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Summary

This econometric study assesses the efficiency of the income tax credit system implemented in France in 2005 on households' retrofitting investment decisions, focusing on insulation measures. A logit model with random individual effects is estimated using an unbalanced panel of 23,879 households surveyed over the period 2002-2011. An estimation in difference is performed to identify the impact of the policy. The tax credit had no significant effect during the first two years, suggesting a latency period related to inertia in households' investment decisions, possibly due to the complexity of the tax credit scheme. The tax credit had an increasing, significant positive effect from 2007 to 2010, before slightly decreasing in 2011. This is in line with changes in the tax credit rates, suggesting a correlation with the level of subsidy. Defined as the situation in which the subsidized household would have invested even in the absence of the subsidy, free-riding progressively decreased over the period and was lower for insulation of opaque surfaces (roofs, walls, etc.) than for insulation of windows. The estimated average proportion of free-riders varies between 40% and 85% after 2006. Finally, we assess the potential bias caused by time-varying unobservable variables and conclude that our estimates of the impacts of the policy are conservative.

Keywords: Energy Conservation, Residential Sector, Thermal Insulation, Tax Credit, Free-Riding, Difference Estimation, Panel Data, France

JEL Classification: Q48, R22, D12

Results and interpretations based on the ADEME TNS-SOFRES «Maitrise de l'énergie» survey, are those of the author and do not reflect the opinion of ADEME or TNS-SOFRES. I wish to thank Philippe Quirion, Laurent Meunier, Amélie Mauroux, François-Charles Wolff and Nicolas Jacquemet for helpful discussions and comments.

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Marie-Laure Nauleau[1]

CIRED

Abstract

This econometric study assesses the efficiency of the income tax credit system implemented in France in 2005 on households' retrofitting investment decisions, focusing on insulation measures. A logit model with random individual effects is estimated using an unbalanced panel of 23,879 households surveyed over the period 2002-2011. An estimation in difference is performed to identify the impact of the policy. The tax credit had no significant effect during the first two years, suggesting a latency period related to inertia in households' investment decisions, possibly due to the complexity of the tax credit scheme. The tax credit had an increasing, significant positive effect from 2007 to 2010, before slightly decreasing in 2011. This is in line with changes in the tax credit rates, suggesting a correlation with the level of subsidy. Defined as the situation in which the subsidized household would have invested even in the absence of the subsidy, free-riding progressively decreased over the period and was lower for insulation of opaque surfaces (roofs, walls, etc.) than for insulation of windows. The estimated average proportion of free-riders varies between 40% and 85% after 2006. Finally, we assess the potential bias caused by time-varying unobservable variables and conclude that our estimates of the impacts of the policy are conservative.

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1. Introduction

In the current context of climate change and given the weight of the residential sector in industrialized countries' energy end use and CO_2 emissions, the promotion of energy efficiency investments in the existing building stock is a major issue in climate policy. This sector is all the more targeted as it is considered as one of the sectors having the highest energy savings potential (Levine & al. 2007), although this potential has been questioned (Allcott & Greenstone 2012). Consequently, in a lot of countries, incentives such as income tax credits have been implemented to encourage households to invest in energy-efficient retrofitting in their dwellings. In some countries the first wave of tax credit implementation occurred in the 1970's, in the post oil-crisis period, and led to a first group of empirical studies, mainly dealing with the US tax credit system from 1977 to 1986.

Among all the barriers faced by households willing to retrofit their dwellings, reviewed notably by Jakob (2007), market imperfections, called "investment inefficiencies" by Allcott and Greenstone (2012), may provide justification for such instruments as tax credits. These market failures mainly refer to imperfect information and may cause households not to undertake privately profitable investments in energy efficiency. Moreover, in the case of negative externalities related to fossil fuels and political difficulties in implementing first-best solutions such as pigouvian taxes, energy efficiency policies might be a reasonable second-best substitute (Allcott & Greenstone 2012). These policies can also address behavioral failures, even if they are imperfect when consumers are heterogeneous (Gillingham & Palmer 2013).

Ideally in public economics, we should assess such policies with regard to social welfare, in the framework of a cost-benefit analysis taking into account all the significant direct and indirect effects of the policy on the economy and society. Empirical papers in fact tend to adopt a cost-effectiveness perspective due to the limitations of empirical "cost-benefit analysis, which is as difficult as it is ambitious" (Ientile & Mairesse 2009).

In order to do this, we first have to assess to what extent households respond to the policy. There is no consensus in the literature, in particular regarding studies of the first US tax credit scheme: results differ depending on data and methodology. Dubin and Henson (1988) studied the scheme for the 1979 tax year, using fiscal data aggregated by Internal Revenue Service (IRS) district and audit class. They assessed the tax credit's effects on both the probability of declaring energy conservation investment and the amount of expenditure. They found no significant incentive effects (1988), neither did Walsh (1989) using micro data from the 1982 Residential Energy Consumption Survey, nor Cameron (1985) using a nested logit model. On the other hand, using micro panel data covering 1979/1981, Hassett and Metcalf (1995) found a significant positive incentive effect of the tax credit on the likelihood of performing energy-efficiency improvements. However, they could not assess free-riding[2], which is defined as behavior occurring "when the agents targeted by the policy take the incentives but would have made the investment anyway" (Alberini & al. 2013).

Free-riding has to be taken into account to avoid overstating a policy's efficiency in terms of additional energy savings. Moreover, free-riding leads to a net social cost in the presence of administrative costs (to attract, to monitor, etc.). Public revenues could have been allocated to other expenditure and subsidies may cause price distortions and have anti-redistributive effects. To our knowledge, Joskow and Marron were the first to discuss free-riding in the literature related to domestic energy conservation. They conducted a meta-analysis by reviewing evaluations of demand-side management (DSM) programs implemented by U.S. utilities (1992), in which estimates of free-riding varied between 4% and 55%. Recent literature studying subsidies implemented to trigger domestic energy efficiency investment has focused on the assessment of free-riding. Using a discrete choice model on German cross-section data, Grösche and Vance (2009) designated potential free-riders as those whose estimated marginal willingness to pay for a particular retrofit option is higher than the observed investment cost without subsidy, and found a proportion of free-riding approaching 50%. Using the same database, Grösche, Schmidt, and Vance (2013) applied a more flexible discrete choice model to generate predicted choice probabilities for each retrofitting option. They found that, as the size of the subsidy increases, the share of program funds allocated to free-riders decreases even as the overall cost of the program increases. Alberini & al. (2013) studied the effects of an Italian tax credit implemented in 2007. Taking into account geographical heterogeneity, they found

[2] "Free-riding" might not be the most appropriate term. We could prefer "windfall gains" in order not to emphasize households' "intention to free-ride" but we will use "free-riding" as this expression is the one commonly used in the related literature.

that the tax credit made the rate of window replacement increase by 37 to 40 percent in sufficiently cold climates. They also found that free-riding seems to be more important in the case of heating system replacement than window replacement. A possible explanation is that heating system replacement only happens when the old equipment breaks down beyond repair[3]. Finally, Mauroux (2012) studied the French tax credit, called CIDD[4], implemented in 2005 in order to trigger households' investment in energy conservation and renewable energy equipment in their dwellings. Using fiscal data over the period 2006/2008, she analyzed the effect of the 2006 reform which increased the CIDD rate from 25% to 40% for investments in old buildings after a recent housing transfer. Her results suggested the presence of significant free-riding in respect of households' decisions to apply for the subsidy in the case of a marginal increase in the tax credit rate. However, she was unable to observe non-subsidized retrofitting investments and therefore could not determine the effect of CIDD on the whole of energy-efficiency retrofitting investments.

In this paper, we assess the same French income tax credit (CIDD) as Mauroux (2012). The originality of our approach is that it first assesses the impact of the introduction of CIDD on energy-saving investments on the extensive margin at the time of its introduction in 2005. The extensive margin corresponds to the number of retrofitting investments that were actually triggered by the implementation of CIDD, in other words the effect of CIDD on the probability of retrofitting. Second, the paper assesses how the effect of CIDD evolved over the period 2005/2011. Third, those estimations enable us to assess the proportion of free-riders. Since action-based estimates are more reliable than reviews of declarations (Malm 1996), we use an unbalanced panel of individual data coming from the "Energy Management" (EM) annual survey conducted over the period 2002/2011 and dedicated to households' energy-efficiency investments in their dwellings. This study is focused on insulation measures (windows, walls, roofs, etc.)[5]. In terms of econometric methodology, we use a quasi-natural experiment relying on time and policy-design change. In the absence of a control group, we use a difference estimator, as in (Alberini & al. 2013). We take care to avoid ascribing to CIDD effects that are due to exogenous unobserved time-varying variables. We

[3] Their free-riding assessment was not complete as data did not provide the share of subsidized households.
[4] *Crédit d'Impôt Développement Durable* in French, for Sustainable Development Tax Credit.
[5] Information on other retrofitting investments, such as efficient heating systems and equipment producing renewable energy, is too scanty to introduce them in the analysis, as discussed in section 3.

conduct a test for pre-trends over the period 2002/2004 and control for factors likely to affect energy-efficiency renovations. We include individual effects to control for unobserved time-constant variables and discuss the effect of path dependency on households' retrofitting investment decisions.

Our results suggest a significant and positive effect of CIDD on the investment decision but with a period of latency during the first two or three years depending on the category of retrofitting. Then, estimated average marginal effects of CIDD progressively increase, especially from 2009, before slightly decreasing at the end of the period. These changes are in line with the changes in the tax credit rates and related to other mechanisms such as inertia in the investment decision-making process. As regards the assessment of free-riding, the estimated shares of free-riders among CIDD beneficiaries vary between 40% and 85% in years for which the effect of CIDD was significant. This is in the range of values present in the literature and shows that free-riding is an important phenomenon. Free-riding is found to be lower for measures relating to opaque surface insulation than for glazed surface insulation and was found to have decreased gradually over the period.

In section 2 we first review the French context and describe the tax credit scheme being studied. Section 3 describes the data and the variables selected in the model, then it presents some descriptive statistics. Econometric methods are explained in section 4. Section 5 presents the results. Those are discussed in section 6, before concluding in section 7.

2. Description of the French context and tax credit scheme[6].

France is committed to reducing its greenhouse gas emissions by 75% by 2050 compared to the 1990 level, and to improving final energy intensity by 2% a year from 2015 onwards (French Climate Plan and Energy Program Act of 13 July 2005 which established France's energy policy priorities). The residential sector consumed 30% of the total French energy supply in 2011 (in final energy)[7], essentially for heating and hot water. The French policy package called "Grenelle de l'Environnement" (voted in 2009) aims at cutting energy consumption in the existing building stock by at least 38% by 2020 compared to the 2008

[6] This review of the French tax credit scheme is based on information from several Official Tax Bulletin publications (BO n°147, September 2005; BO n°183, May 2006; BO n°88, July 2007; BO n°38, April 2009; BO n°65, June 2009; BO n°77, August 2010; BO n°84, December 2011) and public reports or publications (Mauroux et al. 2010), (Pelletier 2011), (Mauroux 2012).
[7] Source: "Le bilan énergétique de la France en 2011" http://www.developpement-durable.gouv.fr/IMG/pdf/LPS130.pdf

level and fixed targets of 400,000 retrofitted dwellings per year from 2013 and retrofitting 800,000 of the least energy-efficient dwellings in the social housing stock by 2020.

The French tax credit scheme CIDD started in 2005[8]. Tax credit was initially implemented between 2005 and 2009 and then extended until 2015. It could possibly continue beyond this date. The purchase of energy efficient equipment and materials for main dwellings[9] is eligible for income tax credits, with rates ranging from 15 to 50% of investment cost. Eligible investments include both energy conservation measures and renewable energy systems. As for conservation, it applies to insulation, for both opaque surfaces and windows/shutters, and to heating system improvements, such as heating regulation systems (mainly including thermostatic valves and programming equipment) and efficient systems (condensation boilers, heat-pumps). Renewable energy production refers to wood-heating appliances, photovoltaic panels, solar heaters and domestic wind turbines. Tax credit subsidy is capped at 8,000€ for a one-person dwelling, 16,000 € for a two-person dwelling (with an additional allowance per child) for a period of 5 consecutive years.

Renewable energy production systems (including heat pumps) are eligible for all types of building, whereas insulation measures are only eligible for buildings more than two years old. Tax credit rates are specific to each category of retrofitting and are based on energy performance criteria. Table 1 gives details for tax credit rate changes. Within each category, rates have changed over time and can be specific to certain households' situations. Changes in the tax credit rates, as well as in energy performance eligibility criteria, have resulted from a compromise between the aim of targeting the most energy-efficient systems, the desire to limit public expenditure and lobbying from the supply side[10]. As regards opaque surfaces in particular, while the tax credit base only subsidized material costs from 2005, it has included labor costs (installation expenditure) in the tax credit base since 2009[11]. Finally, an overall cut of 10% in the tax credit

[8] Earlier legislation allowing fiscal deductions already existed (since 2001 for thermal insulation material) but did not specifically target energy efficiency renovations and its scope was not comparable with that of CIDD: public expenses were around ten times lower (http://www4.minefi.gouv.fr/budget/plf2004/somble04.htm), due to lower level of subsidies and a lower proportion of beneficiaries, especially for insulation measures (according to households' declarations in the EM survey).

[9] The Tax Credit had only subsidized owner-occupiers and tenants but in 2009 it was extended to landlords renting their dwellings.

[10] Heat-pumps are a good example: air-air heat-pumps were only eligible between 2006 and 2008 whereas thermodynamic heat-pumps for water heating started to be eligible in 2010.

[11] Labor cost has always been excluded for other retrofitting categories.

occurred in 2011, due to the economic crisis and concerns about public deficit. These successive modifications could have increased households' uncertainty.

According to statistics from the "Energy Management" (EM)[12] survey on households' intentions to apply for the available economic incentives[13], French households have benefited from CIDD far more than from other contemporary instruments[14]. Since 2005, more than half of the households investing each year in retrofitting have used the CIDD, this proportion having reached nearly 70% since 2007, whereas less than 7 % of them used other subsidies over the same period. Moreover, according to the same survey, CIDD is widely known (56.9% of households were aware of it in 2005, steadily increasing to 85.2% in 2009) and has been considered by households as the most decisive incentive since 2006 (see **Figure 1**). Due to its success, CIDD has led to large public expenditure: 985 M€ in 2005, 1.9 Bn€ in 2006, 2.2 Bn€ in 2007, 2.8 Bn€ in 2008, 2.6 Bn€ in 2009, 1.96 Bn€ in 2010 and 1.1 Bn€ in 2011[15].

After the implementation of CIDD, other economic instruments were created. An interest-free loan (known as EcoPTZ), which could be cumulated with CIDD for the same investment (except in 2011), started in 2009 but has been used much less than CIDD[16]. A total of 70,933 EcoPTZ were issued in 2009 (resp. 78,484 in 2010 and 40,755 in 2011), while by contrast, more than 1 million households have benefited from CIDD every year since 2006. Statistics based on the EM survey show that EcoPTZ has never been perceived as a key incentive, contrary to CIDD (see **Figure 1**). Finally, in the case of insulation measures, EcoPTZ has benefited households much less than CIDD: the proportion of investors intending to apply for CIDD was 49.1% and 84.5% for opaque and glazed surface insulation respectively whereas the proportion of investors intending to apply for EcoPTZ was 3.1% and 3.3% for opaque and glazed surface insulation respectively.

[Insert **Table 1**]

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[12] The Energy Management survey provides the data for this study and will be described in section 3.1.

[13] In this paper, households' declared intentions to apply for the different economic incentives are used to determine the proportion of corresponding beneficiaries, which means assuming that the proportion of applicants who would not be subsidized is negligible.

[14] Available subsidies include regional or local subsidies, national subsidies delivered by the ANAH (National Housing Agency), for which the modalities can vary with income, retrofitting performance, etc.

[15] Data from the Public Finances general Directorate (DGFiP). Public expenses (in million €) for opaque and glazed insulation were estimated at 518 in 2005, 741 in 2006, 948 in 2007, 811 in 2008, 902 in 2009, 417 in 2010 and 363 in 2011 mainly for windows (CGDD 2012).

[16] This has been mainly due to the reluctance of the banking sector to propose such loans (Pelletier 2011). Eligibility criteria have also been tightened.

[Insert **Figure 1**]

3. Data

3.1. Dataset description

The data used in this paper come from the annual "Energy Management" (EM) survey supervised by the French Agency for Environment and Energy Management (ADEME) and conducted by the French market research institute TNS-Sofres. It provides detailed information on the retrofitting decision process, retrofit options, the characteristics of households and dwellings, and on the subsidies they received. We use data collected from 2002 to 2011[17]. We consider an unbalanced panel[18]: over the period 2002/2011, 23,879 households were surveyed with an average turnover rate between two successive years of 49%. Households were observed for 2.4 years on average, with 40.5% of the sample observed only once. The number of annual observations goes from 6,148 households in 2005, to 8,498 in 2009. Every year, households are asked about their residential energy consumption and the investments they have or have not made, in order to improve the energy efficiency of their dwelling. A first questionnaire provides data on socio-economic variables, housing information (type of building, heating energy source, building date, etc.), and information about dweller's situation (occupation status, move-in date). Those who have invested in retrofitting during the last year (7-12% each year) answer a second questionnaire to provide information on retrofitting categories, investment costs, means of payment, the economic or non-economic incentives investors have benefited from (including tax credit), as well as other pieces of qualitative information such as their motivation, personal context, satisfaction, etc. In this second questionnaire, each investment is described by 1 to 4 items taken from a retrofitting options list. Retrofitting options include insulation (external insulation of walls, internal insulation of walls, roof, attic, ceiling, windows, shutters), heating system improvement (thermostatic valves, heat cost allocators, ambient thermostat, programming

[17] The survey has been conducted since 2000 but we restricted the sample to the period 2002/2011 for the econometrics because some explanatory variables such as Individual Preferences are unavailable for 2000 and 2001.

[18] Annual recruitment is carried out by TNS-Sofres to ensure representation of all socio-economic profiles after the departure of households wishing to leave the survey. Attrition will be discussed in section 5.

equipment), new heating system (radiator, boiler, wood stove, heat-pump, solar heater) or heating system replacement (with information on fuel switching).

3.2. Selection of variables

In order to estimate the effect of CIDD on the investment decision on the extensive margin, the dependent variable is the *retrofitting investment decision*, equal to one if the respondent has invested in retrofitting during the past year. We have restricted our analysis to opaque (roofs, indoor walls, outdoor walls, ceilings, floors) and glazed (windows, doors, shutters) surface insulation measures. Indeed, for different reasons, the data are inappropriate to deal with other retrofitting measures: *heating systems*, *heating regulation or ventilation systems*, and *equipment producing renewable energy.* As for the category *"heating system installation or replacement",* it is too aggregated to be studied with respect to the impact of CIDD. We do not observe the energy performance of each system, on which CIDD eligibility is based[19]. Unlike heating systems, we assume that available information is sufficient to consider insulation measures without leading to significant measurement bias since the non-eligibility of the material based on technical criteria is a minor reason for subsidies being refused[20]. As for *heating regulation* and *ventilation systems*, the sample size cannot provide robust statistics given their low retrofitting rates. *Equipment producing renewable energy* is excluded from the analysis since the EM survey does not mention these systems in the list of retrofitting options before the introduction of CIDD[21]. Finally, we chose to keep "undeclared works" (carried out by an unregistered professional) or "DiY works" (carried out by the household) in the studied subsample, even though only retrofits made by a registered professional can be subsidized. Indeed, aside from the fact this is the major reason for receiving no subsidy in the case of insulation of opaque surfaces[22], the households' choice between having work carried out by a declared professional, an undeclared one or themselves is endogenous to CIDD and excluding some alternatives from the choice set would bias the

[19] Moreover, in the case of modification of the heating energy source, the old energy heating source is not reported.

[20] On the basis of households' declarations reported in the EM survey, 26 % of households who retrofitted to insulate and did not benefit from CIDD declared that is was due to non-eligibility (in the case of window replacement or in the case of minor retrofits which are not substitutes for true energy efficiency investments) whereas 60% of those who retrofitted to replace their boiler and did not benefit from CIDD declared that is was due to non-eligibility.

[21] Except for wood stoves which have been observed since 2000 but the annual installation rates are too low to provide robust statistics given our sample size.

[22] On the basis of households' declarations reported in the EM survey, 75% of households who invested in opaque insulation and did not benefit from CIDD declared that is was due to DiY or undeclared works (as opposed to 18% in the case of boiler replacement).

results[23].

The explanatory variables are selected on the basis of the abundant literature on household investment modeling in residential energy, which provides guidance on the main drivers and barriers to consider (Jakob 2007). The basics of those models consist of calculating the return on retrofitting investment by comparing initial cost with future economic savings in a cost-benefit analysis, in which technological, socio-economic and contextual constraints can interact.

The **socio-demographic variables** influencing the investment decision in the model are the *Annual income of the household,* the *Socio-professional category,* the *Family size* and the *Age of the head of the household.* The *Annual income of the household* reflects the households' financial status and theiropportunity cost of time[24]. This variable can also reflect the households' discount rate, included in each profitability calculation. Indeed, several studies have shown that the discount rate decreases with income (Train 1985). Besides, this variable can reflect the impacts of the overall economic variations on individual situations. Given the life cycle theory, the *Age of the head of the household* or the *Family size* may reflect the financial and situational constraints of the dwelling. Distinguishing between a *Business* category (in a wide sense including *company directors, farmers* and *shopkeepers*), *Professionals* (including *liberal professionals* and *executive managers), Employees* and the *Inactive,* the *Socio-professional category* captures aspects linked to education and the opportunity cost of time. We use the *status of occupation (rental or ownership),* which is a key variable to characterize the important barrier linked to the split incentives between tenants and owners. In the econometrics model, we restrict the analysis to homeowners. Indeed, the question in the EM survey about retrofitting investment is ambiguous in the case of tenants since it is not clear what answer a tenant of a dwelling in which retrofitting has been undertaken by the owners should give, which can lead to potential measurement bias. Moreover, even if tenants were potentially concerned by the program, statistics show that CIDD has only impacted home-owners. The *move-in-date* (the duration since the last move) is also included as a recent change in occupancy can indicate a likely time to retrofit (Gans 2012).

[23] Data were however inappropriate to explicitly estimate this first sequence in the decision making.
[24] Since the information collection and implementation phases of a retrofitting project are time-consuming.

In order to capture changes in **individual preferences** about the environment and the economic context, possibly linked to either macroeconomic or social changes, we also include data on households' main concerns. In the EM survey, households are asked every year to rank, in order of importance, their concerns about environmental (e.g. pollution, climate change, renewable energy…) and economic issues (unemployment). *Environmental concern* and *Economic concern* are included as dummy variables equal to one if the household has identified pollution, and, respectively, unemployment, as one of the main concerns.

The *Building completion date,* the *Building type,* the *Dwelling size (surface area* in square meters) and the *Heating energy sources* are the **home characteristics** variables included in the model to describe the energy performance and the level of energy consumption, conditioning the profitability of the investment. The *Building type* variable, which differentiates between individual houses and collective flats, also characterizes the potential barriers raised by a collective decision-making process. Translating energy savings into economic gains, changes in energy prices can also impact the investment decision. We include the average *heating energy price* determined on the basis of the main energy source declared by each household (electricity, gas, fuel, wood, district heating and a mix between electricity and wood) [25][26]. Dwellings heated by wood and district heating have been omitted from the sample in the econometrics estimation since energy prices have only been available since 2003 for these two energy sources.

The *Heating degree days (HDD)* and the *Location Category* are used to represent the **climatic and spatial characteristics of the dwelling.** The regional *HDD* variable, taken from an external data source[27], influences the energy performance of a retrofitting investment, as the energy needs vary according to the outside temperature. The *Location Category*, allows for the differentiation between urban and rural regions, and captures aspects such as storage space availability or the supply-side structure of the residential energy

[25] From statistics produced by the French Ministry of Ecology. http://www.statistiques.developpement-durable.gouv.fr/energie-climat/r/industrie-1.html?tx_ttnews[tt_news]=21083&cHash=fb5b458ff78e44f761db201e5f4a2641.

[26] Even if the EM survey provides data on households' energy bills, we chose not to use it due to the number of missing values and the fact that we do not know if the reported energy bills correspond to the pre or post-retrofitting period for households who retrofitted during the previous year.

[27] From statistics produced by the French Ministry of Ecology. http://www.statistiques.developpement-durable.gouv.fr/energie-climat/r/statistiques-regionales.html?tx_ttnews. Heating degree day (HDD) is a measurement based on the gap between outside temperatures and a comfortable inside temperature. The heating requirements for a given structure at a specific location are considered to be directly proportional to the number of HDD.

efficiency market. Finally, the probability of investing in retrofitting is impacted by former retrofitting investments. We deal with dynamic aspects in the retrofitting investment decision including the *Former retrofitting* variable. Since 2004, households have been asked about their former retrofitting projects which reveals whether households did not undertake such investment because insulation measures had already been taken. This variable is only used in robustness checks as it compels us to omit 2002 and 2003. However, since the implementation of the dynamic panel data model is impossible due to the unbalanced nature of the panel and the short time that people stay in it, this last estimation allows us to identify any potential bias due to neglecting this time dependency in former estimations.

3.3. Descriptive statistics

In order to contextualize the results, **Figure 2** shows retrofitting rates in the main dwellings among all homeowners for all the main retrofitting categories. Retrofitting categories are here accounted for separately, even if the same households have undertaken several measures belonging to different categories. As for *the installation or replacement of standard heating systems with non-renewable energy*, we do not observe any trend. This suggests that CIDD would only potentially impact the decision to invest at the intensive margin (leading to choose more energy-efficient equipment), since the retrofitting rate seems unresponsive to the introduction of CIDD. Unfortunately, as we indicated in section 3.2, this cannot be properly measured as the data do not provide the precise energy performance characteristics of each system. No increasing trend appears for heating regulation/ventilation systems either. We cannot say anything for *equipment producing renewable energy* as the series start in 2005. An exception could be *wood stove installation or replacement (*observed since 2000), whose retrofitting rate seems to slightly increase after 2005 but statistical tests cannot be performed due to the lowness of rates and our limited sample size.

Focusing on insulation measures, **Figure 2** shows investment rates separately for opaque and glazed surface insulation[28]. Investment rates for both insulation types follow similar changes, which indicate some correlations between these retrofitting measures and the necessity to study them all together. We do not see any particular trend for either before 2005. After 2005, we see a slight increase until 2008, especially for glazed surface insulation, then a peak in 2009 and a decline thereafter. This suggests that there was a differentiated effect during two sub-periods of the implementation of CIDD's: 2005/2008 and 2009/2011.

[Insert **Figure 2**]

We pooled all opaque surface insulation measures into one category in order to ensure the statistical validity of the test. Indeed, as shown in **Table 2**, which gives the results of a Pearson's chi-squared test for each insulation measure, the power values prevent us from testing the equality between the investment rates during the pre (2001-2004) and post (2005-2011) CIDD periods for each insulation measure separately (except for roofs), and even more so at the annual level. The power values for the category "all insulation" and "all opaque surface insulation" are respectively 4,686 and 3,998, which are in the range of values of the

[28] We use "window" with an extensive meaning of all glazed surfaces.

annual subsample sizes on which the econometrics estimations are based. The equality of the detailed opaque surface investment rates (null hypothesis) is then rejected for both opaque surface insulation and window insulation.

[Insert **Table 2**]

Table 3 presents the summary statistics of the households' socio- economic variables and dwellings characteristics computed on different subsamples to better assess the effects of CIDD on energy efficiency investments. These are: i) the full sample 2001-2011, ii) the 2001-2004 subsample (before the introduction of CIDD), iii) the 2005-2011 subsample (the CIDD period), iv) the 2005-2011 CIDD-aware subsample (only households aware of CIDD), v) the 2005-2011 retrofitting subsample (only households having invested in opaque or glazed surface insulation), and vi) the 2005-2011 subsidized retrofitting subsample (only dwellers who invested in opaque surface insulation and intended to benefit from CIDD). Lower-income households are under-represented among investors and CIDD beneficiaries, as the lowest income bracket represents 33.7% of the 2005-2011 subsample, 24.3% of the households having invested in insulation and 21.4% of the CIDD beneficiaries. Older households are over-represented among CIDD beneficiaries as they represent 63% of this subsample whereas they represent 53.7% of the 2005-2011 subsample and 55.1% of the households having invested. In the same way, owners dominate the CIDD beneficiaries as they comprise 96.8% of this subsample whereas they represent 64% of the 2005-2011 subsample and 90.3% of the households having invested. Environmental concern was higher between 2001 and 2004 than during the 2005-2011 period (54.8% of the households' top priority was the environment in 2001/2004, 51.5% in 2005/2011). Conversely, economic concern increased during the 2001-2011 period (unemployment was the top priority of 58.2% and 63.3% of the households during the 2001-2004 and 2005-2011 periods respectively). Annual national surveys in fact indicate that the environmental concern of French households started to decline after 2008, while employment was becoming the main concern, probably as a side-effect of the economic crisis.

As regards *Building characteristics*, older buildings are over-represented in the retrofitting and subsidized retrofitting subsamples, especially those built in the 1949/1974 period. Collective flats are relatively under-represented in the retrofitting subsamples. The sample also contains more individual houses during the 2005/2011 period. Dwellings heated by fuel are over-represented in the retrofitting subsamples whereas those heated by electricity and district heating are under-represented. This can be related to correlation between dwelling types and energy sources since electricity and district heating are mostly used in collective flats. The share of dwellings heated by fuel decreases between 2001/2004 and 2005/2011. Heating energy prices increase between 2001/2004 and 2005/2011, especially fuel, then gas prices. Households living in rural areas invested more in energy efficiency than those in urban areas but benefited less from CIDD: they represent 24.9%, 34.1% and 29.7% of 2005/2011datasets, investors and CIDD beneficiaries respectively. This might be due to the fact that rural dwellers have more ability to retrofit by themselves than urban dwellers. The average heating degree days (HDD) is greater in the two retrofitting subsamples than in the total sample, meaning that households invest more in retrofitting in colder regions.

These statistics are in accordance with other empirical studies, providing confidence in our database.

[Insert **Table 3**]

4. Econometric strategy.

4.1. The difference estimation.

Let $\hat{\Delta}$ be the difference estimator:

$$\hat{\Delta} = \overline{I_{it}^{CIDD_{it}=1}} - \overline{I_{it}^{CIDD_{it}=0}} \quad (1)$$

with I_{it} the dependent variable, i.e. the *retrofitting investment decision*, $\overline{I_{it}^{CIDD_{it}=1}}$ and $\overline{I_{it}^{CIDD_{it}=0}}$ the empirical mean of I_{it} respectively before and after the implementation of CIDD,. Let $CIDD_{it}$ be a dummy variable equal to one after the implementation of CIDD and zero before. $\hat{\Delta}$ captures the average effect on the dependent variable of the introduction of CIDD. It is identified by the marginal effect of $CIDD_{it}$ on I_{it} and is unbiased if all unobserved explanatory variables are constant over time (Crépon & Jacquemet 2010). The situation where all unobserved explanatory variables had changed over time would be captured by $CIDD_{it}$. Therefore, in order to avoid ascribing to CIDD effects that are due to exogenous unobserved time-varying variables, we first include all the relevant available variables likely to change over time. Second, the eventual presence of trends in unobservable potential time-varying variables is checked over the period before the implementation of CIDD. Third, we will discuss potential shocks in unobservable variables over the period after the implementation of CIDD in order to see to what extent identification could have been biased.

4.2. Econometrics specification.

We aim to determine the amount by which the probability of investing is increased when households benefit from a partial refund of their expenditure. To estimate the effect of CIDD on energy-saving investments on the extensive margin, we use a Random effect (RE) dichotomous logit model[29]:

$$P(I_{it}=1|CIDD_t, X_{it}, u_i) = \frac{e^{\alpha + \sum_{t=2002}^{2004} \gamma_t T_t + \sum_{t=2005}^{2011} \delta_t CIDD_t + \beta X'_{it} + u_i}}{1+e^{\alpha + \sum_{t=2002}^{2004} \gamma_t T_t + \sum_{t=2005}^{2011} \delta_t CIDD_t + \beta X'_{it} + u_i}} \quad (1)$$

with $P(I_{it}=1|X_{it},u_i)$ the probability of investing in retrofitting for household i at time t, $X_{it}=(x_{1it},...,x_{kit})$ the exogenous observed covariates presented in section 3.2, β the vector of coefficients to be estimated and u_i the unobserved individual effect. We model u_i as a random individual effect, $u_i | X_i \sim Normal(0,\sigma_u^2)$, assuming that c_i and x_i are independent. The individual error terms e_{it} are assumed to follow a standard logistic distribution with mean 0 and variance $\sigma_e^2 = \pi^2/3$ giving the latent intra-class correlation $\rho_{\log it} = \frac{\sigma_u^2}{\sigma_u^2 + \pi^2/3}$ (Rodriguez & Elo 2003). The model is estimated by maximum likelihood.

$(T_t)_{t=2002,..,2004}$ are annual dummies referring to the period before the implementation of CIDD. Their corresponding coefficients γ_t have to be insignificant in order to ensure the absence of trend before the

[29] The conditional fixed effects logit model is not used since it is estimated only on individuals having variation in the outcome, which excludes too many observations. We do not estimate the unconditional fixed effect logit model due to the incidental parameter problem (Wooldridge 2002).

implementation of CIDD, a necessary condition of the difference estimation. As regards the identification of the effect of CIDD, $(CIDD_t)_{t=2005,..,2011}$ are the annual dummies referring to the period after the implementation of CIDD. We make $CIDD_t$ interact with annual dummies in order to allow for temporal heterogeneity in the effect of CIDD.

Contrary to a linear model, a difference estimator Δ is not directly derived from δ. Indeed, the marginal effects of a particular x_{ik} on $P(I_{it}=1|X_{it},u_i)$ is written:

$$\frac{\partial P(I_{it}=1|X_{it},u_i)}{\partial x_{kit}}=\beta_k(1-P(I_{it}=1|X_{it},u_i))P(I_{it}=1|X_{it},u_i)\,. \quad (5)$$

In order to estimate Δ, we compute the average of all the individual marginal effects. From those estimates, we derive the proportion of free-riding. It should be recalled that free-riding is defined as the situation in which the subsidized household would have undertaken the energy saving investment even in the absence of the subsidy. The free-riding rate is defined as: $FRS=1-\frac{\hat{\Delta}}{\alpha_{CIDD}*\tau_R}$, with τ_R the retrofitting rate among owner-occupiers and α_{CIDD} the proportion of retrofitters applying for CIDD, assuming that the measurement error caused by identifying households benefiting from CIDD with those applying for it can be ignored[30].

As for robustness checks, we also estimate linear probability models with fixed and random effects respectively. Finally, based on the same RE logit model as (4), a last model is estimated in order to control for path dependency in the retrofitting investment decision.

5. Results

Table 4 and **Table 5** show logit estimates for the full model over the period 2002-2011 for, respectively, opaque & glazed insulation and opaque insulation only. The tables provide estimates for logit models with (column 2) and without (column 1) random individual effects (RE) plus those of a second RE logit model (column 3) in which retrofitting observations satisfying EcoPTZ eligibility criteria are omitted

[30] More accurate information is unavailable.

from the sample over the period 2002/2011 in order to isolate the effects of CIDD from those of EcoPTZ. It should be recalled that the sample is restricted to owner-occupiers of dwellings heated by fuel, gas or electricity. New buildings and buildings other than individual houses or collective flats are also omitted from the sample. The *heating energy price* variable is introduced as a rate of variation in the regression. Otherwise, it would capture differences between energy sources to a greater extent than changes in the price of each source of energy. At year y, the *energy price variation* variable is the growth rate between y-4 and y-1. We notably assume a certain inertia in the decision-making process, which is why there is a lag in the prices considered and why the growth rates considered are calculated over several years[31]. 2001 has been omitted from the sample since a few variables were not available for that year.

Looking first at the insulation of both glazed & opaque surfaces (**Table 4**), the estimated marginal effects of the control variables reveal significant determinants of the investment decision. As regards household variables, being relatively wealthy has a positive impact on the retrofit decision. *Professionals*, *Employees* (and to a minor extent the *Inactive*) are more likely to invest than the *Business* category (including company directors, farmers and shopkeepers). The *family size* variable is insignificant. The *age of household head* variable was dropped due to correlation between covariates. Households having recently moved in also invest significantly more in energy efficiency. *Environmental preferences* have a significant positive effect on the investment decision whereas the *economic concerns* variable is insignificant. As regards variables relating to the dwelling, households living in old buildings and/or in individual houses are more prone to invest than those living in more recent and/or collective flats. Larger surface area, which implies higher energy consumption for the same behavior in respect of energy use, significantly increases the probability of investing. As for the *energy price variation* variable, its effect is positive though insignificant. Regarding geographic patterns, households living outside Paris, and in particular in small cities or in rural areas, invest more in energy efficiency. The *regional average heating degree days (HDD)* variable, also positively correlated with energy consumption, positively impacts on the retrofit decision albeit with low significance (in column 3 only). Comparing columns 1 and 2, the introduction of RE in the logit models mainly lowers the magnitude of the average marginal effects but can also lead to lower standard errors in

[31] We choose the specification maximizing the log-likelihood. Other specifications have been tested giving the same results (not reported in the paper but available on request).

some cases (the *Location category* variable for example). Columns 2 and 3 have similar results with slight changes in the levels of estimates. Turning to models restricted to the insulation of opaque surfaces only (**Table 5**), we find similar results, except that the effect of the *Economic concerns* variable becomes significantly negative and the *HDD* variable is more significant.

As regards the effect of CIDD, it should first be recalled that we use a difference estimator. The insignificance of annual dummies before 2005 confirms the absence of a temporal trend before the implementation of CIDD, which is a necessary condition for this estimation method. Then, looking first at the insulation of both glazed & opaque surfaces (**Table 4**), we find that, after a three-year latency period (2005-2007) with no significant effect, the effect of CIDD on the investment decision starts to be significantly positive in 2008 at the 10% level. This positive effect strongly increases after 2009: becoming significant at the 1% level, it goes from 0.8 percentage points in 2008 to 3.1 in 2009 decreasing to 2.5 percentage points in 2010 and 1.5 percentage points in 2011 (in the RE logit model column 2). Looking at opaque surface insulation only (**Table 5**), we have the same temporal pattern in the results (tripling from 0.4 percentage points in 2008 to 1.3 in 2009 in the RE logit model column 2). The effect of CIDD becomes positively significant slightly earlier (at the 10% level in 2007 and the 5% level in 2008). The introduction of RE reduces the magnitude of the coefficients in both samples, which means that some of the unobserved individual effects are captured by the covariates in column 1 of the model. Focusing on the period in which the effect of CIDD is significant, the average effect of CIDD is an increase of 2.1 (resp. 0.87) percentage points in the probability of investing over the period 2008/2011 (resp. over the period 2007/2011) for opaque and glazed surface insulation (resp. for opaque surface insulation only). Given an average retrofitting rate of 9% over the period 2008/2011 for opaque and glazed surface insulation and 4% over the period 2007/2011 for opaque surface insulation only, the effect of CIDD represents 23% and 21% of their respective retrofitting rate.

Thus, the results relating to the effect of CIDD reveal an initial latency period of two or three years with no significant effect, followed by an increasing, positive effect on the probability of retrofitting, especially from 2009, although with a decrease in the positive effects at the end of the period. As regards the first years of latency, we can deduce the existence of some inertia in households' response to the policy.

This could first be due to the intrinsic temporality of such an investment decision, known to be a long process[32]. This inertia can also be related to the time such a policy requires to become widely known and to the complexity of the CIDD scheme (see section 2). The increase in the positive effect in 2009 may be linked to the reform carried out in that year (the addition of the installation expenditure to the tax credit base in 2009 for opaque surface insulation measures). The fact that the retrofitting subsample including glazed surfaces presents the same increase is not contradictory due to the fact that most insulation projects on opaque surfaces also include glazed surfaces. It suggests that the effect of CIDD is sensitive to the level of subsidy. Indeed the 2009 reform relating to labor cost eligibility was equivalent to a strong increase in the tax credit rate. Considering that labor costs represent at least 30% of the total cost[33], this reform is equivalent to an increase of at least 50% in the tax credit rate. This strong increase in the CIDD tax credit rate had an immediate effect. In this case, the CIDD effect acted as a price shock, as households' awareness of CIDD did not change much in the meantime[34]. Finally, the decreasing trend in the positive effect of CIDD at the end of the period can be related to the decrease in the CIDD rate for glazed insulation (and secondarily for opaque surfaces, see **Table 1**). The fact that households can only benefit once from a CIDD subsidy over a five-year period can also contribute to a diminishing effect of CIDD in the long run too[35].

In the second RE logit model in which retrofitting potentially eligible for EcoPTZ was excluded over the entire period (column 3 in **Table 4** and **Table 5**), we observe an increase of similar magnitude in 2009. The estimated marginal effect changed from 0.8 (resp. 0.3) percentage points in 2008 to 2.5 (resp. 0.9) in 2009 for opaque & glazed surfaces (resp. opaque surfaces). This confirms our assumptions that this increase in 2009 is mainly driven by the CIDD and not due to the introduction of EcoPTZ.

[Insert **Table 4**]

[Insert **Table 5**]

[32] The average maturation period of a renovation project is more than 6 months, according to the OPEN[32] database, even more for a project including insulation measures (OPEN 2008).

[33] Based on the EM survey over the period 2008/2011 (no data were available making the distinction between labor and material costs before 2008), labor costs as a percentage of total costs go from 32% for roofs to 39% for ceilings.

[34] On the basis of the EM survey, the proportion of households surveyed only once that were aware of CIDD is 56.9% in 2004, 62.9% in 2006, 76% in 2007, 79.4% in 2008, 85.2% in 2009 and 83.4% in 2010.

[35] The CIDD subsidy being capped (at 8 000€ or 16 000€, depending on the dwelling size), for a period of 5 consecutive years, households having invested at the beginning of the CIDD implementation period (2005), or households having reached the subsidy cap, were no longer eligible in 2011, which might have contributed to the 2011 decrease in CIDD effects.

Annual estimates of the proportion of free-riding are presented in **Table 6**, in addition to annual statistics on τ_R (the retrofitting rate among owner-occupiers), α_{CIDD} (the share of retrofitters applying for CIDD) and confidence intervals computed with the delta method. It does not provide estimates of the proportion of free-riding for those years for which the estimated marginal effect of CIDD was not significant, suggesting that free-riding would have been ubiquitous during these years. As regards all insulation measures, annual rates of free-riding decrease from 85% in 2008 to 61% in 2010, with a new increase to 70% in 2011. When focusing on opaque surface insulation, annual rates of free-riding rates steadily decrease from 77% in 2007 to 42% in 2011. Estimates indicate that free-riding is more significant in the case of glazed surface insulation than opaque surface insulation. We remark that households' intentions to benefit from CIDD also decline at the end of the period, probably linked to the the fact that more and more potential CIDD beneficiaries had already undertaken works and also to the decrease in subsidy rates.

[Insert **Table 6**]

Table 7(in the Appendix) provides complementary estimation results for robustness checks for the opaque & glazed surface insulation sample[36]. The first three columns of each table show estimates for linear probability models. The linear probability (LP) model without individual effect is shown in column 1 whereas the LP model with fixed effect FE (resp. random effects RE) is detailed in column 2 (resp. column 3). The LP model with fixed individual effects gives results for CIDD effects which are the most similar to the RE logit model. The RE LP model and the one without individual effects overstates CIDD effects compared to the RE logit model. In order to identify any potential bias resulting from neglecting this time dependency in former estimations, the last column of **Table 7** shows estimates from an RE logit model in which we introduce a *Former retrofitting* variable indicating whether households have already invested in retrofitting. Results show that the *Former retrofitting* variable has a negative, though insignificant, effect on the investment decision and higher effects of CIDD compared to the RE logit model's estimates (column 2 in **Table 4**). Therefore, ignoring the time dependency would potentially understate the effect of CIDD.

[36] Complete estimation results, including those for the sample including opaque surface insulation only, are not reported in the paper but are available on request.

However, we do not place too much confidence in this result given the number of omitted observations (as we explained in section 4.2, the variable is only available from 2004).

Finally, compared to the national situation, couples of elderly and inactive homeowners are over-represented in the EM survey, all the more so if we consider people who are present in the survey over a long time period. Therefore, in estimations not reported in this paper but available on request, we test for attrition[37] in two ways (Gans 2012): by including for each household (i) the number of periods they appear in the sample, and (ii) a dummy variable indicating whether they are present for all periods in the sample. The coefficients on these additional regressors are statistically indistinguishable from zero, which means that attrition is not a concern.

6. Discussion.

6.1. Comparison between estimated levels of free-riding, results in the literature and households' declarations.

As regards estimated annual proportions of free-riders among CIDD beneficiaries, our results are of the same order of magnitude as those in Grösche and Vance's estimates (Grösche & Vance 2009) in Germany. However, they are smaller than in Mauroux (2012), who reported that a marginal change in the CIDD rate of 25% to 40% led to a free-riding rate of around 90%. This discrepancy is likely to be explained by the important differences in context and scope between Mauroux (2012) and the present study. Mauroux (2012) analyzed the response of a very specific subsample of households to changes in the rates of the already-established CIDD. Moreover, Mauroux (2012) dealt with all types of energy efficiency measures, including heating regulation systems and energy-efficient heating systems, whereas we have focused on glazed and opaque surface insulation. Finally, as explained above (section 5), our results indicate that free-riding decreased over time, especially from 2009, which corresponds to an increase in the subsidy rates. This is consistent with Grösche et al. (2013) who found that increasing the level of subsidy decreases the proportion of free-riding.

[37] Attrition exists in the panel. However, it does not lead to a significant selection bias since it is not correlated with specific households' investment in residential energy efficiency and new recruitment compensates for attrition.

In order to compare declared and revealed preferences, we can use households' declarations about free-riding provided in the EM survey. Households intending to benefit from CIDD can clarify the effect of CIDD on their decision. The percentage of households having benefited from CIDD declaring themselves as free-riders decreased from 61.4% in 2006 to 52.4% in 2010 before going up again to 61.8% in 2011[38] (see **Table 8** in the Appendix). Statistics for opaque surface insulation follow the same trend: from 66.9% in 2006 to 48.7% in 2010 and rising to 65.1% in 2011. Compared to our estimates, rates of declared free-riding display the same decreasing trend until 2010, with a new increase in 2011, but are lower in magnitude.

6.2. Limits

After being cautious about explanatory variable selection and conducting successful pre-trend tests, some uncertainties still remain as regards the difference estimator's ability to capture CIDD effects exclusively. In particular, unobserved time-varying factors linked to macroeconomic shocks, especially related to the economic crisis of 2008, still potentially exist. We have been careful to introduce individual subjective declarations in order to capture changes in environmental preferences and the economic conjuncture but other crisis-related time-varying factors could remain unobservable, such as budget and liquidity constraints, precautionary saving, etc. However, another data source can help to assess to what extent the omission of the impact of the economic crisis from the regression could have biased the estimates. OPEN, a French institutional watchdog for renovation provides two surveys about all households' retrofitting investments, also including retrofitting measures outside the scope of CIDD - contrary to our dataset - covering the observation periods 2007/2009 and 2009/2011 respectively. Considering the retrofitting rates for retrofitting categories excluded from the CIDD scheme[39], we can see the impact of the economic crisis independent of the effects of CIDD, assuming that the economic crisis has had the same repercussions on both retrofitting categories and that there is no substitution between them.

[38] The question did not exist in 2005.

[39] Retrofitting measures are grouped into 7 categories: 1) Electricity, lighting, etc., 2) Painting, wallpaper, curtains, etc., 3) Sanitary, plumbing and bathroom furniture, 4) Kitchen furniture and appliances, 5) Stairs, elevators, etc., 6) Furniture, storage and bedding material, 7) Retrofitting relating to the garden.

Transformed into a normalized indicator for the year 2009[40], average retrofitting rates weighted by market share are 0.99 in 2007, 1.55 in 2008, 1 in 2009, 1.2 in 2010 and 1.52 in 2011 suggesting that the economic crisis has had a negative, immediate and temporary impact on the retrofitting rate, which seems to have stopped an increasing trend on these specific retrofitting categories. Therefore, it is reasonable to assume that the economic crisis would have had a similar negative, immediate and temporary effect as regards insulation measures, which means that our CIDD effect estimates would be underestimated after 2008 and especially in 2009.

Although the difference estimation does not eliminate all sources of bias, in the absence of a control group, it is the only applicable method to assess the CIDD effect using our data. Indeed, other identification strategies are inappropriate. As regards the use of the tax credit rate, there are not enough temporal variations within the same retrofitting category. Heterogeneity in tax credit rates mainly relates to different retrofitting categories. Therefore, tax credit rate determination would be endogenous to households' choices. As regards households' declarations related to awareness of tax credits provided in the EM survey, it would be biased by inverse causality[41] and omitted variables[42]. Moreover, a difference estimation allows us to consider the potential two-fold effect of the tax credit, combining the "price effect" with an "announcement effect[43]" (Koomey 2002), which is not possible when tax credit is only identified with the price effect, improving the economic profitability of the investment.

7. Conclusion

This paper assesses the effects on households' retrofitting investments of the most prominent incentive implemented in France to encourage households to retrofit their dwellings: the CIDD tax credit introduced in 2005. Focusing on glazed and opaque surface insulation measures, we use an unbalanced

[40] The two surveys do not have the same scope, providing justification for normalization on the common year 2009. Author's own calculations.

[41] Bias due to inverse causality occurs if the decision to retrofit also makes households aware of CIDD. From the Open survey, 16 to 17% of investors stated that they had learned of the existence of tax credit after having decided to undertake a retrofitting project.

[42] Bias due to omitted variables occurs if unobservable factors influence both the probability of investing in energy conservation and the probability of knowing about tax credits. People's unequal awareness of fiscal incentives can be related to their socioeconomic profile (age, socio-professional category, income but also the social network e.g. word of mouth), the place where they live, etc. These factors can also impact on their investment decision.

[43] Through the announcement effect, the tax credit would act as a label, conferring credibility on certain goods through the approval of the regulator.

panel of individual data from the "Energy Management" (EM) annual survey over the period 2002/2011 in order to estimate the effects of CIDD on the extensive margin of French households' retrofitting investments. In the absence of a control group, we use a difference estimator in a random individual effect dichotomous logit model.

Results reveal a significant positive effect of CIDD on the probability of investing in retrofitting, though after an initial latency period of two or three years with no significant effect. Focusing on the period in which the effect of CIDD is significant and given an average retrofitting rate of 9% over 2008/2011 for opaque and glazed surface insulation and 4% over 2007/2011 for opaque surface insulation only, the effect of CIDD represents respectively 23% and 21% of the retrofitting rate. As regards the first years, we can deduce the existence of some inertia in households' response to the policy, probably due to the intrinsic temporality of such investment decisions, to the time required for CIDD to become widely known and to the complexity of the CIDD scheme. The marginal effect of CIDD increases in 2009, which may be linked to the 2009 reform (the addition of installation costs to the tax credit base in 2009 for opaque surface insulation measures) suggesting that the effect of CIDD is sensitive to the level of subsidy. A decreasing trend in the positive effect of CIDD then appears at the end of the period, which can be related to the decrease in the tax credit rates and to the fact that the majority of potential CIDD beneficiaries had already entered the scheme. Accordingly, the estimated annual proportion of free-riders among CIDD beneficiaries has globally decreased over the period: from 85% in 2008 to 61% in 2010 for all insulation measures (70% in 2011), from 77% in 2007 to 42% in 2011 when focusing on opaque surface insulation (after quasi-ubiquitous free-riding over the period 2005/2007). Therefore, free-riding is an important phenomenon, higher for insulation of glazed surfaces than for opaque surfaces.

We took care not to attribute to CIDD effects that are due to exogenous unobserved time-varying variables, such as the presence of pre-trends in the model or the introduction of EcoPTZ in 2009. We also assess the potential bias caused by the impossibility of including variables reflecting the effects of the economic crisis in 2008 and information on past retrofitting investments. We conclude that our estimated effects of CIDD on households' decision to invest are conservative, possibly underestimated.

In terms of policy implications, the existence of inertia in households' response to the policy invites the implementation of consistent and simple tax credit design, accompanied by good communication. The sensitivity of households' response to the level of subsidy suggests that increasing the level of subsidy while strengthening the eligibility requirements would trigger more additional private investment for the same level of public expenditure.

8. References

Alberini, A., Bigano, A. & Boeri, M., 2013. *Looking for Free-Riding: Energy Efficiency Incentives and Italian Homeowners*, Forthcoming in Energy Efficiency. Available at:http://papers.ssrn.com/abstract=2243427

Allcott, H. & Greenstone, M., 2012. Is There an Energy Efficiency Gap? *Journal of Economic Perspectives, American Economic Association*, 26(1), p.3‑28.

Cameron, T.A., 1985. A Nested Logit Model of Energy Conservation Activity by Owners of Existing Single Family Dwellings. *The Review of Economics and Statistics*, 67(2), p.205‑211.

CGDD, 2012. *Crédit d'impôt développement durable (CIDD): renforcer le pilotage du dispositif*. (Confidential report)Cohen, F. & al., 2012. *ETAT DE L'ART SUR L'EFFET D'AUBAINE DANS LES POLITIQUES ENVIRONNEMENTALES*. Study by BIO Intelligence Service S.A.S. for ADEME.

Crépon, B. & Jacquemet, N., 2010. *Économétrie: méthode et applications* De Boeck.

Dubin, J.A. & Henson, S.E., 1988. The distributional effects of the Federal Energy Tax Act. *Resources and Energy*, 10(3), p.191‑212.

Gans, W., 2012. *The Role of Price and Information in Residential Energy Consumption and Investment Behavior.* PhD Thesis.

Gillingham, K. & Palmer, K.L., 2013. *Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence*, Resources for the Future Discussion Paper No. 13-02-REV. Available at SSRN: http://ssrn.com/abstract=2206995 or http://dx.doi.org/10.2139/ssrn.2206995.

Grösche, P., Schmidt, C.M. & Vance, C., 2013. Identifying Free-riding in Home Renovation Programs Using Revealed Preference Data. *Journal of Economics and Statistics (Jahrbuecher fuer Nationaloekonomie und Statistik)*, 233(5-6), p.600‑618.

Grösche, P. & Vance, C., 2009. Willingness to Pay for Energy Conservation and Free-Ridership on Subsidization: Evidence from Germany. *Energy Journal*, 30(2), p.135‑153.

Hassett, K.A. & Metcalf, G.E., 1995. Energy tax credits and residential conservation investment: Evidence from panel data. *Journal of Public Economics*, 57(2), p.201‑217.

Ientile, D. & Mairesse, J., 2009. A policy to boost R&D: Does the R&D tax credit work? *EIB Papers*, 14(1), p.144‑169.

Jakob, M., 2007. The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners.CEPE working paper No 56.

Joskow, L.P. & Marron, B.D., 1992. What Does a Negawatt Really Cost? Evidence from Utility Conservation Programs. Working paper (Massachusetts Institute of Technology. Center for Energy Policy Research) ; MIT-CEPR 91-016.

Koomey, J.G., 2002. FROM MY PERSPECTIVE Avoiding ''The Big Mistake'' in forecasting technology adoption. *Technological Forecasting & Social Change*, 69, p.511–518.

Levine, M. et al., 2007. Residential and commercial buildings. In *Climate Change 2007: Mitigation Contribution of Working Group III to the Fourth Assessment Report of the IPCC*.

Malm, E., 1996. An Actions-Based Estimate of the Free Rider Fraction in Electric Utility DSM Programs. *The Energy Journal*, Volume17(Number 3), p.41‑48.

Mauroux, A., 2012. Le crédit d'impôt dédié au développement durable : une évaluation économétrique. *Document de travail INSEE*, (n°G2012/11).

Mauroux, A., Clerc, M.-E. & Marcus, V., 2010. Le recours au crédit d'impôt en faveur du développement durable : une résidence principale sur sept rénovés entre 2005 et 2008. INSEE PREMIERE n°1089.

OPEN, O.P. de l'amélioration En. du logement., 2008. *OPEN- résultats campagne 2007 - ADEME*

Pelletier, P., 2011. *Pour une meilleure efficacité des aides à la performance énergétique des logements privés.* Rapport Plan Bâtiment Grenelle.

Rodriguez, G. & Elo, I., 2003. Intra-class correlation in random-effects models for binary data. *Stata Journal*, 3(1), p.32‑46.

Train, K., 1985. Discount rates in consumers' energy-related decisions: a review of the literature. *Energy*, 10(12), p.1243‑1253.

Walsh, M.J., 1989. Energy tax credits and housing improvement. *Energy Economics*, 11(4), p.275‑284.

Wooldridge, J.M., 2002. *Econometric Analysis of Cross Section and Panel Data*, MIT Press.

Table 1. Tax credit rate evolution.

	2001/2004	2005	2006-2007	2008	2009	2010	2011-2012
Insulation							
Roof and wall	0%	25%	25%/40%*	25%/40%*	25%/40%*	25%	22%
Floor	0%	25%	25%/40%*	25%/40%*	25%/40%*	25%	22%
Ceiling	0%	0%	0%	25%/40%*	25%/40%*	25%	22%
Window, shutter	0%	25%	25%/40%*	25%/40%*	25%/40%*	15%	13.50%
Energy production							
Heating regulation syst.	0%	25%	25%/40%*	25%/40%*	25%/40%*	25%	22%
Low-temperature boiler	0%	15%	15%	15%	0%	0%	0%
Condensing boiler	0%	25%	25%/40%*	25%/40%*	25%/40%*	15%	13.50%
Wood heating appliance	0%	40%	50%	50%	40%	25%/40%**	22%/36%**
Specific heat-pump	0%	40%	50%	50%	40%	25%/40%	22%/36%
Renewable energy	0%	40%	50%	50%	50%	25%/50%***	22%/45%***

(*) 25% in the general case, 40% for housing transfer (move-in date less than 3 years before retrofitting) in old constructions (built before 1977).

(**) 25/22% in the general case, 40/36% in the case of replacement.

(***) 25% for photovoltaic panels, 50% for others (solar heater, domestic wind turbines, ...)

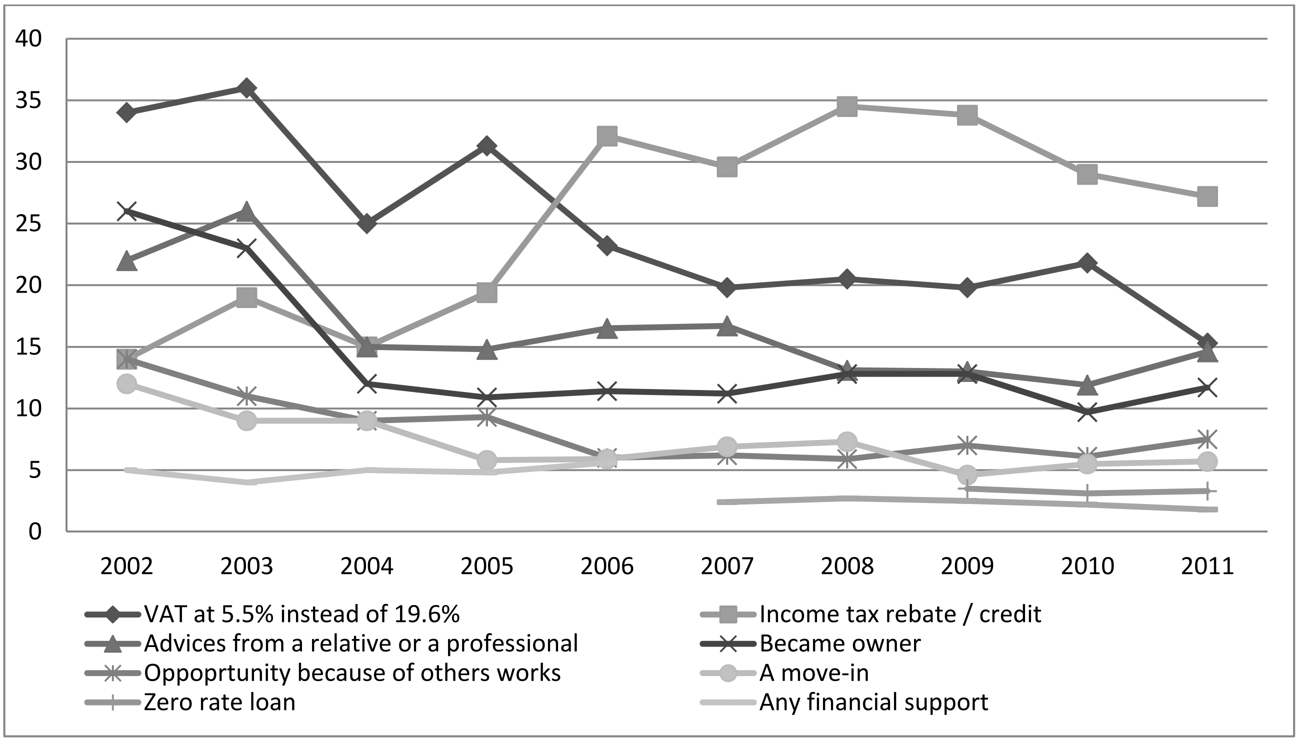

Figure 1. What were the main incentives/opportunities in your decision to retrofit? (in % of households having retrofitted)

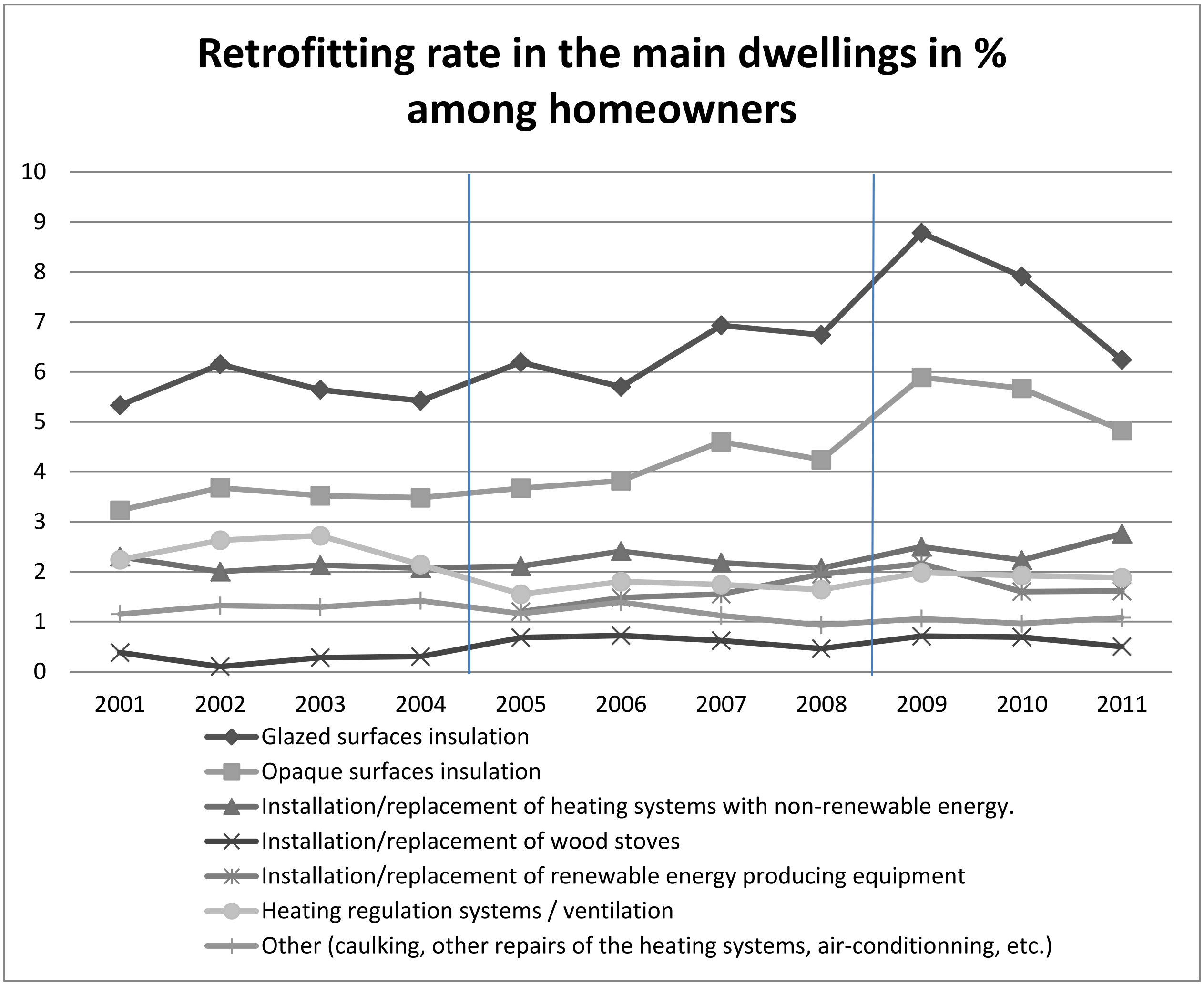

Figure 2. Retrofitting rate in % of all households for all retrofitting measures.

Table 2. Pearson's chi-squared test statistic.

	Investment rate (in %)		Test power*	Statistic	P Value**
	2001/2004	2005/2011			
All Insulation measures	6.62	8.38	4686	41.13	0
All opaque surfaces	2.63	3.91	3998	46.8	0
Internal wall	1.07	1.3	45436	4.09	0.04
External wall	0.3	0.38	126510	1.33	0.25
Roof	1.36	2.43	3442	52.78	0
Floor	0.35	0.34	5550427	0.01	0.92
Window insulation	4.58	5.34	16969	11.41	0
Total sample size (N)* **	14171	29585			

The null hypothesis H0 is the equality between the two investment rates over 2001/2004 and over 2005/2011.

* The power of the test gives the minimum number of observations required in each group to provide robust test statistics given a Type I error probability fixed at 5%.

** H0 is rejected when the p-value is less than the predetermined significance level (5%).

*** Subsample restricted to home-owners of dwellings heated by fuel, gas and electricity.

Table 3. Statistics on socio economic variables and dwellings characteristics.

	2000/2011	2000/2004	2005/2011	2005/2011 CIDD aware*	2005/2011 Retrofit*	2005/2011 Subsidized retrofit*
Annual income of the household (% in columns)						
<18500€	35.88	39.86	33.69	28.37	24.3	21.42
18500/36300€	44.97	45.32	44.77	47.15	50.01	51.58
>36 300€	19.16	14.82	21.54	24.48	25.69	27
The age of household head (% in columns)						
34 years old	2.52	2.66	2.44	2.39	1.11	0.2
35-54years old	45.1	46.56	43.82	45.6	43.78	36.8
> 55 years old	52.38	50.78	53.74	52.01	55.11	63
Family size (% in columns)						
1 person	31.75	29.6	32.89	29.53	23.46	26.07
1 couple	34.01	34.84	33.72	35.11	37.33	40.97
>2 persons	34.24	35.56	33.39	35.36	39.21	32.96
Socio-professional category (% in columns)						
Business	5.76	5.39	5.87	6.45	6.44	5.94
Professionals	25.17	25.03	25.38	27.85	27.59	27.26
Employees	28.66	29.84	27.9	27.24	26.45	19.89
Inactive	40.4	39.74	40.85	38.46	39.53	46.91
Move in date (% in columns)						
< 3 years	19.2	19.78	18.6	19.48	21.53	16.77
3 / 10 years	32.09	31.88	32.57	33.7	29.92	25.86
> 10 years	48.71	48.34	48.83	46.82	48.55	57.36
Status of occupation (% in columns)						
renter	32.83	32.63	32.8	28.07	7.19	1.44
owner	63.94	64.12	63.96	68.85	90.29	96.81
other	3.23	3.25	3.24	3.09	2.52	1.75
Individual preferences/concerns						
Environmental	52.48	54.83	51.5	53.98	51.36	51.08
Economic	61.81	58.19	63.32	61.97	62.77	62.08
Means of HDD	2023.20	2025.41	2021.67	2021.29	2047.90	2041.39

	2000/2011	2000/2004	2005/2011	2005/2011 CIDD aware*	2005/2011 Retrofit*	2005/2011 Subsidized retrofit*
Building completion date (% in columns)						
<=1948	27.73	28.49	26.85	26.95	35.69	29.7
1949/1974	32.99	33.73	32.34	31.36	35.68	40.63
1975/1981	13.41	14.05	13.15	13.27	14.25	17.4
1982/1988	8.84	9.44	8.44	8.66	7.47	7.94
1989/last year	16.22	13.53	18.37	18.86	6.39	4.07
current year	0.8	0.75	0.84	0.9	0.51	0.27
Building type (% in columns)						
individual house	53.34	51.05	55.91	59.72	78.84	76.06
collective flat	46.51	48.77	43.95	40.14	21.03	23.87
Main heating energy source (% in columns)						
gas	42.32	41.45	42.81	41.96	40.23	44.07
fuel	19.11	21.19	17.72	19.01	24.76	25.7
district heating	2.31	2.34	2.25	2.07	0.9	1.22
wood	3.67	4.95	3.47	3.67	5.16	4.1
electricity	28.74	26.32	29.41	28.28	22.57	19.57
mix wood electricity	3.86	3.76	4.34	5.02	6.39	5.34
Location category (% in columns)						
Parisian area	15.48	15.88	15.19	14.79	9.84	11.55
>100.000 inhab.	29.2	29.53	29	28.01	23.29	24.86
20.000/100.000	13.2	13.18	13.18	12.88	12.94	14.63
2.000/20.000 inhab.	17.57	17.45	17.7	17.8	19.79	19.22
Rurals	24.55	23.95	24.94	26.53	34.14	29.74
Means of heating energy prices (€/kWh)						
Gas	0.050	0.042	0.056			
Fuel	0.058	0.040	0.070			
Electricity	0.145	0.139	0.149			
Wood	0.034	0.029	0.035			
District heating	0.062	0.052	0.065			

* CIDD aware sub-sample: households aware of CIDD after 2005; Retrofitting sub-sample : households having invested in retrofitting after 2005; Subsidized retrofitting sub-sample: households having retrofitted and intended to benefit from CIDD after CIDD

Table 4. RE logit's estimated marginal effects for opaque & glazed surfaces insulations

	logit (1)		logit RE (2)		logit RE EcoPTZ excl. (3)	
Variables	M.E.	S.E.	M.E.	S.E.	M.E.	S.E.
Environmental concerns	0.006*	(0.0034)	0.005**	(0.00237)	0.004*	(0.0022)
Economic concerns	-0.001	(0.0034)	0	(0.00239)	0.001	(0.0022)
Annual dummies *(ref:2002)*						
2003	0.001	(0.0062)	0	(0.00464)	0.003	(0.0044)
2004	-0.002	(0.0067)	-0.006	(0.00455)	-0.004	(0.0043)
CIDD dummy_2005	0.002	(0.0068)	0	(0.00477)	0	(0.0044)
CIDD dummy_2006	-0.002	(0.0063)	-0.004	(0.00451)	-0.004	(0.0042)
CIDD dummy_2007	0.011*	(0.0065)	0.006	(0.00462)	0.004	(0.0043)
CIDD dummy_2008	0.013*	(0.0066)	0.008*	(0.00465)	0.008*	(0.0043)
CIDD dummy_2009	0.043***	(0.0074)	0.031***	(0.00538)	0.025***	(0.005)
CIDD dummy_2010	0.038***	(0.0075)	0.025***	(0.00531)	0.02***	(0.0049)
CIDD dummy_2011	0.018***	(0.0066)	0.015***	(0.00502)	0.013***	(0.0047)
HDD	0.0002	(0.006)	0.005	(0.00429)	0.008**	(0.004)
Energy price variation	0.008	(0.0102)	0.008	(0.00751)	0.011	(0.007)
Dwelling size	0.001**	(0.0005)	0.001**	(0.00039)	0.001**	(0.0004)
Building completion date *(ref : < 1974)*						
1975/1988	-0.027***	(0.0045)	-0.022***	(0.00334)	-0.016***	(0.0031)
1989/last year	-0.087***	(0.0033)	-0.065***	(0.00286)	-0.054***	(0.0027)
Collective flat	-0.041***	(0.0044)	-0.031***	(0.00289)	-0.024***	(0.0027)
Annual income of the household *(ref : <18500 euros)*						
18500 /36 300 euros	0.01**	(0.0046)	0.01***	(0.00302)	0.007**	(0.0028)
>36 300 euros	0.007	(0.0057)	0.008**	(0.00381)	0.006*	(0.0035)
Move in date *(ref : < 3 years)*						
3 / 10 years	-0.071***	(0.0076)	-0.062***	(0.00668)	-0.042***	(0.0059)
> 10 years	-0.095***	(0.0078)	-0.082***	(0.00697)	-0.058***	(0.0061)
Location category *(ref : Parisian agglomeration)*						
> 20.000 inhabitants	0.004	(0.0059)	0.008**	(0.00374)	0.006*	(0.0034)
<20.000 inhabitants / rural	0.008	(0.0062)	0.009**	(0.00405)	0.006*	(0.0037)
Socio-professional category *(ref : Business)*						
Professionals	0.029***	(0.0092)	0.023***	(0.00604)	0.022***	(0.0054)
Employees	0.026***	(0.0091)	0.018***	(0.00598)	0.019***	(0.0054)
Inactive	0.021**	(0.0091)	0.014**	(0.00583)	0.014***	(0.0052)
Family size *(ref : 1 person)*						
1 couple	0.008*	(0.0048)	0.004	(0.0035)	0.005	(0.0032)
>2 persons	0.01	(0.0063)	0.004	(0.00406)	0.003	(0.0037)
σ_u^2			1.111	(0.04651)	1.085	(0.0496)
ρ			0.273	(0.01661)	0.264	(0.0177)
Nb of observations	36367		36367		35977	
Nb of individuals			13116		13023	
Log likelihood	-11714.13		-9432.6265		-8617.8839	

*(resp. ** and ***) significant at 10% level (resp. 5% and 1%).

col (1): logit estimates; (2) RE logit estimates; (3) RE logit estimates on the subsample excluding retrofitting measure eligible to EcoPTZ

Table 5. RE logit's estimated marginal effects for opaque surfaces insulations only

	logit (1)		logit RE (2)		logit RE EcoPTZ excl. (3)	
Variables	M.E.	S.E.	M.E.	S.E.	M.E.	S.E.
Environmental concerns	0.005*	(0.0023)	0.002**	(0.0011)	0.002*	(0.0009)
Economic concerns	-0.006***	(0.0023)	-0.002**	(0.00109)	-0.001	(0.0009)
Annual dummies *(ref:2002)*						
2003	0.001	(0.0041)	0	(0.0019)	0.001	(0.0017)
2004	0	(0.0043)	-0.001	(0.00188)	-0.001	(0.0016)
CIDD dummy_2005	0.003	(0.0044)	0.001	(0.00201)	0.001	(0.0017)
CIDD dummy_2006	-0.001	(0.0041)	-0.001	(0.00185)	-0.001	(0.0016)
CIDD dummy_2007	0.007*	(0.0043)	0.003*	(0.00198)	0.001	(0.0016)
CIDD dummy_2008	0.008*	(0.0043)	0.004**	(0.00202)	0.003*	(0.0017)
CIDD dummy_2009	0.025***	(0.0051)	0.013***	(0.00255)	0.009***	(0.0021)
CIDD dummy_2010	0.023***	(0.0051)	0.011***	(0.0025)	0.007***	(0.0021)
CIDD dummy_2011	0.016***	(0.0044)	0.009***	(0.00238)	0.008***	(0.0021)
HDD	0.005	(0.0041)	0.004*	(0.00204)	0.005***	(0.0018)
Energy price variation	0.002	(0.0071)	0.001	(0.00341)	0.002	(0.0029)
Dwelling size	0.0001	(0.0004)	0.0002	(0.00018)	0.0001	(0.0001)
Building completion date *(ref : <1974)*						
1975/1988	-0.017***	(0.0032)	-0.009***	(0.00164)	-0.006***	(0.0013)
1989/last year	-0.037***	(0.0024)	-0.019***	(0.00168)	-0.013***	(0.0014)
Collective flat	-0.038***	(0.0024)	-0.017***	(0.00143)	-0.013***	(0.0013)
Annual income of the household *(ref : <18500 euros)*						
18500 /36 300 euros	0.005	(0.003)	0.003**	(0.0014)	0.002	(0.0012)
>36 300 euros	0.004	(0.0038)	0.003	(0.00175)	0.002	(0.0015)
Move in date *(ref : < 3 years)*						
3 / 10 years	-0.043***	(0.006)	-0.024***	(0.00378)	-0.013***	(0.0028)
> 10 years	-0.061***	(0.0061)	-0.034***	(0.00412)	-0.02***	(0.0031)
Location category *(ref : Parisian agglomeration)*						
> 20.000 inhabitants	0.001	(0.0038)	0.002	(0.00177)	0.002	(0.0015)
<20.000 inhabitants / rural	0.008*	(0.004)	0.004**	(0.00188)	0.003*	(0.0016)
Socio-professional category *(ref : Business)*						
Professionals	0.011*	(0.0062)	0.006**	(0.0028)	0.006***	(0.0023)
Employees	0.011*	(0.0061)	0.005*	(0.00276)	0.006**	(0.0022)
Inactive	0.003	(0.0061)	0.001	(0.00269)	0.002	(0.0021)
Family size *(ref : 1 person)*						
1 couple	0.005	(0.0035)	0.002	(0.00167)	0.001	(0.0014)
>2 persons	0.006	(0.0044)	0.002	(0.00187)	0.001	(0.0016)
σ_u^2			1.556	(0.0749)	1.539	(0.083)
ρ			0.424	(0.02351)	0.419	(0.0263)
Nb of observations	36367		36367		36090	
Nb of individuals			13116		13045	
Log likelihood	-6266.76		-5129.0113		-4371.4581	

*(resp. ** and ***) significant at 10% level (resp. 5% and 1%).

col (1): logit estimates; (2) RE logit estimates; (3) RE logit estimates on the subsample excluding retrofitting measure eligible to EcoPTZ

Table 6. Free-ridership estimation

	2005	2006	2007	2008	2009	2010	2011
All retrofit incl. Insulation (opaque and glazed surfaces)							
τ_R *	6.77	6.59	8.22	7.99	10.91	9.61	7.8
α_{CIDD} **	62.88	67.57	67.52	68.46	74.29	73.43	64.79
Estimated CIDD M.E.	0	-0.004	0.007	0.008	0.029	0.027	0.015
Standard errors	0.0047	0.0044	0.0044	0.0046	0.0049	0.005	0.0048
Estimated free-riding rate	-	-	-	0.8537	0.6424	0.6176	0.703
Confidence interval	-	-	-	[0.6904 - 1]	[0.5238 - 0.7611]	[0.4776 - 0.7575]	[0.5174 - 0.8885]
Opaque Insulation							
	2005	2006	2007	2008	2009	2010	2011
τ_R *	2.91	2.83	3.7	3.51	4.93	4.6	3.89
α_{CIDD} **	.	29.96	36.29	39.37	48.83	42.02	39.95
Estimated CIDD M.E.	0.001	-0.001	0.003	0.004	0.013	0.011	0.009
Standard errors	0.002	0.0019	0.002	0.002	0.0026	0.0025	0.0024
Estimated free-riding rate	-	-	0.7761	0.7101	0.4606	0.4301	0.4194
Confidence interval			[0.4865 - 1]	[0.4232 - 0.997]	[0.2532 - 0.668]	[0.1762 - 0.6839]	[0.1184 - 0.7203]

(*) the retrofitting rate in % among occupying homeowners, (**) the % of households having invested in retrofitting who apply for CIDD.

Table 7. Full model 1. Opaque & glazed insulation. Robustness check

	LP (1)	L.P. RE (2)	L.P. FE (3)	logit RE (4)
Variables	Est. Coeff.	Est. Coeff.	Est. Coeff.	M.E.
Former retrofit				-0.988
Annual dummies *(ref:2002)*				
2003	0.001	0.002	-0.0004	
2004	-0.003	-0.005	-0.008	
CIDD dummy_2005	0.003	0.003	0	-0.001
CIDD dummy_2006	-0.001	-0.003	-0.005	0.002
CIDD dummy_2007	0.012**	0.011*	0.007	0.015***
CIDD dummy_2008	0.014**	0.015**	0.01*	0.019***
CIDD dummy_2009	0.043***	0.042***	0.038***	0.044***
CIDD dummy_2010	0.037***	0.035***	0.029***	0.033***
CIDD dummy_2011	0.019***	0.024***	0.018***	0.03***
Nb of observations	36367	36367	36367	29392
Nb of individuals		13116	13116	11333
R2 within		0.0047	0.0063	
R2 between		0.0182	0.0182	
R2 overall	0.0314	0.0317	0.0125	
Log likelihood				-5996.5695

*(resp. ** and ***) significant at 10% level (resp. 5% and 1%). Standard errors are not reported.
col (1) : Linear probability model; col (2) : Linear probability model with random effect;
col (3) : Linear probability model with fixed effect; col (4) : Random effect logit model over 2004/2011.

Table 8. Declared free-riding share among CIDD beneficiaries in the EM survey.

	2006	2007	2008	2009	2010	2011
Glazed and opaque surfaces insulation						
% of free-riders*	61.4	56.2	48.8	55.1	52.4	61.8
N**	255	310	335	425	398	275
Opaque surfaces insulation only						
% of free-riders*	66.9	60.6	60.1	58.3	48.7	65.1
N**	123	169	142	227	224	167

*% of CIDD beneficiaries stating that CIDD had no effect on their decision. ** Number of respondents to the question "What was the CIDD effect on your decision to retrofit?"

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