic bandwidth selection and imposing common support, performed using the Stata module *kmatch* by Jann [42]. Bootstrapped (200 replications) standard errors are reported in parentheses. Pseudo-R^2 is obtained from probit estimation of the conditional treatment probability on all the covariates on the matched sample. Mean bias and median bias are summary indicators of the distribution of the absolute standardized percentage bias for each covariate after matching. B and R are the standardized difference in the means and the ratio of the variances of the propensity scores between treated and untreated firms after matching, respectively. ***, ** and * denote significance of the ATETs at the 1, 5 and 10% levels, respectively. **Source**: Own elaboration on Eurobarometer data.

Table 6. Impact of external support on resource efficiency actions: ATETs for the subsample of large firms.

	(1)		(2)		(3)		(4)	
	Any External Support		**External Funding**		**External Advice**		**External Funding and Advice**	
	ATET		**ATET**		**ATET**		**ATET**	
(a) Resource Efficiency Actions	0.062		0.350	*	0.369	**	0.627	***
	(0.146)		(0.217)		(0.168)		(0.222)	
(a1) Re-engineering Actions	−0.014		0.212		0.197	*	0.429	***
	(0.106)		(0.155)		(0.118)		(0.168)	
- Saving Water	0.027		0.091	*	0.095	**	0.152	**
	(0.043)		(0.056)		(0.050)		(0.064)	
- Saving Energy	0.023		0.029		0.042		0.053	
	(0.030)		(0.036)		(0.028)		(0.037)	
- Using Renewable Energies	−0.020		0.055		0.005		0.042	
	(0.044)		(0.057)		(0.046)		(0.069)	
- Saving Materials	0.032		0.048		0.090	***	0.123	**
	(0.034)		(0.043)		(0.035)		(0.051)	
- Re-designing Products	0.076	*	−0.012		−0.035		0.059	
	(0.047)		(0.065)		(0.052)		(0.073)	
(a2) Waste Management Actions	0.077		0.143		0.182	**	0.208	*
	(0.074)		(0.104)		(0.081)		(0.118)	
- Reducing Waste	0.067	*	0.068	*	0.086	***	0.091	**
	(0.032)		(0.038)		(0.032)		(0.039)	
- Selling Scrap Materials	−0.018		0.084		0.003		0.117	*
	(0.040)		(0.053)		(0.042)		(0.066)	
- Recycling Materials	0.028		−0.009		0.093	*	0.000	
	(0.044)		(0.060)		(0.050)		(0.075)	
(a3) Other RE Actions	−0.001		−0.005		−0.010		−0.010	
	(0.011)		(0.012)		(0.008)		(0.012)	
(b) Resource Efficiency Investment	−0.031		−0.029		0.002		−0.001	
	(0.045)		(0.055)		(0.050)		(0.076)	
(c) Production Costs Decreased	0.032		0.068		0.041		0.151	**
	(0.038)		(0.052)		(0.051)		(0.062)	
Bandwidth	0.017		0.018		0.025		0.021	
Matched sample:								
N. treated	318		136		243		88	
N. controls	409		561		476		534	
Region of common support	[0.159, 0.792]		[0.042, 0.613]		[0.027, 0.775]		[0.026, 0.640]	
Matching quality indicators:	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
Pseudo-R2	0.080	0.005	0.078	0.006	0.122	0.008	0.111	0.012
Mean bias	9.3	2.0	8.8	2.5	11.5	2.7	11.7	3.4
Median bias	8.1	1.4	6.0	2.0	9.1	1.8	10.1	2.0
B	68.8	17.0	71.0	17.4	86.7	20.6	87.8	19.6
R	0.86	1.45	0.95	0.90	0.61	0.94	0.96	0.64

Notes: The table reports the ATETs of different types of external support measures on alternative indicators of resource efficiency actions and on the benefit from the implementation of RE actions (in terms of reductions in production costs), estimated on the subsamples of large firms. The ATETs are computed using Epanechnikov kernel matching, with automatic bandwidth selection and imposing common support, performed using the Stata module *kmatch* by Jann [42]. Bootstrapped (200 replications) standard errors are reported in parentheses. Pseudo-R^2 is obtained from probit estimation of the conditional treatment probability on all the covariates on the matched sample. Mean bias and median bias are summary indicators of the distribution of the absolute standardized percentage bias for each covariate after matching. B and R are the standardized difference in the means and the ratio of the variances of the propensity scores between treated and untreated firms after matching, respectively. ***, ** and * denote significance of the ATETs at the 1, 5 and 10% levels, respectively. **Source**: Own elaboration on Eurobarometer data.

In the subsample of SMEs, the estimated ATETs remain positive and statistically significant (at the 1 and 5% level), confirming the estimation results obtained in the whole sample. For small and medium enterprises, coherently with Bodas-Freitas and Corrocher [8], direct financial support and indirect support in the form of advice and consulting significantly contribute to increase the number of green practices adopted, with estimated ATETs varying from 0.496 to 0.702. This result suggests that the two types of external support allow firms to overcome both the financial barriers hampering the acquisition of new equipment and technologies and the knowledge barriers related to lack of competencies and technical expertise necessary to implement resource efficiency practices. In particular, the combined use of external funding and advice exerts the largest effect on the number of re-engineering practices (0.454), while the external consultancy seems particularly important for waste management actions (0.257) and for the cost-related benefits from the adoption of resource efficiency measures. In this latter respect, those firms using external advice and consultancy are 8.7% more likely to experience a reduction in production costs compared to firms in the control group. Both types of external support also have a significant and positive impact on firm investment in greening processes: SMEs relying on direct and indirect support are about 11.8 to 16.6% more likely to invest at least 1% of their turnover to implement resource efficiency measures than similar SMEs not recurring to external support. As in the whole sample, external financing significantly contributes to increase the probability of resource efficiency investments of SMEs. Firms in the treated group have, on average, a 16.6% higher probability to invest in resource efficiency activities than firms in the control group. This probability increase is equal to 11.8% for those firms that receive external consulting and to 14.7% for those relying on both external financial and consulting.

Focusing on the subsample of large firms, most of the estimated ATETs lose their statistical significance, demonstrating that the additional effects of external support on the implementation of resource efficiency practices and on the benefits from the adoption are not particularly relevant. This evidence suggests that large firms tend to rely more on their internal resources for the adoption of green practices, having more financial resources to invest and better internal competencies and expertise. Specifically, for the subsample of large enterprises, external advice and consultancy is the type of support that contributes the most to the adoption of green practices, while direct financial support has an irrelevant impact on firms' engagement in greening processes. The impact of external advice strongly contributes to determine the significant effect of the combined use of direct and indirect support on the number of resource efficiency practices implemented by the firm. Large companies relying on both types of external support implement, on average, a number of resource efficiency measures 0.627 higher than those in the control group. As in the whole sample, the ATET is higher for the adoption of re-engineering practices (0.429) than for the adoption of waste management practices (0.208). It is also worth remarking that the combined use of external funding and advice significantly affects the cost-related benefits of adopting resource efficiency measures. Specifically, the estimated ATET indicates that larger firms relying on both direct and indirect support are, on average, 15% more likely to benefit from a reduction in production costs compared to larger enterprises in the control group.

6. Conclusions

This paper explores the impact of different types of external support on a firm's adoption of resource efficiency actions and investment behavior and on the benefits from the adoption of such actions (in terms of reduction in production costs). We rely on cross-sectional data from the third and fourth waves of the Flash Eurobarometer survey "SMEs, resource efficiency and green markets", focusing on 6595 SMEs and large manufacturing firms from 35 European countries.

We use a propensity score matching approach, which compares the effect of the recourse to external support in the subsamples of treated and untreated firms with similar observable characteristics. In particular, we focus on the additional effect of external

support on the adoption of resource efficiency actions and estimate the average treatment effect on the treated (ATET).

Our main results show that the overall effect of external support is positive and statistically significant, on both the adoption and the benefits from the adoption of green practices. Firms recurring to any type of external support implement, on average, a number of resource efficiency actions higher than those in the control group; the effect is particularly high for those firms that have jointly used external funding and advice. Even the probability to invest in resource efficiency activities is higher for those firms that can rely on external support, especially in the case of recourse to external financial support, demonstrating the relevance of external funding in boosting a firm's investments in greening processes. Moreover, the recourse to any form of external support fosters production cost savings, in particular, the simultaneous use of external financing and consultancy exerts a higher effect on the cost-related benefits.

The analysis on the subsamples of SMEs and large firms reveals significant heterogeneity in the impact of external financing and advice on environmental behavior. While the estimated ATETs for SMEs substantially confirm the results obtained in the whole sample, empirical results for large firms highlight that the additional effects of external support on the implementation of resource efficiency practices and on the benefits from the adoption are not particularly relevant. Large firms tend to rely more on their internal financial resources and expertise for the adoption of green practices. In particular, direct financial support has an irrelevant impact on firms' engagement in greening processes, while in the subsample of SMEs, it exerts a crucial role especially in boosting resource efficiency investments.

Our findings suggest that public policies, aimed at enhancing firms' involvement in greening processes, should be designed by taking into account firm size and different types of environmental practices. Specifically, for small and medium-sized firms, public and private financial support can directly improve the extent of resource efficiency investments, while external advice can contribute to integrate the lack of specific expertise and overcome the erroneous perception of environmental practices as an additional burden. On the other hand, the recourse to external advice and consulting services plays a particularly important role for large firms, enhancing the implementation of technological and managerial solutions that may improve the efficiency of environmental actions and encourage eco-innovation activities.

Our analysis has some limitations, mainly related to the data used in the empirical analysis, that need to be acknowledged. First, the cross-sectional nature of the data does not allow to fully control for unobservable heterogeneity at the firm level. At the same time, it prevents any attempt to investigate the intertemporal relationship between firms' implementation of resource efficiency practices and the recourse to direct and indirect support. Future analyses should exploit longitudinal firm-level data to estimate the average treatment effects of external support on firms' environmental practices and assess the validity of the evidence obtained in this study. The use of panel data will also allow to develop an intertemporal framework to analyze firms' environmental behavior. Furthermore, as pointed out by Hoogendoorn et al. [14], the available data do not allow to distinguish between stakeholder groups nor to identify the specific products or services offered by the firm. This prevents properly assessing stakeholders' influence and the effect of firm tangibility on the extent and types of environmental practices and on the related recourse to external support. Finally, our study provides first empirical evidence on the heterogenous effects of external support on the environmental practices of SMEs and large firms. Future research efforts are needed to shed additional light on these firm-size heterogeneities.

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Appendix A

Table A1. Variable definitions.

Variable	Definition
(a) Outcome variables	
Resource Efficiency Actions	Number of any resource efficiency actions adopted by the firm
Re-engineering Actions	Number of resource efficiency actions requiring process re-engineering (i.e., saving water, saving energy, using renewable energy, saving materials, and designing products easier to maintain/repair) adopted by the firm
- Saving Water	Equal to 1 if the firm has adopted actions to save water; 0 otherwise
- Saving Energy	Equal to 1 if the firm has adopted actions to save energy; 0 otherwise
- Using Renewable Energies	Equal to 1 if the firm has adopted actions to use predominantly renewable energy; 0 otherwise
- Saving Materials	Equal to 1 if the firm has adopted actions to save materials; 0 otherwise
- Re-designing Products	Equal to 1 if the firm has adopted actions to design products that are easier to maintain or repair; 0 otherwise
Waste Management Actions	Number of resource efficiency actions related to waste management (i.e., minimizing waste, selling scrap material, recycling) adopted by the firm
- Reducing Waste	Equal to 1 if the firm has adopted actions to minimize waste; 0 otherwise
- Selling Scrap Materials	Equal to 1 if the firm has adopted actions to sell scrap material; 0 otherwise
- Recycling Materials	Equal to 1 if the firm has adopted actions to recycle by reusing material or waste; 0 otherwise
Other RE Actions	Equal to 1 if the firm has adopted other resource efficiency actions; 0 otherwise
Resource Efficiency Investment	Equal to 1 if, over the last two years, the firm has invested at least 1% of their annual turnover to be more resource efficient
Production Costs Decreased	Equal to 1 if, over the last two years, the resource efficiency actions undertaken by the firm have contributed to decrease its production costs; 0 otherwise
(b) Treatment variables	
Any External Support	Equal to 1 if the firm has relied on any form of external support in its efforts to be more resource efficient; 0 otherwise
External Funding	Equal to 1 if the firm has relied on (public and private) external financial support in its efforts to be more resource efficient; 0 otherwise
External Advice	Equal to 1 if the firm has relied on (public and private) external advice and consultancy in its efforts to be more resource efficient; 0 otherwise
External Funding and Advice	Equal to 1 if the firm has relied on both (public and private) external financial support and external advice and consultancy in its efforts to be more resource efficient; 0 otherwise

Table A1. *Cont.*

Variable	Definition
(c) Independent variables	
Age	Firm age in years
Small	Equal to 1 if the firm has 10 to 49 employees; 0 otherwise
Medium	Equal to 1 if the firm has 50 to 249 employees); 0 otherwise
Large	Equal to 1 if the firm has 250 or more employees; 0 otherwise
Low turnover	Equal to 1 if the firm's turnover is lower than 2 million Euro; 0 otherwise
Own financial resources	Equal to 1 if the firm relies on its own financial resources to implement greening processes; 0 otherwise
Own technical competencies	Equal to 1 if the firm relies on its own technical competencies to implement greening processes; 0 otherwise
B2C Market	Equal to 1 if the firm sells products or services directly to consumers; 0 otherwise
B2B Market	Equal to 1 if the firm sells products or services to other firms; 0 otherwise
PA Market	Equal to 1 if the firm sells products or services public administrations; 0 otherwise
2017	Equal to 1 if the reference year of the survey is 2017; 0 otherwise

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