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# Green Investment Challenges in European Firms: Internal vs. External Resources

**Andrea Bacchiocchi [1], Alessandro Bellocchi [1,2] and Germana Giombini [1,3,*]**

[1] Department of Economics, Society, Politics (DESP), University of Urbino Carlo Bo, Via Saffi 42, 61029 Urbino, Italy; andrea.bacchiocchi@uniurb.it (A.B.); alessandro.bellocchi@uniurb.it (A.B.)
[2] SEEDS, 44121 Ferrara, Italy
[3] Mo.Fi.R., 60121 Ancona, Italy
* Correspondence: germana.giombini@uniurb.it

**Abstract:** This paper examines the impact of internal and external resources on the adoption of eco-efficiency actions by European firms. The empirical analysis is based on an ordered logit model on data from the fifth wave of the Flash Eurobarometer survey (2021) for a sample of 9158 firms. We obtain three main results. First, we show that internal and external financial resources are positively correlated with firm eco-innovations, but the association with the former is stronger. Second, we observe a high degree of complementarity between public and private funds. Finally, besides financial resources, both in-house technical expertise and external non-financial assistance seem to play an important role for the implementation of eco-efficiency actions at the firm level. These findings have some relevant policy implications. European policy-makers should increase opportunities for public co-financing, while providing support to firms for developing the necessary competencies to enable green investments.

**Keywords:** eco-efficiency actions; funding sources; technical expertise

**JEL Classification:** D24; Q01; Q56



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## 1. Introduction

The transition to a more sustainable economy is a priority of the European Union's policy agenda [1]. The Eco-Innovation Action Plan (Eco-AP), as part of the European Green Deal, aims to support and finance firms' eco-innovations to facilitate the transition to a zero-carbon economy by 2050 [2]. Firms are key players in EU climate efforts, both as drivers of technological change and as adopters of green business models and practices to reduce their ecological footprint.

European firms are facing several challenges, including environmental compliance, switching to more sustainable sources of supply, improving energy efficiency, reducing production waste and financing green innovation [3]. Indeed, green investments are becoming a key factor to achieve a lasting competitive advantage, better reputation and strategic market positioning.

However, despite firms' growing interest in eco-innovations, limited access to finance and lack of technical expertise still represent significant obstacles to their implementation [4].

A growing number of studies point to the existence of a significant financial gap for green investments, which are characterized by high-risk capital-intensive innovations [5,6]. Furthermore, SMEs with innovative activities are more likely to be adversely affected by a shortage of funding: the combination of high risk, long-term (uncertain) returns, information asymmetries and lack of collateral often results in market imperfections and eventually credit rationing [7–9]. The European Commission stressed that access to finance is of paramount importance to support firms in developing new technologies and resource-efficient solutions [10]. Therefore, a better understanding of the financial and non-financial

resources needed to support eco-innovations, as well as an analysis of their potential complementarity, is crucial for more accurate policy formulation.

The aim of this paper is to analyze the correlation between the use of internal and external resources and the adoption of resource efficiency actions by European firms. Specifically, we test whether firms with access to various financial and non-financial resources (such as proprietary technical expertise, managerial skills or consultancy) are more likely to introduce eco-innovations. In addition, we explore the degree of complementarity between different types of resources. The aim is to provide useful policy insights and ultimately encourage a higher level of eco-innovations in the European economy.

The empirical analysis is based on an ordered logit model on data from the Flash Eurobarometer 498: "Small and Medium Enterprises, Resource Efficiency and Green Markets, wave 5", a survey conducted by the European Commission on a sample of firms from the 28 member states of the EU. This includes a large sample of 9158 firms, most of which are SMEs.

We find that, while both internal and external financial resources are significantly correlated with the number of eco-efficiency actions undertaken by the firm, the correlation with the former is stronger. Moreover, firms that have either access to public or private external funds are no more likely to undertake eco-innovations than the average firm in the population. However, the association between the use of public and private financing and eco-innovations becomes significant when these resources are employed together. In other words, public and private funds show a high degree of complementarity. Interestingly, besides financial resources, both in-house technical expertise and external non-financial assistance are relevant for eco-innovation, being the most correlated variables with the eco-efficiency actions of the firm. Again, the complementarity and synergy benefits of using internal and external technical expertise, combined with adequate financial resources, suggest that the introduction of eco-innovation is a complex process that requires a balanced mix of different resources.

Our study contributes to the existing literature on financial and non-financial business support for investments in resource efficiency actions. Unlike previous studies that have focused on the role of either internal or external resources and/or on narrow samples of countries and industries, we focus with a holistic approach on multiple factors and a large sample of European firms. Although, due to data limitations, we refrain from interpreting the relationships as causal, the representativeness of the sample and the robustness of correlations allow us to provide useful insights to policy-makers and industry associations on how best to support firms in their transition to more sustainable business models.

The rest of this paper is organized as follows. Section 2 presents the literature review and outlines the main research questions. In Section 3, we describe the data and illustrate the empirical strategy. Section 4 presents the results. Finally, Section 5 concludes and discusses policy implications.

## 2. Literature Review and Hypotheses

The drivers of eco-innovation in firms have been widely discussed in the literature, which recognizes the importance of supply, demand and regulatory factors [11]. Surprisingly, little attention has been paid to financial and non-financial constraints, which are often the main obstacles to the implementation of green innovation projects [12,13].

Scholars pointed out that access to finance is one of the main obstacles to innovative activity and firm growth [14,15]. If firms lack sufficient internal funds for innovation, they must rely on external financing in the form of bank loans, equity capital or public financial support (e.g., grants or loans). However, innovation returns are uncertain, and information asymmetries on inputs and outcomes make it difficult to rely on accurate "contingent" contracts [15]. This is particularly true in the context of green innovations, where externalities in the introduction and diffusion stages increase risks and uncertainties compared to standard innovations [16]. Indeed, the uncertainty of the return on investments and their payback period is one of the most serious obstacle to adaptation to a low-carbon

economy [17]. Therefore, to support the transition toward a sustainable economy, eco-innovation activity is often publicly funded, due to the lack of competitiveness of clean technologies compared to alternatives and the uncertain effectiveness of regulation.

Our contribution lies within this strand of the literature and aims to understand whether and how different types of internal and external (financial and non-financial) resources make the introduction of eco-innovations by the firm more likely. This complements the picture drawn by other major works that have instead focused on either individual resources [15], countries [18] or industries [19]. Figure 1 provides an overview of our theoretical framework.

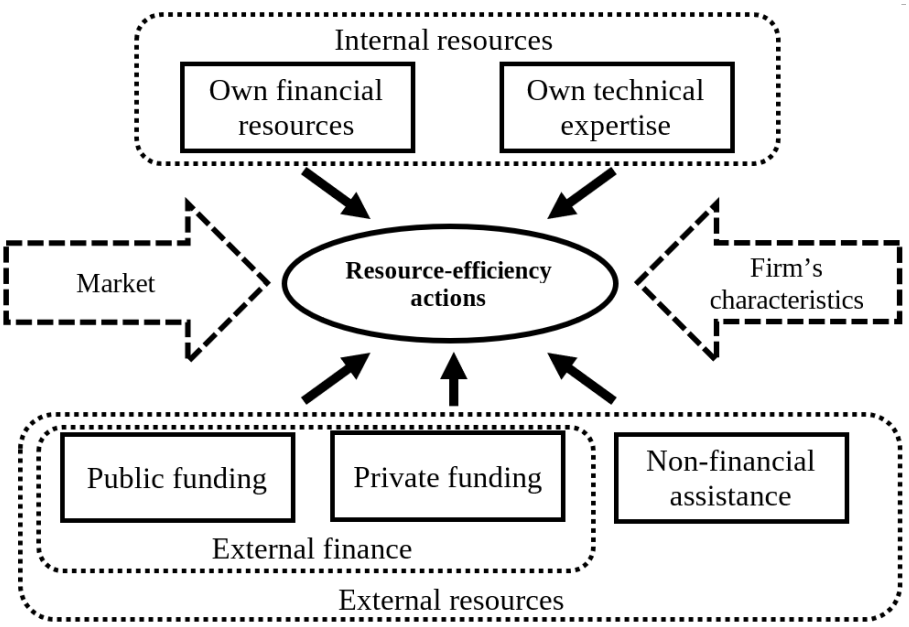


**Figure 1.** Framework of analysis. Note. The eco-innovation activity of the firm is influenced by resources internal or external to it. Internal resources are composed of financial resources and technical expertise. External resources are financial (public and private funding) or non-financial (mainly assistance and consulting). Finally, additional controls related to the country, market and other observable characteristics of the firm that may potentially influence its resource efficiency actions are included. Source: Authors' own elaboration.

To capture the conditional correlation between the use of internal and external resources and eco-innovation, we must control for all other factors (at the firm and/or market level) that can influence the firm's resource-efficiency actions. Given data limitation, our empirical analysis is unable to examine the entire chain of causality from funding sources to ecological innovation, as we cannot disentangle the effects determined by green policies or the private market. Nevertheless, this study still represents a useful compass for policy-makers because it quantifies the actual relationship between the use of a particular mix of financial and technical resources (internal and external) by the firm and its eco-innovative activity.

### *2.1. Eco-Innovation Actions and Financial Resources*

The framework employed to discuss firms' demand for external financing is Pecking Order Theory (POT) [20]. The main implication of this theory is that firms have a hierarchical preference over funding sources, favoring first internal sources and then, only if necessary, debt. In this context, the costs of external financing are higher than those of internal sources, and different sources of financing incur different costs [21,22].

Indeed, a large body of literature supports POT and confirms that most SMEs primarily rely on internal financial resources to finance their investments [8,23,24]. Ref. [25] shows that the lack of internal funds (as well as public funds) negatively affects the likelihood

that a firm will introduce green innovations. Interestingly, these results are particularly strong for SMEs, confirming that these suffer the most from financial constraints and would benefit from targeted public support policies. Similarly, Ref. [26] shows that the more financially constrained firms are, the less likely they are to pursue mitigation measures to reduce energy costs and their carbon footprint.

Moreover, in the case of innovative SMEs, internal resources may not be sufficient to finance innovation projects and firms must rely on external financing. Yet, these firms are affected by significant market imperfections when they seek external financing. Innovation projects are often risky, uncertain and characterized by information asymmetries. In this context, innovative small and medium-sized firms lack tangible collateral that can secure debt [27–29].

Several studies have analyzed the impact of external financing sources on SMEs' green investments. Ref. [30] found that external financing and credit supply are positively associated with eco-innovation practices. On the contrary, other studies pointed out that a lack of internal funding may hinder the development of eco-innovations, while a shortage of external funding does not appear to be a significant obstacle [15]. Therefore, to shed light on the conflicting results of empirical research on the nature of financial resources to support eco-innovation, we formulate the following hypothesis:

**H1a.** *Firms' access to financial resources (internal and external) is positively correlated with their eco-actions.*

Our second stream of research develops along the lines of recent studies that suggest the need to investigate the degree to which public support policies complement private ones. Indeed, public financial instruments, including grants and tax credits, can ease financial constraints for innovating firms [31–33].

Similarly, it has been shown that there is enormous potential in supplementing private funding with public support, particularly for climate change-related eco-innovation. This is because persistent information asymmetries between innovators and funders mean that private initiative alone can be ineffective in mobilizing the necessary investment [34,35]. Therefore, a combination of public (e.g., grants) and private (e.g., venture capitalist—VC) instruments is the most effective way to generate synergies and complementarities in the sphere of eco-innovation financing. Notable examples include institutional innovation intermediaries, which reduce uncertainty and risk, thus complementing the actions of informed investors such as VCs [35–37].

Ref. [25] highlight that access to public funds is effective in improving a firm's ability to introduce eco-innovations, but only when the firm is not short of funds (either internal or external), thus suggesting that public funds are somewhat complementary to other funds. Ref. [38] add that the circular economy is driven in particular by "soft" (i.e., social, regulatory and institutional) factors. In this context, public agencies play a crucial role in establishing an appropriate institutional framework, from infrastructure to legal agreements, R&D support and social awareness. Despite the importance of regulatory interventions, however, adequate public funding seems to be indispensable in many cases to attract private investments [39–41]. In light of the results reported in the literature, we formulate the following hypothesis to be tested empirically:

**H1b.** *Firms' access to public and private funding is positively correlated with their eco-actions and the correlation is higher when public and private external resources are used together (i.e., public and private funds are complementary).*

### *2.2. Eco-Innovation Actions and Non-Financial Resources*

Skill constraints and limited managerial capacity in implementing eco-innovations represent major obstacles to the adoption of sustainable practices by firms, particularly SMEs. Several recent contributions have highlighted the importance of technical knowledge

and expertise in facilitating green investments. For example, Ref. [42] found that SMEs with a greater understanding and awareness of environmental issues are more likely to adopt sustainable production processes. They also distinguish between the relative contributions of small and large firms (in a co-evolutionary logic) to increasing the sustainability of industries. Indeed, in the early stages of an industry's transformation toward sustainability, it is typically small firms and environmentally sensitive new entrants that spur disruptive eco-innovation. Then, attracted by the market successes of these firms, medium-sized and large pioneer companies follow with larger corporate sustainability initiatives. Due to their broader scope, these initiatives take the sustainable transformation of the industry to the next level.

In the same vein, Ref. [26] found that SMEs with access to technical expertise and better management can overcome information barriers and are more likely to adopt sustainable supply chain practices. Ref. [12] pointed out that eco-innovation differs from standard innovation in terms of pecuniary incentives due to the importance of regulations. It also requires additional knowledge that does not belong to the core competencies of firms or the traditional industrial knowledge base. Thus, cooperative agreements [43,44] and external knowledge sourcing [45,46] are particularly important to complement the firm's investments in organizational and technological capabilities [47,48].

Similarly to general innovation activities, eco-innovation is also stimulated by the availability of capabilities (internal or external to the firm) in terms of knowledge stock, human capital and organizational features (i.e., technology push factors), and by market stimuli in terms of "green" demand from consumers, other firms and public procurement (i.e., market pull factors) (see [49]). In this perspective, other studies have highlighted the challenges SMEs face in acquiring the necessary skills and knowledge and building adequate capacity, particularly in relation to complex technologies and regulatory frameworks [50,51]. An interesting work in this regard is that of [19], who, studying the Canadian wine sector, observed how internal firm resources (especially technical expertise) are the main drivers of both ecological and conventional innovation. Considering the literature cited above, our hypothesis on the role of non-financial resources (i.e., own technical expertise and external non-financial assistance) in stimulating eco-innovation activities is the following:

**H2.** *The availability of in-house technical expertise and access to external non-financial assistance are both associated with more eco-actions by the firm.*

### *2.3. The Joint Effect of Financial and Non-Financial Resources*

The literature examining the joint effect of financial and non-financial resources on firms' green actions presents a nuanced picture [52]. As previously mentioned, several studies highlight how financial resources facilitate sustainability initiatives and allow investments in eco-friendly technologies and practices [15]. Other works emphasize the significance of non-financial resources, such as organizational culture and employee engagement, to drive resource-efficiency actions [53]. The interplay between these resources is complex, as financial strength alone may not guarantee a commitment to sustainability without the support of a conducive organizational environment. Conversely, a strong environmental ethos may face limitations without the necessary financial backing for implementation.

Ref. [54] analyzes the effects of barriers to innovation on the propensity of firms to undertake radical and incremental innovations. The author estimates the effect of three types of constraints (financial, knowledge and competition) on the propensity to innovate. Empirical results reveal heterogeneous effects of constraints. Specifically, while knowledge and competition constraints hinder radical innovation, financial and knowledge constraints reduce the likelihood of incremental innovation. Given the propensity of SMEs to introduce incremental innovations [55], these results corroborate those of [56,57] which show that, for innovative firms, non-financial systemic obstacles have a more important deterrent effect than financing problems to limit the SMEs' ability to innovate.

The mixed results in the literature underscore the complex nature of the relationship between financial and non-financial resources in shaping firms' green initiatives. Indeed, in line with the resource-based view, a firm that wants to produce using its resources efficiently must necessarily mobilise an appropriate mix of financial and non-financial resources [58,59]. Coherently, we formulate our final research hypothesis as follows:

**H3.** *Firms' access to financial and non-financial resources is positively correlated with their eco-actions and the correlation is higher when financial and non-financial resources are used together (i.e., financial and non-financial resources are complementary).*

## 3. Data Description and Empirical Strategy

### *3.1. Database and Descriptive Statistics*

The data source used for this work is the Flash Eurobarometer 498 (FLE498) survey on "SMEs, Resource Efficiency and Green Markets", wave 5. It was conducted between November 8th and 10 December 2021, and follows earlier Eurobarometer waves (FLE342 in 2012, FLE381 in 2013, FLE426 in 2015 and FLE456 in 2017) (As suggested by a referee, Flash Eurobarometer 315: "Attitudes of European entrepreneurs towards eco-innovation" is the European Commission's most important research on the topic). The database includes the 28 member states of the European Union, plus Albania, Macedonia, Montenegro, Serbia, Turkey, Iceland, Moldova, Norway, the UK and the US (For additional information, see https://europa.eu/eurobarometer/surveys/detail/2287, accessed on 1 January 2023).

In the Flash Eurobarometer Survey 498, a total of 17,662 managers (14,482 from the EU28) were selected using a stratification procedure according to the dimensions of the firm (1–9 employees, 10–49 employees, 50–249 employees and 250 employees or more) and sector (manufacturing, retail, services and industry). As in any survey, the reliability of data strictly depends on how the participating managers interpret and answer the relevant questions. Although some questions are subjective, we are confident that the overall data collected represent the general attitude of top management of firms involved in resource-efficiency innovations [60].

Unlike other empirical environmental databases that offer only aggregate data at the country level, the Flash Eurobarometer 498 survey includes four micro-dimensions: country, industry, age and size. This is a relevant strength of the present work as it allows us to investigate at the most disaggregated level with information on individual firms.

Due to the main focus of our analysis, i.e., to study the relationship between access to various financial and non-financial resources and eco-efficiency actions of European firms, and the data cleaning procedure (in order to remove observations with missing values for selected variables), our final sample comprises 9158 companies. Notably, these include EU28 firms that are actively taking measures to be more resource-efficient and have invested in these actions in the last two years. Table 1 provides an overview of the sample by country, sector and firm size.

Table 1 shows that the most represented countries are Sweden, Romania and Greece (with a total of 423–440 firms each), while the least represented ones are Cyprus, Luxembourg and Malta (with less than 200 firms). The sample is dominated by three industries, namely wholesale and retail trade, manufacturing and construction. Together, these industrial sectors account for roughly 67% of the firms, reflecting the actual aggregate composition of the EU economy [61]. In terms of size, the firms in our sample are 36% micro-enterprises ($\leq$9 employees), 38% small enterprises (10–49), 19% medium-sized companies (50–249) and only the remaining 7% are large-sized firms ($\geq$250). Finally, as far as age is concerned, most of the firms are less than 50 years old (88%), and many of them are relatively young (the share of firms under the age of 25 alone reaches 50% of the total). Only about 13% of the firms are historical (i.e., older than 50).

**Table 1.** Distribution of the sample.

| Firms by Country | | | Firms by Industry | | |
|---|---|---|---|---|---|
| **Country** | **Firms** | **Percent** | **Industry** | **Firms** | **Percent** |
| AT—Aust | 337 | 3.68% | B—Minin | 89 | 1.22% |
| BE—Belg | 417 | 4.55% | C—Manuf | 2139 | 25.21% |
| BG—Bulg | 276 | 3.01% | D—Elect | 181 | 2.02% |
| CY—Cypr | 150 | 1.64% | E—Water | 161 | 2.07% |
| CZ—Czec | 377 | 4.12% | F—Const | 1592 | 17.71% |
| DE—Germ | 355 | 3.88% | G—Whole | 2402 | 23.69% |
| DK—Denm | 222 | 2.42% | H—Trans | 666 | 7.97% |
| EE—Esto | 292 | 3.19% | I—Accom | 609 | 7.08% |
| ES—Spain | 418 | 4.56% | J—Infor | 411 | 3.98% |
| FI—Finl | 359 | 3.92% | K—Finan | 234 | 1.99% |
| FR—Fran | 287 | 3.13% | L—Real | 195 | 2.19% |
| GB—Unit | 296 | 3.23% | M—Profe | 479 | 4.86% |
| GR—Gree | 423 | 4.62% | Total | 9158 | 100% |
| HR—Croa | 394 | 4.30% | **Firms by Employees** | | |
| HU—Hung | 231 | 4.01% | **Employees** | **Firms** | **Percent** |
| IE—Irel | 302 | 3.30% | 1 to 9 | 3288 | 35.90% |
| IT—Ital | 348 | 3.80% | 10 to 49 | 3492 | 38.13% |
| LT—Lith | 314 | 3.43% | 50 to 249 | 1768 | 19.31% |
| LU—Luxe | 135 | 1.47% | >250 | 606 | 6.62% |
| LV—Latv | 292 | 3.19% | Don't know | 4 | 0.04% |
| MT—Malt | 132 | 1.44% | Total | 9158 | 100% |
| NL—Ned | 394 | 4.30% | **Firms by Age** | | |
| PL—Pola | 342 | 3.73% | **Age** | **Firms** | **Percent** |
| PT—Port | 351 | 3.83% | <10 | 1556 | 16.99% |
| RO—Roma | 436 | 4.76% | 10 to 25 | 3115 | 34.01% |
| SE—Swed | 440 | 4.80% | 25 to 50 | 3368 | 36.78% |
| SI—Slove | 387 | 4.23% | 50 to 100 | 859 | 9.38% |
| SK—Slova | 315 | 3.44% | >100 | 260 | 2.84% |
| Total | 9158 | 100% | Total | 9158 | 100% |

Source. Author's own elaboration on Flash Eurobarometer 498.

For the purpose of this study, resource efficiency is defined as the use of natural resources in a sustainable and environmentally sound manner at different stages of the firm's supply chain, from sourcing and production to, for example, waste management [62].

Business managers were asked to answer the following question Q1: "*What actions is your company undertaking to be more resource efficient?*". As shown in Figure 2, the most common resource efficiency actions undertaken by the firms of the sample are: minimizing waste (16%), saving energy (15.9%), saving materials (14.4%), recycling by reusing material or waste within the company (11.4%) and saving water (11.3%). Other relevant actions include switching to greener suppliers of materials (9.4%), selling your residues and waste to another company (8.7%), designing products that are easier to maintain, repair or reuse (7.2%), using predominantly renewable energy (e.g., including own production through solar panels) (5.7%).

For our empirical analysis, we clustered eco-actions according to the number implemented by each firm. To this aim, we used the three-category classification proposed by Eurobarometer. Specifically, firms that implemented one or two eco-efficiency actions were classified in the group "few actions", those that implemented three to four actions in the group "some actions"and finally, those with more than four actions were included in the group "many actions". The result of this grouping is shown in Figure 3. Overall, the first cluster contains 4731 enterprises (51.7% of the total), the second cluster 2550 (27.8% of the total) and the third cluster 1877 (20.5% of the total). Thus, the new variable obtained represents our dependent variable and captures the intensity of a firm's resource-efficiency innovation [63].

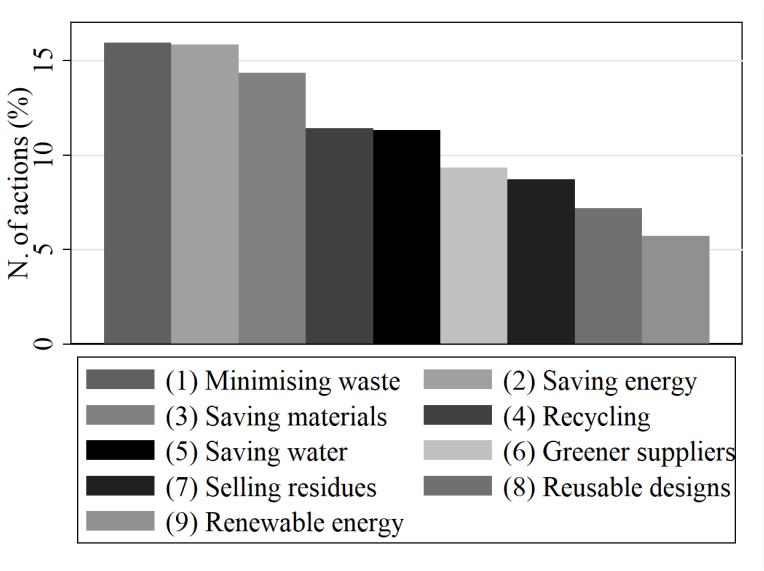


**Figure 2.** What actions is your firm undertaking to be more resource efficient? Source. Authors' own elaboration on Flash Eurobarometer 498.

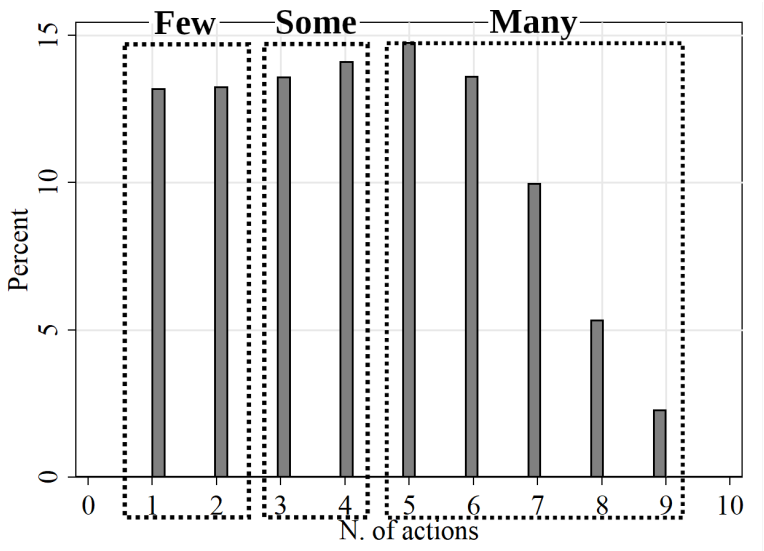


**Figure 3.** How many actions is your firm taking to be more resource efficient? Source. Authors' own elaboration on Flash Eurobarometer 498.

The last step to prepare the dataset for estimation involves identifying the type of resources (internal vs. external and financial vs. non-financial) used by firms to invest in eco-innovations. To this aim, we rely on question Q5: "Which type of support does your company rely on in its efforts to be more resource efficient?". The possible answers to Q5 are: (1) own financial resources; (2) own technical expertise; and (3) external support. Then, only for firms that answered "external support" (that we identify as external resources), we also retrieve information from Q6: "More precisely, which type of external support is it?". The possible answers are: (1) Public funding such as grants, guarantees, or loans; (2) Private funding from a bank, an investment company, or venture capital fund; (3) Private funding from friends and relatives; (4) Advice or other non-financial assistance from public administration; (5) Advice or other non-financial assistance from private consulting and audit companies; (6) Advice or other non-financial assistance from business associations and clusters; (7) Advice or other non-financial assistance from supply chain partners. While we take question Q5 in its original form, as for Q6, due to the heterogeneity of possible

answers by the interviewed managers, we group external finance (including both private and public funding) and external non-financial assistance (mainly advices and other forms of assistance). The descriptive statistics of these variables (in dummies) are shown in Table 2.

**Table 2.** Descriptive statistics (main variables).

| | | | | |
|---|---|---|---|---|
| **Panel (a)** | | | | |
| | **Internal Resources** | | **External Resources** | |
| 0 | 919 | 10.03% | 6393 | 69.81% |
| 1 | 8239 | 89.97% | 2765 | 30.19% |
| Total | 9158 | 100.00% | 9158 | 100.00% |
| | **Own Financial Resources** | | **Own Technical Expertise** | |
| 0 | 1470 | 17.84% | 2988 | 36.26% |
| 1 | 6769 | 82.15% | 5251 | 63.73% |
| Total | 8239 | 100.00% | 8239 | 100.00% |
| **Panel (b)** | | | | |
| | **External Finance** | | **Ext. Non-Financial Assistance** | |
| 0 | 1092 | 39.49% | 690 | 24.95% |
| 1 | 1673 | 60.51% | 2075 | 75.05% |
| Total | 2765 | 100.00% | 2765 | 100.00% |
| | **Public Funding** | | **Private Funding** | |
| 0 | 464 | 27.73% | 749 | 44.77% |
| 1 | 1209 | 72.27% | 924 | 55.23% |
| Total | 1673 | 100.00% | 1673 | 100.00% |

Source. Author's elaboration on Flash Eurobarometer 498.

What emerges from Panel (a) is that the vast majority of firms in the sample (90%) relied on their internal resources that include own financial resources and/or own technical expertise, while only 30% of firms relied on external resources that include external finance and/or external non-financial assistance. Breaking down the 8239 firms that employed internal resources, we observe that 82% of them used own financial resources, while own technical expertise covered 64% of the firms. Of course, several firms benefited from both of them in their eco-efficiency actions.

In Panel (b), we further break down the type of external resources received by the 2765 firms that specified using it. Specifically, 60% of them benefited from external finance from both public funding and private funding (in the form of grants, guarantees or loans), while 75% received external non-financial assistance (in the form of advice or other non-financial assistance from governments, private consulting and auditing firms, business associations and supply chain partners). Finally, the last distinction concerns the 1673 firms that received external finance. Of these, we distinguish between public funding (e.g., grants, guarantees or government loans) for 72% of firms, while private funding from banks, lending institutions, investment companies or venture capital funds, friends and relatives accounts for 55% of firms. It is important to remember that these types of assistance are not mutually exclusive: several firms may benefit from both public and private funding, as well as from different forms of internal and external resources. Indeed, as we show in the results section, the most eco-innovative firms are likely to make use of more types of resources.

### *3.2. Empirical Models*

We estimate an ordered logit model (ologit in Stata) (The command "ologit" (Ordered logistic regression) fits ordered logit models of ordinal variable on the independent variables. Estimation using Stata 17, where we compare the impact of different internal and external (financial and non-financial) resources on the number of actions undertaken by

the firms to be more resource efficient (variable Q1): few actions, some actions and many actions. As is known, models for ordinal outcomes can be described in terms of a latent variable [64]. The basic structure is as follows:

$$y_i{}^* = X_i\beta + \epsilon_i \tag{1}$$

where $y_i$ is the latent variable (number of resource efficiency actions undertaken by firm $i$), $X$ is a vector of explanatory and control variables, and $\epsilon_i$ is the idiosyncratic error term. The latent variable can be split into $N$ ordinal categories, so that the observed variable is

$$y_i = j \;\text{ if }\; \alpha_j < y_i{}^* \leq \alpha_{j+1}, \quad \forall i \in \{1, ..., N\} \tag{2}$$

and the probabilities of observing $y_i{}^* = j$ are

$$P(y_i = j|X_i) = F(\alpha_{j+1} - X_i\beta) - F(\alpha_j - X_i\beta) \tag{3}$$

where $F$ denotes the logistic cumulative distribution function. The three categories for our "*eco_actions*" dependent variable $y^*$—How many actions is your company undertaking to be more resource efficient?—are: few ($j = 1$), some ($j = 2$), and many ($j = 3$).

To test our first hypothesis (H1a), we include our ordered variable with the three categories indicating the number of resource efficiency actions undertaken by each firm $i$ and the use of internal ("*int_res*") or external resources ("*ext_res*") to support these actions (Equation (4) below). Then, following the argument that it is necessary to distinguish between different types of support to assess their effect on firms' resource efficiency strategies (H2), we specify Equation (5), separating proprietary financial resources ("*own_fin*") from in-house technical expertise ("*own_tech*"). A relevant issue discussed in the literature concerns the degree of complementarity among different resources used by firms for eco-innovation (H3). To answer this question, we use the specification in Equation (6), which traces Equation (5), but includes interactions among the variables.

$$\begin{aligned} Eco\_actions_i = {} & \alpha_{0a} + \alpha_{1a} \times int\_res_i + \alpha_{2a} \times ext\_res_i \\ & + \alpha_{3a} \times control\_var_i + \delta \times sector_i + \rho \times country_i + \epsilon_i \end{aligned} \tag{4}$$

$$\begin{aligned} Eco\_actions_i = {} & \alpha_{0b} + \alpha_{1b} \times own\_fin_i + \alpha_{2b} \times own\_tech_i + \alpha_{3b} \times ext\_res_i \\ & + \alpha_{4b} \times control\_var_i + \delta \times sector_i + \rho \times country_i + \epsilon_i \end{aligned} \tag{5}$$

$$\begin{aligned} Eco\_actions_i = {} & \alpha_{0c} + \alpha_{1c} \times own\_fin_i + \alpha_{2c} \times own\_tech_i + \alpha_{3c} \times ext\_res_i \\ & + \alpha_{4c} \times own\_fin_i \times own\_tech_i + \alpha_{5c} \times own\_fin_i \times ext\_res_i \\ & + \alpha_{6c} \times own\_tech_i \times ext\_res_i + \alpha_{7c} \times own\_fin_i \times own\_tech_i \times ext\_res_i \\ & + \alpha_{8c} \times control\_var_i + \delta \times sector_i + \rho \times country_i + \epsilon_i \end{aligned} \tag{6}$$

In the second stage of our analysis, we shift our focus to the relationship between external resources and firm's eco-innovations (Note that this sample represents a subsample compared to that used to test H1a, as not all firms rely on external resources (see Table 2)). This is relevant considering that the literature has identified different effects of external financial and non-financial resources to stimulate eco-innovation [65]. To this end, we introduce a dummy that captures the firm $i$ use of external financial ("*ext_fin*") and non-financial ("*non_fin_ass*") resources, using "*int_res*" as control. This is performed in Equation (7). Then, following the literature, we try to disentangle the effect of different sources of external finance, distinguishing between public ("*pub_fund*") and private funding ("*priv_fund*") (H1b), as specified in Equation (8). Finally, as in the previous exercise, we use the specification outlined in Equation (9) to capture the extent of complementarity between external financial (public and private funding) and non-financial resources ("*non_fin_ass*") (H3).

$$Eco\_actions_i = \beta_{0a} + \beta_{1a} \times ext\_fin_i + \beta_{2a} \times non\_fin\_ass_i + \beta_{3a} \times int\_res_i + \beta_{4a} \times control\_var_i + \delta \times sector_i + \rho \times country_i + \epsilon_i \quad (7)$$

$$Eco\_actions_i = \beta_{0b} + \beta_{1b} \times pub\_fund_i + \beta_{2b} \times priv\_fund_i + \beta_{3b} \times non\_fin\_ass_i + \beta_{4b} \times int\_res_i + \beta_{5b} \times control\_var_i + \delta \times sector_i + \rho \times country_i + \epsilon_i \quad (8)$$

$$Eco\_actions_i = \beta_{0c} + \beta_{1c} \times pub\_fund_i + \beta_{2c} \times priv\_fund_i + \beta_{3c} \times non\_fin\_ass_i + \beta_{4c} \times pub\_fund_i \times priv\_fund_i + \beta_{5c} \times pub\_fund_i \times non\_fin\_ass_i + \beta_{6c} \times priv\_fund_i \times non\_fin\_ass_i + \beta_{7c} \times pub\_fund_i \times priv\_fund_i \times non\_fin\_ass_i + \beta_{8c} \times control\_var_i + \delta \times sector_i + \rho \times country_i + \epsilon_i \quad (9)$$

To minimize any estimation bias due to potential omitted variables, we include a large set of controls in all the specifications presented above [66]. As illustrated in the theoretical framework outlined in Figure 1, these aim to eliminate all potential confounding factors (at market or company level) that could distort the relationship between the financial resources used by the firm and its eco-innovations. To select the relevant variables, we follow the literature already cited and the availability of variables surveyed by the Eurobarometer. Specifically, to account for the observable characteristics of the firms, we included: firm size—captured by the number of employees (in log), age—as a proxy for experience (in log), the growth of the firm's annual turnover in the past two years, whether the firm is in a B2B, B2C o B2P business, whether it offers products or services (categorical variables) and whether it sells green products or plans to sell them in the future ("*Green prod. Yes*" or "*Green prod. Planned*", respectively). Finally, as is usually the case, we include industry (manufacturing, retail, services, etc.) and country dummies.

## 4. Results

The results of the ordered logit model are displayed in Tables 3–6 below. A total of six different specifications have been estimated. All specifications have the same dependent variable "$eco\_actions_i$", that is, the number of actions that the firm $i$ undertakes to be resource efficient (Q1). Starting from Table 3, Specification 1 (columns 1–3) uses overall internal and external resources as the main regressors. Then, Specification 2 (columns 3–6) breaks down internal resources into financial (i.e., own finance) and non-financial (i.e., own technical expertise) ones. The interactions between these different types of resources (i.e., the degree of complementarity) are shown in Table 4, where their joint effect is compared to a baseline model.

Similarly, in Table 5 we report the results of the impact of external resources on the firm's $i$ eco-activity. As in the previous case, Specification 3 (columns 1–3) captures the impact of financial (i.e., external finance) and non-financial (i.e., non-financial assistance) external resources. Specification 4 (columns 3–6) breaks down the variable external finance, providing specific insights into the importance of public and private funding. Finally, Table 6 analyzes the degree of complementarity between public, private and non-financial (i.e., non-financial assistance) external resources.

In general, to anticipate some general results, our findings suggest the need to carefully consider the relationships between different types of resources involved in the eco-innovation process, as their effects on green actions are heterogeneous. Due to data limitation, in the following, we simply comment on correlations between variables rather than making considerations on causality.

### *4.1. The Role of Internal Resources*

Tables 3 and 4 provide a first overview of research hypotheses H1a, H2 and H3, that is, whether firms with access to internal and external resources (financial and non-financial) are more likely to introduce eco-innovations and to what extent different types of resources complement each other. In *Specification 1* of Table 3, we find that greater access to internal and external resources is generally associated with more numerous eco-efficiency actions by the firms of the sample. Moreover, this correlation seems to be stronger

with the use of internal resources than with external ones. Notably, at the margin, the likelihood of resource-using firms being in the many actions group is 14.1% and 10.7% higher, respectively, compared to an average firm in the sample. This confirms, according to POT, the priority ascribed by firms to internal resources in financing eco-innovation.

As expected, when we split internal resources into own finance and own technical expertise (*Specification 2* of Table 3), the correlation of these additional variables on the likelihood of introducing eco-efficiencies remains positive and statistically significant. Indeed, for a firm using its proprietary financial resources or its in-house technical expertise, the probability of falling into the group of firms performing many eco-actions is 10.5% and 10.4% higher, respectively, compared to an average firm in the sample.

Similarly to what we have just observed, columns 1–2 and 3–4 of Table 3 show that, if the firm employs internal resources (financial or technical ones) or external resources, it is less likely to fall into the group of firms characterized by some or few eco-actions. This is because firms in the sample that implement fewer green innovations are typically those with the least availability or access to resources, further confirming hypothesis H1.

**Table 3.** Internal resources vs. external resources.

| Variable | Q1: How Many Actions Is Your Company Taking to Be Resource Efficient? | | | | | |
|---|---|---|---|---|---|---|
| | **Few Actions** | **Some Actions** | **Many Actions** | **Few Actions** | **Some Actions** | **Many Actions** |
| Internal resources | −0.0975 *** | −0.0440 *** | 0.141 *** | | | |
| | (−8.90) | (−8.78) | (9.01) | | | |
| Own finance | | | | −0.0729 *** | −0.0323 *** | 0.105 *** |
| | | | | (−10.20) | (−10.07) | (10.38) |
| Own tech. expertise | | | | −0.0721 *** | −0.0319 *** | 0.104 *** |
| | | | | (−11.14) | (−11.11) | (11.43) |
| External resources | −0.0734 *** | −0.0331 *** | 0.107 *** | −0.0700 *** | −0.0310 *** | 0.101 *** |
| | (−9.78) | (−9.74) | (9.97) | (−9.78) | (−9.74) | (9.97) |
| Green prod. Yes | −0.0957 *** | −0.0464 *** | 0.142 *** | −0.0922 *** | −0.0438 *** | 0.136 *** |
| | (−14.35) | (−12.27) | (14.17) | (−13.82) | (−11.79) | (13.60) |
| Green prod. Planned | −0.0626 *** | −0.0251 *** | 0.0877 *** | −0.0609 *** | −0.0242 *** | 0.0851 *** |
| | (−6.93) | (−5.73) | (6.61) | (−6.80) | (−5.64) | (6.49) |
| Employees | −0.0108 *** | −0.00485 *** | 0.0156 *** | −0.0101 *** | −0.00447 *** | 0.0146 *** |
| | (−4.93) | (−4.92) | (4.96) | (−4.63) | (−4.62) | (4.65) |
| Age | −0.0150 *** | −0.00675 *** | 0.0217 *** | −0.0146 *** | −0.00647 *** | 0.0211 *** |
| | (−3.40) | (−3.39) | (3.41) | (−3.33) | (−3.32) | (3.34) |
| N | | 9158 | | | 9158 | |
| Country dummies | | YES | | | YES | |
| Industry dummies | | YES | | | YES | |
| Robust SE | | YES | | | YES | |
| Degrees of freedom | | 51 | | | 52 | |
| Pseudo-$R^2$ | | 0.103 | | | 0.110 | |
| Log-likelihood | | −8395.90 | | | −8333.20 | |
| $\chi^2$ | | 1659.60 | | | 1768.20 | |

Note. t statistics in parentheses. *, **, and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: (Q1) How many actions is your company undertaking to be more resource efficient? (1) Few actions, (2) Some actions, (3) Many actions. Additional controls: Turnover growth in the last two years (yes/no/unchanged), final market (B2B/B2C/B2P), production type (products/services), country, industry (manufacturing, retail, services, etc.). Estimation conducted with the Ologit package using Stata 17.

Table 4 allows us to make some observations on research hypothesis H3 and thus on the degree of complementarity between financial and non-financial resources. While individual correlations have been studied so far, we now focus on the joint relationship between the use of financial and non-financial resources and the eco-innovations of the firm. It is interesting to note that, in general, firms that fall into the many actions group typically make use of both internal and external resources.

Regarding complementarities, the combination of own finance and external resources or the mix between own technical expertise and external resources are both significantly associated with a higher likelihood of the firm being an eco-innovator. Indeed, as can be seen from the baseline (row 1) of Table 4, given the structural characteristics of the sample, the likelihood of a firm being in the few actions group is 34.5%, in the some actions group 31.8%, and in the many actions group 33.6%. The likelihood that the firm falls into the many action group rises to 56.4% (+22.8) for firms that use a combination of internal and external resources, independently from the typology of internal resources employed (either financial or technical ones). This positive effect still holds for a combination of proprietary finance and technical expertise with a 44.9% (+11.3) likelihood of falling into the many action group. This result, thus, corroborates hypothesis H3 and is in line with the resource-based view. This theory claims that a company that wants to produce using its resources efficiently must necessarily mobilise an appropriate mix of financial and non-financial resources.

**Table 4.** The complementarity between internal and external resources (interactions).

| **Interactions** | **Q1: How Many Actions Is Your Company Taking to Be Resource Efficient?** | | |
|---|---|---|---|
| | **Few Actions** | **Some Actions** | **Many Actions** |
| Baseline | 0.345 *** | 0.318 *** | 0.336 *** |
| | (0.027) | (0.005) | (0.026) |
| Own finance | 0.236 *** | 0.303 *** | 0.459 *** |
| | (0.007) | (0.005) | (0.009) |
| Own technical expertise | 0.24 *** | 0.305 *** | 0.454 *** |
| | (0.009) | (0.005) | (0.012) |
| External resources | 0.19 *** | 0.284 *** | 0.525 *** |
| | (0.012) | (0.006) | (0.016) |
| Own finance and Own tech. exp. | 0.244 *** | 0.306 *** | 0.449 *** |
| | (0.005) | (0.005) | (0.008) |
| Own finance and external resources | 0.166 *** | 0.269 *** | 0.564 *** |
| | (0.010) | (0.008) | (0.017) |
| Own tech. exp. and external resources | 0.165 *** | 0.269 *** | 0.564 *** |
| | (0.015) | (0.009) | (0.023) |
| Own fin. and own tech. and external res. | 0.114 *** | 0.225 *** | 0.66 *** |
| | (0.007) | (0.007) | (0.014) |
| N | | 9158 | |
| Country dummies | | YES | |
| Industry dummies | | YES | |
| Robust SE | | YES | |
| Degrees of freedom | | 56 | |
| Pseudo-$R^2$ | | 0.110 | |
| Log likelihood | | −8331.80 | |
| $\chi^2$ | | 1770.20 | |

Note. Standard errors in parentheses. *, **, and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: How many actions is your company undertaking to be more resource efficient? (1) Few actions, (2) Some actions, (3) Many actions. Additional controls: Employees, Age, Turnover growth in the last two years (yes/no/unchanged), final market (B2B/B2C/B2P), production type (products/services), country, industry (manufacturing, retail, services, etc.). Estimation with the Ologit package using Stata 17.

In this perspective, a combination of internal and external resources seems to better foster eco-innovation than a mix of proprietary financial and non-financial resources. Indeed, one of the peculiarities of eco-innovation vs conventional innovation is the additional knowledge required following sustainable supply chain regulations. This knowledge, in many instances, does not belong to the core competencies of firms or the traditional industrial knowledge base [12]. This calls for cooperative agreements, non-financial assistance and external knowledge sourcing to complement the firm's investments in organizational and technological capabilities. For this reason, in the next subsection, we particularly focus on the role of external resources in eco-innovation.

Finally, firms that jointly employ all three typologies of resources (internal financing, in-house expertise and external resources) are the most likely to fall among the companies that undertake many eco-innovations. Compared to the baseline, the measured likelihood reaches 66% (+32.4), while the likelihood of being in the least innovative group drops to 11.4% (against 34.5% in the baseline). In other words, eco-innovative firms require an articulated mix of internal and external (financial and non-financial) resources to conduct several resource-efficiency actions.

### *4.2. The Role of External Resources*

Tables 5 and 6 complete the picture of research hypotheses H1a, H2 and H3, and provide insight on the hypotheses H1b. Among external resources, the non-financial ones exhibit, on average, a stronger correlation with the firm eco-innovation activity than the financial ones. Indeed, as highlighted in Specification 3 of Table 5, at the margin, the likelihood of being in the many actions group is 14.2% and 6.27% higher than the average for firms with access to non-financial assistance and external finance, respectively. This result underlines how eco-innovators usually look outside the company in search of technical expertise and capabilities rather than financial resources, proving hypothesis H2.

**Table 5.** External finance vs. non-financial assistance.

| Variable | How Many Actions Is Your Company Taking to Be Resource Efficient? | | | | | |
|---|---|---|---|---|---|---|
| | **Few Actions** | **Some Actions** | **Many Actions** | **Few Actions** | **Some Actions** | **Many Actions** |
| External finance | −0.0369 *** | −0.0257 *** | 0.0627 *** | | | |
| | (−3.82) | (−3.85) | (3.87) | | | |
| Public funding | | | | −0.0284** | −0.0197** | 0.0481** |
| | | | | (−2.94) | (−2.98) | (2.97) |
| Private funding | | | | −0.0426 *** | −0.0295 *** | 0.0721 *** |
| | | | | (−4.19) | (−4.18) | (4.23) |
| Non-fin.assistance | −0.0835 *** | −0.0582 *** | 0.142 *** | −0.0839 *** | −0.0580 *** | 0.142 *** |
| | (−7.49) | (−7.90) | (7.93) | (−7.57) | (−7.99) | (8.03) |
| Internal resources | −0.0722 *** | −0.0503 *** | 0.122 *** | −0.0711 *** | −0.0492 *** | 0.120 *** |
| | (−6.55) | (−6.57) | (6.73) | (−6.47) | (−6.47) | (6.64) |
| Green prod. Yes | −0.0900 *** | −0.0671 *** | 0.157 *** | −0.0870 *** | −0.0645 *** | 0.151 *** |
| | (−8.80) | (−8.01) | (8.85) | (−8.47) | (−7.73) | (8.5) |
| Green prod. Planned | −0.0546 *** | −0.0346 *** | 0.0892 *** | −0.0531 *** | −0.0336 *** | 0.0866 *** |
| | (−3.94) | (−3.50) | (3.79) | (−3.84) | (−3.43) | (3.70) |
| Employees | −0.00901 ** | −0.00628 ** | 0.0153 ** | −0.00908 ** | −0.00629 ** | 0.0154 ** |
| | (−2.72) | (−2.71) | (2.73) | (−2.75) | (−2.74) | (2.76) |
| Age | −0.0145 * | −0.0101 * | 0.0246 * | −0.0144 * | −0.00994 * | 0.0243 * |
| | (−2.23) | (−2.22) | (2.23) | (−2.23) | (−2.21) | (2.23) |
| N | 2765 | | | 2765 | | |
| Country dummies | YES | | | YES | | |
| Industry dummies | YES | | | YES | | |
| Robust SE | YES | | | YES | | |
| Degrees of freedom | 52 | | | 53 | | |
| Pseudo-$R^2$ | 0.147 | | | 0.150 | | |
| Log-likelihood | −2200.00 | | | −1479.50 | | |
| $\chi^2$ | 606.30 | | | 616.20 | | |

Note. t statistics in parentheses. *, **, and *** correspond to significance levels of 1%, 5% and 10%, respectively. Dependent variable: How many actions is your company undertaking to be more resource efficient? (1) Few actions, (2) Some actions, (3) Many actions. Additional controls: Turnover growth in the last two years (yes/no/unchanged), final market (B2B/B2C/B2P), production type (products/services), country, industry (manufacturing, retail, services, etc.). Estimation with the Ologit package using Stata 17.

Then, decomposing external financial resources between public and private (Specification 4 of Table 5), we observe that the relationships remain significant for both variables, even though the effect of private funding seems to be stronger in magnitude than that of public funding. Indeed, while the probability of being an eco-innovator with many actions increases by 4.8% for firms employing external public financial resources, the same value rises to 7.2% in the case of firms employing external private financial resources. Thus,

the most innovative firms seem to make more use of private funding than public ones, consistently with the latter's purpose, which very often comes as a stimulus to innovation for financially constrained firms that do not have access to other types of resources.

Again, similar to what has just been observed, columns 2–3 and 4–5 of Table 5 show that if the firm accesses either external public funding or external private funding, they are less likely to fall into the group of firms that perform few or some eco-actions. Indeed, firms in the sample that undertake few resource efficiency innovations are typically characterized by no access to external finance (either public or private). This result confirms hypothesis H1b.

Finally, Table 6 allows us to measure the degree of complementarity between different typologies of external resources. As can be seen from the baseline (row 1), given the structural characteristics of the sample, the probability of a firm doing few eco-innovations is 18.9%, doing some is 27.4% and doing many is 53.6%. The use of non-financial external assistance seems to be particularly correlated with the green actions of companies. Firms that have access to this resource have a 69.9% likelihood of being among the best eco-innovators (+16.3% compared to the baseline scenario). Interestingly, if non-financial assistance is employed in combination with other types of resources, e.g., public or private funding, the likelihood of being in the group of firms undertaking many eco-actions is slightly reduced. For example, the combination of public funding and non-financial assistance is associated with only +11.9% compared to the baseline scenario, whereas the combination of private funding and non-financial assistance, has a higher likelihood of +8.7% compared to the same baseline. As we have already pointed out in the discussion of Table 5, the relationship between private-only or public-only external financing and firms that introduce many eco-actions is rather weak. Indeed, if a firm uses only public funding it has a likelihood of being among the best eco-innovators of 59% compared to 53.6% of the baseline. On the other hand, companies using only private funding are even less likely to be in the group of innovators than a random company in the sample (45.3% vs. 53.6% of the baseline).

Eco-innovators typically use a mix of public funding and non-financial assistance or private funding and non-financial assistance. This again underscores the complexity of eco-innovation processes: introducing many resource efficiency and waste reduction actions requires a heterogeneous mix of (financial and non-financial) resources [67]. The firms that can benefit from a combination of resources characterized by the presence of external non-financial support are the best eco-performers, as identified in the hypothesis H3. This finding suggests that financial strength alone may not guarantee a commitment to sustainability without the support of adequate technical capabilities and organizational environment. Furthermore, it is a confirmation that, for eco-innovative firms, non-financial systemic obstacles such as compliance with regulations, knowledge and technical expertise have a more important deterrent effect than financing problems to limit the ability to implement resource efficiency actions.

Indeed, the holistic mix of private, public and external non-financial resources shows a very significant degree of complementarity. In this case, their joint effect on the probability of making eco-efficiency actions is 18.5% higher than that of the baseline scenario. The firms that jointly employ this combination of factors are most likely to fall among the best eco-innovators (72.1%).

**Table 6.** The complementarity between external finance and non-financial assistance (interactions).

| Interactions | Q1: How Many Actions Is Your Company Taking to Be Resource Efficient? | | |
|---|---|---|---|
| | **Few Actions** | **Some Actions** | **Many Actions** |
| Baseline | 0.189 *** | 0.274 *** | 0.536 *** |
| | (0.022) | (0.014) | (0.033) |
| Public funding | 0.155 *** | 0.253 *** | 0.59 *** |
| | (0.009) | (0.009) | (0.013) |
| Private funding | 0.248 *** | 0.297 *** | 0.453 *** |
| | (0.026) | (0.011) | (0.032) |
| Non-fin.assistance | 0.098 *** | 0.201 *** | 0.699 *** |
| | (0.011) | (0.013) | (0.023) |
| Public fund. & Private fund. | 0.238 *** | 0.294 *** | 0.467 *** |
| | (0.022) | (0.011) | (0.028) |
| Public fund. & Non-fin.assistance | 0.12 *** | 0.224 *** | 0.655 *** |
| | (0.009) | (0.010) | (0.018) |
| Private funding & Non-fin.assistance | 0.137 *** | 0.239 *** | 0.623 *** |
| | (0.023) | (0.020) | (0.042) |
| Public fund. & Private fund. & Non-fin.assist. | 0.088 *** | 0.189 *** | 0.721 *** |
| | (0.010) | (0.013) | (0.022) |
| N | | 2765 | |
| Country dummies | | YES | |
| Industry dummies | | YES | |
| Robust SE | | YES | |
| Degrees of freedom | | 57 | |
| Pseudo-$R^2$ | | 0.153 | |
| Log likelihood | | −2184.70 | |
| $\chi^2$ | | 629.60 | |

Note. Standard errors in parentheses. *, **, and *** correspond to significance levels of 1%, 5% and 10%, respectively. *Dependent variable*: How many actions is your company undertaking to be more resource efficient? (1) Few actions, (2) Some actions, (3) Many actions. *Additional controls*: Employees, Age, Turnover growth in the last two years (yes/no/unchanged), final market (B2B/B2C/B2P), production type (products/services), country, industry (manufacturing, retail, services, etc.). Estimation with the Ologit package using Stata 17.

### *4.3. Control Variables*

The literature warns of several firm-specific characteristics that may have an important impact in determining the competitiveness and performance of the firm, thus influencing its eco-actions and innovative activity [68–72]. Therefore, in all our empirical specifications we use a large set of control variables to capture some of these dimensions. These additional regressors include employees (in log), age of the firm (in log), turnover growth in the last two years (yes/no/unchanged), type of business (B2B/B2C/B2P), production type (products/services), country and sector (manufacturing, retail, services, and industry). In general, the signs and magnitudes of the estimated coefficients confirm the correct specification of the model: larger and older firms have a higher probability of undertaking many eco-actions than smaller and younger firms. Specifically, the number of employees (as a proxy for firm size) increases, on average, the likelihood of introducing many eco-innovations by around 1.5%, while the age of the firm (as a proxy for experience in the industry) increases the same probability by around 2.5%.

Among the controls included, the most relevant one appears to be the firm's attitude towards green products. This variable captures the so-called market-pull driver of eco-innovation highlighted in Figure 1. Estimates show that firms that produce (*"Green Prod. Yes"*) or are planning to produce green products (*"Green Prod. Planned"*) are more likely to perform many eco-innovations than an average firm in the sample (around +15.1% and 8.66%, respectively).

## 5. Conclusions

This paper focuses on the role of internal and external, financial and non-financial resources for the development of eco-innovations by European firms. Firms are key players in the EU's climate efforts, both as drivers of technological change and as adopters of green business practices, so their innovative activities are crucial for sustainable economic growth [73].

However, the development of eco-innovations by EU firms faces significant obstacles, ranging from funding problems to more general resource constraints, including a lack of appropriate technical skills and access to external expertise. All these aspects pose significant challenges for the ecological transition.

In this context, we analyze the extent to which resources, financial and non-financial, internal and external, public or private, are associated with the introduction of eco-efficiency actions by the firm. A strength of our work compared to the existing literature is to consider these resources altogether to measure their degree of complementarity. This is crucial given the specificity of eco-innovations and the heterogeneity of the obstacles faced by firms, which go beyond the problem of their financing. By jointly focusing on financial and technical capabilities, our paper takes a more holistic approach to eco-innovation.

Our results suggest that firms with access to both internal and external financial resources are more likely to undertake ecological innovations, but the correlation with the former is stronger. Consistent with the theory, the larger influence of internal financial resources on a firm's adoption of green innovations may be due to lower cost, greater control and strategic autonomy that these resources offer compared to debt. Indeed, internal funds empower firms to align their innovation agendas to sustainability goals without external constraints or transaction costs associated with debt financing.

Interestingly, with regard to external financial resources, firms that receive either public funds or private funds are not particularly likely to undertake eco-innovation compared to an average firm in the sample. However, when public and private resources are employed in combination, the correlation between them and the firms's eco-innovations is strong and statistically significant. This result suggests a high degree of complementarity, highlighting the synergy benefits of the simultaneous use of public and private financing, and the importance of a diversified funding approach to support firms' green innovation activity.

Finally, we stress the strong positive association between firms' access to specialized technical capabilities and their eco-innovation activities. Indeed, human capital and technical expertise are increasingly crucial to implementing resource-efficient technologies, optimizing production processes, and strategically aligning business operations with environmentally sustainable practices. The access of companies to external financial resources, although not always closely correlated with firms' eco-actions, is of paramount importance in facilitating this process. Overall, these results underline that firms that introduce many resource efficiency innovations usually employ a synergy combination of technical expertise and sufficient financial support.

These findings have some relevant policy implications. They emphasize that innovation policies, in particular direct support for eco-innovation development, should consider all firm constraints, including non-financial ones. On the one hand, the availability of public funding is perceived by firms as a relevant enabling factor of eco-innovation. On the other hand, however, if this support is provided in the absence of adequate external support, such as non-financial assistance measures, the risk of public funds being ineffective is high.

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