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Results from an experiment

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Authors:

Philipp-Bastian Brutscher (European Investment Bank)

Pauline Ravillard (European Investment Bank)

The EIB Economics Department

The mission of the EIB's Economics Department is to provide economic analyses and studies to support the Bank in its operations and in its positioning, strategy and policy. The Department, a team of 40 staff, is headed by Debora Revoltella, Director of Economics.

economics@eib.org

www.eib.org/economics

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Promoting energy audits: Results from an experiment

Energy audits are key to increase investments in energy efficiency, as they allow to overcome the 'information gap'- one of the biggest obstacles to this type of investment. However, on average only 30% of SMEs said to have carried out an energy audit between 2015 and 2018. This paper assesses the effectiveness of policy interventions in promoting energy audits by relying on evidence from a unique online experiment, as part of the European Investment Bank's annual Investment Survey. 1,178 EU firms were asked about their willingness to invest in an energy audit, given different scenarios of randomly drawn policy interventions. These are a level of support, whether it comes in the form of a grant or a tax credit, and whether the audit is conditional on investing in an energy efficiency project after. Findings allow us to quantify by how much the probability that firms invest in energy audits increases, as the combinations of policy interventions vary.

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1. Introduction

There is now more than ever an urge to tackle global warming and climate change, as recalled the Intergovernmental Panel on Climate Change (IPCC) last October 2018 in Seoul, South Korea. As there is a direct link between CO2 emissions and global warming (Stamatiou and Dritsakis 2017), the emphasis is on reducing the emissions of greenhouse gas. One way to achieve this is by promoting improvements in energy efficiency, as the latter is 'one of the most cost-effective ways to (…) reduce energy-related emissions' (Hirzel and Behling, 2016:5). Energy efficiency captures how efficiently an appliance, building, organisation or country uses energy. Besides reducing CO2 emissions, it also ensures affordable energy prices, improves economic competitiveness, as well as the security of supply (Stamatiou and Dritsakis, 2017).

One of the effective ways to increase investments in energy efficiency is to promote energy audits, as these overcome the information gap on the cost-benefit trade-off that companies face before investing in energy efficiency improvements' projects (Schleich, 2004; Schleich and Gruber, 2008). This information gap is due to imperfect information and is one of the biggest obstacles to energy efficiency investments. Evidence from the literature shows that firms lack information about opportunities to reduce energy costs (Kluczek and Olszewski, 2016; Schleich, 2004; Trianni et al., 2013). Another aspect

of imperfect information is the lack of awareness of firms of existing support schemes directed towards energy efficiency improvements investments in their countries. Indeed, in our survey, 36% of EU firms that declared to be unaware of any support schemes in their country were ignorant of the fact that their countries had a support scheme for firms of their size or from their sector[1].

At the EU level, promoting energy efficiency is a central component of the 2030 Climate and Energy Framework and of the post-2020 Multiannual Financial Framework, while support for energy audits became an integral part of the 2012 Energy Efficiency Directive under Article 8 (Torregrossa, 2015; Brems et al., 2016). The latter states that large enterprises are required to be subject to an energy audit by December 2015 and at least every four years thereafter (Hirzel et al., 2016). This requirement is nonetheless limited to large enterprises, highlighting the need to encourage SMEs to also undertake energy audits. Results from the European Investment Bank Investment Survey (henceforth EIBIS) show that on average, only 30% of SMEs surveyed in the general module in 2018 declared to have carried out an energy audit over the previous three years, with considerable disparity between the countries. According to Figure 1, in Croatia, one SME out of two carried out an energy audit, while in Bulgaria it is around one firm out of ten. The data from the EIBIS is representative.

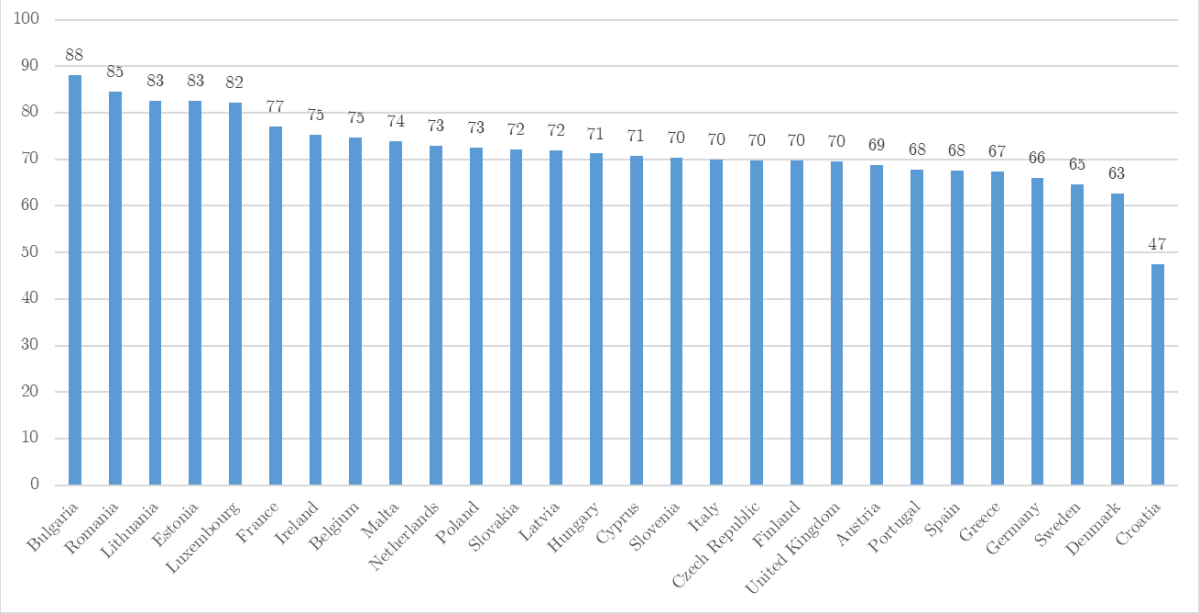

Figure 1. The percentage share of SMEs that declared that they did not carry out an energy audit in the three years prior to 2018 using value added weights (%)

[1] This percentage comes from our own calculations, based on information gathered in Table 1 below and from our database. This percentage is only applicable to SMEs, as per EU law large firms are obliged to have carried out an energy audit by 2015, as is discussed further below.

While the literature acknowledges that energy audits are effective in promoting investments in energy efficiency, less is known about which policy is the most effective in promoting them (Anderson and Newell, 2016; Kalantzis et al., 2018). This is where this research becomes essential, as it assesses the effectiveness of policy interventions on the willingness of firms to carry out an energy audit by relying on unique data from a new online experiment. We look at three dimensions of policy interventions. The first one is the level of support, ranging from 10% to 90% of costs. The second dimension is the form in which the support comes, meaning either a grant, or as a tax credit. The third dimension is whether the energy audit is conditional on investing in an energy efficiency improvement's project after. The analysis also groups firms according to different characteristics, to compare their degrees of responsiveness to these policy interventions in the context of energy audits.

We rely on unique experimental data from an online module of the European Investment Bank's annual Investment Survey, which covers all EU countries and firms with over five employees and four economic sectors: manufacturing, construction, services and infrastructure. In the online module, firms are shown four screens with different combinations of policy interventions that are randomly drawn, and can then decide whether or not they would carry out the energy audit based on the scenario.

This paper makes several contributions. First of all, the existing literature either looks at the effectiveness of policy instruments in promoting energy efficiency improvements, or at the impact of energy audits on the adoption of energy efficiency technologies, but rarely at the link between policy instruments and the implementation of energy audits *per se*. We aim to fill this gap in the literature by assessing the effectiveness of policy interventions on energy audits. Secondly, the few studies that exist are limited to single case studies, or household data. In this research, we make use of an exclusive firm-level data set that includes all 28 EU countries. Thirdly, our experimental set-up helps us to overcome several obstacles that are often found in the literature when it comes to causally linking policy measures to outcomes, such as reverse causality and omitted variable bias. This allows us not only to assess the impact of different policy measures in terms of stimulating the use of energy audit, but also the degree to which these are subject to free-riding; i.e. firms benefiting from policy support that would have carried out an energy audit even in the absence of this support.

The remaining part of this paper is organised as follows. First of all, the existing literature around policy interventions and energy audits is reviewed. Secondly, novel data from the online experiment of the 2018 EIBIS is presented. Thirdly, we introduce our model and methodology. The fourth section looks at findings, for all firms and for the different groups of firms. Finally, we conclude with a discussion on the methodology and some policy recommendations.

2. Literature review

Since the early noughties, governments and policy-makers have set several targets and taken initiatives at both the EU and national levels in order to promote investments in energy efficiency improvements. In 2006, the Energy Service Directive targeted a 9% increase in energy saving. In 2009, a 20% reduction of CO2 gas emissions target by 2020 was launched. More recently, the 2030 Climate and Energy Framework declared to aim for a 32.5% increase in energy efficiency by 2030. The latter also includes national incentives for SMEs to undergo energy audits, as the 2012 Energy Efficiency Directive only made it compulsory for large companies to carry out an energy audit by 2015 and then once every four years.

Several policy instruments can be used to target energy efficiency improvements. These can be grouped into three categories: communication, economic incentives and normative incentives (Blok et al., 2002). Communication has to do with the provision of information that is likely to affect firms' decision. Economic incentives affect the costs or benefits of the improvement action. Normative incentives imply some compulsory or prohibited action. To give examples for each category, an instrument linked to communication can be an energy audit, if the aim of the instrument is to increase investments in energy efficiency. The audit would provide the firm with information on how much it can save in terms of energy use, if it decides to make a specific investment. Having this information can influence the firm's decision to invest. An economic incentive can simply be a grant or subsidy covering a certain percentage of the total costs of the investment. Making binding emission limit prescriptions for large firms in the EU is an example of a normative incentive.

When it comes to the effectiveness of policy instruments, the literature focuses on energy efficiency improvement. In a paper on Dutch firms, Blok et al. (2002) assess how effective subsidies, energy efficiency standards and negotiated agreements are in boosting energy efficiency improvements. They found that government subsidies could explain 15-20% of the latter, amongst others. A wide range of studies also look at how energy audits can enhance energy efficiency improvements (Schleich et al., 2015; Backlund and Thollander, 2015; Barbetta et al., 2015; Murphy, 2014). For instance, Schleich et al. (2015) look at the impact of an energy audit programme on energy efficiency measures amongst small German companies in the tertiary sector. Using propensity score matching with a logit model, they find that the programme was effective in driving the adoption of four generic energy efficiency measures (i.e. lighting, insulation, heating and heating optimisation). They also find that estimates are higher (lower) for lower (higher) cost measures, and that the effectiveness of audits will vary by technology. In a more recent study that is part of the European Investment Bank's 2018-9 Investment

Report, findings also reveal a strong correlation between energy audits carried out and investments in energy efficiency improvements (Kalantzis et al., 2018).

If energy audits prove to enhance energy efficiency improvements, then more attention should be paid to which policy instruments are the most effective in promoting these energy audits. The literature on this topic is scarce, however. One of the few studies that exists looks at the impact of a publicly financed energy audit programme aimed at helping Swedish SMEs finance energy audits (Backlund and Thollander, 2015). The programme comes in the form of a grant that covers 50% of an energy audit, for total costs that do not exceed 3000 euros. It addresses firms that use more than 500 MWh per year or farms with more than 100 livestock units. Initial results are positive, while the authors warn that these are still at the preliminary stage, as the programme was only three years old at the time of the study.

One of the reasons why evidence on the effectiveness of policy instruments in promoting energy audits is scarce, is because of the difficulty of establishing causality between the two and the 'free rider problem'. The latter refers to the case where firms would have carried out a project or action even without a policy intervention. In their studies on Dutch manufacturing firms, Blok et al. (2002) found that between half and two-thirds of the firms receiving a subsidy for an energy efficiency improvement were free riders, meaning that they would have carried out the investment regardless of the subsidy. The authors could make this calculation using two different methods based on survey data, including one with a cost-benefit analysis that looks at the profitability of the project, and another where firms were directly asked whether they would still have made the investment without the subsidy. No comparable data has been collected in the context of energy audits. This drawback has been pointed out by Backlund and Thollander (2015) in their assessment of a grant programme on energy audits in Sweden.

One of the main advantages of the format of the survey's online module used in the present research is that it helps overcome this drawback. It puts firms in a spontaneous situation in which they have to make a decision on whether or not to go ahead with an energy audit based on randomly drawn policy interventions' scenarios. On the basis of their responses, we can not only calculate firms' sensitivity to changes in policy intervention, but also compare the share of firms that go ahead under a specific policy intervention with those that that would without or with a very low level of support only.

What is particularly interesting from a policy perspective in this context is the comprehensiveness of our data. It allows us to make sub-population comparisons, looking at the level of responsiveness of firms across different economic sector and the firm characteristics (De Groot et al., 2001; Schleich and

Gruber, 2008; Hrovatin et al., 2016). The selection of policy interventions that are part of our random experiment were selected in such a way to be as realistic as possible.

Table 1 gives an overview of the different policy instruments for energy audits that exist at the national level across EU countries and some non-EU States[2], for comparison. Most of the instruments have to do with economic incentives. The content of the table draws from a report by the European Commission (Hirzel et al., 2016). It provides details on the different instruments and their pre-requisites, if applicable. Instruments vary from subsidies, to grant schemes and agreements, to cite some examples. Information on the size of the firms targeted and on the country where the instruments are applied is also provided[3]. Many observations can be drawn from this table. First, not all EU countries have national policy incentives directed at encouraging energy audits, despite the common umbrella of compulsory energy audits for large firms mentioned above. Second, across the EU countries with national policy incentives, the types of instruments and their description vary considerably. Finally, within the EU countries, instruments can also vary and target firms of different sizes.

To give a detailed example of an instrument, the German Ministry of Economic Affairs launched the Energy Audit Scheme for SMEs from all sectors in 2008. The programme includes two types of audits that can be combined or used separately. The first one is a screening audit lasting 1-2 days, including a short check of the energy-consuming equipment, and giving recommendations for improvement. In this case, 80% of the total audit cost is subsidised. The second option allows to have a comprehensive audit taking up to 10 days, including a detailed inspection and suggestions for energy efficiency measures. Here, up to 60% of the audit cost is subsidised (Brems et al., 2016).

Country	**Firms targeted**	**Instruments**	**Type of instrument[4]**
EU			
Austria	Large & SMEs	Regional programme	Financial
Belgium (Flanders)	Large SMEs	Audit covenant Self-scan for SMEs	Voluntary Voluntary
Belgium (Wallonia)	Large	Subsidies for energy audits	Financial
Bulgaria	SMEs Large & SMEs	Energy Efficiency and Green Economy Programme	Financial Voluntary

[2] Only countries that have additional policy instruments that fall outside of the mandatory energy audit for large firms in the EU have been included in the table.

[3] Some instruments are more detailed than others, depending on the information available in the report.

[4] These are the different State policy instrument to support the implementation of energy audits. They can be regulatory instruments, information-based instruments, financial instruments and voluntary agreements.

		Industrial Energy Efficiency Targets for industrial energy enterprise owners	
Croatia	Large & SMEs	Subsidies for energy audits (of EUR 6,600 only until 2015)	Financial
Denmark	Large & SMEs SMEs	Energy saving obligation targeting energy companies Subsidy for energy audits and implementation of energy saving measures	Financial Financial
Finland	Large & SMEs	Voluntary Energy Efficiency Agreement	Voluntary
France	SMEs	Energy efficiency support	Financial
Germany	SMEs SMEs Large & SMEs Large & SMEs Large & SMEs	Energy Consulting Programme (financial support for detailed energy audits, up to 80% of funding of eligible costs) Eco tax cap for manufacturing industry Special equalisation scheme[5] BAFA support programme for cross-cutting technologies Energy efficiency networks[6] (including conducting energy audits)	Financial Financial Financial Financial Information
Italy	SMEs	Call for co-funding of regional programmes (50% level of support with a grant to cover energy audit costs)	Financial
Luxembourg	Large & SMEs Large & SMEs Large & SMEs	Mandatory energy audits for energy-intensive companies Funding scheme for energy audits in energy-intensive companies (up to 40% of the audit costs with a limit of EUR 30,000) Voluntary agreement on industrial energy efficiency	Regulatory Financial Voluntary
Malta	SMEs Large & SMEs Large & SMEs	Malta Enterprise Scheme (co-financing of energy audits by national funds) ERDF Energy Grant Scheme[7] Programme from MHRA (Malta Hotels and Restaurants Association) [8]	Financial Financial Voluntary
Netherlands	Large & SMEs	Long Term Agreements	Voluntary
Poland	Large & SMEs	Energy/electricity supply audit of an enterprise[9] (subsidy of 70% of the eligible audit costs)	Financial
Portugal	Large & SMEs	Refund of energy audit costs[10] (50% of the audit costs refunded, with a maximum of EUR 750)	Financial

[5] Only applies to companies with an electricity consumption of less than 5 GWh.

[6] Only applies to companies with energy costs above EUR 500,000.

[7] Ran during 2007-2013, currently not accepting further applications. At the time of publication, a new scheme was planned under the new EU Funding Period 2014-2010.

[8] Under preparation at the time of publication.

[9] For SMEs it only applies to companies with an energy consumption > 20 GWh per year.

[10] Only applies to companies with an annual energy consumption of less than 1000 toe/year.

Slovakia	Large & SMEs	SlovSEFF (Slovak Sustainable Energy Finance Facility) III programme	Financial
Sweden	SMEs SMEs	Energy audit vouchers[11] (subsidy of 50% of the audit costs, with a maximum of EUR 5,500) Support scheme for energy efficiency investments (companies with <50 employees can apply for funding of up to 70% of the total project costs, while medium-sized companies can obtain funding of up to 60% of the eligible costs, conditional on having carried out an energy audit)	Financial Financial
Non-EU			
China	Large & SMEs	Top-10,000 programme[12] (includes compulsory energy audit and rewards if energy saving projects are successfully implemented and exceed a minimum savings threshold of 147 TJ)	Regulatory
Japan	SMEs	Free Energy Audit	Financial
Switzerland	Large & SMEs Large & SMEs Large	Canton de Vaud audit programme Voluntary target agreements Reimbursement of network charge[13]	Financial Voluntary Financial
United States	SMEs	Industrial Assessment Centres (IACs) (free energy audits for manufacturers only conducted by university engineering students)	Information
Australia	Large & SMEs	National Greenhouse and Energy Reporting Act (compulsory energy audit if regulator suspects firms that operate facilities with more than 25 kt of greenhouse gas emissions (GHG) per year not to be respecting the obligatory purchase of "carbon units", which are tradable permits for each tonne of GHG emitted)	Regulatory
India	Large & SMEs	Energy Conservation Act (ECA) (compulsory energy audit to nine energy-intensive sectors)	Regulatory
South Africa	Large & SMEs	National Energy Efficiency Leadership Network (EELN)	Voluntary
Turkey	Large & SMEs	Energy Efficiency Law	Voluntary

Table 1. Summary of national policy instruments to promote energy audits in EU and non-EU countries

Besides the policy interventions presented in the random experiment that are similar to existing EU policy instruments aimed at promoting energy audits, the value of the energy audit is also tailored around the firm's annual energy spend. It is budgeted at 1.5% of the firm's total annual energy spend,

[11] Companies eligible for support are those involved in the primary production of agricultural products with at least 100 livestock units and all other companies with a final energy demand exceeding 0.3 GWh/year.

[12] The programme addresses the largest 1,000 energy-intensive companies consuming each more than 5.275 TJ/year, and representing in total about 33% of China's energy demand.

[13] Applicable only if companies have electricity costs equivalent to at least 10% of their gross value added, if they meet all eligibility requirements, if the refund amount is at least CHF 20,000 per year and if the company signs a target agreement with the federal government to increase energy efficiency. Additionally, 20% of the refunded tax amount has to be invested in less cost-effective measures that are not an integral part of the target agreement.

between the lower bound of 1,500 euros and the higher bound of 15,000 euros, and select the lowest value[14]. We describe the data into more details in the next section.

3. EIBIS data

The data used in our study comes from the online module of the EIB's Investment Survey[15] of 2018. The EIBIS is carried out annually and gathers quantitative and qualitative information on companies' characteristics and their performance, their past and future investment activities, their sources of finance, financing issues and other challenges that they might be facing, such as access to finance; amongst others. It was initiated in 2016 and aims to build a firm-level data set, in order to provide a representative view of the investment situation of firms in the 28 EU Member States. The information collected usually refers to the previous financial year of the companies.

The survey is based on a telephone interview (i.e. the general module) of 12,500 firms from the 28 EU Member States. Fieldwork is carried out by the intermediary of Ipsos-MORI. Following the telephone interview, companies are invited to take part in an online experiment. The third wave of the online module, which is the one we will be using here, focuses on energy efficiency investments. The previous two waves were on firms' preferences for loans characteristics, and on the trade-off between equity and debt loan, respectively (Brutscher et al., 2017; Brutscher and Hols, 2018).

In the preliminary section of the online module, firms are first asked about their approximate total annual energy spend[16]. Then they are asked about whether they are aware of any support schemes for similar firms directed towards energy efficiency investments in their countries (Figure 2). Out of the firms surveyed, 70% said not to be aware of such scheme, out of which over a third were located in countries that actually have a scheme supporting energy efficiency investments. The next question is only directed to firms that said to be aware of such schemes, which is the remaining 30% of the firms surveyed. It asks about the degree of importance of these schemes in the firms' decisions to carry out an investment in energy efficiency projects. One firm out of five said that it made a big difference in

[14] This energy audit cost estimation is tailored around the individual energy cost of the company. This is necessary, as the costs of energy audits vary considerably by country, sector and company type. For instance, they are cheaper in cohesion countries and more expensive for multinationals (Brems et al., 2016). The costs will also depend on the type of audit required, the size of the firm and how energy intensive it is. As stated in Brems et al., 'in practice, many other parameters seem to influence the hours and efforts spent by the auditors and therefore the typical audit prices' (2016). While one could argue that the hypothetical energy audit cost is a drawback to our study, it has still been tailored around the firm's real energy costs.

[15] Henceforth EIBIS.

[16] The online module is divided into four sections. The first one asks preliminary questions on support schemes and past experience with energy audits. The second section focuses on energy audits and different combinations of policy interventions. Section three looks at the characteristics of energy efficiency investment projects and of financing offers. The concluding section captures how firms assess energy efficiency investments to those that are not related to energy efficiency.

their decision to invest in energy efficiency, while about 54% said that it made some difference. The remaining firms claimed that it made no difference at all.

The last two questions of the preliminary section ask whether the firm has carried out an energy audit in the last three years, and if they have not, whether they would go ahead with an energy audit with a specific audit cost.

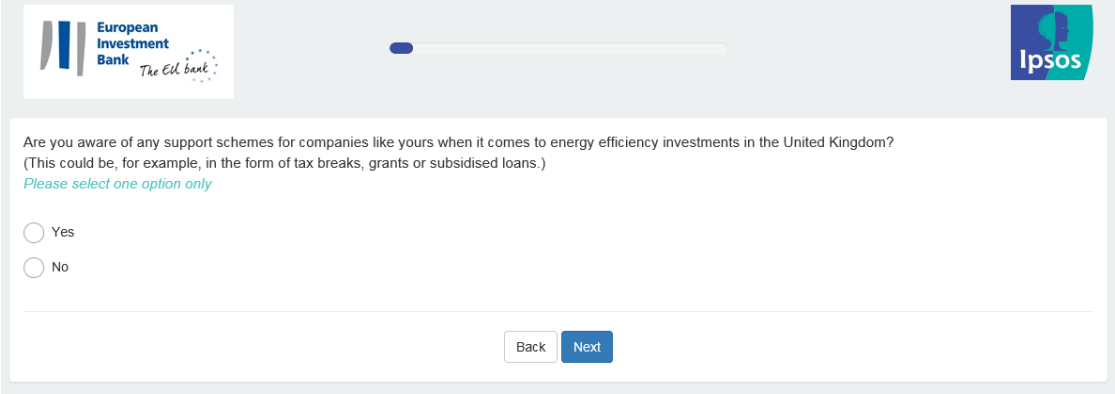

Figure 2. Screenshot of preliminary section question on support schemes (country: UK)

When the firm is asked whether it would be willing to carry out the energy audit, five possible responses are suggested. These are whether it would 'definitely go ahead', 'probably go ahead', 'might or might not go ahead', 'probably not go ahead' or 'definitely would not go ahead' with the energy audit, as in Figure 3. This is the same for all following questions about the willingness of the firm to go ahead with the energy audit.

An energy audit is defined as a 'systemic analysis of the energy use and energy consumption'. The various dimensions of policy interventions are: the percentage of the cost that will be financially supported (i.e. the 'level of support'- equal to 10%, 30%, 50%, 70% or 90%), whether the support is in the form of a grant or tax credit, and whether the support is conditional or unconditional on the firm carrying out the investment project following the energy audit. All policy interventions are drawn randomly.

Figure 3 gives an example of the module screen on energy audits presented to a British firm where the level of support is 10% with a tax credit conditional on carrying out the investment project after:

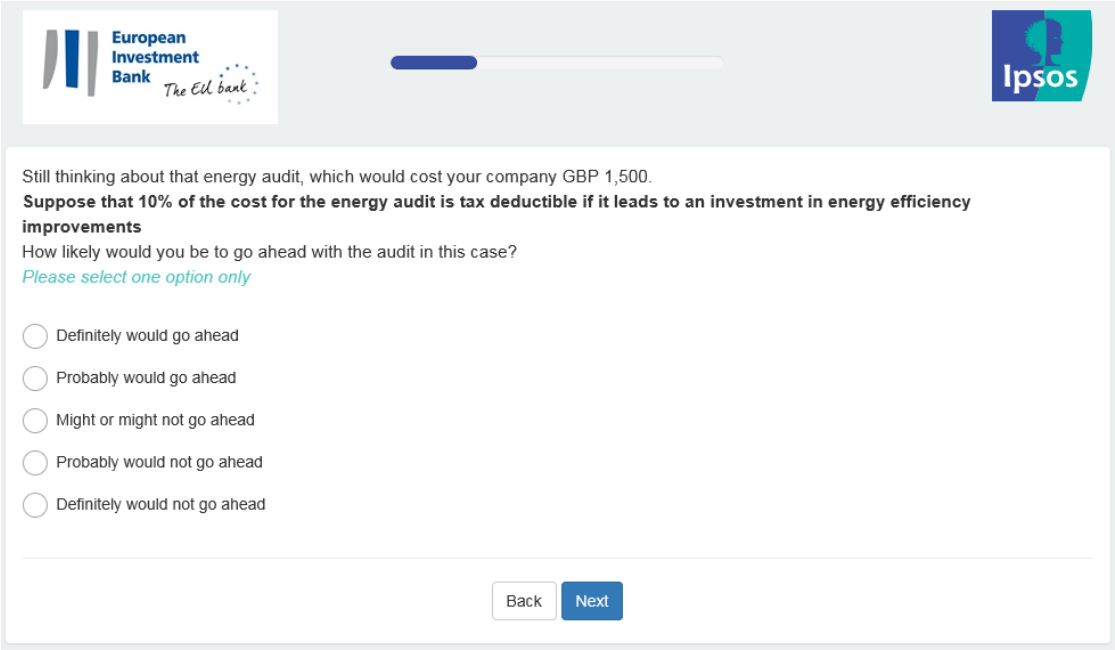

Figure 3: Screenshot of question on the willingness to carry out the energy audit according to a specific combination of policy interventions (country: UK)

Figure 4 gives another example of the module screen on energy audits presented to a British firm but with a level of support of 70%, coming with a grant and unconditional on going ahead with the investment after.

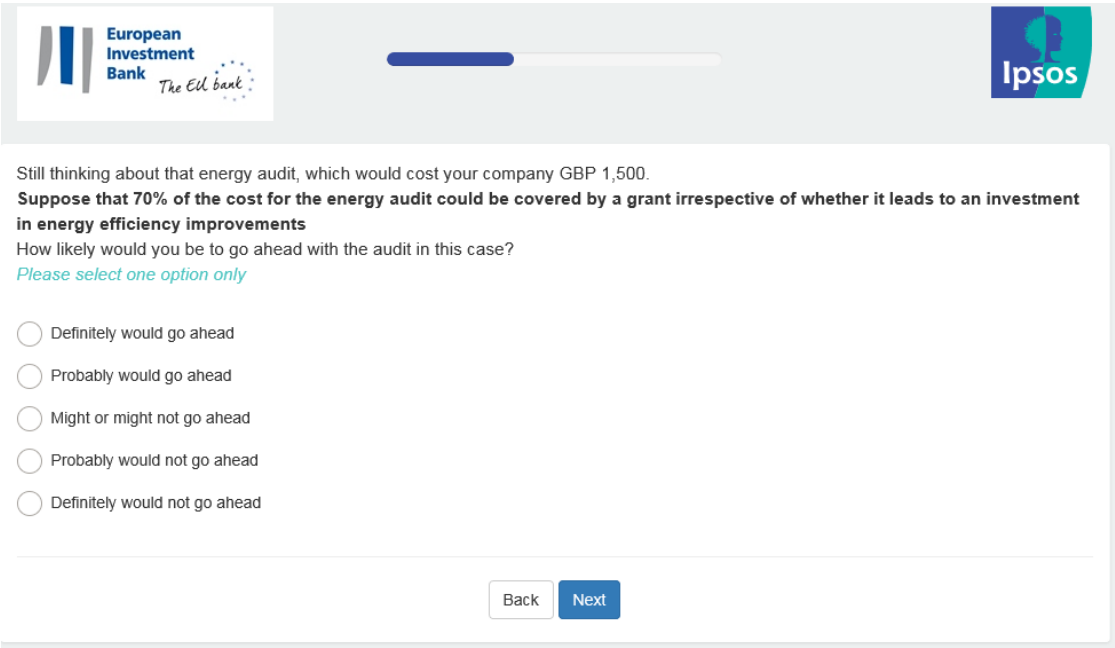

Figure 4: Screenshot of question on the willingness to carry out the energy audit according to a specific combination of policy interventions (country: UK)

Each firm is shown four of these screens with different combinations of policy interventions, all randomly drawn. The structure of the experiment presents firms with sometimes more and sometimes less favourable policy interventions. Only firms that said that they did not carry out an energy audit over the three years prior to when they were being surveyed (i.e. 2018) participated in this section of the module.

A total of 1,178 firms were interviewed. Each firm was shown four screens. Not all firms answered the module fully. We treat each observation independently, as all policies were randomly drawn, and as we use control variables for firm effects. Figure 5 shows the distribution of observations by country, both in terms of numbers and percentage shares. About 8% of the observations comes from Finnish firms, while 0.7% come from Cyprus. Firms in Finland, the Netherlands, Italy, Spain, Bulgaria, Denmark, Belgium and Hungary represent 50% of the total observations.

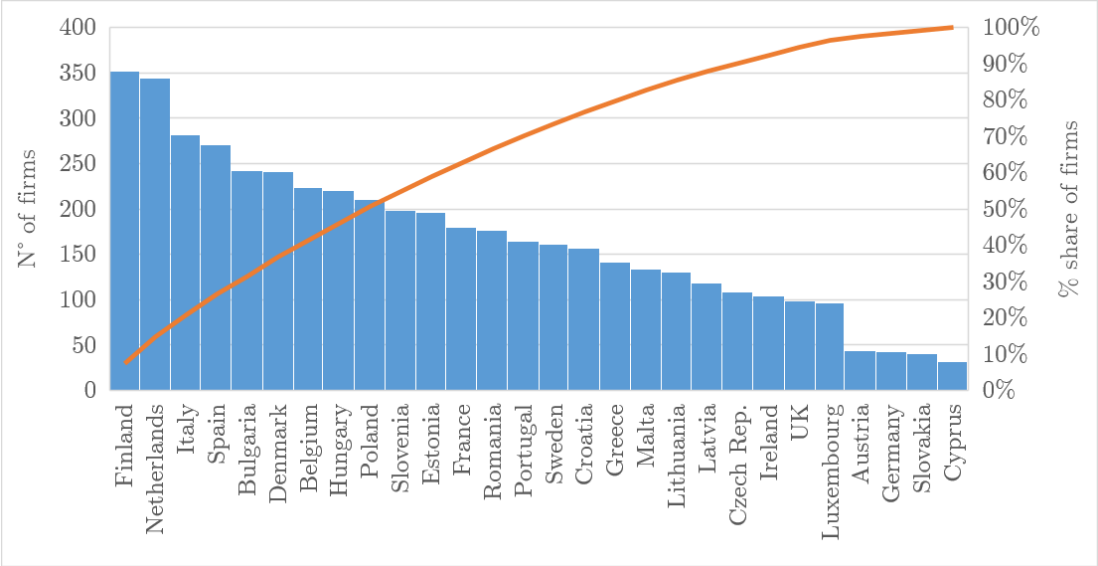

Figure 5. Observations by country (number of firms and firm percentage share)

4. Empirical methodology and model

We have gathered the five different possible outcomes shown above (e.g. 'would definitely go ahead', 'would probably go ahead', 'might or might not go ahead', 'would probably not go ahead', and 'definitely would not go ahead') into two possible answers: 'yes' or 'no'[17]. A 'yes' to carrying out the energy audit is assumed if the firm replied 'would definitely go ahead' or 'would probably go ahead',

[17] This is inspired by a paper by Brutscher and Hols (2017).

and a 'no' for all other possible answers[18]. As the dependent variable is dichotomous (0,1), we use logit analysis for the empirical estimation.

The firms' preferences can be represented with a utility function. Let's assume that there are I firms indexed by *i* that can choose whether to go ahead with the energy audit or not in each of the four screens shown to them, which are indexed by *s*=1,…,4. Whether the energy audit is carried out is indexed by j∈ {no,yes}. Firm *i*'s preferences can be represented by a utility function to the extent that they meet the conditions of rationality, transitivity and completeness. Preferences are assumed to be monotonic, where firms will always prefer more to less, implying a quasi-concave utility function.

Firm i going for energy audit j from screen s has the following utility function:

$$u_{is}(j) = \sum_{k=1}^{K} \beta_k x_{kis}(j) + e_{is}(j) \qquad (1)$$

Where $k = 1, \dots, K$ is an index of policy interventions x, $e_{is}(j)$ is the unobserved utility function derived by firm i going for energy audit j, β_k is the coefficient that measures the contribution of the policy intervention k to utility.

While it is not possible to determine utility from the data, it is still possible to identify firms' preferences for policy interventions, such that:

$$y_{is} = \begin{cases} 0 & if \quad u_{is}(no) > u_{is}(yes) \\ 1 & if \quad u_{is}(no) < u_{is}(yes) \end{cases}$$

Where $u_{is}(no)$ is the utility derived from choosing not to go ahead with the energy audit, while $u_{is}(yes)$ is the utility derived from going ahead with the energy audit.

Our model looks as follows:

$$y_{is} = \beta_0 + \beta_1 x_{1is} + \beta_2 x_{1is} * x_{2is} + \varepsilon_{is} \qquad (2)$$

Where y_{is} is the binary outcome, 'yes' or 'no', on whether the firm would go ahead with the energy audit, x_{1is} is one policy intervention dimension for firm *i* on screen *s*, x_{2is} is another policy intervention dimension for firm *i* on screen *s*, and ε_{is} is the error term for the specific firm and screen. The relationship between x_1 and x_2 denotes an interaction term

In our analysis, x_1 represents the level of support, which can take the values 10%, 30%, 50%, 70% and 90%. The variable x_2 denotes whether the level of support comes with a grant, or whether it comes in the form of a tax credit. It takes the value 1 if it is a grant, and 0 if it is a tax credit. This is why we use

[18] Whether we put the answer 'might or might not go ahead' in the 'yes' or 'no' answer group does not alter our overall results.

an interaction term, as the form in which comes the support, i.e. a grant or a tax credit, will certainly affect how the support is perceived by the firm. We repeat the analysis for two groups; one where the audit is conditional on investing after, and one where it is not[19].

5. Results

This section presents marginal effects from our logit estimation for all firms, and then by firm groups, according to different characteristics. The regressors are the level of support, which is a continuous variable, and the interaction between the level of support and the binary variable that takes 1 when the support is in the form of a grant and 0 if it comes with a tax credit. The individual term of the binary variable is not included, as in our case if the level of support is equal to zero, whether the support comes in the form of a grant or a tax credit makes no difference on the probability that the firm carries out the energy audit.

a) All firms

Table 2 presents the marginal effects from the logit analysis for Equation (2). The coefficient of the variable 'support' shows how an increase in the level of support affects the willingness of firms to carry out an energy audit when it comes in the form of a tax credit (i.e. when the variable 'grant' equals zero). It shows that for each 10 pp increase in the level of support, the willingness of firms to go ahead with the energy audit will increase by 4.2 pp. In the case of support coming in the form of a grant, the willingness would increase by 5.2 pp, an increase driven by the value of the coefficient of the interaction between the level of support and the grant.

	(1)
VARIABLES	Go ahead with the audit
Support	0.00421***
	(0.000288)
Support with a grant	0.00102***
	(0.000242)
Observations	4,712

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2. Marginal effects from the logit analysis

[19] *Nota bene:* the model assumes an intercept that is ideal for the sub-groups considered, as these are chosen randomly, and as a level of support equal to zero should be the same whether it comes with a grant or tax credit, and whether it is conditional or unconditional on investing after.

The fact that an increase in the level of support implies an increased willingness of firms to go ahead with an energy audit is intuitive: it is in the firm's interest to reduce its costs. The preference for a grant over a tax credit follows the explanation that a tax credit is conditional on making profits and not operating at losses, while a grant is more easily accessible to all firms and does not come with any financial prerequisite. Another reason could be that the grant will be paid right away, while the tax credit concretises only the next time taxes are declared. In this respect, grants are transferred directly, while the tax credit comes with a time lag.

	(1)	(2)
VARIABLES	Go ahead with the audit conditional	Go ahead with the audit unconditional
Support	0.00348***	0.00498***
	(0.000399)	(0.000417)
Support with a grant	0.000757**	0.00128***
	(0.000337)	(0.000349)
Observations	2,363	2,349

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 3. Marginal effects from the logit analysis conditional and unconditional on the investment after

Table 3 shows the marginal effects from the logit analysis of Equation (2) when the level of support with a grant or with a tax credit is conditional and unconditional on having to invest after.

A 10 pp increase in the level of support in the form of a tax credit conditional on carrying out the investment after increases the probability of firms to carry out the energy audit by 3.5 pp. The same support level also in the form of a tax credit unconditional on carrying out the investment after increases that probability by 5 pp. If the support level comes with a grant and is unconditional, the increase in the probability of the firm going ahead with the energy audit becomes 6.3 pp[20].

Figure 6 gathers all these findings into a simplified graph in order to compare them. To put the situation in a more realistic context and based on some already existing subsidy programmes, we look at the effect of a 50 pp increase in the level of support with a grant or with a tax credit, and conditional or

[20] There is no statistical difference between the two sub-groups.

unconditional on investing after. Results show that a 50 pp increase in the level of support on its own increases the probability that firms will carry out an energy audit by 24 pp. The probability is 24% higher if the level of support comes in the form of a grant rather than a tax credit (from 21 pp to 26 pp). If this increase comes with a grant and is unconditional on investing after, the probability goes up by 32 pp. If it comes with a tax credit and is conditional on investing after, the increase is only of 18 pp.

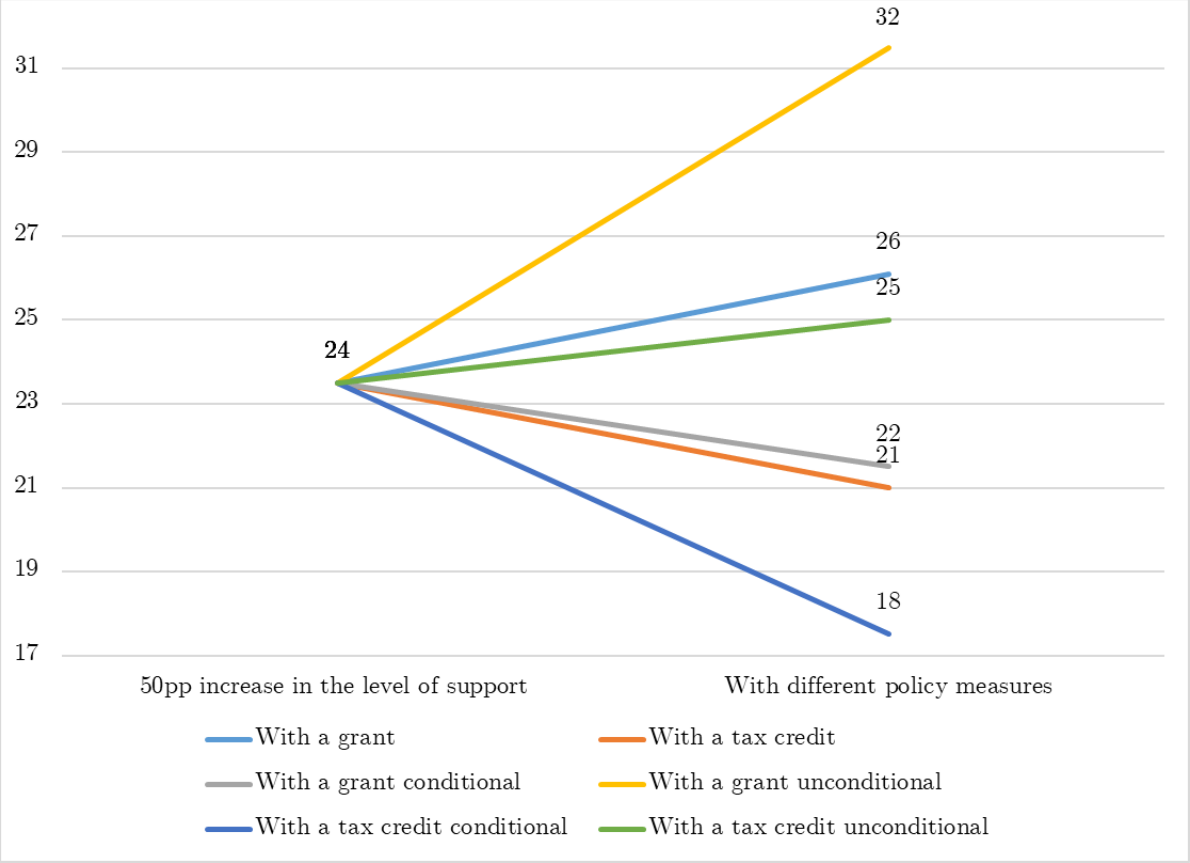

Figure 6. Comparison of the impact on the probability that firms carry out the energy audit of the different policy interventions' combinations

If 30% of the firms surveyed said to have carried out an energy audit in the past three years[21], a 50pp increase in the level of support in the form of a grant would increase this share to 56% (or by 87%). If the 50pp increase in the level of support came with a tax credit, this increase would be of 51% (or by 70%). Put more bluntly, if we wanted to increase the number of firms carrying out an energy audit

[21] Based on our sample in the general module of the EIBIS data.

from one out of three to at least half of the firms, we would need to increase the level of support by at least 50pp[22].

We also carried out a sensitivity analysis to see how the probability that firms carry out the energy audit increases when there is a change from a tax credit to a grant in the form of the level of support, for each level of support existing in the experiment (Figure 7). Several observations can be made. First, the predicted probability is higher, the higher the level of support. Second, the predicted probability is always higher when the support is in the form of a grant, compared to a tax credit, for each given level of support. Finally, the difference between the predicted probability with a grant and with a tax credit becomes larger, as the level of support also increases.

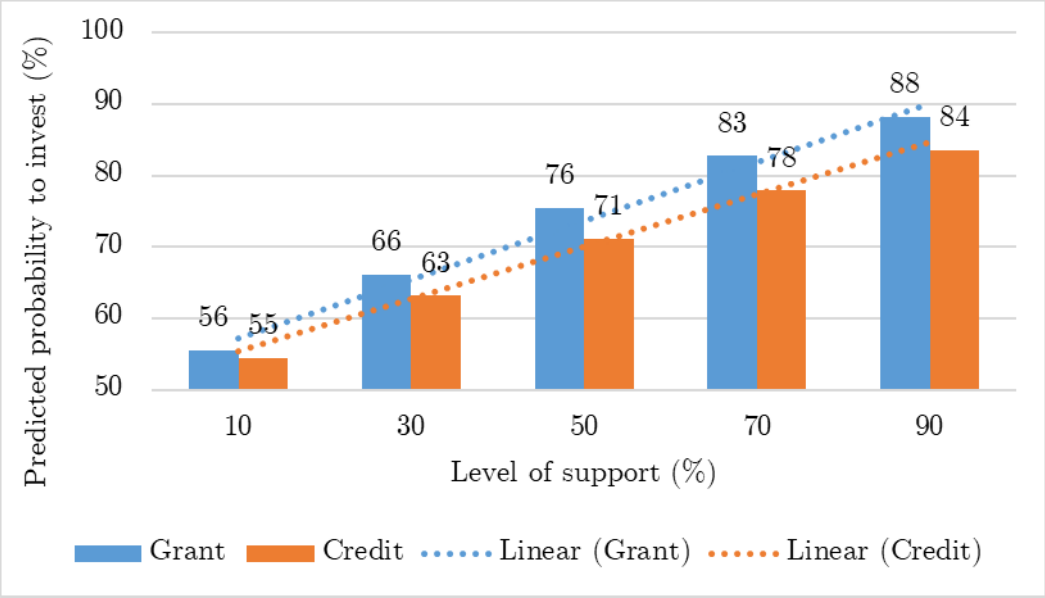

Figure 7. The predicted probability that firms invest when the support type goes from a tax credit to a grant for each level of support

b) By group

One of the advantages of the EIBIS data is that it allows to reproduce the same analysis for different groups of firms. The purpose is to compare these groups to assess whether their responsiveness to the same combinations of policy interventions varies. The grouping has been done according to different characteristics of firms. These are their size, sector, whether they perceive energy costs as an obstacle, whether they have high or low energy costs, whether they are financially constrained, their energy

[22] We reproduce the same results by giving the dependent variable all five possible outcomes, from 1 to 5, with '1' corresponding to the reply 'would definitely not go ahead' and '5' to 'would definitely go ahead'. Our findings do not change in terms of the most effective combination of policy interventions.

efficiency standards, whether they invest in energy efficiency, whether there is a national support programme in their country, and the region of the firm.

Before looking at the results, Figure 8 shows the distribution of observations in our survey according to firm sector and size. The distribution is fairly balanced across sectors, with most firms in the manufacturing and services sectors (28%, respectively), while 90% of our observations are SMEs. To recall, large firms in the EU face compulsory energy audits since 2012. However, firms that took part in the online module are those who have not carried out an energy audit in the past three years. This explains why only 10% of the firms are large.

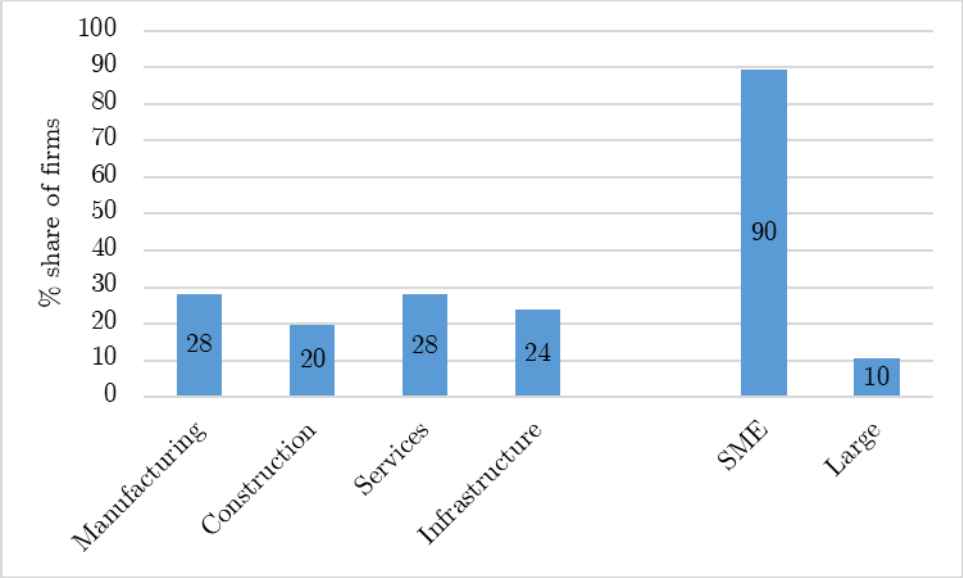

Figure 8. Distribution of observations by sector and firm size (percentage share of firms)

Table 4 compares the marginal effects from the logit analyses for the different firm sizes[23]. Our results show that the larger firms are the more responsive to policy support. Also, larger firms seem to be more sensitive to the type of policy support, that is whether it comes in the form of a grant or tax credit.

[23] We exclude large firms for two reasons. First, they only represent 10% of the observations. Second, under EU law it is compulsory for them to carry out an energy audit, meaning that they are likely to be unresponsive to policy interventions.

VARIABLES	(1) Micro	(2) Small	(3) Medium
Support	0.00372***	0.00444***	0.00413***
	(0.000496)	(0.000480)	(0.000524)
Support with a grant	0.000492	0.000913**	0.00141***
	(0.000391)	(0.000405)	(0.000452)
Observations	1,065	1,606	1,548

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 4. Marginal effects from the logit analyses for different firm sizes

The next group analysis is done according to the firm's sector. Results from Table 5 show that there are very few differences in firms' responsiveness to policy support; but that there are differences in what type of support they prefer. While construction sector firms make no difference between grants and tax credits, service sector firms and infrastructure sector firms reveal a strong preference for the former, most probably reflecting differences in cash flow (across sectors).

VARIABLES	(1) Manufacturing	(2) Construction	(3) Services	(4) Infrastructure
Support	0.00441***	0.00445***	0.00429***	0.00386***
	(0.000562)	(0.000606)	(0.000556)	(0.000584)
Support with a grant	0.00109**	0.000340	0.00117**	0.00130***
	(0.000487)	(0.000492)	(0.000468)	(0.000484)
Observations	1,311	920	1,303	1,106

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 5. Marginal effects from the logit analyses for different sectors

We also look at whether firms that are unaware of a support scheme for energy efficiency investments in their country (e.g. tax breaks, grants, subsidised loans) respond differently to policy interventions than those that are aware. This analysis is based on a question in the preliminary section of the online module of the survey, where firms were asked about their awareness of a national support scheme.

VARIABLES	(1) Aware	(2) Unaware
Support	0.00450***	0.00410***
	(0.000533)	(0.000341)
Support with a grant	0.00105**	0.000995***
	(0.000455)	(0.000284)
Observations	1,475	3,237

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 6. Marginal effects from the logit analyses for aware and unaware firms

Table 6 shows that firms that are aware of a national support scheme for energy efficiency investments are overall more responsive to an increase in the level of support covering energy audits costs than firms that are not aware of any scheme of this type; which is likely to reflect the greater concern regarding energy costs on the part of these firms. Further analysis further show that firms for which energy costs are an obstacle are generally more responsive to policy interventions than firms for which they are not (Figure 7).

VARIABLES	(1) Energy costs are not an obstacle	(2) Energy costs are an obstacle
Support	0.00372***	0.00467***
	(0.000396)	(0.000416)
Support with a grant	0.00112***	0.000950***
	(0.000326)	(0.000355)
Observations	2,292	2,396

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 7. Marginal effects from the logit analyses for firms that say energy costs are an obstacle versus those for which they are not

This is also the case for firms that have high energy costs[24]. This is because these firms are the ones for which it is a priority to reduce their costs in energy.

[24] Energy costs are measured relative to the number of employees per firm and against the median by country, size and sector.

VARIABLES	(1) Low energy costs	(2) High energy costs
Support	0.00390***	0.00472***
	(0.000373)	(0.000464)
Support with a grant	0.00100***	0.00123***
	(0.000309)	(0.000401)
Observations	2,672	1,923

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 8. Marginal effects from the logit analyses for firms with low versus high energy costs

The probability that firms carry out an energy audit is higher if they are also financially constrained, in both cases where an increase in the level of support comes in the form of a tax credit or as a grant (Table 9). This is because these firms do not have an access to finance that would allow them to cover all costs of energy audits, or that they would direct their available finance towards other expenses.

VARIABLES	(1) Not financially constrained	(2) Financially constrained
Support	0.00423***	0.00545***
	(0.000322)	(0.00107)
Support with a grant	0.00108***	0.00185**
	(0.000272)	(0.000875)
Observations	3,872	333

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 9. Marginal effects from the logit analyses for firms that are financially and not financially constrained

Additional information on firms included in our data also allows us to compare firms' responsiveness to the different combinations of policy interventions according to their energy efficiency standards and investment in energy efficiency. Table 10 shows how firms with low energy efficiency standards respond to the policy interventions compared to those with high energy efficiency standards. A firm has high energy efficiency standards if the percentage of its commercial stock building that meets high energy efficiency standards is higher than its country's median. If it below or equal to the national median, then it is considered to have low standards. Findings demonstrate that firms with high energy efficiency standards are more responsive to support coming in the form of a tax credit, but that when

the support is in the form a grant, whether the firm meets low or high energy efficiency standards does not matter anymore.

VARIABLES	(1) Low energy efficiency	(2) High energy efficiency
Support	0.00410***	0.00455***
	(0.000404)	(0.000456)
Support with a grant	0.00125***	0.000881**
	(0.000340)	(0.000385)
Observations	2,395	1,971

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 10. Marginal effects from the logit analyses for firms with high and low energy efficiency

Table 11 shows that firms located in countries where there is no existing national support scheme programme for energy audits are more responsive to an increase in the level of support, regardless of whether it comes in the form a grant or a tax credit, compared to firms located in countries where there is a programme. This grouping has been made according to information in Table 1.

VARIABLES	(1) There is no programme	(2) There is a programme
Support	0.00439***	0.00395***
	(0.000371)	(0.000456)
Support with a grant	0.00116***	0.000803**
	(0.000310)	(0.000386)
Observations	2,840	1,872

Standard errors in parentheses
*** p< 0.01, ** p< 0.05, * p< 0.1

Table 11. Marginal effects from the logit analyses for firms located in countries with and without a national support scheme programme for energy audits

One observation worth noting is that regardless of the firm grouping, an increase in the level of support coming in the form of a grant instead of a tax credit always leads to a higher probability of carrying out the energy audit in all cases. The differences in the responsiveness of sub-groups of firms to the policy

interventions is nonetheless not to be taken at face value, as in most cases the coefficients are not statistically different.

6. Conclusions and policy recommendations

This section summarises our results, the contribution of our work, highlights its limitations and makes some policy recommendations.

Using a randomised experiment, this paper assessed the effectiveness of policy interventions in promoting energy audits in the EU. We considered three policy interventions: the level of support covering the audit costs, the type of support (i.e. grant vs tax credit), and whether the audit was (un-)conditional on making a follow-on investment in energy efficiency after. Policy support matters when it comes to energy audits, as the latter can have a positive influence on energy efficiency investments, which themselves come with significant positive externalities. Energy audits inform firms on the potential of investments in energy efficiency, and on how their investment is best spent, by overcoming the information gap.

Results show that a higher level of support increases the probability that a firm carries out an energy audit, and even more so when it comes in the form of a grant. Conditionality on investing in the project after does not seem to matter, and the characteristics of firms either.

One of the main contributions of this research is that it allows to *quantify* the effectiveness of the selected policy interventions. Findings demonstrate that a 50 pp increase in the level of support covering the costs of an audit will boost the probability of it being carried out by 24 pp. If the increase in the level of support comes in the form of a grant, the probability that firms carry out the energy audit increases by 26 pp, compared to 21 pp if it comes in the form of a tax credit, which is a 24% increase.

The fact that we use a comprehensive dataset for our analysis also makes possible sub-populations analysis. This is because we could match the firms' financial and investment data to their responses in the random experiment. In addition, all 28 EU countries were included, and firms from all sizes and all economic sectors were covered.

Our selection of policy interventions was not unfounded, as they closely relate to existing national policy instruments put in place in the EU that target energy audits. They also include different incentives, related to information, economic or normative. The energy audit costs were also realistic, as they were calculated on a case-by-case basis, taking into account the firm's declared annual energy spend.

Another important contribution of the present work is the fact that common methodological obstacles, such as omitted variable bias, reverse causality and the 'free rider effect', are overcome. This is because the policy interventions are randomly drawn in the experiment and because firms that have not carried out an energy audit in the past three years are put into a realistic situation in which they have to make an immediate decision given the information they have. This implies that no other explanatory variable is omitted, that it is not the fact that they already carried out energy audits that would affect their decision, and that there is no other situation where they could carry out the same energy audit without the policy interventions.

Like all methodologies, using a random experiment also has its limitations. The participation of firms in the experiment is voluntary, and hence results also reflect the firms' stated willingness in a way, and hence are to be interpreted with a pinch of salt. In addition, while the coverage of firms is broad, the sample of firms that accepted to take part in the online experiment on energy audits is not necessarily representative. Despite these limitations, this study on the effectiveness of policy instruments in promoting energy audits is the first of its kind, and is hence a good starting point to inform policy-makers on which are the best measures to boost firms' willingness to carry out energy audits.

Several policy recommendations flow from our results. The first one is that financially supporting the costs of an energy audit increases the likelihood that a firm carries out the energy audit. As Figure 7 demonstrates, even covering 10% of the total costs of an energy audit leads to more than one chance out of two that the firm carries out the energy audit, other things held constant. If this level of support now covers as much as 90% of the energy audit's costs, then the predicted probability that the firm invests in the energy audit will reach between 84% and 88%, depending on whether the support comes in the form of a tax credit or a grant, respectively. For any level of support, a 50pp increase in its level will lead to a 26pp-increase in the probability that the firm carries out an energy audit if the support comes in the form of a grant, and 22pp if it comes in the form of a tax credit.

In other words, having in place a national support scheme directed towards energy audits can considerably affect the number of energy audits carried out. Additionally, an increase in the level of support covering the energy audits' costs will have a positive impact on the probability that firms carry them out. This impact will be even stronger if the support comes in the form of a grant, compared to a tax credit.

When it comes to the question of whether policy support for energy audits should be made conditional on future investment activities in energy efficiency projects or not, policy makers too have some room for maneuver: whereas firms' willingness to carry out an energy audit is more responsive to a given support measure if it is unconditional, the difference between conditional and unconditional policy

support is probably small enough to justify conditional measures on the basis that they reduce 'leakage'.

Finally, our results give strong support to the idea of better communication of policy measures. About 36% of firms in our sample said that they are unaware of any policy support scheme in their home country (that is applicable to them), even though our research suggests otherwise. When confronted with a hypothetical support measure these firms respond positively; albeit less so than firms that are aware of existing schemes already. What this suggests is that to have a maximum impact any policy scheme (new or existing) needs to be accompanied with a strong communication campaign making firms aware of their availability.

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Promoting energy audits:
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Economics Department
economics@eib.org
www.eib.org/economics

European Investment Bank
98 -100, boulevard Konrad Adenauer
L-2950 Luxembourg
+352 4379-22000
+352 4379-62000
www.eib.org – **info@eib.org**

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