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DISCUSSION PAPER

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Supporting Residential Energy Conservation under Constrained Public Budget: Cost-effectiveness and Redistribution Analysis of Public Financial Schemes in France

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Abstract

In the context of tight public budgets and increasingly ambitious climate objectives, the performance of the support policies for residential energy conservation works needs to be assessed. We compare the performance of four types of support schemes in France, namely the income tax credit, a grant scheme, the reduction of the value-added tax, and the White Certificates scheme. The analysis employs a dataset covering close to 14,000 French households who conducted conservation works in France. To address self-selection bias and potential endogeneity concerns, we use a double-robust inverse probability weighting estimator, a method mostly used in epidemiology so far. We assess the effect of the adoption of each scheme on the funding acquired, the private investment, total investment and the reduction of the household energy expenses. We deduct metrics of cost-effectiveness, redistribution and the ability to trigger private investment and additional total investment in energy conservation works via the schemes. We find funding from the schemes to reduce energy expenses most cost-effectively via the White Certificates. Additional private and total investment is highest with the adoption of the VAT reduction. The redistribution of public funds to low-income households is highest with the grant scheme.

Keywords: Energy efficiency, energy conservation, residential retrofits, cost-effectiveness, redistribution, inverse probability weighting.

JEL classification: H23, Q58, Q84.

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1 Introduction

As global greenhouse gas emission constraints are becoming more stringent, substantial reductions must be achieved in the residential sector.[1] The latter represented on average 18.4% of the total fuel consumption in OECD countries in 2017 (IEA, 2019). In the EU, it amounts to 25.7% (EC, 2018). The energy efficiency gap remains high in this sector due to reasons such as inattention of residents (Palmer and Walls, 2015), the landlord-tenant dilemma (Allcott and Greenstone, 2012) and high non-monetary costs of energy efficiency investments (Fowlie et al., 2015). National governments offer a diversity of publicly funded financial incentives to encourage households to conduct conservation works that improve energy efficiency and cut GHG emissions. In times of constrained public budgets, in particular following the COVID pandemic, evaluating the performance of financial support schemes for energy conservation is essential.[2]

In this paper, we assess the performance of four types of financial schemes used to support residential energy conservation works in France: a grant scheme, a reduction of the value-added tax (VAT), an income tax credit and the White Certificates. We use the TREMI2017 survey data produced by the French Environment and Energy Agency (ADEME). The dataset covers close to 14,000 observations at household-level, with information on energy conservation work activities and financial support scheme adoption. To address potential endogeneity and self-selection bias, we employ double-robust inverse probability weighting (IPW) estimators, mostly used in epidemiology so far. We estimate the effect of adopting each scheme on the funding acquired, the private and total investment by households and the reduction of households' energy expenses, conditioned on energy efficiency works conducted. We use these estimates to construct metrics to characterize the schemes' cost-effectiveness, their ability to induce private investment (leverage effect), their capacity to increase total investment (additionality) and the redistribution of public support to low-income households they involve. We compare the four schemes

[1] For example, in the European Union, the Commission plans an initiative to accelerate the annual renovation rate in the EU. The European Green Deal assumes a current average annual renovation rate of 0.4% and requests an acceleration to 1.2% (EC, 2019).

[2] As examples of the amount of dedicated public spending, the Italian government invested €5.5 billion in energy efficiency in 2015, more than half of which for the residential sector, and the French government had planned to spend €2.4 billion for energy-efficient renovation of buildings in 2020 (RF, 2020). For 2021, the French government had planned to spend €1.2 billion for energy efficiency works in buildings via a reduction of the value-added tax or an interest-free loan scheme (RF, 2021).

along these dimensions.

We find that the White Certificates scheme is most cost-effective, followed by the VAT reduction and the grant scheme. The income tax credit is the least cost-effective. The VAT reduction triggers most additional private investment into conservation works, followed by the income tax credit. The leverage effect is 0 for both the grant and White Certificates schemes. The VAT reduction also has the highest capability to increase total investment, followed by the income tax credit and the White Certificates. The grant scheme induces least additional total investment. Redistribution of public funds to low-income households tends to be highest with the grant scheme, but this effect is not statistically significant. As no scheme is strictly superior, a trade-off exists between the four policy objectives when choosing a scheme to develop at a national scale, especially between cost-effectiveness of public funds and the capacity to trigger additional investment on the one hand and redistribution to low-income households on the other hand.

Earlier studies set in the US context have diverse findings. While Walsh (1989) does not find any effect of a change in the income tax credit on the propensity to invest, Hassett and Metcalf (1995) find that a 10 percentage point decrease in the value-added tax on energy investment increases the propensity to invest by 24%. Gillingham et al. (2018) review peer-reviewed studies that evaluate the cost-effectiveness of financial support schemes to increase residential energy efficiency. They report reduction costs in a range between US$3.9 cent and US$47.9 cent per kWh in a heat pump rebate program in Maryland (Alberini and Towe, 2015; Alberini et al., 2016). Few studies exist in the European context. Alberini and Bigano (2015) find an Italian income tax credit program to have no effect on the propensity to replace heating equipment. Blaise and Glachant (2019) assess the average impact of conservation works on energy savings in France without differentiating between support schemes.

The novelty of our work in comparison with the existing literature is fourfold. First, we employ IPW to evaluate the performance of financial support schemes and account for self-selection into adoption of these schemes. Mostly used in epidemiology so far, this method is particularly well suited for samples with a small treated group as it sustains the sample size and avoids discarding information. It allows us to identify the causal effect of the adoption of each scheme. Second, we present a comprehensive comparison

of the performance of the adoption of four different financial support schemes, while previous studies have commonly focused on one or two schemes and have analyzed whether schemes encourage the uptake of conservation works, but not the performance of adoption. Third, we assess this performance according to the dimensions of cost-effectiveness, redistribution, additionality of investment and leverage for private investment, whereas earlier studies usually focus on one dimension only. Finally, we provide new insights on the EU perspective. Previous studies that focus on the US context may not carry external validity for the EU context since they are placed in a different institutional and cultural setting. Further empirical evidence on EU member states matters.

2 Literature review

The literature on financial support schemes is much focused on the US. Numerous studies evaluate tax credits for conservation works (e.g Walsh, 1989; Hassett and Metcalf, 1995; Alberini and Towe, 2015); fewer studies evaluate other types of schemes, such as grants, interest-free loans and rebates (Amstalden et al., 2007; Fowlie et al., 2018). Studies which compare the relative performance of schemes are scarce (e.g. Zhao et al., 2012).

Policy evaluation of financial support schemes is conducted at the extensive and intensive margin; at both margins schemes can affect households' investment behavior. First, households take the binary decision to invest into energy conservation. Schemes can affect the households' propensity to invest, operating at the extensive margin. Second, households decide how much to invest. Here, schemes can affect the size of households' investment, operating at the intensive margin.

Previous literature focuses on the first stage decision, i.e. whether schemes encourage the uptake of conservation works. To our knowledge, there are no studies that analyze the second stage decision, to what extent schemes increase the amount invested into conservation works.

Two seminal papers study the effect of financial support schemes on the propensity to invest; they find contradicting evidence. Walsh (1989) assesses the effect of a change in the income tax credit rate on take-up of energy conservation works, exploiting variations between US state income tax credit rates. It is found that a change in the income tax

credit rate does not affect the propensity to invest. Hassett and Metcalf (1995) assess how reduced VAT tax rates on energy investment affect the take-up of conservation works in various US states, and find that a 10 percentage point decrease in the tax increases the propensity to invest by 24%.

More recent studies have likewise found ambiguous evidence. Zhao et al. (2012) compare the impact of income tax credits and interest-free loans on the propensity to invest, based on a household survey in Florida, US. They find tax credits to be more attractive than interest-free loans. The interest-free loan does not increase the propensity to invest, but the tax credit increases the rate of investing households by 12%. Alberini and Bigano (2015) find an Italian income tax credit program to have no effect on the propensity to replace heating equipment. Grösche and Vance (2008) estimate the proportion of inframarginal households who would even have invested in the absence of a financial support scheme by the German government. Around 50% of households are found to be inframarginal adopters, no hidden costs of adoption assumed. Rivers and Shiell (2016) assess the proportion of inframarginal households who adopt a natural gas furnace replacement scheme in Canada. They find that around 50% of adopters would have replaced their gas furnace even in absence of the scheme. Boomhower and Davis (2014) measure inframarginal participation in an appliance replacement program in Mexico. They estimate that at least 65% of the participating households are inframarginal and would have invested into en energy-efficient appliance even without subsidy.

The cost-effectiveness of financial support schemes has been evaluated for different contexts and schemes. Gillingham et al. (2018) compare the cost-effectiveness of financial schemes from different studies on energy efficiency subsidies. Reduction costs per kWh lie in a range between US$3.9 cent and US$47.9 cent in a heat pump rebate program in Maryland (Alberini and Towe, 2015; Alberini et al., 2016). Blaise and Glachant (2019) find that conservation works in France reduce the energy bill on average by only 0.64%. They express concerns about the effectiveness of financial support schemes that aim to save energy.

Financial support schemes provided by the government reallocate taxpayers' money to recipients; distributional effects of the reallocation depend on a scheme's design and target group. Both these features affect which socio-economic strata adopts a scheme.

For instance, high-income households benefit most from income tax credits since these can deduct costs of conservation from higher tax liabilities (Neveu and Sherlock, 2016). Lower-income households preferably use grants and rebates when they are pessimistic about paying back loans. Marketing and implementation conditions can play a crucial role in determining the socio-economic background of recipients (Hoicka et al., 2014). For instance, demanding requirements of paperwork to apply for financial support schemes can be a barrier to less-educated households, and the design of information campaigns can determine to which groups a scheme reaches out (Walsh, 1989). Empirical studies find recipients of financial support schemes to be a homogenous group with regressive effects on the income distribution. Using survey data, Allcott et al. (2015a) show that the majority of households benefitting from conservation subsidies are wealthy environmentalist homeowners. Rivers and Shiell (2016) find likewise that recipients of a gas furnace replacement scheme in Canada are in large parts middle- and high-income households.

3 Institutional background

In France, the Pope law of 2005 (RF, 2005) introduced the White Certificates to oblige energy suppliers help consumers to lower their energy consumption. This followed the 2002 EU Directive on energy performance of buildings (EU, 2002), which introduced minimum energy performance requirements for buildings and energy performance certificates. In 2009, the Grenelle I law (RF, 2009) set the target to renovate 800,000 social housing units in order to halve their energy consumption by 2020, to encourage the construction of low-energy consumption buildings, and aim for a 38% reduction in energy consumption in old buildings by 2020. The Grenelle II law of 2010 (RF, 2010) introduced the objective to reduce energy consumption in new buildings by a factor of five by 2012. The 2010 Amendment of the 2002 EU Directive (EU, 2010) stated the objective to have all new building nearly zero-energy after 2020 (after 2018 for new building occupied and owned by public authorities). In this context, the Housing Energy Renovation Plan (Plan de Rénovation Energétique de l'Habitat, PREH) of 2013 (RF, 2013) introduced the objective to renovate 500,000 housing units per year by 2017[3] (including 380,000 privately owned

[3]In 2018, the "Plan gouvernemental de rénovation énergétique des bâtiments" (Governmental energy renovation plan for buildings) extended this objective of renovation to 500,000 housings per year for five more

units) and to reduce energy consumption in the housing sector by 38% by 2020. To do so, national public aids were developed, which are presented below.[4]

In France, households can benefit from a variety of financial support schemes for renovation works that aim to improve the energy efficiency of private dwellings. In the following, we discuss four types of at national level available schemes on which we focus our analysis: an income tax credit, a reduction of the VAT, a grant scheme and the White Certificates scheme. Further information on the financial support schemes can be found in RF and ADEME (2020).

The income tax credit (*Credit d'Impôt pour la Transition Energétique*, CITE) that is offered by the French government allows deductions from the income tax of up to 30% of the invoice sum.[5] The maximum amount of expenses that could be considered was €8,000 for a single person and €16,000 for a couple.[6] Only home owners can use this tax credit scheme. The amount of funding received by the income tax credit strongly depends on the marginal tax rate paid by the household and whether the reduction of taxable income by the costs of the conservation works reduces this rate.

Another financial instrument funded by the government is the reduction of the value-added tax (VAT) from the regular 20% to 5.5%. Every household can benefit from the VAT reduction as long as it conducts renovation works that target the energy efficiency of their dwellings. The granted amount directly depends on the amount of private investment into energy efficiency works, funding being a fixed proportion of the latter; the higher the private investment, the higher is the funding received from the VAT reduction.

The French housing agency (*Agence Nationale pour l'Amélioration de l'Habitat*, ANAH)[7] provides the program *"Habiter Mieux"* to help households by supplying a direct grant of between 35% and 60% of renovation work net expenses. The maximum amount that can be allocated is €10,000 on top of which a bonus[8] can be added if the energy efficiency

years.

[4] In 2015, the "Loi de transition énergétique pour une croissance verte" (law on the energy transition of green growth) introduced the objective to achieve a level of energy performance of low-energy building standards for the entire housing stock by 2050.

[5] The CITE was implemented from 2014 onwards, it replaced the Crédit d'Impôt Développement Durable (CIDD).

[6] These are the criteria which were in force during the time period considered for TREMI2017.

[7] The main funding sources of ANAH are the auctioning of carbon quotas, subsidies and taxes. Additionally, energy suppliers contribute to the funding of ANAH in return for the issue of White Certificates (CEE).

[8] The bonus consists of 10% of the expenses without VAT. The maximum amount that can be received is between €1,600 and €2,000.

improvement obtained is at least 25%. The grant aims at supporting households with low-income levels. Hence the eligibility depends on the joint annual income and the number of persons in the household and whether the household is located in the Paris region (Île-de-France) or not. The lower the household income and the higher the number of persons in the household, the higher is the maximum amount granted by ANAH. The survey data however suggests that the eligibility criteria are not strictly enforced.

Finally, since 2006, French energy suppliers have been obliged to collect a certain volume of *Certificats d'Economie d'Energie* (CEEs), which correspond to the so-called "White Certificates". In exchange for assisting energy consumers to lower their energy consumption, energy suppliers receive certificates. To achieve the required energy savings, programs which inform about energy consumption and savings are offered to households. In addition, many programs include the installation of small equipment (e.g. thermostats). This scheme does not only support energy efficiency of residential buildings but also of industrial and public buildings. By design, funds provided for energy conservation measures stem from the firms obtaining White Certificates, not from the public sector. The amount of funding received by households from this scheme depends on the specific program. The programs differ widely in their scope and the type of works that they support.

A non-negligible share of households in our sample adopted more than one scheme. The VAT reduction has the highest absolute number of adopters in the sample and is frequently adopted in combination with one of the other three schemes. The VAT reduction seems to be a scheme "for everyone", possibly due to a simple application process and being pointed out to households by professionals conducting the works. The grant scheme is predominantly adopted by households with lower average income due to its eligibility criteria. Households who adopt more schemes in parallel tend to be households with higher incomes and older family heads. A larger number of schemes adopted in parallel also correlates with a higher amount of acquired funding and higher private investment by households.

4 Material and methods

4.1 Data

We use data from the TREMI survey (*"Travaux de Rénovation Energétique dans les Maisons Individuelles"*), conducted by "KANTAR PUBLIC /TNS SOFRES", Énergies Demain and Pouget Consultants for ADEME, the French Agency for the energy transition, in spring 2017. The survey targets energy conservation works by households. The household sample was randomly drawn from the data base of the national statistics agency (*Institut National de la Statistique et des Études Économiques*, INSEE). The questionnaire was approved by TNS SOFRES. The resulting data set has a cross-sectional structure at the household level and contains 44,921 observations, whereof 14,081 households conducted renovation works. In the following, we present the variables that we employ for our analysis. Detailed summary statistics are reported in appendix A.

The survey provides information on the household and housing characteristics, as well as on the works conducted and the types of schemes used. Household characteristics include the age of the household's reference person, the number of persons living in the household (household size), the annual household net income, the profession of the household's reference person, the region where the household lives as well as the size of the agglomeration. The housing characteristics include the type of housing - 29,253 households in individual houses, of which 9,964 conducted works, and 15,481 in apartments, of which 3,990 conducted works - the construction date, the status of ownership (owner versus renter) and living space of dwellings.

The data also includes the type of renovation works conducted, the types of schemes used, funding that households acquired from schemes, the total amount invested including public money and private investment, and the reduction of energy expenses observed in the household. In total, the dataset includes 32,876 individual renovation works. Most of the works are related to doors and windows (22.5%), walls (e.g. insulation, 18.6%), the roof (17.8%) and the heating system (17.6%). Other types of works relate to warm water (7.4%), the floors (9.3%) and ventilation (5.4%). A variable specifies the year in which all works in the household were finalized. Apart from the national schemes, households also

used regional and local schemes that are only available in specific regions.[9] Given the low rate of adoption of regional aids in the survey data, we only analyze the performance of national schemes. The nationally available schemes on which the analysis focuses include the grant scheme by ANAH, adopted by 7.9% of the households who conducted retrofits, the VAT reduction to 5.5%, adopted by 41.2% of the households, the income tax credit (*Crédit d'Impôt à la Transition Énergétique*, CITE), adopted by 9.8% of households, and the White Certificates scheme, adopted by 7.8% of households. Households report the total amount of funding received, the amount invested into conservation works, and whether they observed a reduction of their energy expenses after conducting the works. In addition, households were asked what triggered the uptake of works. 27.5% of those who answer the question indicate it is the replacement of an equipment, 16.1% mention the funding opportunity, and 8.2% the DPE measure.[10] Other reasons are given that are not necessarily related to energy efficiency (see details in summary statistics in appendix A). Households were also asked what motivated the works. Of those who answered the question, respectively 45.4% and 13.6% replied that it was the reduction of energy expenses and environmental issues. Households were also asked if their work could be improved due to the financial support scheme. 22.6% of households answered that their works did not change. Of the 77.4% of households whose works changed, 56.6% could afford to have the work done by a professional, 25.0% could expand works. 24.0% of the households could afford to start the project and 22.0% said that their work benefitted from better quality.

To check the representativeness of the survey, we compare the proportion of each type of housing in the survey and in the French population, the income distribution, the number of persons living in the household as well as the share of home owners. In the survey sample, 65% of households live in individual houses, whereas the proportion is 57% for the French population (INSEE, 2017). According to TREMI, 64.7% of households in the survey are home owners, compared to 57.9% of the entire population INSEE (2017). The

[9] Regional schemes reported in the dataset include Picardie Pass renovation, Cheque Eco-énergie Normandie, Eco-chèque de la Région Midi-Pyrénées, Prêt bonifié RénovLR de la Région Languedoc-Roussillon, AREEP de la Région Pays de la Loire, ISOLARIS (Région Centre-Val de Loire) and SEM Artee (Région Nouvelle-Aquitaine).

[10] The DPE measures the energy consumption of a dwelling per m^2 and is calculated by either using information from previous energy bills or estimating the energy consumption based on dwelling characteristics, such as the type of heating, insolation etc. The DPE is established on guidelines by the EU, but the measure differs across member states.

distribution of the number of persons living in the households differs between TREMI and the French population (see detailed statistics in appendix A). The income distribution in the survey and the French population are comparable (see detailed statistics in appendix A).

4.2 Methodology

We use Inverse Probability Weighting (IPW) to account for self-selection into adoption of financial support schemes. IPW allows us to estimate the causal effect of the adoption of each scheme, on the reduction of energy expenses, private and total investment and funding received.

When treatment is not randomly assigned and self-selection bias is likely, the use of a quasi-experimental econometric technique is recommended. IPW is one of these quasi-experimental techniques pioneered by Robins and Rotnitzky (1995). This method has predominantly been used in epidemiology (Cole and Hernán, 2008; Mansournia and Altman, 2016; Liu et al., 2018), but is gaining acceptance in economics (Azoulay et al., 2009). IPW is related to matching techniques, invoking the conditional independence assumption that selection into treatment is based on observed characteristics and can be modelled as independent of confounders.

IPW makes use of the propensity score to compute weights based on the inverse probability of treatment, constructing a pseudo-population with equally large control and treated groups that are balanced on observables. Weights are constructed in a way that gives higher weights to observations in the control and treated groups which are most alike, and, therefore represent the most credible counterfactuals for one another: observations in the treated group with low probability to be treated are assigned large weights, as well as control observations with a high probability to be treated. The IPW method has virtues that make it a prudent alternative to matching methods. Unlike nearest-neighbor matching that restricts the sample to treated observations and one to few control observations each, IPW sustains the sample size and does not discard information. The IPW estimator has been found to perform best in finite sample applications in a variety of treatment effect estimators (Busso et al., 2014), though small sample properties are poor when propensity scores get close to zero or one (Glynn and Quinn, 2010).

In our survey data, self-selection of households into scheme adoption is likely. Households who use a scheme for conducting conservation works potentially differ in important characteristics from households who do not use a scheme. Our dataset offers a wide range of observed variables, covering household and housing characteristics, information on the conservation work conducted and other schemes used in parallel. Assuming conditional independence, we can model the probability of adopting a scheme based on observed variables. We specify the treatment model by including all variables that potentially affect the decision to adopt scheme A. We employ logit models to estimate four variants of the propensity score for household i to adopt scheme A:

$$logit(P(Scheme_A\ adoption = 1|H_i)) = \beta_0 + \beta_1 H_i \tag{1}$$

$$logit(P(Scheme_A\ adoption = 1|H_i, W_i)) = \beta_0 + \beta_1 H_i + \beta_2 W_i \tag{2}$$

$$logit(P(Scheme_A\ adoption = 1|H_i, W_i, N_i)) = \beta_0 + \beta_1 H_i + \beta_2 W_i + \beta_3 N_i \tag{3}$$

$$logit(P(Scheme_A\ adoption = 1|H_i, W_i, N_i, R_i)) = \beta_0 + \beta_1 H_i + \beta_2 W_i + \beta_3 N_i + \beta_4 R_i \tag{4}$$

where H is a vector of household and housing characteristics. W is a vector including dummies for each type of work conducted and the variable specifying the year when the works were finalized. N is a vector of dummies for national schemes adoption, and R is the same for regional and local schemes. We specify the variables included in each vector in appendix B.

The choice of variables in models (1) to (4) is guided by going from the most parsimonious specification with strictly exogenous variables to richer specifications that additionally include the types of work conducted and account for parallel scheme adoption. The basic specification (1) of the treatment model includes all important household and housing characteristics that can affect the decision of households to adopt scheme A. Specification (2) adds the motivation and trigger for conducting the works and dummies for the types of work conducted. Specifications (3) and (4) account for the choice portfolio of national, regional and local schemes adopted in parallel that potentially interact with the decision to adopt scheme A, adding dummies for national schemes in model (3) and adding dummies for national, regional and local schemes in model (4). We thereby test if the effect

of parallel scheme adoption is robust to different ways of controlling for it.

Using the resulting fitted values p_i from the estimation of the propensity score, we reweigh the observations in our sample using weights w_i defined as

$$w_i = \frac{T}{p_i} + \frac{1-T}{1-p_i}$$

with $T \in \{0,1\}$ indicating treatment status, so that for, $T = 1, w_i = \frac{1}{p_i}$ and, for $T = 0, w_i = \frac{1}{1-p_i}$. Outcomes are reweighted using corresponding weights to obtain the difference in means of reweighted outcomes, so that the treatment effect is

$$\begin{aligned}\beta_{IPW} &= n^{-1}\sum_{i=1}^{n} Y_i \frac{T_i}{p_i} - n^{-1}\sum_{i=1}^{n} Y_i \frac{(1-T_i)}{(1-p_i)} \\ &= n^{-1}\sum_{i=1}^{n}\left(Y_i \frac{T_i}{p_i} - Y_i \frac{(1-T_i)}{(1-p_i)}\right)\end{aligned}$$

where Y_i is the outcome for observation i.

An extension to the β_{IPW} estimator is the so-called double-robust estimator that adds a separate outcome model for both the treated and the control group (Robins et al., 1994). The double-robust estimator utilizes information of the covariates on the probability of treatment as in the simple β_{IPW} estimator, and in addition it employs predictive information on the outcome variables from the covariates (Glynn and Quinn, 2010). Taking advantage of both these features, the double-robust estimator is robust to incorrect specification of the propensity score model or the outcome model. If either one of the two models is correctly specified, the double-robust estimator is consistent (Scharfstein et al., 1999). The treatment model is correctly specified if the propensity score indicates the true probability of treatment given all confounders. And the outcome models are correctly specified if all relevant confounders are included as covariates in the regression. The double-robust IPW estimator is then:

$$\beta_{double-robust\ IPW} = \\ n^{-1}\sum_{i=1}^{n}\left(Y_i \frac{T_i}{p_i} - \frac{(T_i - p_i)}{p_i}\, m_1(x_i)\right) - n^{-1}\sum_{i=1}^{n}\left(Y_i \frac{(1-T_i)}{(1-p_i)} + \frac{(T_i - p_i)}{(1-p_i)}\, m_0(x_i)\right)$$

with $m_0(x_i) = Y(T = 0, X_i)$ and $m_1(x_i) = Y(T = 1, X_i)$. The outcome models m_0 and m_1 estimate predicted outcomes for the control and the treated group respectively. The adjustment terms added to each outcome model have two convenient properties. First, when propensity scores are correctly specified, the adjustment term has expectation 0 over the sum of observations i. Second, the adjustment term stabilizes the estimator when estimated propensity scores are close to 1 or 0, curing one undesirable property of the simple IPW estimator (Glynn and Quinn, 2010, for a formal proof).

We specify the outcome models to entail a comprehensive set of covariates controlling for household and housing characteristics, the types of work conducted and the national schemes used in parallel.[11] We define the outcome model for the treated m_0 and the outcome model for the controls m_1:

$$m_0(T = 0, H_i, W_i, N_i) = \alpha_1 + \alpha_2\ H_i + \alpha_3\ W_i + \alpha_4\ N_i + \epsilon_i$$
$$m_1(T = 1, H_i, W_i, N_i) = \alpha_1 + \alpha_2\ H_i + \alpha_3\ W_i + \alpha_4\ N_i + \epsilon_i$$

For each of the four outcome variables (funding received, the reduction in energy expenses, and private and total investment) the outcome models are estimated with each of the four treatment model specifications in the double-robust IPW estimator, resulting in four estimates for each outcome for each scheme. We bootstrap standard errors (using 50 repetitions) as recommended in the literature (Huber, 2013; Austin, 2016; Bodory et al., 2020).

5 Results and discussion

In Section 5.1, we present the estimation results of the impact of scheme adoption on the acquired funding, the private and total investment and the reduction of energy expenses. In Section 5.2, we use the estimates to construct and compute metrics of the cost-effectiveness, leverage effect for private investment, additionality and redistribution. This allows us to compare the schemes' performance along different dimensions and discuss the advantages and drawbacks of each of them.

[11] Household and housing characteristics include net income, profession, age, household size, region, agglomeration size, living space, construction date and ownership status. Work types include dummies for works on the floor, heating, roof, ventilation, windows and doors, walls and water, and the end year of works. Dummies for national scheme use include the grant, VAT reduction, income tax credit and White Certificates scheme.

5.1 Funding acquired, private and total investment, reduction of energy expenses

This section presents the estimation results of the impact of scheme adoption on the reduction of energy expenses, the private and total amount invested and the acquired funding. The use of the double-robust IPW estimator addresses potential endogeneity concerns and corrects the self-selection bias. For each scheme, the analysis compares households who conducted conservation works using funding from the scheme with households who did not use this scheme (controlling for potential use of other schemes).

Funding

We estimate the effect of adopting each scheme on the acquired funding. The acquired funding is defined as the amount of funding that household i receives from all adopted schemes in €. The treatment effect of scheme adoption on the amount of funding received is estimated in a separate regression for each scheme. In Table 1, we present a compiled overview of the estimations of the coefficient of interest for all regressions that we conducted (four specifications estimated for each of the four scheme types, as explained in section 4.2).[12]

The effect of adoption is positive and significant for all schemes and across all specifications. The effect of the grant scheme is between €2351.62 and €2788.72; in comparison with the three other schemes, it provides the largest amount of funding as it provides a full grant. Adoption of the income tax credit induces funding between €1013.97 and €1100.80, a lower amount than for the grant scheme. The amount of funding received from the income tax credit depends on the total amount invested as it determines the deductions from the taxable income and whether the marginal tax rate for the household is reduced due to the deduction. The VAT reduction and White Certificates scheme provide the smallest amounts of funding. The funding received from the White Certificates is between €765.40 and €998.67; most of the corresponding programs provide rather small grants, for instance, for small equipment. The coefficients for the VAT reduction imply that funding increases by €732.75 to €786.83; the funding received from the VAT

[12]Detailed regression results are available in the online appendix. We report examples of treatment model and outcome model estimations in appendix C. Due to the structure of the data, some models leave out a few of the explanatory variables in the treatment model or outcome model in order that the estimations converge.

Table 1: Impact of scheme adoption on funding

	(I)	(II)	(III)	(IV)
Direct grant	2788.724***	2572.218***	2511.413***	2351.620***
	(233.899)	(331.566)	(315.813)	(274.324)
N	7,188	6,739	6,739	6,739
VAT reduction	786.832***	750.443***	752.984***	732.746***
	(87.613)	(87.370)	(103.654)	(104.625)
N	7,188	6,573	6,739	6,739
Income tax credit	1100.803***	1026.882***	1017.373***	1013.967***
	(181.737)	(164.088)	(170.958)	(168.271)
N	7,188	6,739	6,739	6,739
White Certificates	998.665***	765.395***	765.395***	768.604***
	(148.205)	(201.129)	(206.454)	(216.857)
N	7,188	6,739	6,739	6,739

Note: The table provides a compiled overview of coefficients of interest for all conducted regressions. Bootstrapped standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

reduction is a direct percentage of total investment for this scheme.

Private investment

We estimate the treatment effect of adopting each scheme on private investment. This quantifies the increase in private investment induced by the scheme adoption. We apply a log transformation to the outcome variable private investment to take into account observations corresponding to very large investments in the sample. The estimated coefficients can then be interpreted as percentage increases in private investment due to scheme adoption. The treatment effect of each scheme is estimated in a separate regression. We compile the results and report them in Table 2.

The effect of adopting the VAT reduction and the income tax credit is positive and significant across all specifications. Adopting the VAT reduction increases private investment by between 34.7 and 37.7%.[13] The effect of the income tax credit is smaller; adopting this scheme induces between 20.2 and 22.6% of additional private investment. For the grant scheme and the White Certificates, the effect of adoption is not significant from zero across all specifications. This can be understood by the fact that neither of these two requires any own additional investment to be able to claim funding from both schemes,

[13] We use the common formula $\%\Delta = 100 * (e^{\beta_{IPW}} - 1)$ to interpret coefficients in percentage changes.

Table 2: Impact of scheme adoption on private investment

	(I)	(II)	(III)	(IV)
Direct grant	0.058	0.002	-0.013	-0.038
	(0.077)	(0.092)	(0.089)	(0.079)
N	7,139	6,698	6,698	6,698
VAT reduction	0.320***	0.301***	0.298***	0.299***
	(0.029)	(0.035)	(0.032)	(0.031)
N	7,139	6,698	6,698	6,698
Income tax credit	0.184***	0.195**	0.204**	0.199***
	(0.050)	(0.059)	(0.062)	(0.049)
N	7,139	6,698	6,698	6,698
White Certificates	0.142	0.096	0.107	0.111
	(0.078)	(0.092)	(0.084)	(0.083)
N	7,139	6,698	6,698	6,698

Note: The table provides a compiled overview of coefficients of interest for all conducted regressions. Bootstrapped standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

whereas the VAT reduction and the income tax credit require some private investment to be able to receive funding from these schemes.

Total investment

The total investment variable is the sum of the funding acquired and the additional private investment. We estimate the treatment effect of adopting each scheme on total investment. This estimation quantifies the impact of adoption on the combined increases in private investment and funding. While the impact on private investment informs about the leverage effect of the scheme to induce additional private investment, the effect on total investment indicates whether the scheme adoption increases the total amount invested or whether the funding induces a windfall gain to the recipient.

We apply a log transformation to the total investment variable to take into account observations corresponding to very large total investments in the sample. The estimated coefficients can then be interpreted as percentage increases in the total amount invested. The treatment effect of each scheme is estimated in a separate regression. We compile the results and report them in Table 3.

The effect of adoption on total investment is positive and significant for all schemes and robust across specifications. It is larger for the grant scheme and the VAT reduction,

Table 3: Impact of scheme adoption on total investment

	(I)	(II)	(III)	(IV)
Direct grant	0.423***	0.375***	0.353***	0.315***
	(0.065)	(0.068)	(0.075)	(0.069)
N	7,169	6,727	6,727	6,727
VAT reduction	0.421***	0.401***	0.398***	0.398***
	(0.028)	(0.026)	(0.025)	(0.027)
N	7,169	6,727	6,727	6,727
Income tax credit	0.311***	0.310***	0.319***	0.314***
	(0.049)	(0.047)	(0.049)	(0.048)
N	7,169	6,727	6,727	6,727
White Certificates	0.337***	0.268***	0.273***	0.275***
	(0.071)	(0.071)	(0.074)	(0.060)
N	7,169	6,727	6,727	6,727

Note: The table provides a compiled overview of coefficients of interest for all conducted regressions. Bootstrapped standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

and smaller for the income tax credit and the White Certificates scheme. Adopting the grant scheme increases total investment by 37.0 to 52.7%, a large increase since the grant scheme induces the largest amount of funding, but no private investment. Benefiting from the VAT reduction increases the total amount invested by 48.7 to 52.3%, also a large increase, as induced private investment is high and induced funding is moderate for the VAT reduction. Using the income tax credit increases total investment by between 36.3 and 37.6%, a moderate figure, as funding and private investment induced by the income tax credit are also moderate. The White Certificates program increases total investment by 30.7 to 40.1%. The moderate increase is in line with the moderate amounts of funding and the absence of induced private investment. None of the four schemes analyzed appears to induce pure windfall gains to recipient households as all schemes increase the total amount invested.

Reduction of energy expenses

We estimate the impact of adopting each scheme on the reduction of energy expenses. The treatment effect of each scheme is estimated in a separate regression. We compile the results and report them in Table 4. The effect of adoption is positive and significant for all schemes across all specifications.

Table 4: Impact of scheme adoption on the reduction of energy expenses

	(I)	(II)	(III)	(IV)
Direct grant	0.340***	0.328***	0.322***	0.299***
	(0.050)	(0.073)	(0.061)	(0.060)
N	6,187	5,791	5,791	5,791
VAT reduction	0.145***	0.104***	0.100***	0.102***
	(0.025)	(0.023)	(0.024)	(0.028)
N	6,187	5,791	5,791	5,791
Income tax credit	0.105*	0.103*	0.108*	0.109*
	(0.049)	(0.044)	(0.045)	(0.045)
N	6,187	5,791	5,791	5,791
White Certificates	0.241***	0.195***	0.195***	0.203***
	(0.039)	(0.039)	(0.050)	(0.047)
N	6,187	5,791	5,791	5,791

Note: The table provides a compiled overview of coefficients of interest for all conducted regressions. Bootstrapped standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

Coefficients for the grant scheme range between 0.299 and 0.340, corresponding to a reduction of energy expenses of between 0.32 and 0.36 standard deviations,[14] the highest reduction achieved by the analyzed schemes. Lower-income households that are targeted by the grant scheme tend to live in smaller housings so that the same investment may improve energy efficiency more than in larger housings. The coefficients for the White Certificates range between 0.195 and 0.241, corresponding to a reduction of expenses of 0.21 to 0.25 standard deviations, the second highest reduction. The VAT reduction and income tax credit induce smaller but still significant reductions in energy expenses. Coefficients associated with the VAT reduction are between 0.100 and 0.145, corresponding to a decrease in energy expenses by 0.11 to 0.15 standard deviations. Coefficients for the income tax credit range between 0.103 and 0.109, inducing a reduction in energy expenses by 0.11 to 0.12 standard deviations.

Our estimates indicate which schemes induce most funding, private and total investment as well as which schemes reduce energy expenses most. We can however not directly compare the performance of the schemes using these results. We need to account for the

[14]The reduction of energy expenses is a categorical variable that provides a qualitative measure of the monetary reduction of energy expenses. We express the effect of adoption in standard deviations of the reduction of energy expenses to faciliate the interpretation of the coefficients. In our sample, the standard deviation of the reduction of energy expenses is 0.946. The range in standard deviations is obtained by dividing the highest and lowest coefficient by the sample standard deviation and round them to two decimals: $\frac{0.299}{0.946} = 0.32$ and $\frac{0.340}{0.946} = 0.36$.

facts that the schemes involve different amounts of funding, that they induce different amounts of additional private investment and that they are adopted by different groups of households. For instance, the same reduction in energy expenses may be driven by a lower amount of funding for one scheme than for another, so that the cost-effectiveness differs widely. Also, additional private investment induced by each scheme should be related to the amount of funding provided by the scheme to be able to compare the leverage effect per unit of received funding. We hence construct four metrics by means of which we compare the schemes according to their cost-effectiveness, their leverage effect for private investment, the additionality of investment via the induced funding and the redistribution between higher- and lower-income households.

5.2 Cost-effectiveness, leverage effect, additionality and redistribution

We construct metrics of the cost-effectiveness of public funds, the ability of public funding to trigger additional private investment, the additionality of investment via the induced funding, and the redistribution involved by each scheme.

Cost-effectiveness of public funds

We define the cost-effectiveness Φ of public funds to reduce energy expenses under scheme A by normalizing the estimates for the reduction of energy expenses with the estimates for the funding acquired:

$$\Phi = \frac{\hat{\beta}_A^{\,energy\ expenses\ reduction}}{\hat{\beta}_A^{\,funding\ received}} * 10\,000$$

This allows us to compare the four schemes according to their relative capacity to reduce energy expenses per € of funding received. The larger the ratio, the more cost-effective the public funds are in promoting energy conservation. The computation results are presented in Table 5.

The reduction in energy expenses is most cost-effective via the White Certificates scheme: the average amount of funding received via this scheme is moderate, but the reduction in energy expenses is substantial. The VAT reduction and the grant scheme are found less cost-effective. While the grant scheme induces a high reduction in energy expenses, it also provides high amounts of funding. The reduction in energy expenses induced

Table 5: Cost-effectiveness of public funds

Scheme	Grant	VAT reduction	Income tax credit	White Certificates
$\hat{\beta}_A^{red.\ energy\ expenses}$	0.299 - 0.340	0.100 - 0.145	0.103 - 0.109	0.195 - 0.241
$\hat{\beta}_A^{funding\ received}$	2351.62 - 2788.72	732.75 - 786.83	1013.97 - 1100.80	765.40 - 998.67
Cost-effectiveness Φ	1.1 - 1.5	1.3 - 2.0	0.9 - 1.1	2.0 - 3.2

by the VAT reduction is moderate, but so is the amount of funding provided by this scheme. The income tax credit is least cost-effective; the relative reduction in energy expenses is lowest per € of funding as the reduction in energy expenses is moderate but the amount of funding provided is substantial. The different levels of cost-effectiveness could be partially due to differences in adoption groups.[15]

Leverage effect as ability to induce private investment

To know which scheme induces most additional private investment per € of funding, we divide the estimates for private investment by the estimates for the acquired funding. The larger this metric Λ, the more private investment the scheme A is able to induce per € of funding.

$$\Lambda_A = \frac{\hat{\beta}_A^{private\ investment}}{\hat{\beta}_A^{funding\ received}} * 10\,000$$

The results of our computations are presented in Table 6. We find that the leverage effect is the highest one for the VAT reduction. It induces most additional private investment per € of funding, as the average funding received is the lowest in comparison with the other schemes. The leverage effect for the income tax credit is lower, since this scheme only induces moderate amounts of additional private investment but higher funding. The grant and the White Certificates schemes do not induce significant amounts of additional private investment. Their leverage effect is 0.

Additionality of investment

We characterize additionality by the amount invested beyond what would have been invested without adoption of a given scheme. The metric we employ is the estimates of

[15] As Allcott et al. (2015b) note, energy efficiency subsidies are generally primarily taken up by consumers who are wealthier, homeowners and more informed about energy costs so that limiting the eligibility of subsidies to specific household groups can lead to large efficiency gains.

Table 6: Leverage effect for private investment

Scheme	Grant	VAT reduction	Income tax credit	White Certificates
$\hat{\beta}_A^{private\ investment}$	0	0.298 - 0.320	0.184 - 0.204	0
$\hat{\beta}_A^{funding\ received}$	2351.62 - 2788.72	732.75 - 786.83	1013.97 - 1100.80	765.40 - 998.67
Leverage effect Λ	0	3.8 - 4.4	1.7 - 2.0	0

the increase in total investment over the estimates of funding acquired for a scheme A as presented below. The larger this ratio Γ, the more capable the scheme is to induce additional investment for each € of funding:

$$\Gamma_A = \frac{\hat{\beta}_A^{total\ investment}}{\hat{\beta}_A^{funding\ received}} * 10\,000$$

The results of this computation are displayed in Table 7. Additional total investment per € of funding is the highest one for the VAT reduction: this scheme induces only moderate amounts of funding but induces the highest increase in total investment jointly with the grant scheme. The VAT reduction is followed by the income tax credit which induces a higher amount of funding and less additional total investment. The White Certificates scheme ranks third behind the income tax credit; additional total investment is lower but so is also the amount of funding received. The grant scheme induces least additional total investment per € of funding: Its adoption increases total investment substantially, but the scheme also induces the largest amount of funding.

Table 7: Additionality of investment

Scheme	Grant	VAT reduction	Income tax credit	White Certificates
$\hat{\beta}_A^{total\ investment}$	0.315 - 0.423	0.398 - 0.421	0.310 - 0.319	0.268 - 0.337
$\hat{\beta}_A^{funding\ received}$	2351.62 - 2788.72	732.75 - 786.83	1013.97 - 1100.80	765.40 - 998.67
Additionality Γ	1.1 - 1.8	5.1 - 5.7	2.8 - 3.1	2.0 - 2.7

Redistribution

Studies have found substantial heterogeneity in energy efficiency gaps across households so that schemes targeted at specific households (for instance, low-income households or

households who have not yet participated in another program) can potentially generate larger welfare gains than general schemes (Allcott and Greenstone, 2012). To assess whether the effect of the four schemes is heterogeneous across income groups, we compare the funding received and the reduction in energy expenses induced by each scheme for lower- and higher-income households separately. We analyze the redistribution of public money involved by the schemes by computing the redistribution metric Ψ that relates funding received by households in the lower half of the income distribution to funding received by households in the upper half of the income distribution. To compute the welfare impact of each scheme, we need to consider not only the funding received but also the reduction in energy expenses induced by the schemes by income groups. We first look at the funding received by income groups.

Using the double-robust IPW estimator as for the estimations on the whole sample in section 5.1, we estimate the effect of scheme adoption on funding received for the split samples of households with a net income below the median, €30,700, (lower-income households), and households with a net income equal or higher than €30,700 (higher-income households) for each of the four schemes.[16] The results for each of the subsamples of lower- and higher-income households are reported in Table 8. On average, the grant scheme and VAT reduction induce more funding to lower-income households than to higher-income households, while the income tax credit and the White Certificates scheme induce more funding to higher-income households. The absolute difference is largest for the grant scheme and smallest for the VAT reduction.

We define the redistribution metric as follows:

$$\Psi_A = \frac{\hat{\beta}_A^{funding\ to\ lower-income\ households}}{\hat{\beta}_A^{funding\ to\ higher-income\ households}}$$

If this ratio is equal to 1 for a scheme, lower-income households receive on average the same amount of funding via this scheme as higher-income households. If the ratio is greater than 1, the scheme provides on average more public money to lower-income households than to higher-income households. If the ratio is less than 1, the opposite is true. The results for the computation of Ψ are presented in the bottom line of Table 8. We find

[16] We use specification (I) which includes household and housing characteristics in the treatment model and household and housing characteristics, work types and national scheme dummies in the outcome model.

the grant scheme to redistribute public money most in favour of lower-income households, followed by the VAT reduction. The grant scheme provides on average 30% more funding to lower-income households, a substantial difference which is driven by the eligibility thresholds in income for this scheme, whereas the difference for the VAT reduction is only at 10% more funding for lower-income households. The income tax credit and the White Certificates scheme both transfer on average 10% less public money to the lower-income households than to the higher-income households.

Table 8: Redistribution to lower- and higher-income households

$\hat{\beta}$ *funding received*	Grant	VAT reduction	Income tax credit	White Certificates
Low-income households	2,971.082***	782.991***	1,003.623***	868.586**
< €30,700	(282.597)	(122.385)	(244.297)	(276.334)
N	3,231	3,221	3,221	3,212
High-income households	2,323.307***	715.785***	1,104.552***	989.570**
≥ €30,700	(621.619)	(107.391)	(184.116)	(293.891)
N	3,967	3,967	3,967	3,965
Redistribution Ψ	1.3	1.1	0.9	0.9

However, as the coefficients for lower- and higher-income households are not significantly different from each other, this means that Ψ is actually significantly different from 1 for neither of the four schemes.[17]

Additionally, we estimate the reduction in energy expenses induced by each scheme separately for the lower- and higher-income households (see Table 9).[18] We find that the reduction in energy expenses is higher in the lower-income households for each of the four schemes. We check the significance of the difference between lower- and higher-income households as we did for the coefficients on the funding received. Again, we find the difference between the coefficients to be statistically insignificant at conventional levels. We conclude that the average amount of funding received does not significantly differ

[17] We check the significance of the difference between lower- and higher-income households with a z-test for comparison of coefficients from different regressions using the formula $z = \frac{\beta_1 - \beta_2}{\sqrt{SE_1^2 + SE_2^2}}$ (Cohen et al., 2013) where β_1 and β_2 are the coefficients to be compared, and SE_1 and SE_2 are the corresponding standard errors. We find none of the differences to be statistically significant at conventional levels.

[18] We use specification (I), as we do for the split sample estimations on the funding received, which includes household and housing characteristics in the treatment model and household and housing characteristics, work types and national scheme dummies in the outcome model.

Table 9: Reduction in energy expenses in lower- and higher-income households

$\hat{\beta}$ *reduction in energy expenses*	Grant	VAT reduction	Income tax credit	White Certificates
Low-income households	0.349***	0.175***	0.109	0.277**
$<$ €30,700	(0.054)	(0.038)	(0.095)	(0.094)
N	2,808	2,808	2,808	2,792
High-income households	0.329***	0.129***	0.085	0.213**
$\geq$ €30,700	(0.073)	(0.033)	(0.068)	(0.078)
N	3,405	3,405	3,405	3,405

between lower- and higher-income households. All four schemes are neither progressive nor regressive in the sense that the welfare effect taking into account the funding received and the reduction in energy expenses does not differ significantly between income groups.

Trade-offs between schemes

The metrics we defined to characterize the cost-effectiveness, additionality, as well as the leverage and redistribution effects of each scheme are interdependent and trade-offs arise between these policy targets. Interactions between the metrics are mathematically given since the same figures are used as denominator in different metrics. No scheme is found to perform best along all dimensions. While the VAT reduction performs best in additionality and leverage, it ranks in the average in terms of cost-effectiveness. The White Certificates scheme achieves the highest cost-effectiveness, but it is average in terms of additionality and its leverage effect is 0. The income tax credit performs average for leverage and additionality, but it does poorly for cost-effectiveness. The grant scheme performs best in terms of redistribution to lower-income households but this effect is not statistically significant. It performs average for cost-effectiveness, but it does poorly in terms of leverage and additionality. Noticeably, none of the four schemes distributes significantly more funding to either lower- or higher-income households; and none can be classified as either progressive or regressive. In summary, the VAT reduction performs very well in two dimensions. The White Certificates and grant schemes perform well in one dimension and average in at least one other dimension. The income tax credit performs average or poorly in all dimensions.

6 Conclusion

The residential sector plays a pivotal part in efforts to reduce energy consumption and GHG emissions. At present, national governments offer a diverse spectrum of financial support schemes to encourage energy conservation works in the residential sector. Given the current public budget constraints, in particular following the COVID pandemic, the cost-effectiveness and the redistribution involved by these schemes need to be assessed.

To account for self-selection into adoption of financial support schemes and address potential endogeneity concerns, our analysis employs double-robust IPW estimators, a methodology that has mostly been used in epidemiology so far. We compare the performance of adoption of the four following types of financial support schemes available in France: a grant scheme, a VAT reduction, an income tax credit and the White Certificates scheme. We use the TREMI2017 survey data from the French Environment and Energy Agency (ADEME). The dataset covers close to 14,000 households and reports information on conservation work activities and financial support scheme adoption. We estimate the effect of scheme adoption on the reduction of energy expenses, the amount invested and the acquired funding and use these estimates to construct metrics of cost-effectiveness, additionality, redistribution and ability to trigger private investment.

We find that the VAT reduction has the highest leverage for private investment and achieves the highest increase in total investment; its cost-effectiveness is average compared to the other three schemes. The White Certificates scheme has the highest cost-effectiveness, and induces an average increase in total investment, but its leverage effect is 0. The income tax credit has the lowest cost-effectiveness, and induces an average leverage for private investment. It is also average for increasing total investment. The grant scheme is found to be average in terms of cost-effectiveness. It provides the lowest increase in total investment and its leverage effect for private investment is 0. The grant scheme performs best in terms of redistribution to lower-income households but this effect is not statistically significant. Concerning redistribution, none of the four schemes provides significantly more funding to either lower- or higher-income households. The reduction in energy expenses is balanced between different income groups so that no scheme can be classified as either progressive or regressive.

To conclude, trade-offs exist between the policy targets to consider when choosing which support scheme to develop. If cost-effectiveness is the priority for energy conservation policies, the White Certificates scheme should be favored, but its leverage effect for private investment and ability to increase total investment are low. If the aim is to trigger additional investment, the VAT reduction should be developed, but its cost-effectiveness is only average. If redistribution of public support to lower-income households is wished, no scheme is clearly superior. The income tax credit does a mediocre job for all four criteria.

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Appendix A.

Table 10: Summary statistics - Continuous variables

Variable	Unit	Observations	Mean	St. Dev.	Min.	Max.
Funding	€	12,776	726.46	2,516.92	0	50,000
Private Investment	€	12,250	10,063.74	20,557.12	0	799,451
Total Investment	€	12,250	10,789.93	21,141.84	50	799,451
Living space	m^2	13,730	114.62	68.62	9	700

Note: The number of observations differs for some variables due to the structure of the survey. It was not compulsory to answer the questions about received funding, investment and the size of the living space.

Table 11: Summary statistics - Dummy variables

Variable	Observations	Percentage positive answers
Ownership	13,804	25.7%
Work type		
Floor	13,804	22.2%
Heating	13,804	41.8%
Roof	13,804	42.3%
Ventilation	13,804	12.9%
Water	13,804	17.7%
Walls	13,804	44.3%
Windows & doors	13,804	53.5%
National schemes		
Grant	7,939	7.9%
VAT reduction	7,939	41.2%
Income tax credit	7,939	9.8%
White Certificates	7,939	7.8%
Regional and local schemes		
Local schemes	7,939	5.4%
Picardie-Pass	7,939	0.1%
Cheque Eco-energie Normandie	7,939	0.3%
Eco-Cheque Midi-Pyrenees	7,939	0.4%
RenovLR Languedoc-Roussillon	7,939	0.5%
SEM Artee	7,939	0.1%
AREEP Pays de la Loire	7,939	0.5%
Pret a taux zero ISOLARIS	7,939	0.2%
Motivation		
Reduction of energy expenses	11,800	45.4%
Accumulating wealth	11,800	28.7%
Warmer/cooler home	11,800	37.8%
Soundproof home	11,800	8.7%
Improved air quality	11,800	16.8%
Environmental concern	11,800	13.6%
Beautify dwelling	11,800	38.4%
Trigger		
Replacement of equipment	13,804	27.5%
Funding opportunity	13,804	16.1%

- Continued on next page -

Table 11 – continued from previous page

Variable	**Observations**	**Percentage positive answers**
DPE measured	13,804	8.2%
Other work done	13,804	17.5%
Inspired per peer group	13,804	8.3%
Life situation	13,804	14.6%
None of the above	13,804	19.7%

Note: The number of observations differs for some variables due to the structure of the survey. The questions about national, regional and local scheme adoption were asked to all households who finished conservation works in 2016, but only to one in five households who finished works in 2014 and 2015. The motivation for conducting works was only asked to households who indicated that they took the decision themselves, i.e. households who own the dwelling in which they live.

Table 12: Summary statistics - Reduction of energy expenses

Reduction of energy expenses	Significant reduction	A bit	Not so much	Not at all
% Obs.	32.22%	37.97%	20.53%	9.28%

Note: Question in the survey: "Have you observed a reduction of your energy expenses following the works you have conducted?" The answer to this question was not compulsory.

Table 13: Summary statistics - Net income

Net income	% Obs.
<€14,000	9.62%
€14,000 - 18,999	10.11%
€19,000 - 24,999	14.53%
€25,000 - 31,699	16.92%
€31,700 - 39,999	17.84%
€40,000 - 49,999	13.98%
€50,000 - 59,999	8.25%
€60,000 - 69,999	4.25%
≥ €70,000	4.51%

Table 14: Summary statistics - Age of reference person

Age	<25 years	25-34 years	35-49 years	50-65 years	>65 years
% Obs.	5.70%	15.83%	32.58%	33.65%	12.24%

Table 15: Summary statistics - Household size

Household size	1 person	2 persons	3 persons	≥ 4 persons
% Obs.	14.96%	37.18%	20.25%	27.62%

Table 16: Summary statistics - Agglomeration size

Agglomeration size	rural	2,000-20,000	20,000-100,000	>100,000	parisienne
% Obs.	21.57%	17.28%	14.71%	37.09%	9.35%

Table 17: Summary statistics - Housing type

Housing type	Individual house	Apartment	Other
% Obs.	71.57%	28.43%	0.33%

Table 18: Summary statistics - Construction date

Construction date	1948 or before	1949 -1974	1975 -1981	1982 -1989	1990 -2000	2001 -2011	2012 and after
% Obs.	21.02%	19.84%	16.26%	13.83%	12.39%	11.92%	4.72%

Table 19: Summary statistics - Profession of the reference person

Profession	% Obs.
Farmer, winemaker, forester, horticulturist, fish farmer, fisherman	0.71%
Craftsman, shopkeeper, entrepreneur, general manager	4.61%
Liberal profession	3.35%
Public service executive, professor (high school or university), scientific, intellectual or artistic profession	6.56%
Corporate executive	13.29%
Teaching (elementary school, secondary school, trainer...), healthcare	8.30%
Intermediary profession in commercial or administrative service of a company (banking customer service, technician)	4.59%
Technician, foreman, supervisor, team supervisor, site manager...	7.97%
Public service employee (category C and D staff, caregiver, firefighter, policeman...)	15.15%
Worker in the industrial, agricultural, building, transport, energy, crafts and entertainment sectors	9.11%
Unemployed	26.35%

Table 20: Summary statistics - Year when works were finished

Year	2014	2015	2016
% Obs.	6.37%	12.58%	81.05%

Table 21: Summary statistics - Region

Region	% Obs.
Alsace, Champagne-Ardenne,Lorraine	9.25%
Aquitaine, Limousin, Poitou-Charentes	9.66%
Auvergne, Rhône-Alpes	10.852%
Bourgogne, Franche-Comté	5.27%
Bretagne	6.43%
Centre	5.10%
I.D.F.	11.10%
Languedoc-Roussillon, Midi-Pyrénées	10.27%
Nord, Pas-de-Calais, Picardie	10.75%
Basse-Normandie, Haute-Normandie	5.78%
Pay de la Loire	6.85%
Provence-Alpes, Côte d'Azur	8.69%

Table 22: Representativeness - Income distribution

Percentile	INSEE 2015*	TREMI2017**
10%	€13,630	<€14,000
50%	30,040	€25,000-€31,699
90%	€63,210	€50,000-€59,999

Note: *Data source: INSEE-DGIF-Dnav-CCMSA, *Enquête Revenus fiscaux et sociaux 2015*. Disposable income includes the income declared to the tax administration (income from paid work, pensions, unemployment benefits and some property income), undeclared and imputed financial income, social benefits and the premium for employment, net of direct taxes (income tax, housing tax, generalized social contribution, contribution to the reduction of social debt, and social contributions on property income) (INSEE, 2015). **Question used in the TREMI2017 survey: In which of these ranges falls the net income of your household? Take into account all your household's sources of income: wages and salaries of all household 13^{th} members, month bonuses, family allowances, pensions, real estate income, investment income etc.).

Table 23: Representativeness - Number of persons in the household

Number of persons in household	INSEE 2016*	TREMI2017
1	35.8%	19.9%
2	32.7%	37.1%
3	13.9%	18.5%
4 and more	17.7%	34.6%

Note: Data source: INSEE, *Recensement de la population 2016*.

Appendix B.

Table 24: Treatment model specifications I to IV

Variable	I	II	III	IV
Household and housing characteristics				
Net income	x	x	x	x
Profession	x	x	x	x
Age	x	x	x	x
Household size	x	x	x	x
Region	x	x	x	x
Agglomeration size	x	x	x	x
Living space	x	x	x	x
Construction date	x	x	x	x
Ownership	x	x	x	x
Housing type	x	x	x	x
Trigger		x	x	x
Motivation		x	x	x
Work types				
Floor		x	x	x
Heating		x	x	x
Roof		x	x	x
Ventilation		x	x	x
Walls		x	x	x
Water		x	x	x
Windows & doors		x	x	x
End year of work		x	x	x
National schemes dummies				
Grant scheme			x	x
VAT reduction			x	x
Income tax credit			x	x
White Certificates			x	x
Regional and local schemes dummies				
Locals				x
Picardie-Pass				x
Cheque Eco-energie Normandie				x
Eco-Cheque Midi-Pyrenees				x
Pret bonifie RenovLR Languedoc-Roussillon				x
Tiers-financement et prets de la SEM Artee				x
AREEP Pays de la Loire				x
Pret a taux zero ISOLARIS				x

Appendix C.

Table 25: Treatment model I: Adoption of the grant scheme

	Coefficient	Robust Standard Error
Age		
Younger than 25	Ref. cat.	
25 to 34	-0.140	0.204
35 to 49	-0.439	0.200
50 to 64	-0.518	0.199
65 and older	-0.349	0.250
Household size		
1	Ref. cat.	
2	0.131	0.161
3	0.480	0.170
4 and more	0.739	0.164
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	-0.380	0.200
€19,000 to €24,999	-0.291	0.181
€25,000 to €31,699	-0.924	0.192
€31,700 to €39,999	-1.021	0.197
€40,000 to €49,999	-1.006	0.200
€50,000 to €59,999	-1.056	0.223
€60,000 to €69,999	-1.297	0.275
€70,000 and more	-1.197	0.258
Ownership	0.039	0.132
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	-0.543	0.434
Liberal profession	-0.103	0.439
Public service executive, professor etc.	-0.445	0.423
Corporate executive	-0.284	0.407
Teaching and healthcare	-0.427	0.415
Intermediary profession in company	-0.540	0.441
Technician, foreman, supervisor etc.	-0.552	0.422
Public service employee	-0.541	0.406
Worker in the private sector	-0.365	0.413
Unemployed	-0.691	0.410
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-0.186	0.208
Auvergne, Rhone-Alpes	0.126	0.189
Bourgogne, Franche-Comte	-0.025	0.245
Bretagne	-0.115	0.226
Centre	-0.345	0.263
Ile-de-France	0.298	0.340
Languedoc-Roussillon,		

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Table 25 – continued from previous page

	Coefficient	Robust Standard Error
Midi-Pyrenees	-0.131	0.193
Nord, Pas-de-Calais, Picardie	-0.076	0.197
Basse-Normandie, Haute-Normandie	-0.313	0.255
Pays de la Loire	-0.429	0.241
Provence-Alpes-Cote d'Azur	-0.339	0.218
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	0.241	0.150
20,000 to 100,000	0.322	0.159
more than 100,000	0.439	0.139
Ile-de-France	0.610	0.338
Housing type		
House	Ref. cat.	
Apartment	-0.014	0.135
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-0.027	0.146
1975 to 1981	0.037	0.151
1982 to 1989	0.099	0.153
1990 to 2000	0.044	0.156
2001 to 2011	0.092	0.154
2012 and later	0.230	0.207
Living space	0.000	0.001
Constant	-1.489	0.492

Note: N = 7,188

Table 26: Treatment model I: Adoption of the VAT reduction

	Coefficient	Robust Standard Error
Age		
Younger than 25	Ref. cat.	
25 to 34	0.493	0.175
35 to 49	0.596	0.168
50 to 64	0.786	0.165
65 and older	0.907	0.181
Household size		
1	Ref. cat.	
2	-0.141	0.090
3	-0.131	0.099
4 and more	-0.251	0.099
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	0.173	0.149
€19,000 to €24,999	0.190	0.138
€25,000 to €31,699	0.576	0.133
€31,700 to €39,999	0.649	0.134

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Table 26 – continued from previous page

	Coefficient	Robust Standard Error
€40,000 to €49,999	0.756	0.138
€50,000 to €59,999	0.818	0.148
€60,000 to €69,999	0.982	0.168
€70,000 and more	1.018	0.168
Ownership	-1.039	0.091
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	-0.108	0.321
Liberal profession	0.186	0.325
Public service executive, professor etc.	0.005	0.313
Corporate executive	0.321	0.308
Teaching and healthcare	0.048	0.311
Intermediary profession in company	0.083	0.322
Technician, foreman, supervisor etc.	0.185	0.312
Public service employee	-0.064	0.308
Worker in the private sector	0.077	0.312
Unemployed	0.104	0.306
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	0.017	0.114
Auvergne, Rhone-Alpes	-0.021	0.112
Bourgogne, Franche-Comte	0.085	0.134
Bretagne	0.032	0.123
Centre	-0.065	0.136
Ile-de-France	-0.447	0.212
Languedoc-Roussillon, Midi-Pyrenees	-0.330	0.112
Nord, Pas-de-Calais, Picardie	-0.338	0.113
Basse-Normandie, Haute-Normandie	-0.342	0.131
Pays de la Loire	-0.188	0.125
Provence-Alpes-Cote d'Azur	-0.192	0.123
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	0.008	0.078
20,000 to 100,000	0.075	0.084
more than 100,000	-0.095	0.074
Ile-de-France	0.058	0.221
Housing type		
House	Ref. cat.	
Apartment	0.023	0.084
Other	-1.858	1.069
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-0.040	0.080

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Table 26 – continued from previous page

	Coefficient	Robust Standard Error
1975 to 1981	0.049	0.082
1982 to 1989	0.109	0.086
1990 to 2000	-0.077	0.090
2001 to 2011	-0.261	0.092
2012 and later	-0.586	0.155
Living space	0.000	0.000
Constant	-1.148	0.371

Note: N = 7,188

Table 27: Treatment model I: Adoption of the income tax credit

	Coefficient	Robust Standard Error
Age		
Younger than 25	Ref. cat.	
25 to 34	0.530	0.280
35 to 49	0.470	0.272
50 to 64	0.266	0.273
65 and older	0.149	0.299
Household size		
1	Ref. cat.	
2	0.084	0.142
3	-0.251	0.164
4 and more	-0.325	0.160
Net income		
less than € 14,000	Ref. cat.	
€ 14,000 to € 18,999	-0.285	0.235
€ 19,000 to € 24,999	-0.153	0.211
€ 25,000 to € 31,699	-0.198	0.208
€ 31,700 to € 39,999	-0.030	0.204
€ 40,000 to € 49,999	-0.059	0.210
€ 50,000 to € 59,999	-0.158	0.228
€ 60,000 to € 69,999	-0.350	0.269
€ 70,000 and more	-0.095	0.258
Ownership	-1.089	0.173
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	-0.653	0.474
Liberal profession	-0.330	0.475
Public service executive, professor etc.	-0.095	0.447
Corporate executive	-0.109	0.436
Teaching and healthcare	-0.326	0.445
Intermediary profession in company	-0.079	0.460
Technician, foreman, supervisor etc.	-0.458	0.449
Public service employee	-0.294	0.437
Worker in the private sector	-0.542	0.453
Unemployed	-0.120	0.435
Region		
Alsace, Champagne-Ardenne,		

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Table 27 – continued from previous page

	Coefficient	Robust Standard Error
Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-0.352	0.188
Auvergne, Rhone-Alpes	0.056	0.170
Bourgogne, Franche-Comte	0.009	0.206
Bretagne	0.048	0.187
Centre	-0.226	0.216
Ile-de-France	0.132	0.302
Languedoc-Roussillon, Midi-Pyrenees	-0.303	0.180
Nord, Pas-de-Calais, Picardie	-0.026	0.172
Basse-Normandie, Haute-Normandie	-0.615	0.236
Pays de la Loire	-0.260	0.198
Provence-Alpes-Cote d'Azur	-0.184	0.196
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	-0.106	0.124
20,000 to 100,000	0.019	0.132
more than 100,000	-0.061	0.117
Ile-de-France	-0.324	0.322
Housing type		
House	Ref. cat.	
Apartment	-0.078	0.144
Other	-14.085	0.339
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	0.109	0.127
1975 to 1981	0.018	0.132
1982 to 1989	0.115	0.136
1990 to 2000	0.066	0.146
2001 to 2011	-0.402	0.162
2012 and later	-0.075	0.227
Living space	0.001	0.001
Constant	-1.928	0.542

Note: N = 7,188

Table 28: Treatment model I: Adoption of the White Certificates

	Coefficient	Robust Standard Error
Age		
Younger than 25	Ref. cat.	
25 to 34	-0.424	0.231
35 to 49	-0.617	0.220
50 to 64	-0.643	0.210
65 and older	-0.730	0.244
Household size		

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Table 28 – continued from previous page

	Coefficient	Robust Standard Error
1	Ref. cat.	
2	0.025	0.155
3	-0.068	0.173
4 and more	-0.085	0.168
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	-0.031	0.248
€19,000 to €24,999	-0.143	0.236
€25,000 to €31,699	0.046	0.226
€31,700 to €39,999	-0.094	0.229
€40,000 to €49,999	-0.183	0.238
€50,000 to €59,999	-0.180	0.254
€60,000 to €69,999	-0.012	0.279
€70,000 and more	0.132	0.278
Ownership	-0.522	0.160
Housing type		
House	Ref. cat.	
Apartment	-0.351	0.148
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	-0.695	0.504
Liberal profession	-0.170	0.496
Public service executive, professor etc.	-0.011	0.467
Corporate executive	-0.155	0.456
Teaching and healthcare	-0.034	0.465
Intermediary profession in company	-0.652	0.507
Technician, foreman, supervisor etc.	-0.274	0.469
Public service employee	-0.354	0.460
Worker in the private sector	-0.489	0.477
Unemployed	-0.289	0.455
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-0.291	0.193
Auvergne, Rhone-Alpes	-0.030	0.179
Bourgogne, Franche-Comte	-0.227	0.229
Bretagne	-0.130	0.205
Centre	-0.152	0.223
Ile-de-France	-0.200	0.342
Languedoc-Roussillon, Midi-Pyrenees	-0.548	0.197
Nord, Pas-de-Calais, Picardie	-0.061	0.179
Basse-Normandie, Haute-Normandie	-0.831	0.271
Pays de la Loire	-0.314	0.211
Provence-Alpes-Cote d'Azur	-0.777	0.237

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Table 28 – continued from previous page

	Coefficient	Robust Standard Error
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	0.081	0.138
20,000 to 100,000	0.115	0.146
more than 100,000	0.066	0.131
Ile-de-France	0.072	0.369
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	0.311	0.147
1975 to 1981	0.550	0.144
1982 to 1989	0.547	0.148
1990 to 2000	0.021	0.173
2001 to 2011	-0.009	0.172
2012 and later	0.058	0.247
Living space	0.001	0.001
Constant	-1.581	0.562

Note: N = 7,188

Table 29: Outcome model: Results on funding received via the grant scheme

	Coefficient	Robust Standard Error
OME0		
Work		
Floor	355.615	89.728
Heating	127.390	59.089
Roof	470.062	49.964
Ventilation	189.144	111.274
Walls	238.780	50.200
Water	274.686	90.235
Windows & doors	414.520	49.012
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-172.994	119.546
Auvergne, Rhone-Alpes	71.445	136.246
Bourgogne, Franche-Comte	197.632	147.925
Bretagne	-169.659	118.68
Centre	-2.299	162.918
Ile-de-France	-5.324	230.844
Languedoc-Roussillon, Midi-Pyrenees	44.849	127.012
Nord, Pas-de-Calais, Picardie	-79.501	0.134.353
Basse-Normandie, Haute-Normandie	24.632	137.956
Pays de la Loire	-148.100	125.996
Provence-Alpes-Cote d'Azur	38.206	174.000

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Table 29 – continued from previous page

	Coefficient	Robust Standard Error
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	-70.752	79.889
20,000 to 100,000	45.721	96.602
more than 100,000	25.330	96.034
Ile-de-France	59.106	258.668
Ownership	-83.383	73.164
Housing type		
House	Ref. cat.	
Apartment	-439.867	64.341
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-45.080	78.082
1975 to 1981	31.447	84.013
1982 to 1989	96.007	99.878
1990 to 2000	166.709	121.634
2001 to 2011	174.219	96.278
2012 and later	206.385	198.371
Net income		
less than € 14,000	Ref. cat.	
€ 14,000 to € 18,999	268.310	137.162
€ 19,000 to € 24,999	147.280	136.958
€ 25,000 to € 31,699	3.767	111.403
€ 31,700 to € 39,999	-33.617	112.087
€ 40,000 to € 49,999	66.337	128.031
€ 50,000 to € 59,999	248.670	146.139
€ 60,000 to € 69,999	189.187	180.445
€ 70,000 and more	547.793	272.657
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	155.121	350.341
Liberal profession	326.696	414.722
Public service executive, professor etc.	-156.606	343.256
Corporate executive	196.506	343.264
Teaching and healthcare	-155.574	322.215
Intermediary profession in company	-32.384	347.009
Technician, foreman, supervisor etc.	-81.256	326.444
Public service employee	-157.474	322.201
Worker in the private sector	101.976	328.578
Unemployed	-81.800	318.876
Age		
Younger than 25	Ref. cat.	
25 to 34	-283.058	309.092
35 to 49	-370.619	306.382
50 to 64	-362.902	286.769
65 and older	-313.876	266.128
Household size		
1	Ref. cat.	

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Table 29 – continued from previous page

	Coefficient	Robust Standard Error
2	-70.706	71.113
3	30.375	94.096
4 and more	-1.061	107.941
VAT reduction	777.459	60.868
Income tax credit	1091.875	138.499
White Certificates	985.136	177.495
Constant	-96.365	401.510
OME1		
Work		
Floor	1652.477	665.241
Heating	1559.165	477.821
Roof	1182.051	431.328
Ventilation	2334.198	791.748
Walls	976.755	481.994
Water	723.613	625.947
Windows & doors	832.504	536.796
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-2560.585	1267.995
Auvergne, Rhone-Alpes	175.971	1431.954
Bourgogne, Franche-Comte	2489.166	1798.518
Bretagne	516.559	1609.062
Centre	-1472.500	1590.862
Ile-de-France	1849.988	1776.96
Languedoc-Roussillon, Midi-Pyrenees	-1317.497	1237.378
Nord, Pas-de-Calais, Picardie	-802.163	1323.468
Basse-Normandie, Haute-Normandie	729.115	1388.366
Pays de la Loire	450.827	1438.329
Provence-Alpes-Cote d'Azur	-278.993	1497.312
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	583.057	922.875
20,000 to 100,000	1233.925	954.222
more than 100,000	-479.315	791.417
Ile-de-France	-3558.654	1733.367
Ownership	-241.088	639.704
Housing type		
House	Ref. cat.	
Apartment	-1921.588	648.494
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-275.008	776.917
1975 to 1981	-813.521	826.355

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Table 29 – continued from previous page

	Coefficient	Robust Standard Error
1982 to 1989	-1490.352	919.0507
1990 to 2000	-1637.587	986.222
2001 to 2011	-1475.698	1181.374
2012 and later	1197.748	1917.347
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	401.143	941.969
€19,000 to €24,999	-109.206	893.441
€25,000 to €31,699	-575.839	1003.01
€31,700 to €39,999	-652.339	923.373
€40,000 to €49,999	-545.122	1094.336
€50,000 to €59,999	61.267	1164.21
€60,000 to €69,999	-2388.154	1197.586
€70,000 and more	1613.04	2304.099
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	125.196	2059.859
Liberal profession	1257.537	2265.56
Public service executive	1464.329	2254.9
Corporate executive	2494.98	2004.942
Teaching and healthcare	1874.194	2188.914
Intermediary profession in company	2293.270	2134.621
Technician, foreman, supervisor etc.	2432.155	2105.015
Public service employee	1132.77	1923.567
Worker in the private sector	612.732	2006.327
Unemployed	469.215	1961.523
Age		
Younger than 25	Ref. cat.	
25 to 34	885.255	1003.033
35 to 49	1951.443	1027.212
50 to 64	1790.582	1077.725
65 and older	2092.114	1311.433
Household size		
1	Ref. cat.	
2	707.814	784.015
3	1620.118	887.905
4 and more	555.0318	799.089
VAT reduction	303.528	667.999
Income tax credit	-606.062	919.480
White Certificates	1838.927	1213.807
Constant	-1560.425	2692.933

Table 30: Outcome model: Results on funding received via the VAT reduction

	Coefficient	Robust Standard Error
OME0		
Work		

- Continued on next page -

Table 30 – continued from previous page

	Coefficient	Robust Standard Error
Floor	444.724	143.518
Heating	172.812	109.155
Roof	356.256	79.208
Ventilation	666.761	203.943
Walls	254.293	78.674
Water	292.704	145.215
Windows & doors	346.375	86.694
year-work-end	199.037	87.846
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-559.446	269.180
Auvergne, Rhone-Alpes	-327.420	297.728
Bourgogne, Franche-Comte	286.151	421.504
Bretagne	-236.846	286.112
Centre	-436.319	294.546
Ile-de-France	-261.029	457.013
Languedoc-Roussillon, Midi-Pyrenees	-263.595	300.926
Nord, Pas-de-Calais, Picardie	-205.465	289.000
Basse-Normandie, Haute-Normandie	-34.057	278.062
Pays de la Loire	-178.031	279.323
Provence-Alpes-Cote d'Azur	-300.308	308.380
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	49.567	135.148
20,000 to 100,000	221.176	155.279
more than 100,000	-9.815	136.434
Ile-de-France	-47.855	442.447
Ownership	-73.676	96.290
Housing type		
House	Ref. cat.	
Apartment	-382.498	122.399
Living space	2.487	1.893
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	12.126	112.179
1975 to 1981	47.666	142.739
1982 to 1989	15.133	168.533
1990 to 2000	125.515	203.182
2001 to 2011	167.185	197.334
2012 and later	-35.945	320.094
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	368.089	193.427

- Continued on next page -

Table 30 – continued from previous page

	Coefficient	Robust Standard Error
€19,000 to €24,999	79.769	178.619
€25,000 to €30,699	-91.152	167.521
€31,700 to €39,999	-149.615	170.965
€40,000 to €49,999	112.810	203.921
€50,000 to €59,999	291.189	248.263
€60,000 to €69,999	-192.491	245.266
€70,000 and more	446.636	499.816
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	419.608	558.173
Liberal profession	871.608	702.386
Public service executive	71.326	520.223
Corporate executive	599.174	525.591
Teaching and healthcare	119.925	500.074
Intermediary profession in company	130.370	509.251
Technician, foreman, supervisor etc.	254.057	529.708
Public service employee	146.670	503.462
Worker in the private sector	299.771	512.015
Unemployed	220.973	503.618
Age		
Younger than 25	Ref. cat.	
25 to 34	-184.544	340.048
35 to 49	-31.454	339.416
50 to 64	25.199	326.885
65 and older	73.847	312.698
Household size		
1	Ref. cat.	
2	-71.439	102.162
3	138.946	166.492
4 and more	-65.355	165.055
Grant	3729.471	340.896
Income tax credit	1380.756	196.103
White Certificates	1791.493	337.740
Constant	-1449.002	688.130
OME1		
Work		
Floor	511.119	185.228
Heating	348.710	113.264
Roof	656.577	126.259
Ventilation	47.625	273.650
Walls	379.044	103.953
Water	173.232	191.325
Windows & doors	802.327	102.399
year-work-end	-25.352	213.463
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin,		

- Continued on next page -

Table 30 – continued from previous page

	Coefficient	Robust Standard Error
Poitou-Charentes	-224.193	187.650
Auvergne, Rhone-Alpes	419.247	244.457
Bourgogne, Franche-Comte	476.939	249.454
Bretagne	-21.751	221.563
Centre	159.545	252.910
Ile-de-France	451.863	397.658
Languedoc-Roussillon, Midi-Pyrenees	83.609	273.680
Nord, Pas-de-Calais, Picardie	-230.309	189.223
Basse-Normandie, Haute-Normandie	143.252	263.428
Pays de la Loire	323.736	542.047
Provence-Alpes-Cote d'Azur	510.421	312.133
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	-28.539	170.825
20,000 to 100,000	386.297	209.487
more than 100,000	171.495	236.015
Ile-de-France	-372.194	435.647
Ownership	218.537	277.314
Housing type		
House	Ref. cat.	
Apartment	-671.599	274.365
Living space	6.539	2.335
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-65.227	184.198
1975 to 1981	-149.600	173.779
1982 to 1989	-116.426	178.878
1990 to 2000	13.231	226.825
2001 to 2011	186.918	183.465
2012 and later	1592.564	824.769
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	-952.847	678.369
€19,000 to €24,999	-985.336	717.386
€25,000 to €30,699	-1031.183	667.742
€31,700 to €39,999	-1042.471	662.862
€40,000 to €49,999	-1059.418	660.48
€50,000 to €59,999	-830.204	637.148
€60,000 to €69,999	-693.872	649.695
€70,000 and more	-638.784	710.851
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	-173.982	523.902
Liberal profession	-282.235	524.643
Public service executive	143.335	532.293

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Table 30 – continued from previous page

	Coefficient	Robust Standard Error
Corporate executive	102.769	493.319
Teaching and healthcare	-96.399	495.852
Intermediary profession in company	671.750	634.532
Technician, foreman, supervisor etc.	247.760	500.044
Public service employee	206.654	499.337
Worker in the private sector	392.231	555.249
Unemployed	-13.656	485.867
Age		
Younger than 25	Ref. cat.	
25 to 34	1626.885	671.881
35 to 49	1429.854	553.974
50 to 64	1276.059	565.585
65 and older	1326.843	622.470
Household size		
1	Ref. cat.	
2	88.366	207.028
3	378.220	316.843
4 and more	36.108	232.719
Grant	4230.477	860.954
Income tax credit	742.944	189.823
White Certificates	188.424	220.862
Constant	-1621.337	1042.122

Table 31: Outcome model: Results on funding received via the income tax credit

	Coefficient	Robust Standard Error
OME0		
Work		
Floor	452.396	105.541
Heating	218.171	71.666
Roof	486.107	57.630
Ventilation	441.671	147.116
Walls	255.463	58.769
Water	321.212	113.185
Windows & doors	431.233	60.620
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-382.249	148.114
Auvergne, Rhone-Alpes	106.095	186.513
Bourgogne, Franche-Comte	326.869	225.551
Bretagne	-26.888	174.402
Centre	-73.392	188.764
Ile-de-France	167.564	327.921
Languedoc-Roussillon, Midi-Pyrenees	-52.104	170.957

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Table 31 – continued from previous page

	Coefficient	Robust Standard Error
Nord, Pas-de-Calais, Picardie	-134.110	169.919
Basse-Normandie, Haute-Normandie	105.563	184.385
Pays de la Loire	-63.231	172.236
Provence-Alpes-Cote d'Azur	70.310	211.102
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	22.724	105.395
20,000 to 100,000	175.482	128.565
more than 100,000	-52.661	111.702
Ile-de-France	-209.077	350.304
Ownership	-61.350	91.289
Housing type		
House	Ref. cat.	
Apartment	-600.660	90.818
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-68.169	92.745
1975 to 1981	-49.316	103.878
1982 to 1989	-91.499	124.390
1990 to 2000	-2.643	136.493
2001 to 2011	67.165	130.415
2012 and later	27.615	244.510
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	136.961	180.536
€19,000 to €24,999	-65.831	161.294
€25,000 to €30,699	-135.243	162.624
€31,700 to €39,999	-184.987	163.878
€40,000 to €49,999	-52.587	181.319
€50,000 to €59,999	93.045	204.052
€60,000 to €69,999	-25.472	205.061
€70,000 and more	637.937	343.985
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	10.280	514.148
Liberal profession	313.754	559.624
Public service executive	44.435	520.832
Corporate executive	222.690	505.578
Teaching and healthcare	-124.022	490.905
Intermediary profession in company	33.446	511.633
Technician, foreman, supervisor etc.	14.638	498.929
Public service employee	-83.001	490.052
Worker in the private sector	139.449	496.658
Unemployed	-27.129	489.658
Age		
Younger than 25	Ref. cat.	

- Continued on next page -

Table 31 – continued from previous page

	Coefficient	Robust Standard Error
25 to 34	0.121	0.165
35 to 49	-0.126	0.159
50 to 64	-0.267	0.158
65 and older	-0.304	0.178
Household size		
1	Ref. cat.	
2	-40.462	90.487
3	158.570	120.142
4 and more	-6.496	113.299
Grant	3525.345	288.549
VAT reduction	821.353	76.481
White Certificates	1255.613	218.369
Constant	-436.182	522.437
OME1		
Work		
Floor	248.999	481.223
Heating	591.710	314.136
Roof	841.501	259.291
Ventilation	449.040	395.744
Walls	444.633	272.934
Water	-555.282	272.897
Windows & doors	745.731	285.303
year-work-end	0.127	0.074
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	465.775	512.258
Auvergne, Rhone-Alpes	748.238	386.539
Bourgogne, Franche-Comte	1183.933	693.339
Bretagne	-25.577	387.012
Centre	-114.797	623.506
Ile-de-France	-4.370	803.216
Languedoc-Roussillon, Midi-Pyrenees	176.152	478.098
Nord, Pas-de-Calais, Picardie	579.854	773.247
Basse-Normandie, Haute-Normandie	-433.115	495.770
Pays de la Loire	-313.376	450.114
Provence-Alpes-Cote d'Azur	258.933	462.793
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	-547.265	343.178
20,000 to 100,000	-101.483	402.744
more than 100,000	20.754	432.465
Ile-de-France	-993.860	840.046
Ownership	-1055.274	437.751

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Table 31 – continued from previous page

	Coefficient	Robust Standard Error
Housing type		
House	Ref. cat.	
Apartment	-532.143	295.179
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-430.002	440.672
1975 to 1981	-287.353	456.892
1982 to 1989	-92.266	453.372
1990 to 2000	-610.582	488.615
2001 to 2011	-238.822	606.106
2012 and later	400.538	1075.043
Net income		
less than €14,000	Ref. cat.	
€14,000 to €18,999	234.298	542.427
€19,000 to €24,999	372.622	696.280
€25,000 to €30,699	-427.470	478.855
€31,700 to €39,999	-320.340	512.826
€40,000 to €49,999	-238.023	519.632
€50,000 to €59,999	401.597	614.411
€60,000 to €69,999	-288.761	842.721
€70,000 and more	356.977	866.460
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	0.110	0.477
Liberal profession	-0.762	0.560
Public service executive	-0.213	0.390
Corporate executive	0.246	0.388
Teaching and healthcare	-0.109	0.409
Intermediary profession in company	0.366	0.413
Technician, foreman, supervisor etc.	-0.027	0.487
Public service employee	-0.257	0.362
Worker in the private sector	0.006	0.374
Unemployed	-0.121	0.364
Age		
Younger than 25	Ref. cat.	
25 to 34	0.183	0.429
35 to 49	0.368	0.421
50 to 64	0.713	0.400
65 and older	0.912	0.413
Household size		
1	Ref. cat.	
2	417.049	305.806
3	272.724	356.057
4 and more	295.581	478.625
Grant	2998.26	671.745
VAT reduction	250.149	250.304
White Certificates	-116.361	278.975
Constant	536.552	790.714

Table 32: Outcome model: Results on funding received via the White Certificates

	Coefficient	Robust Standard Error
OME0		
Work		
Floor	332.064	102.702
Heating	275.737	67.310
Roof	461.960	59.393
Ventilation	500.493	142.087
Walls	269.420	56.765
Water	116.417	97.009
Windows & doors	453.656	57.318
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin, Poitou-Charentes	-190.562	130.096
Auvergne, Rhone-Alpes	252.180	162.114
Bourgogne, Franche-Comte	550.346	221.237
Bretagne	130.230	156.239
Centre	149.437	178.606
Ile-de-France	98.424	272.406
Languedoc-Roussillon, Midi-Pyrenees	36.551	141.574
Nord, Pas-de-Calais, Picardie	-4.554	157.582
Basse-Normandie, Haute-Normandie	266.583	164.011
Pays de la Loire	136.302	152.228
Provence-Alpes-Cote d'Azur	229.773	187.254
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	4.662	101.297
20,000 to 100,000	181.347	120.277
more than 100,000	12.583	109.582
Ile-de-France	-56.814	288.385
Ownership	-36.160	91.047
Housing type		
House	Ref. cat.	
Apartment	-553.755	85.654
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	-173.529	93.343
1975 to 1981	-62.672	109.952
1982 to 1989	-73.185	121.514
1990 to 2000	-127.862	119.961
2001 to 2011	54.485	132.927
2012 and later	6.830	251.644
Net income		
less than €14,000	Ref. cat.	

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Table 32 – continued from previous page

	Coefficient	Robust Standard Error
€14,000 to €18,999	175.429	173.373
€19,000 to €24,999	23.809	168.122
€25,000 to €30,699	-110.219	154.774
€31,700 to €39,999	-161.994	158.412
€40,000 to €49,999	-57.324	171.566
€50,000 to €59,999	127.695	196.096
€60,000 to €69,999	52.719	209.924
€70,000 and more	560.614	314.550
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	142.547	477.208
Liberal profession	-72.937	475.611
Public service executive	173.798	484.597
Corporate executive	453.377	475.747
Teaching and healthcare	87.700	456.066
Intermediary profession in company	206.550	476.284
Technician, foreman, supervisor etc.	222.734	465.234
Public service employee	99.218	455.653
Worker in the private sector	236.362	462.549
Unemployed	152.360	455.743
Age		
Younger than 25	Ref. cat.	
25 to 34	197.464	263.357
35 to 49	205.217	257.952
50 to 64	214.410	242.187
65 and older	247.924	233.695
Household size		
1	Ref. cat.	
2	-2.738	86.251
3	183.738	115.132
4 and more	88.055	120.704
VAT reduction	4.992	0.063
Income tax credit	1290.492	151.380
Grant	3522.494	279.680
Constant	-998.343	531.589
OME1		
Work		
Floor	1507.922	418.517
Heating	144.163	281.358
Roof	951.156	253.765
Ventilation	60.354	388.042
Walls	4.529	258.239
Water	994.885	374.266
Windows & doors	572.381	252.866
Region		
Alsace, Champagne-Ardenne, Lorraine	Ref. cat.	
Aquitaine, Limousin,		

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Table 32 – continued from previous page

	Coefficient	Robust Standard Error
Poitou-Charentes	-1276.901	749.830
Auvergne, Rhone-Alpes	-976.132	748.561
Bourgogne, Franche-Comte	-672.402	691.439
Bretagne	-1878.965	765.085
Centre	-1733.444	726.006
Ile-de-France	98.516	1309.688
Languedoc-Roussillon, Midi-Pyrenees	-165.113	895.746
Nord, Pas-de-Calais, Picardie	-894.106	738.744
Basse-Normandie, Haute-Normandie	-1014.820	715.467
Pays de la Loire	-1984.084	777.074
Provence-Alpes-Cote d'Azur	-1592.316	749.720
Agglomeration size		
Rural	Ref. cat.	
2,000 to 20,000	-439.398	372.986
20,000 to 100,000	396.677	477.208
more than 100,000	-430.642	338.968
Ile-de-France	-1634.225	1235.023
Ownership	-278.669	459.096
Housing type		
House	Ref. cat.	
Apartment	-1137.637	477.681
Construction date		
1948 and earlier	Ref. cat.	
1949 to 1974	906.963	412.676
1975 to 1981	170.422	293.726
1982 to 1989	71.819	323.282
1990 to 2000	754.588	544.480
2001 to 2011	241.393	536.299
2012 and later	2202.474	1184.576
Net income		
less than € 14,000	Ref. cat.	
€ 14,000 to € 18,999	-1.184	654.447
€ 19,000 to € 24,999	-477.489	550.726
€ 25,000 to € 30,699	250.886	665.134
€ 31,700 to € 39,999	231.205	616.879
€ 40,000 to € 49,999	572.302	688.094
€ 50,000 to € 59,999	851.994	679.259
€ 60,000 to € 69,999	18.545	741.512
€ 70,000 and more	1374.824	1167.81
Profession		
Agriculture and fishery	Ref. cat.	
Craftsman, shopkeeper, entrepreneur etc.	1803.363	1217.614
Liberal profession	3295.445	2018.292
Public service executive	107.088	1156.314
Corporate executive	325.282	1144.322

- Continued on next page -

Table 32 – continued from previous page

	Coefficient	**Robust Standard Error**
Teaching and healthcare	-164.208	1155.599
Intermediary profession in company	1529.546	1380.204
Technician, foreman, supervisor etc.	-43.543	1141.483
Public service employee	-266.915	1091.555
Worker in the private sector	562.289	1104.183
Unemployed	-226.142	1096.329
Age		
Younger than 25	Ref. cat.	
25 to 34	-957.886	988.527
35 to 49	168.581	1057.527
50 to 64	-37.896	1053.045
65 and older	-2.544	1042.877
Household size		
1	Ref. cat.	
2	-652.561	515.524
3	-303.130	517.765
4 and more	-1037.078	591.394
VAT reduction	-15.025	258.705
Income tax credit	78.746	300.790
Grant	4110.803	843.236
Constant	1610.061	1553.741

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