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Turning the heat up.
How sensitive are households to fiscal incentives on energy efficiency investments?

Abstract

This article studies the sensitivity of French households to fiscal incentives, focusing on the French tax credit on home energy efficient renovations. We estimate the ajustment of the households'average expenditures after an unexpected increase in the tax credit rate (intensive margin). This evaluation complements Mauroux's (2012) results on the number of additional beneficiaries (extensive margin). In 2006, a reform was restricted to new owners of pre-1977 dwellings, allowing us to develop an original difference-in-differences model. It is combined with a Tobit model and censored quantile regressions and estimated on exhaustive fiscal data. In reaction to this tax credit increase, households increased their housing improvement expenditures. This effect appears to be highly heterogeneous depending on the level of expenditures and households characteristics. On average the final net expenditures would have stayed constant. The multiplier of this program is assessed at 1.5, due to the extensive margin.

Keywords: tax credit, energy efficiency investments, sustainable development, public policy evaluation, censored quantile regressions, difference-in-differences estimates.

Dépenses de rénovation résidentielle et crédit d'impôt développement durable

Résumé

Cet article étudie la sensibilité des ménages français aux incitations fiscales en s'intéressant au crédit d'impôt développement durable. Nous estimons l'ajustement des dépenses d'amélioration de l'efficacité énergétique du logement suite à une hausse du taux de crédit d'impôt (marge intensive). Cette évaluation vient compléter les résultats de Mauroux (2012) sur le nombre additionnel de bénéficiaires (marge extensive). En 2006, une réforme, qui ciblait les nouveaux propriétaires de logements achevés avant 1977, permet de développer un modèle original en différence-de-différences. Il est couplé à un modèle Tobit et à des régressions quantiles censurées et estimé sur données fiscales exhaustives. Suite à la hausse de taux, les ménages ont accru leurs dépenses d'amélioration de l'efficacité énergétique. Cet effet serait très hétérogène selon les montants dépensés et les caractéristiques des ménages. En moyenne, le reste à charge final des ménages resterait inchangé. Le multiplicateur budgétaire associé à cette mesure serait de 1,5 du fait de la marge extensive.

Mots-clés : crédit d'impôt, développement durable, évaluation des politiques publiques, estimation en différence de différences, *matching*, régression quantile censurée, Tobit

Classification JEL : H31, H23, D12

1 Introduction and motivation

In energy efficiency policies, price-based instruments (tax credit, subsidies...) may seem more attractive than regulatory tools (norms, standards...) to achieve environmental goals. Indeed new standards will take fewer years to diffuse, especially when equipment replacement rates are low like in the automobile sector (15% per year) or the housing sector (1% per year). But these policies may come at a high budgetary cost, especially if they are *ex ante* ill-designed. On the French bonus-malus scheme introduced for car purchases in December 2007, Durrmeyer et al. (2011) found that the bonus had an impact on car sales three times larger than the impact that could be *ex ante* expected based on the price elasticity they estimate on past car sales. As a result, this policy cost 250 million Euros only in the first year even though it was designed to be *ex ante* cost-neutral. A better understanding of the responsiveness of households to price-based instruments is crucial, especially in a context of fiscal constraints.

Are French households sensitive to environmental fiscal incentives? In this paper we study another emblematic French environmental fiscal policy, the "Crédit d'impôt Développement Durable" (CIDD), a tax credit on housing energy efficiency improvements and renewable energy investments. It was created in 2005 in order to encourage households to improve the energy efficiency of their dwellings and to install renewable energy equipments in their primary residences. It allows households to deduct a 15% to 50% of these expenditures from their income taxes. It was a major success: between 2005 and 2010, 6.2 million households used it at least once, so almost one primary residence in four was renovated or modernized in only six years (Mauroux et al. 2010; Marcus et al. 2012). The total budgetary cost was about 12 billion euros from 2005 to 2010. In 2010, the budgetary cost represented 1.9 billion euros, namely 0.1% of French GDP. In this paper we try to assess the sensitiveness of the French households to this fiscal incentive by measuring the impact of an increase in this tax credit on their energy efficiency improvement investment.

The theoretical impact is straightforward: a tax credit is equivalent to a reduction in the marginal cost of energy efficiency investment. This can trigger the decision to retrofit by turning profitable investments which were previously not profitable (extensive margin). It may also incentive households who had already decide to retrofit to increase their expenditures (intensive margin). Nevertheless, empirical evidence on the incentive impact of energy efficiency tax credit is rather mixed. The first *ex post* evaluations of the impact of the Energy Tax Act suggested that an increase in the fiscal incentive had a low (if not negative) impact on both the probability to retrofit (Wash, 1989) and the amount invested (Dubin and Henson, 1988). The Energy Tax Act was a federal credit available in the US from 1978 to 1985, which allowed taxpayers to reduce their income tax by 15% of amount spent for eligible conservation equipment (up to $2,000). Those studies rely on geographical variation in the reduction rates to identify the impact of the fiscal incentive, which can be sensitive to fixed effect and endogeneity. Using panel and controlling for fixed effects, Hasset and Metcalf (1995) found results more consistent with intuition and theory: a 10 percentage point change in the tax price for energy investment would lead to a 24 percent increase in the probability of making an investment. Recent findings on a similar policy in Italy tend to questioned the incentive effect of tax credits (Alberini et al., 2013). The Italian tax credit rate also allowed homeowners to deduct up to 55% of their expenses from their income taxes. The Italian fiscal incentive is quite massive, in particular compared to the 15% American tax credit. Alberini et al. (2013) found that door and window replacements became significantly more frequent after the implementation of the tax credit in 2007, especially in colder climates regions of Italy, but not the heating system replacement rate. This result leads them to the conclusion that free riding must have been pervasive. Nevertheless, their data source, the Italian Consumer Expenditure Survey, does not guarantee that the households actually claimed nor benefited from the tax credit for which they were eligible. Thus, it is not clear whether the absence of effect is due to free-riding or to a low use of the tax credit (ineffective measure).

In France, the tax credit rates range between 10% and 50% and it brings us back to our question of the effectiveness of the fiscal instruments to encourage households to undertake energy efficiency investments. Mauroux (2012) showed that a marginal tax credit increase targeted on new homeowners of pre-1977 dwellings had a positive and significant impact on the number of tax credit claimed for energy efficient investments (positive intensive margin). Based on a survey data from 2001 to 2011, Nauleau (2014) studied the impact of the creation of the CIDD in 2005 on the thermal renovation activity (retrofitting rate/probability of retrofitting investments) and on the average expenditures of the households who retrofit (including non CIDD items). Her results suggest that the CIDD has no impact before 2007 both neither on the probability to retrofit nor on the average amount spent on retrofitting. Starting from 2007, the CIDD has a significant and increasing impact on the amount by which the households that invest in energy efficiency increased. This suggests that there was a latency period during which households did not adjust their behavior to the new fiscal incentive. There are more and more pieces of evidence that fiscal policies may have a signal effect in addition to the price effect, as showed by Durrmeyer et al. (2011). Indeed, the estimated impact of the implementation of bonus on energy efficient cars cannot be explained only by a price effect. They show that the bonus itself had a specific impact five times higher than the price elasticity. Koomey (2002) warns that price-based instruments may have a two-fold effect: a "*direct price effect*" and an "*announcement effect*". This second effect is the impact of a rebate that is independent of the size of the rebate. Koomey also cites changes in marketing strategies of the people selling the product as they may use the existence of the new tax credit. It can also come from the credibility conferred to certain goods by the regulator through a labeling effect. This effect may be even stronger in the case of energy efficiency equipments because of the complexity of the technical characteristics, of the retrofitting options,... The eligibility to a bonus or a tax credit can act as an implicit label on the performance of the equipment. At the implementation, both the price and behavioral effects are mixed. A "before-after" approach as in Nauleau (2014) does not disentangle those two effects. In this paper we propose an empirical strategy to identify the price effect of the CIDD.

From 2006 to 2009, households who had purchased in the past 2 years a dwelling constructed prior to 1977 could claim a 40% tax credit rate on their energy efficiency expenditures (higher efficient boilers, insulation materials, etc) instead of a 25% tax credit rate for the others. The reform was announced at the end of 2005 so it was not anticipated by the households. We take advantage of this quasi-natural experiment to identify the sensitivity of energy efficiency expenses to the level on the fiscal incentive (intensive margin). We develop a triple differences (DDD) strategy as in Mauroux (2012) to control for fixed effects for each of the eligibility criteria: housing unit built before 1977, purchased in the past 2 years. Mauroux (2012) only estimated the extensive margin of the 2006 reform. Our estimation of the intensive margin allows us to now provide an evaluation of the total incentive impact of the 2006 reform.

We had access to fiscal files from 2005 to 2008 ; they contain the tax credit claims and informations on both households and dwellings. The use of fiscal data guarantees exhaustiveness and a high level of reliability on the energy efficiency expenditures. To guarantee homogeneity in housing units characteristics and households renovation behaviour, we restrict to observations "close" to the two eligibility thresholds: housing units whose construction was completed between 1969 and 1988 and households who purchased it in the past 5 years.

Each year only a small fraction of the French households fill a tax credit claim form. To control the potential censoring bias we estimate a Tobit-DDD model. We combine it with a matching method to control for the potential structural differences between the treatment and control group. To gain some insights on the heterogeneity of the sensitivity of investments to the fiscal incentive and overcome the statistical limits of the Tobit model (Maddala and Nelson 1975, Goldberger 1980, Arabmazar and Schmidt 1981, 1982), we also run censored quantile regressions (Powell, 1986) on various clusters of the population.

Our results suggest that households did adjust upward their energy efficiency expenditures after the tax credit rate increase, confirming that they are price sensitive. On average, in 2006, expenditures were 1% to 28% higher than if the tax credit rate had remained 25%, 23% to 47% in 2007 and 27% to 41% in 2008. Censored quantile regressions confirm those results but provide strong evidence that the impact is highly heterogeneous across quantiles and households. Price sensitivity seems to be lower at the top of the distribution of expenditures and stronger for relatively well-off middle age couples with children living in Ile de France. Computing the expenditures net of the tax credit refund (in constant euros), our results suggest that in 2007 and 2008 the average final cost was equal or slightly higher than the average final cost in case of a 25 percent tax credit. As shown in Mauroux (2012) a majority of households would have undertaken energy efficiency investments but they adjusted their investments choices to match their home renovation budget. They either installed a more efficient version of the same equipment - quality effect - or installed more equipments - quantity effect. Finally, reconciling results on the extensive margin (Mauroux, 2012) and our results on the intensive margin, we estimate that, in 2007 and 2008, on average one euro of budgetary cost caused by the 2006 reform generated 1.5 euro of private investment. This greater than one ratio is mainly explained by the increased in the number of households investing in energy efficiency expenditures.

The article is structured as follow: the second part presents the tax credit on residential energy efficiency, the data and some stylized fact. In the third part, we investigate the determinants of energy efficiency expenditures by homeowners with a censoring model, before estimating in the fourth part the sensitivity of these expenditures to the level of the tax credit rate. The results are reported in the last part.

2 The tax credit on residential energy efficiency

2.1 The program

Households can deduct from their income taxes from 15 to 50 percent of their expenditures on energy conservation or renewable energy equipments in their primary home. If the tax credit exceeds the tax liability of the household then the household is refunded the difference. It is in particular the case for households not paying income taxes.

The tax credit is calculated on the price of equipments and materials costs (net of taxes), labor cost not included. The eligible items are selected according to energy efficiency criteria which are regularly updated. They fall into two main categories:

- energy efficiency and energy conservation investments: thermal insulation materials (insulating walls and ceiling, thermal windows, shutters and doors), clock thermostats, high efficiency boiler (low temperature, condensing);
- equipments using a renewable source of energy: photovoltaic, solar water heat, heat pumps, wood heating or other biomass heating, geothermal energy.

The tax credit rate ranges from 15% to 50% depending on the installed item, on the home construction year and the equipment installation year. There is a five-year ceiling on the total amount of expenditures taken into account to calculate the tax credit for the household and the home. The ceiling depends on the household composition (8,000 euros for a single person, 16,000 euros for a couple, plus 400 euros per dependent). The tax credit is calculated on the price excluding taxes, so it can be claimed in addition to the 5.5% VAT rate on housing repair services and products. If the household receives local or other national subsidies for the equipment purchase (regional council, department councils, Housing National Agency), the tax credit is calculated on the total expenditures net of the other public subsidies.

2.2 Data

We use exhaustive fiscal files from 2006 to 2009. Tax payers fill a tax credit claim and report their total energy efficiency expenditures on their income tax returns. French households fill tax files in year N+1 for income earned in year N so we follow French households home renovation investments undertaken between 2005 and 2008. The use of fiscal data guarantees exhaustiveness and a high level of reliability on the energy efficiency expenditures.

The first drawback of using this fiscal data source is that we do not observe the total amount spent by households in energy efficiency improvement expenditures, nor on home renovation. Households only report the share spent on items eligible to the tax credit that were installed by a professional, not including labor cost.[1] Our study only covers the CIDD investments and not the entire scope of thermal home repair investments. We know the expenditures only if the household knows the existence of the tax credit. Nevertheless, surveys on housing renovation show that this information quickly spread as 53% of the households knew this tax credit the first year of its existence, 63% in 2006, 74% in 2007 and 78% in 2008 (survey "Maîtrise de l'énergie" on all tenants and homeowners, Ademe).

The second drawback is that we have no detailed information on the installed equipments because households are only asked to give their total expenditures by tax credit rate (15%, 25%, 40% or 50%). Nevertheless, between 2005 and 2008, tax credit rates on energy conservation equipments were different from tax credit rates on renewable so we are able to discriminate between those two main types of expenditures.

We use income tax return files and merge them with the local residence tax files to match households with their dwellings. We observe between 2005 and 2008 each housing unit (year of construction, number of rooms, size, apartment or private house, year of household moving in), its occupants (homeowner or tenant, size, age, total fiscal income), and on the total amount of energy efficiency investments spent on CIDD equipments and

[1] Labor cost was only included in 2009 for wall insulation interventions.

installed by a professional. The main characteristics of the French fiscal households are stable between 2005 and 2008 (see table 14 in annex A).

Between 2005 and 2008 the number of households filling a tax credit claim more than doubled, reaching 1.6 million in 2008 (table 1). 70% of households declared energy conservation investments and 30% renewable energy equipment expenditures. Households seldom declare more than once so each year one million households use this tax credit for the first time. On average, reported expenditures rose from 3,700 euros in 2005 to 5,125 euros in 2008. Total expenditures almost tripled in four years (3.6 billions in 2005, 8 billion euros in 2008). In total, between 2005 and 2008, 4.1 million households invested at least once in energy conservation and|or renewable energies, declaring in total 23.1 billion euros, for a total budgetary cost of 7.8 billion euros. By the end of 2008 one primary residence in 16 had been renovated.

Table 1: Evolution of tax credit claims between 2005 and 2008 (in current euros)

	2005	2006	2007	2008	Total
Fiscal households (in thousands)	25,785	26,080	26,400	26,687	
Households claiming a tax credit (in thousands)	984	1,267	1,336	1,569	5,156
Energy efficiency	767	901	947	1,064	3,679
Renewable energy	217	365	389	505	1,477
Declaration rate	3.8%	4.9%	5.1%	5.9%	
Energy efficiency	3.0%	3.4%	3.6%	4.0%	13.8%
Renewable energy	0.8%	1.%	1.5%	1.9%	5.5%
Households claiming a tax credit for the first time (in thousands)	959	1,046	993	1,082	4,080
Total expenditures (in million euros)	3,632	5,390	6,044	8,039	23,106
Energy efficiency	2,771	3,439	3,684	4,319	14,212
Renewable energy	862	1,952	2,360	3,720	8,894
Average expenditures (in euros)	3,691	4,254	4,524	5,124	4,481
Energy efficiency	3,612	3,814	3,892	4,059	4,613
Renewable energy	3,959	5,336	6,060	7,365	6,350
Budgetary cost (in billion euros)	1	1.9	2.1	2.8	7.8
Average refund (in euros)	1,002	1,493	1,577	1,774	1,820
Average refund rate	27.0%	33.8%	33.3%	32.4%	32.4%

Note: the year refers to the date of investments. Households declare their housing renovation expenditures in May of the following year in the income tax return file.
Source: fiscal data from 2006 to 2009, authors' own calculation.

2.3 Energy efficiency tax credit claims

Not surprisingly, this tax credit is mainly used by homeowners: in 2008, 6.3% of the homeowners of private houses and 4.9% of apartments filled a tax credit claim whereas 1% of tenants did (table 2). Nevertheless, when tenants do undertake home renovation, they tend to spend more than owners. Energy efficiency investments and tax credit use is strongly correlated with fiscal income: in 2008, 6.5% of the households among the 10% more affluent filled a claim whereas less than 1% did among the 10% less affluent households. More than a third of the households filling a tax credit claim belong to the two top deciles and 5% to the two bottom deciles of fiscal income (table 15 in annex A). On average, expenditures of households belonging to the most affluent 10% are 10% higher than expenditures of the less affluent 10% (table 16 in annex A). Nonetheless, once taken into account the size of the dwelling, average expenditures in energy conservation investments are almost similar across decile (42 euros per square meter).

Home renovation behaviors highly depend on the composition and age of the households too. Couples tend to fill a tax credit claim twice more often than single person households (table 17 in annex A). Tax credit use sharply increases with age until 75 then decreases. Expenditures also increase with age but start decreasing sooner, after 50. Differences between households by living standards and age can partly be explained by unequal access to property. Only a third of the households belonging to the less affluent own their primary residence whereas 80% of the most affluent do.

Not surprisingly, the older the dwelling, the more frequent the renovation works and the higher the expenditures (top figure 1, table 15 in annex A). The fraction of tax payers filling a claim is roughly constant for dwellings constructed prior to the 1970s, peaks for for dwellings constructed in 1980 and then slowly decreases with construction year, as well as energy efficiency expenditures (top figure 1). This might result from a combination of two effects: more stringent thermal norms on residential construction in 1982, 1988, 2000 and 2005 and less old equipments.

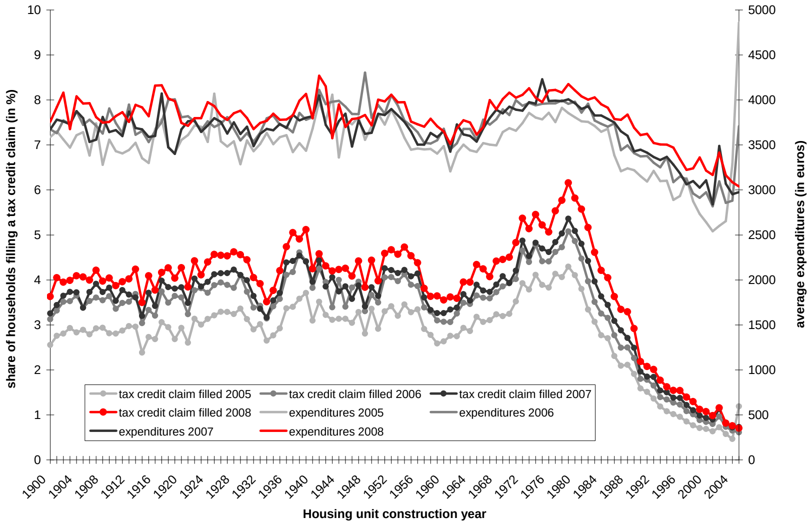
It is in large dwellings, located in rural towns, in regions with a mild climate or in dwellings constructed prior to the 1980s that the use of the tax credit and the energy efficiency expenditures are the highest (table 2).

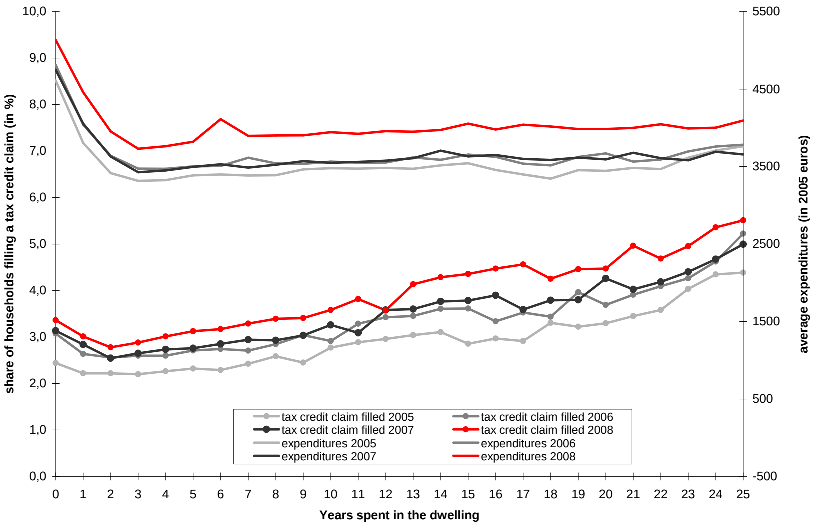
Table 2: In 2008, who filled energy conservation tax credit claim and how much did they spend?

	Tax credit claim filled (in %)	Expenditures (among declarant) (in current euros)	(in 2005 euros)
Average	3.6	3,869	3,650
Household's characteristics			
Status and housing unit			
Tenant of an apartment	0.2	4,170	3,934
Tenant of a private house	0.9	4,479	4,225
Homeowner of an apartment	4.9	3,225	3,042
Homeowner of a private house	6.3	3,978	3,753
Age			
Less than 30 year old	1.4	3,528	3,328
30 to 39 year-old	3.3	3,885	3,665
40 to 49 year-old	3.4	4,169	3,933
50 to 59 year-old	4.3	4,052	3,823
60 to 74 year-old	5.1	3,803	3,588
75 year-old and more	2.9	3,294	3,108
Household's composition			
Single persons	2.2	3,349	3,159
Couples with no child enfant	5.7	3,928	3,706
Single persons with children	2.4	3,876	3,657
Couples with children	4.8	4,233	3,993
Others	3.2	4,522	4,266
Fiscal Standards of living (*)			
1^{st} decile	0.6	4,250	4,009
2^{nd} decile	1.3	3,757	3,544
3^{rd} decile	2.0	3,627	3,422
4^{th} decile	2.6	3,508	3,309
5^{th} decile	3.3	3,446	3,251
6^{th} decile	4.0	3,472	3,275
7^{th} decile	4.6	3,570	3,368
8^{th} decile	5.4	3,707	3,497
9^{th} decile	6.1	3,926	3,704
10^{th} decile	6.5	4,826	4,553
Dwelling's characteristics			
Size			
Smaller than 30 m^2	0.4	2,705	2,552
30 to 59 m^2	1.3	2,993	2,824
60 to 89 m^2	3.3	3,490	3,293
90 to 119 m^2	5.3	3,880	3,660
Greater than 119 m^2	6.2	4,586	4,326
Housing unit construction year			
Before 1948	4.0	3,837	3,620
1949-1975	4.5	3,899	3,679
1976-1982	5.6	4,094	3,862
1983-1989	3.8	3,877	3,657
1990-2000	1.6	3,455	3,259
2001-2005	0.9	3,213	3,031
after 2005	1.3	3,881	3,661
Town size			
Rural town	4.6	4,031	3,803
Less than 20,000 inhabitants	4.1	3,902	3,681
Between 20,000 and 99,999 inhabitants	3.8	3,749	3,537
100,000 inhabitants and more	3.6	3,669	3,461
Paris	3.0	4,067	3,837
Thermal regulation climate zones			
H1 (ex. Paris)	3.6	3,964	3,739
H2 (ex. Nantes)	4.2	3,715	3,505
H3 (ex. Marseille)	2.8	3,837	3,619

(*) Fiscal standards of living are defined as the net fiscal income of the households divided by the number of consumption units in the household (1 for the first adult, 0.4 for each child under 14 and 0.5 for additional adults or children above 14). Source: fiscal data for 2009, authors' own calculation.

Figure 1: Use of the tax credit (left axis) and expenditures of the claimants (right axis), by construction year (top) and years spent in the dwelling (bottom)





Source: fiscal data from 2006 to 2009, authors' own calculation.

3 Determinants of housing energy efficiency investments

3.1 Households' demand for energy investments

Few households undertake energy efficiency investments each year. If the decision to install a more efficient equipment is the result of an economic trade-off between cost and expected profit, we can interpret it as the optimal solution of the household's consumption program. Dubin and Henson (1988) developed a model of residential energy conservation behavior that predicts which households will be more likely to weatherize their homes and how much they will invest. Using the household production framework, they assume households derive utility from consumption and housing comfort, defined as the indoor temperature. Comfort is produced from purchased energy inputs and using a technology that depends on climate and on the thermal integrity of the housing unit. To improve comfort, the household can either increase her use of energy or improve the integrity of her house, by undertaking energy efficiency investments. Households face a tradeoff between comfort and other goods. The consumer's decision problem consists in allocating her income optimally among energy inputs, energy efficiency measures and other goods to achieve maximum utility. Solving this program, Dubin and Henson find that positive expenditures are interior solutions and zeros correspond to corner solutions characterized by the Kuhn and Tucker conditions:

$$w^* > 0 \Leftrightarrow (1-\tau)c^{'}(0) < -p_e \frac{\partial H}{\partial w}(t, 0) \tag{1}$$

$$(1-\tau)c^{'}(w^*) = -p_e \frac{\partial H}{\partial w}(t, w^*) \tag{2}$$

where w is the amount of energy efficiency investments, τ is the tax credit rate, $c(w)$ is the energy efficiency cost function ($c^{'}(w) < 0$), p_e is the unit price of energy, $H(t, w; R, t_0)$ is the quantity of energy needed to reach an indoor temperature of t when the outdoor temperature is t_0 and the thermal resistance of the dwelling is R (heating "production function", $\partial H | \partial w < 0$).

The first condition can be interpreted as a condition for positive energy efficiency investments: the household invests in energy efficiency (interior solution) if and only if the marginal benefit (equal here to the decrease in the marginal cost of heating) is greater than the threshold value $(1-\tau)c'(0)$. The second equation gives the amount spent given energy prices, income, outdoor temperature and the tax credit rate. A consumer undertaking an improvement in thermal integrity does so up to the point where the marginal cost of improvement equals the present value of the marginal reduction in energy costs (Dubin and Henson, 1988). This specification is consistent with the additional assumptions of myopia - also called energy efficiency gap (Allcott and Greenstone, 2012) - and of imperfect access to credit.

The statistical counterpart is a censoring model:

$$y = \max\{0, X\beta + u\} \tag{3}$$

where y is the variable of interest, X the covariates and u the residual. Ordinary least square regressions either on the entire sample or on the subsample of positive outcomes ($y_i > 0$) give inconsistent estimates of the parameters because they rely on the assumption that y is linear in X when it is only partly linear (Wooldridge, 2002). When $y > 0$, $E[y|X]$ cannot be linear in X unless the range of X is limited and without further restrictions OLS predicted values can be negative for many combinations of X and β.

The most frequently used model to correct for the censoring bias is the Tobit model. The latent variable y^* is linear in x but we only observe the positive part of its distribution[2], under the assumption that the residuals are normal and homoscedastic $(u|X(0, \sigma^2))$ it provides consistent estimates of β.

$$\begin{aligned} y_i^* &= X_i\beta + u_i, \qquad u|X(0, \sigma^2) \\ y_i &= \max\{0, y_i^*\} \end{aligned} \tag{4}$$

Using the properties of the normal distribution, the conditional expectation of $E[y|X, y > 0]$ when y follows Tobit model is equal to:

$$E[y|X, y > 0] = X\beta + \sigma\lambda\left(\frac{X\beta}{\sigma}\right) \tag{5}$$

where $\lambda(x) = \phi(x)/\Phi(x)$ is the inverse Mills ratio.

Here we only observe expenditures if the households do fill a claim so we do not directly observe energy efficiency investments. Some households installed CIDD eligible items but did not fill a tax credit claim because they were not aware of the tax credit, did not understand it... If we think that the two decisions (investing and filling a claim) are driven by different motivations, thus a selection model would be more appropriate than a censoring model. Unfortunately since we only observe households who actually filled a claim form, we do not separately observe the two decisions and we cannot deal with the selection problem.

[2] In corner solution, the latent variable interpretation is less relevant but the statistical models are the same.

3.2 Estimation

We estimate a Tobit model for homeowners. They represent more than 95% of the households who use the tax credit so it is likely that tenants' expenditures obey to a different housing improvement model. Tenants only benefit from the energy savings during the time spent in the dwelling whereas from the homeowner point of view, renovation expenditures and energy efficiency improvements are a way to maintain or increase the value of their capital. For computational reasons, we run for each year a Tobit regression on a sub-sample of the population.[3] Results of Tobit estimations on the expenditures in euro, on the log of expenditures[4] and on expenditures per square meters are reported in table 3.

Results are consistent with intuition. All else equal, expenditures increase with fiscal standards of living of the households, the size of the dwelling and if it is a house. Middle age households (between 40 and 49 years) spent more on energy efficiency and energy saving than younger and older households. Households living in rural towns report higher energy efficiency expenditures than households living in Paris. Renovation expenditures in dwellings constructed before 1948 or after 1983 are lower than in dwelling constructed between 1949 and 1982. More surprisingly homes located in the Mediterranean part of France (Thermal regulation climate zone H3) tend to benefit from higher energy efficiency expenditures than homes located in mild and continental regions. Without the CIDD, energy efficiency investments were probably less profitable in the area because of warmer climate than in the other regions. As a result, it is probable that, all else equal, homes locates in the Central and Northern parts of France were already better insulated and equipped with more energy efficient devices then the Southern part of France.

[3] We draw a 1/1,000 subsample of the households who report zero expenditures and then weight them. The subsample is exhaustive for the tax credit claimants.

[4] We use log(dep+1). Given the nature and the level of the expenditures, results should not be sensitive to this shift.

Table 3: Determinants of the energy efficiency expenditures

	in log euro	in euro	in euro per m^2
Household's characteristics			
Age			
Less than 30 year old	-0.06 ***	-714 ***	4.0 ***
30 to 39 year-old	-0.04 ***	775 ***	10.2 ***
40 to 59 year-old	ref	ref	ref
60 to 74 year-old	0.01 ***	-625 ***	-3.3 ***
40 to 74 year-old	-0.04 ***	-727 ***	-4.8 ***
75 year-old and more	-0.11 ***	-3,682 ***	-31.5 ***
Household's composition			
Single persons	-0.04 ***	-1,658 ***	-13.6 ***
Couples with no child	-0.02 ***	-2,363 ***	-10.9 ***
Single persons with children	0.02 ***	-89 **	6.1 ***
Couples with children	ref	ref	ref
Years spent in the dwelling	0.0003 ***	-8 ***	-0.3 ***
Fiscal Standards of living (*)	0.10 ***	0.012 ***	0.0001 ***
Dwelling's characteristics			
Private house	0.28 ***	2,357 ***	13.5 ***
Size (in m^2)	0.21 ***	5 ***	0.03 ***
Construction year			
Before 1948	-0.13 ***	-1,688 ***	-14.8 ***
1949-1975	-0.03 ***	-210 ***	3.7 ***
1976-1982	ref	ref	ref
1983-1989	-0.11 ***	-2,425 ***	-25.1 ***
1990-2000	-0.28 ***	-6,270 ***	-54.8 ***
2001-2005	-0.42 ***	-8,651 ***	-93.1 ***
after 2005	-0.11 ***	-2,891 ***	-58.2 ***
Town size			
Rural town	0.05 ***	-2,003 ***	-4.4 ***
Less than 20,000 inhabitants	0.05 ***	-1,538 ***	2.7 ***
Between 20,000 and 99,999 inhabitants	0.02 ***	-1,114 ***	6.3 ***
100,000 inhabitants and more	0.00	-822 ***	5.5 ***
Paris	ref	ref	ref
Thermal regulation climate zones			
H1 (ex. Paris)	-0.06 ***	-2,046 ***	1.8 ***
H2 (ex. Nantes)	-0.10 ***	-1,564 ***	5.1 ***
H3 (ex. Marseille)	ref	ref	ref
Year of the housing improvement			
2005	ref	ref	ref
2006	0.04 ***	702 ***	7.1 ***
2007	0.03 ***	1,046 ***	10.3 ***
2008	0.06 ***	1,801 ***	17.0 ***
Eligible to the 40 % rate	0.24 ***	3,571 ***	30.1 ***
Constant	5.59 ***	-16,531 ***	-182.4 ***
Sigma	1.06 ***	11,405 ***	106.5 ***
Log likelihood	-4,152,690	-2,161,803	-1,393,169
Number of observations	2,804,852	2,971,445	2,966,739

(*) Fiscal standards of living are defined as the net fiscal income of the households divided by the number of consumption units in the household.
Note: * coefficient significant at the 10% level, ** at the 5% level and *** at the 1% level.

Source: fiscal data from 2006 to 2009, authors' own calculation.

4 Sensitivity of energy efficiency expenditures to the tax credit rate

We now turn to the estimation of the sensitivity of French households to environmental fiscal incentives on energy efficiency investments. The tax credit rates were changed many times, upward in 2006 then mainly downward since 2009. We use variations in the tax credit rate as a natural experiment to identify the incentive impact of the green tax credit on the French households' energy efficiency investments. To control for the potential censoring issue, we adapt Tobit and Censored quantile regressions to a difference-in-differences set-up.

4.1 Preliminary discussion

Let $w_i(\tau)$ be the optimal amount household i invests in energy efficiency improvement when the tax credit rate is equal to τ. A tax credit rate increase from τ to $\tau^{'}$ $(\tau^{'} > \tau)$ is equivalent to a decrease in the marginal cost of energy efficiency improvement. This may trigger the decision to retrofit by turning profitable investments which were previously not profitable (extensive margin). It may also incentive households who had already decided to retrofit to increase their expenses (intensive margin). At the individual level, there are three categories of households:

- those who invest but who would have invested even if the rate were τ:

$$\begin{aligned} w_i(\tau) &> 0 \\ w_i(\tau') &> 0 \end{aligned} \tag{6}$$

- those who invest but would have not invested if the rate were τ:

$$\begin{aligned} w_i(\tau) &= 0 \\ w_i(\tau') &> 0 \end{aligned} \tag{7}$$

- those who do not invest even when the rate is equal to $\tau^{'}$:

$$w_i(\tau) = w_i(\tau') = 0 \tag{8}$$

Let N_τ be the number of households filling a claim form when the tax credit rate is equal to τ, W_τ be the total amount of expenditures declared when the rate is equal to τ and $\bar{w}_\tau$ the average expenditures. At the aggregate level, a tax credit rate increase has two impacts. First, by turning profitable investments which were not it increases the number of households investing $(N_{\tau'} > N_\tau)$. Second, households who would have invested anyway may adjust upward their expenditures $(w_i(\tau^{'}) > w_i(\tau))$.

$$W_{\tau'} - W_\tau = \underbrace{(N_{\tau'} - N_\tau)}_{\text{Increase in the number of claims}} \quad \bar{w}(\tau^{'}) + \underbrace{N_\tau}_{\text{nb of claims without incentive increase}} \underbrace{(\bar{w}(\tau^{'}) - \bar{w}(\tau))}_{\text{Increase on average expenditures}} \tag{9}$$

The global impact of a tax credit rate increase on total expenditures is a combination of those two effects, commonly referred to as the extensive and intensive margins in labor economics (see for example Rogerson and Wallenius 2007, Blundell et al. 2011) or international trade literature (see for example Buono and Lalanne, 2012). The extensive margin is usually defined as the evolution of discrete factors (number of workers, number of exporting firms) whereas the intensive margin refers to the evolution of continuous factors (number of worked hours per person, average exportations per firm).

In the case of the CIDD, at the individual level the extensive margin corresponds to the decision whether to undertake thermal renovation (individual probability to invest). Its aggregate counterpart is simply the evolution of the number of tax credit claims. As for the intensive margin, at the micro level it corresponds to the decision of how much more to spend on thermal renovation. A straightforward macro counterpart could be the average amount spent on thermal renovation by households undertaking thermal renovation. Nevertheless, with this definition of a macro intensive margin, the variations of the mean expenditures capture the variations of investment both by the households would have invested even without the tax credit rate increase ($w_i(\tau^{'}) - w_i(\tau) > 0$) and by households who would have not invested ($w_i(\tau^{'}) - 0$). As a consequence the micro-elasticity of investment to tax credit rate will differ from the macro-elasticity, as showed by Rogerson and Wallenius (2007) on the labor market. A "strict" definition of the intensive margin would be the variation of the average amount spent by the households who would have invested even without the tax credit rate increase.

We are not able to identify in the data the households who would have retrofitted even at a lower tax credit rate ($w_i(\tau) > 0$). As a consequence we cannot estimate this strict intensive margin and will only estimate the impact of the tax credit rate increase on the overall expenditures ("gross intensive margin"). In this paper we will refer to "intensive margin" as the increase on the average expenditures of the households reporting energy efficiency investments:

$$\delta_{Int} = \bar{w}(40) - \bar{w}(25) \tag{10}$$

where $\bar{w}(25)$ is the average expenditures we would have observed in the absence of the reform. We will not be able to interpret the results at the individual level (*"household i spent x additional euros thanks to the reform"*) but only at a macro level ("*on average, the expenditures were x euros higher"*). From a budgetary perspective, $W_{40} - W_{25}$ gives a clue to estimate the efficiency of this policy.

After presenting the identification strategy, we estimate the impact of a tax credit rate increase on the average expenditures (intensive margin) applying difference-in-differences models to censoring models.

4.2 Identification strategy

4.2.1 Definition of the treatment

We use the same identification strategy as in Mauroux (2012): in 2006 the tax credit rate on energy efficiency investments was raised from 25% to 40% but the 40% rate was restricted to households who had purchased in the past 2 years a home constructed prior to 1977 as shown in table 4. Each year only one homeowner in ten meets the two eligibility criteria (table 5) so only a fraction of the households benefited from this tax credit rate increase. The 40% tax credit rate was suppressed in 2010.

Table 4: Tax credit rate on energy efficiency expenditures from 2006 to 2009

	Construction completed	
	before 1977	1977 or after
Dwelling purchased in the past 2 years	**40%**	25%
Dwelling purchased 3 years ago or more	25%	25%

Source: "Bulletins officiels" n°147 September 1 2005 and n°83 May 18 2006.

Table 5: Households meeting the 40%-rate eligibility criteria

	Eligible households		
	in thousands	share of households	share of homeowners
2005	1.53	5.9%	10.3%
2006	1.52	5.8%	10.1%
2007	1.50	5.7%	9.8%
2008	1.44	5.4%	9.3%

Source: fiscal data from 2006 to 2009, authors' own calculation.

We define the treatment as being eligible to the 2006 credit tax rate increase on energy efficiency expenditures, that is to say being able to claim a 40% instead of a 25% tax credit. The estimated effect will be interpreted as the impact of a marginal 15 percentage points increase in an already existing tax credit on the flow of housing energy efficient improvement investments. It does not correspond to the impact of the introduction of a new 15% tax credit on energy conservation expenditures.

Table 6: Maximum tax refund according to household composition and tax credit rate

	ceiling	maximum refund for a 25% rate	maximum refund for a 40% rate	difference
Single persons	8,000	2,000	3,200	1,200
Couples without children	16,000	4,000	6,400	2,400
Couples with child	16,400	4,100	6,560	2,460
Couples with two children	16,800	4,200	6,720	2,520

Let C_1 be a dummy variable taking the value 1 if the household satisfies the first criterion: "the dwelling was purchased in the past 2 years". Let C_2 be a dummy variable taking the value 1 if the dwelling satisfies the second criterion: "construction was completed before 1977". Let E_{it} be a dummy variable taking the value 1 if the household is eligible to the 40% tax rate in year t. Then:

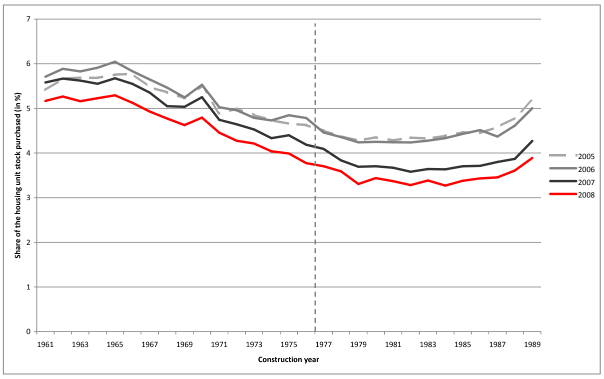
$$E_{it} = C_1 \times C_2 \tag{11}$$

The 2006 tax credit rate increase was announced by the end of 2005, so it was not anticipated by the households and can be seen as a natural experiment. We are also pretty confident that households did not massively purchase homes built before 1977 rather than in 1977 or after to get a 40% tax credit rate instead of a 25% and did not self selected themselves into the treatment group. The figure 2 represents the distribution of dwellings bought between 2005 and 2008 according to their construction year. If the raise in the tax credit rate had influenced the home buyers' choice, we should observe after 2005 a relative increase in the proportion of pre-1977 dwellings and a relative decrease in the proportion of post-1976 dwelling but we do not. Self-selection into the treatment group assumes that households can perfectly compare a set of homes, across all characteristics and choose the one that perfectly matches their preferences. In practice, housing supply is constraint and this arbitrage is not possible. Even if it were, the marginal benefit from buying a pre-1977 rather, all else being equal, than a post-1976 dwelling appears to be too small compared to housing prices to systematically be crucial in the decision of buying a house. The additional refund a household could get is limited to 15% of its ceiling. For a couple without children whose ceiling is 16,000 euros the maximal benefit is 2,400 euros. For a couple with two children with a ceiling of 16,800 euros the maximal benefit is 2,540 euros, it is of 1,200 for a single person (table 6).

Based on this exogenous increase in the tax credit rate only for a small number of households, it is possible to build a counter-factual of the behavior of the eligible households without the 2006 reform by observing the behavior of similar households not meeting the eligibility criteria, and estimate the impact of the 15 percentage points increase in the tax credit rate.

Our data set includes all French dwellings and households but the treatment effect

Figure 2: Housing stock purchased between 2005 and 2008 by construction year



Source: fiscal data from 2006 to 2009, authors' own calculation.

may be different across dwellings and households. For instance, retrofitting investment returns are likely to be higher in home built before the introduction of thermal norms on residential construction in 1974 than in homes constructed in the 2000s. To ensure a relative homogeneity across housing units in the data set, we restrict to dwellings constructed a few years before and after the eligibility threshold, taking thermal norms on construction years as boundaries (1969 and 1988). At first thermal regulation was not too restrictive so it is likely that the selected dwellings have relatively similar insulation properties. To insure comparability in the home renovation behaviors, we also restrict the data set to households who have recently purchased their home. Indeed, it is in the first two years after purchase that the share of households filling a tax credit claim is the largest. It then drops and starts increasing again only after 15 years. We do not want to capture the effect of the replacements of equipments during this second cycle of housing investments so we restrict to households who purchased their dwellings in the past 5 years. Our estimation dataset contains between 1.1 and 1.2 million households per year (table 7) and 24% of them are in the treatment group.

Table 7: Homeowners for 5 years or less of a dwelling constructed between 1969 and 1988

	2005	2006	2007	2008
Eligible	287,262	283,315	278,591	266,442
Non eligible	924,280	910,026	889,362	866,321
Total	1,220,047	1,202,798	1,178,007	1,141,628

Source: fiscal data from 2006 to 2009, authors' own calculation.

4.2.2 Expenditures of the treated and the non treated households

Households meeting the two criteria filled more often tax credit claim forms. When they did, they reported higher expenditures than households that did not meet the eligibility criteria (tables 8 and 9). After 2005, their housing energy efficiency improvement expenditures seem to have risen slightly faster than the expenditures of the rest of the households. We observe a 282 euros increase (+6.8%) between 2005 and 2006 while in the meantime non treated households' expenditures increased by 223 euros (+6.4%). The differences in expenditures evolution suggest that the tax credit rate increase may have had a small but positive impact on the expenditures of the eligible households (+59 euros in 2006, +143 euros in 2007 and +71 euros in 2008).

We may be concerned by the fact that part of these expenditures increase is in reality due to a price increase, and thus may not correspond to an increase in the demand for housing improvement. Indeed the index price on housing improvement (IPEA, SOeS) rose by 1.6% between 2005 and 2006, by 3.1% between 2005 and 2007 and by 6% between 2005 and 2008. Using this price index to control for inflation in the housing improvement sector, we estimate the density of the expenditures for the treated and the non treated in 2005 euros in 2006, 2007 and 2008 (figure 3). In 2005 euros, the difference of evolution of the expenditures of the treated and non treated is divided by half, and becomes negative in 2008. If we narrow the dataset to a window around the eligibility thresholds, the difference-in-differences again suggest that the tax credit rate increase had a positive impact on the expenditures of the eligible households. The difference-in-differences on the log of the expenditures suggest that after the tax credit raise, the eligible households slightly increased their expenditures (+ 2% in 2006, + 7% in 2007 and + 5% in 2008). We now need to check if this small treatment effect is not due to selection effects and if it is significatively different from zero when controlling for the characteristics of the households and their dwellings and for the censoring bias. For all our following estimations, we use the index price on housing improvement to control inflation in the housing repair sector.

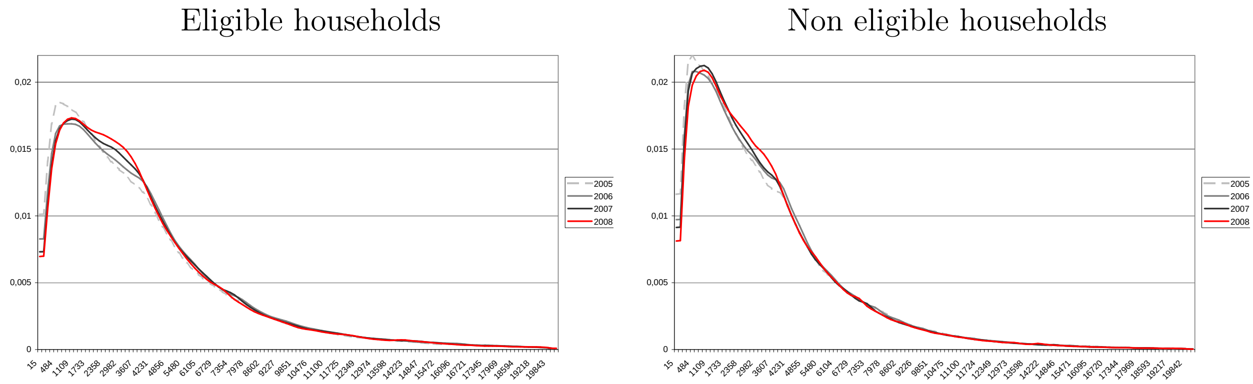
Table 8: Tax credit claim filling rate and reported expenditures between 2005 and 2008, by eligibility status

All homeowners							
	2005	2006	2007	2008	Δ 2006-2005	Δ 2007-2005	Δ 2008-2005
Use of the tax credit (in %)							
Eligible	8.1	10.0	10.7	11.4	+ 1.9	+ 2.6	+ 3.3
Non eligible	4.0	4.7	4.9	5.5	+ 0.7	+ 0.9	+ 1.5
Δ Eligible - Non eligible	+ 4.1	+ 5.4	+ 5.8	+ 5.9	1.3	1.7	1.8
Expenditures (in current euros)							
Eligible	4,153	4,435	4,609	4,753	+ 282	+ 456	+ 600
Non eligible	3,462	3,685	3,776	3,991	+ 223	+ 314	+ 530
Δ Eligible - Non eligible	+ 691	+ 750	+ 834	+ 762	59	143	71
Expenditures (in 2005 euros)							
Eligible	4,153	4,256	4,236	4,184	+ 104	+ 84	+ 31
Non eligible	3,462	3,536	3,470	3,514	+ 74	+ 8	+ 52
Δ Eligible - Non eligible	+ 691	+ 720	+ 766	+ 671	29	75	-21
Difference-in-differences of the log (/2005)					0.00	0.02	-0.01

Homeowners for 5 years or less of a dwelling is constructed between 1969 and 1988							
	2005	2006	2007	2008	Δ 2006-2005	Δ 2007-2005	Δ 2008-2005
Use of the tax credit (in %)							
Eligible	8.6	10.7	11.5	12.4	+ 2.0	+ 2.9	+ 3.7
Non eligible	5.9	6.9	7.2	8.0	+ 1.0	+ 1.3	+ 2.1
Δ Eligible - Non eligible	+ 2.8	+ 3.8	+ 4.3	+ 4.4	1.1	1.6	1.6
Expenditures (in current euros)							
Eligible	4,134	4,543	4,956	5,043	+ 409	+ 822	+ 909
Non eligible	3,618	3,880	4,041	4,200	+ 262	+ 423	+ 581
Δ Eligible - Non eligible	+ 516	+ 662	+ 914	+ 843	147	399	328
Expenditures (in 2005 euros)							
Eligible	4,134	4,360	4,555	4,439	+ 225	+ 421	+ 305
Non eligible	3,618	3,724	3,714	3,697	+ 106	+ 96	+ 79
Δ Eligible - Non eligible	+ 516	+ 636	+ 841	+ 742	120	325	227
Difference-in-differences of the log (/2005)					0.02	0.07	0.05

Source: fiscal data from 2006 to 2009, authors' own calculation.

Figure 3: Density of energy efficiency expenditures (in 2005 euros)



Source: fiscal data from 2006 to 2009, authors' own calculation.

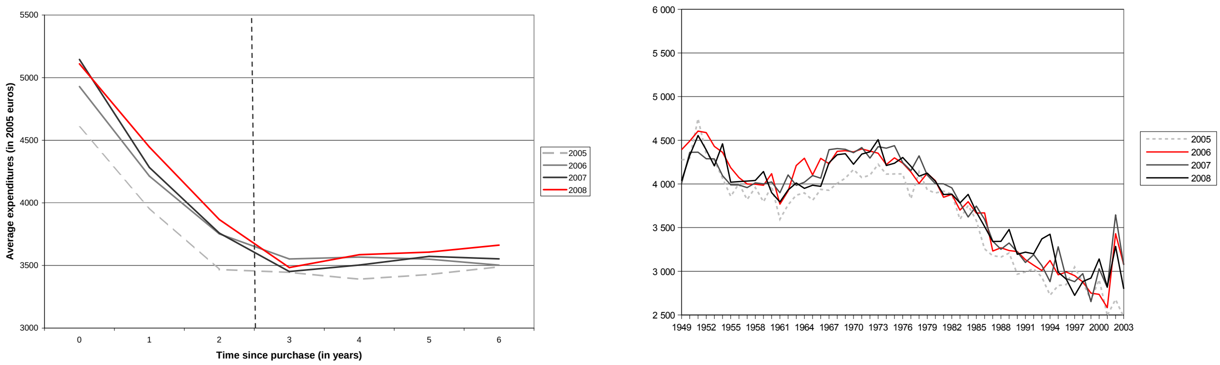
Table 9: Quantiles of energy efficiency expenditures (in euros)

Year	Quantiles (in euros)											
	88	89	90	91	92	93	94	95	96	97	98	99
A - Eligible households ($C_1 \times C_2$)												
2005	0	0	0	0	353	1,018	1,733	2,555	3,462	4,500	5,949	8,332
2006	0	0	397	1,035	1,669	2,360	3,088	3,858	4,620	5,648	7,137	9,753
2007	0	344	977	1,584	2,236	2,916	3,600	4,320	5,180	6,264	7,799	10,394
2008	259	895	1,500	2,126	2,750	3,382	4,005	4,700	5,567	6,665	8,194	11,008
B - Non eligible households												
2005	0	0	0	0	0	0	0	690	1,582	2,679	4,030	6,161
2006	0	0	0	0	0	0	673	1,475	2,400	3,487	4,778	7,000
2007	0	0	0	0	0	190	970	1,755	2,677	3,757	5,080	7,457
2008	0	0	0	0	0	791	1,537	2,343	3,248	4,258	5,610	7,971

Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling that was constructed between 1969 and 1988, authors' own calculation.

Figure 4: Expenditures conditional on the dwelling construction year (left) and on the years spent in the dwelling (right)

Pre-1977 dwellings ($C_2 = 1$) Owners for 2 years or less ($C_1 = 1$)



Homeowners of a dwelling built before January 1st 1977 (left) and homeowners of their dwelling for 2 years or less (right)
Source: fiscal data from 2006 to 2009, authors' own calculation.

4.2.3 Definition of the control groups

Even before the reform, households meeting the eligibility criteria reported higher expenditures than non eligible households. To control for the selection effect of the eligibility criteria, we plot how expenditures vary according to one criterion, controlling for the other one. Figure 4 on the left plots the evolution of the expenditures of homeowners of relatively old dwellings ($C_2 = 1$) according to the number of years spent in it. Expenditures of the non eligible households (3 years or more in the dwelling) are pretty similar before and after 2006 but there is a clear upward shift in 2006 in the expenditures of the eligible households (2 years or less). Figure 4 on the right plots the new homeowners' expenditures ($C_1 = 1$) according to the year of construction of the dwelling. Expenditures of non eligible households (constructed after 1976) do not seem to differ much before and after the reform. After 2005 we observe a slight shift upward of the curves representing the eligible households' expenditures (dwellings constructed before 1977). Nevertheless this conditional effect is not as clear cut as the one we observe on left figure for the other eligibility criterion.

Households forming the control group are to be selected among the non-eligible households. In the difference-in-differences model, the control group is composed of all the non-treated households. The double differences estimator compares the evolution of the expenditures of the treated with the evolution of the expenditures of the non treated. The treatment effect on the treated is identified under the two following assumptions:

- the treatment and control groups are stable across periods (constant group fixed effect) ;

- the treatment and control groups are equally affected by cyclical shocks (common trend).

The common trend assumption means that in the absence of the treatment, the outcome of interest would have evolved the same way in the treatment and control groups. It is a strong assumption here because it states that in the absence of the reform, the energy efficiency investments of households who purchased in the past 2 years a relatively old dwelling would have evolved exactly the same way as the energy efficiency investments of households who purchased a more recent dwelling or households who purchased a dwelling three years ago or more. On the contrary, it is likely that the energy efficiency equipments and the structural shell of older dwellings has poorer thermal properties than more recent dwellings so the former may need more capital intensive energy efficiency investments then the later. Moreover, if there are specific time trends for households meeting just C_1 and for households meeting just C_2, then the double differences estimate will be biased.

To correct for this potential bias and control for the specific effect of each eligibility criterion on energy efficiency investments, we extend the difference-in-differences setting and following Mauroux (2012), we divide the control group into three groups, corresponding to each one of the three 25% cells in table 4:

- households satisfying C_1 (duration since purchase) but not C_2 (dwelling construction year),
- households satisfying C_2 criterion but not C_1,
- households satisfying none of the two criteria.

We call the corresponding estimator a difference-in-difference-in-differences estimator (DDD). In a linear model, it can be estimated with the following equation:

$$y_{it} = \alpha + \beta_1 T + \beta_2 C_1 + \beta_3 C_2 + \beta_4 C_1 C_2 + \beta_5 T C_1 + \beta_6 T C_2 + \delta_T T C_1 C_2 + u_{it} \tag{12}$$

where y_{it} is the energy efficiency expenditures of household i at date t, T is a dummy of the treatment year T and u_{it} is an error term. The treatment effect on the treated year T is given by δ_T.

This DDD estimator will be identified under additional assumptions. It is based upon the assumption that the specific effect of the eligibility criteria C_1 and C_2 are additive, so that all the group and time effects are linear and additive. What is more, the DDD estimator relaxes the strict common trend assumption and so additional assumptions are needed: it is assumed that each control sub-group is stable across periods and that there are specific additional shocks common for households meeting each criterion. This assumption means that there are common time effects for all households who respectively purchased a house in the past 2 years (e.g. credit constraints....) and for all households who own a pre-1977 home (e.g. marketing operation or add campaigns targeted to old homes, additional public subsidies....). If those assumptions are verified, the fixed effects for each criterion and time cross effects guarantee that we control for energy efficiency investments behavior specific to each sub groups and for exogenous shocks affecting them.

The DDD estimator can be written as the sum of the classical double difference estimator and two correction terms:

$$\begin{aligned}
\hat{\delta}_{DDD} &= [(\bar{y}_{C_1=1,C_2=1,T} - \bar{y}_{C_1=1,C_2=1,t_0}) - (\bar{y}_{C_1=1,C_2=0,T} - \bar{y}_{C_1=1,C_2=0,t_0})] \\
&\quad -[(\bar{y}_{C_1=0,C_2=1,T} - \bar{y}_{C_1=0,C_2=1,t_0}) - (\bar{y}_{C_1=0,C_2=0,T} - \bar{y}_{C_1=0,C_2=0,t_0})] \\
\hat{\delta}_{DDD} &= \hat{\delta}_{DD} - K_{C_1} - K_{C_2} \\
&= \left[(\bar{y}^T_{11} - \bar{y}^{t_0}_{11}) - (\bar{y}^T_{\neq 11} - \bar{y}^{t_0}_{\neq 11})\right] \\
&\quad - \tfrac{n_{01}+n_{00}}{n_{\neq 11}} \left[(\bar{y}^T_{10} - \bar{y}^{t_0}_{10}) - (\bar{y}^T_{00} - \bar{y}^{t_0}_{00})\right] - \tfrac{n_{10}+n_{00}}{n_{\neq 11}} \left[(\bar{y}^T_{01} - \bar{y}^{t_0}_{01}) - (\bar{y}^T_{00} - \bar{y}^{t_0}_{00})\right]
\end{aligned} \tag{13}$$

where $\bar{y}^t_{d_1,d_2}$ states for the average expenditures of households satisfying $C_1 = d_1$ and $C_2 = d_2$ at time t, and n_{d_1,d_2} for the number of households satisfying $C_1 = d_1$ and $C_2 = d_2$. T is a treatment year and t_0 the year before treatment.

If K_{C_1} and K_{C_2} are null, then the double differences and the triple differences estimates are equal. Mauroux (2012) showed that K_{C_1} is positive and significatively different from zero when assessing the probability of using the tax credit. In that case, the double differences over-estimates the treatment effect on the probability of using the tax credit.

As already stated before we face a corner data issue, we only observe the CIDD expenditures y_i of households who had a positive optimal investment level y_i^* (profitability condition verified).

$$\begin{aligned}
y^*_{it} &= \alpha + \beta_1 T + \beta_2 C_1 + \beta_3 C_2 + \beta_4 C_1 C_2 + \beta_5 T C_1 + \beta_6 T C_2 + \gamma_T T C_1 C_2 + \theta X + u_{it} \\
y_{it} &= \max\{0, y^*_{it}\}
\end{aligned} \tag{14}$$

The difference-in-differences estimators are based on the assumption that in the absence of treatment the outcome of the treated and control groups would have evolved the same way (common trend assumption) and on the assumption of additive separability of the error term conditional on the observables. These assumptions become particularly unrealistic when the outcome of interest is not a continuous variable, as it is the case for censored data (Blundell and Costa Dias 2009). Nevertheless not controlling for censoring could lead to negative predicted expenditures and biased estimates. We will thus make the additional assumption that the difference-in-differences identification conditions are verified by the latent variable y^* and not the observed variable as in Ai and Norton (2003) and Puhani (2012).

4.2.4 Controlling for structural differences between treated and non-treated households

Homeowners meeting the two eligibility criteria live more often in apartments, in relatively smaller dwellings and are more often located in Paris than non treated homeowners (table 10). To quantify the structural differences between treated and non treated households, we follow Imbens and Wooldridge's (2008) suggestion to compute a normalized difference on averages for each covariate, by treatment status. It is equal to the difference on averages, scaled by the square root of the sum of the variances. It is thus a scale-free measure of the difference in distributions:

$$\Delta_X = \frac{\bar{X}_1 - \bar{X}_0}{\sqrt{S_1^2 + S_0^2}} \tag{15}$$

where $S_j^2 = \sum_{i:T_i=j}(X_i - \bar{X}_j)^2(N_j - 1)$ is the sample variance of X_i in the group j and $\bar{X}_j$ the sample mean in the group j, with $j \in \{0, 1\}$.

Imbens and Wooldridge (2008) suggest as a rule of thumb that with a normalized difference exceeding one quarter, linear regression methods tend to be sensitive to the specification. It is the case for households' composition and age, and for the dwelling type and size, so we may be worried our estimation will be sensitive to the specification and may need to control for structural differences between the treated and the non treated.

To compose a control group similar to the treatment group and control for differences in the distribution of covariates between the two groups we adapt the method of matching combined with difference-in-differences introduced by Heckman et al. (1998). The matching estimator compares at a given date the treated households' probability of declaring conservation investments to that of similar non-treated households. Under common support and "conditional independence assumption" (CIA), matching allows controlling for disequilibrium in the distribution of characteristics of the two groups. The common support condition imposes that there exist both treated households and non treated households for all values of the observable characteristics. If it is not the case, it is not possible to find a non-treated counterpart for each treated household. The CIA states that given observable characteristics and without treatment, the energy efficiency investment level is independent of the fact of being part or not of the treatment group. Nevertheless, Heckman et al. (1998) show that there is still a selection bias on the unobservable variables. They propose to combine matching and difference-in-differences. Under the assumption that, conditionally on the observable characteristics, selection bias on unobservable variables are the same on average at the different periods of the program, this estimator gives an unbiased estimate of the impact of the treatment on the treated.

We choose matching by cluster (Marbot and Roy 2011, Mauroux 2012). The difference-in-differences model will be estimated within cells defined according to covariates values. The overall effect is then the weighted average of the cell estimator, the weight being the

Table 10: Characteristics of the eligible and non eligible households in the estimation sample in 2005 (%)

	Eligible	Non eligible	Normalized difference
Age			
Less than 30 year old	9.4	4.5	0.51
30 to 39 year-old	23.5	21.7	0.07
40 to 49 year-old	16.6	21.6	-0.23
50 to 59 year-old	15.9	22.7	-0.31
60 to 74 year-old	23.1	20.4	0.11
75 year-old and more	11.6	9.1	0.19
Household's composition			
Single persons	23.0	29.4	-0.24
Couples with no child	20.5	23.5	-0.12
Single persons with children	13.0	13.4	-0.02
Couples with children	42.8	33.1	0.30
Others	0.7	0.6	0.03
Fiscal Standards of living (*)			
1^{st} decile	5.4	4.3	0.18
2^{nd} decile	6.3	5.8	0.07
3^{rd} decile	7.3	6.9	0.04
4^{th} decile	8.1	7.9	0.02
5^{th} decile	9.2	9.2	0.00
6^{th} decile	10.6	10.7	-0.01
7^{th} decile	12.0	12.2	-0.01
8^{th} decile	13.1	13.6	-0.03
9^{th} decile	14.3	14.8	-0.03
10^{th} decile	14.2	14.6	-0.02
Dwelling's characteristics			
Housing unit			
Apartment	36.3	22.2	0.49
Private house	63.7	77.8	-0.49
Size			
Smaller than 30 m^2	1.3	1.1	0.13
30 to 59 m^2	10.8	7.3	0.29
60 to 89 m^2	43.0	35.8	0.21
90 to 119 m^2	29.8	36.1	-0.20
Greater than 119 m^2	15.2	19.7	-0.22
Town size			
Rural town	23.3	30.1	-0.25
Less than 20,000 inhabitants	18.4	20.5	-0.10
Between 20,000 and 99,999 inhabitants	13.2	12.6	0.04
100,000 inhabitants and more	28.1	24.6	0.13
Paris	16.9	12.1	0.28
Thermal regulation climate zones			
H1 (ex. Paris)	56.9	52.4	0.13
H2 (ex. Nantes)	28.7	30.6	-0.06
H3 (ex. Marseille)	11.9	14.4	-0.15

Source: fiscal data from 2006, authors' own calculation.

(*) fiscal standards of living are defined as the net fiscal income of the households divided by the number of consumption units in the household.

number of treated households the year of treatment in each cell. Standard deviations are computed by bootstrap.[5] This matching method is similar to a "closest neighbors" matching since within each cell treated and non-treated households share exactly the same characteristics.

The estimator of the impact of the treatment on the treated is the following:

$$\delta_{T,C} = \frac{1}{N_{11,T}} \sum_{j=1}^{N_C} N_{11,T/j} \hat{\delta}_{T,j} \tag{16}$$

where $\hat{\delta}_{T,j}$ is the treatment effect estimate in cell j, $N_{11,T}$ is the number of treated households at time T, $N_{11,T/j}$ is the number of treated households at time T in cell j and N_C is the total number of cells.

The set of covariates is limited and we face a trade-off between controlling for the structural differences between treated and non-treated on the one hand, and the goodness of fit of the censoring estimation on the other hand (see infra). To construct the cells we use in priority the variables for which the adjusted mean differences are the largest (table 10): age of the head of the household, housing unit type (house or apartment) and the household composition. We define three specifications, from 4 to 40 cells (table 11). To respect the common support condition we exclude cells that do not include both eligible and non eligible households.

Table 11: Definition of cells

	Age	Housing unit type	Household's composition	Theoretical	Existing	Kept (*)	Size(**)
Specification A	4			4	4	4	286,826
Specification B	4	2		8	8	8	143,413
Specification C	4	2	5	40	40	40	28,683

Note: Variables used to constitute the cells are the following:

- *Housing unit type*: equals one if the dwelling is a private house, zero if it is an apartment
- *Age*: age of the head of the household in four modalities (20-29 year old, 30-49 year old, 50-74 year old, 75 year old and more)
- *Household's composition*: composition of the household depending on the marital status and the presence of children (single persons, couples, single persons with children, couples with children, others).

(*) Cells containing both treated and non treated households.
(**) Average number of households per cell and per year.

[5] We draw with replacement M samples of size N from the data, we compute the triple differences estimates for each bootstrap sample, then we compute the 2.5^e et 97.5^e quantiles of those M-bootstrap estimate distribution.

4.3 Estimation strategy

The economic value we are interested in is the difference of potential outcome of the treatment group with treatment (Y^1) and without treatment (Y^0):

$$\delta_T \quad = \quad E[Y^1|T=1, C_1C_2=1] - E[Y^0|T=1, C_1C_2=1] \tag{17}$$

4.3.1 Censoring model (1): Tobit

The Tobit model is the most frequently used model to control for censoring. Because of non linearity, the following "difference-in-difference-in-differences" Tobit model does not give an estimate the treatment effect (Puhani 2012, Ai and Norton 2003, see annex D for detailed explanations).

$$\begin{aligned} y^*_{it} &= \alpha + \beta_1 T + \beta_2 C_1 + \beta_3 C_2 + \beta_4 C_1 C_2 + \beta_5 T C_1 + \beta_6 T C_2 + \gamma_T T C_1 C_2 + \theta X + u_{it} \\ y_{it} &= \max\{0, y^*_{it}\} \\ u|X &\sim N(0, \sigma^2) \end{aligned} \tag{18}$$

Indeed, in the DDD Tobit model, the difference of potential outcome of the treatment group with and without treatment is equal to:

$$\delta_T \quad = \quad \gamma_T + \sigma \left[\lambda\left(\tfrac{\alpha+\beta_1+\beta_2+\beta_3+\beta_4+\beta_5+\beta_6+\gamma_T+\theta X}{\sigma}\right) - \lambda\left(\tfrac{\alpha+\beta_1+\beta_2+\beta_3+\beta_4+\beta_5+\beta_6+\theta X}{\sigma}\right)\right] \tag{19}$$

where $\lambda(x)$ is the inverse Mills ratio. It is important to notice that the interaction term coefficient γ_T is no longer equal to the treatment effect and gives a biased estimate of δ_T. However, it has the same sign as δ_T and given that $\lambda(.)$ is strictly monotonic δ_T is equal to zero if and only if γ_T is equal to zero too. So if the coefficient is not significant, the treatment effect will not be significant.

The Mills ratio $\lambda(x)$ is a known strictly monotonous parametric function so it is possible to compute the bias and then back out the treatment effect. First we estimate the "difference-in-difference-in-differences" Tobit model (equation 18) and get estimates for α, β_1 to β_6 and γ_T. We then compute the treatment effect taking the average value of the inverse Mills ratios to get the average treatment effect on the treated:

$$\hat{\delta_T} \quad = \quad \hat{\gamma_T} + \hat{\sigma}\left[\bar{\lambda}\left(\frac{\hat{\alpha} + \sum_{i=1}^{6}\hat{\beta}_i + \hat{\gamma_T} + \hat{\theta}X}{\hat{\sigma}}\right) - \bar{\lambda}\left(\frac{\hat{\alpha} + \sum_{i=1}^{6}\hat{\beta}_i + \hat{\theta}X}{\hat{\sigma}}\right)\right] \tag{20}$$

The Tobit model is widely used to correct for censoring but suffer from limits both from a statistical and economical point of view. The estimation heavily relies on the assumptions that residuals are normal and homoscedastic. As a consequence the results will be sensitive to misspecifications and the Tobit estimator will not be consistent if the residuals are non normal (Goldberger 1980, Arabmazar and Schmidt, 1982) and if they are heteroscedastic (Maddala and Nelson, 1975, Arabmazar and Schmidt, 1981).

From an economic point of view, the Tobit model only estimates a mean effect. When the marginal effects differ at different points of the distribution as compared to the conditional mean, the Tobit estimates may then provide inaccurate results. In the case of energy efficiency investment, it is likely that the impact of a tax credit rise on expenditures differs across classes of investments and renovation works. Indeed the lowest investments correspond to light renovation works (heating regulation devices, thermal insulation material, ...) whereas the highest investments correspond to heavy renovation works (boiler, windows replacement, combination of works,. . .). Due to differences in the characteristics of the equipments installed and the non divisibility of the equipment demand (one cannot increase its retrofitting demand by half a boiler for instance), the price elasticity of demand for energy efficiency improvements may not be constant across levels of investment. A solution to the statistical critics of the Tobit model is to use non parametric censoring models as they are robust to the potential heteroscedasticity of the residuals.

4.3.2 Censoring model (2): Censored quantile regressions

Powel (1986) showed that under some fairly weak regularity conditions, the censored quantile regression (CQR) estimator is a consistent estimator, regardless of the distribution of the error term and even in the presence of heteroscedasticity. Another desirable feature of quantile regressions is that they estimate marginal effects at different point in the distribution and thus provide information on the heterogeneity of energy conservation behavior.

By the equivariance to monotone transformation property of quantile regressions (Powel, 1986), in the presence of censoring the quantile regression model rewrites as follows:

$$Q_Y(\tau) \quad = \quad \max(0, X^{'}\beta(\tau)) \qquad (21)$$

where $Q_Y(\tau)$ is the τ^{th} quantile of Y's distribution.

Contrary to uncensored quantile regressions, in the CQR model, the constraints are no longer linear: for some values of X, the τ^{th} quantile may be below the censoring point and the real value is unobserved. The semi-linearity turns the estimation by standard linear optimization techniques uneasy.

Powell suggested the following censored quantile regression estimator of $\beta(\tau)$ as the solution to the following problem:

$$\min_{\beta \in R} \sum_{i=1}^{n} \rho_\tau \{\max{(0, Y_i - X_i^{'}\beta)}\} \qquad (22)$$

where $\rho_\tau(x) = (\tau - 1(x \leq 0))x$ is the "check" function (Koenker, 2005). This estimator is known as the Censored Least Absolute Deviation (CLAD) and is asymptotic normal. Nevertheless, it is biased at finite distance (Paarsch 1984, Moon 1989) and the objective function is not globally convex so it leads to poor convergence rate and to computational difficulties (Buchinsky 1994, Fitzenberger 1997). Other methods based on iterative procedures were developed to overcome these issues (Buchinsky and Hahn 1998, Khan and Powell 2001, Chernozhukov and Hong 2002).

As in Athey and Imbens (2006), we extend the difference-in-differences model to the quantile models. The principle is straightforward: difference-in-differences estimates apply to each quantile rather than to the mean. So individuals are compared across groups and time according to their quantile. To get the counter-factual value, the difference is added over time in the control group at quantile τ to the $Q_{Y|E=1,t=t_0}(\tau)$ quantile in the treatment group.

Conditionally on the date T and group G, for each quantile, the Quantile difference-in-differences model proposed by Athey and Imbens is the following:

$$Q_{Y|E,t}(\tau) = \alpha(\tau) + \beta_T(\tau)T + \beta_E(\tau)C_1C_2 + \delta(\tau)C_1C_2T \tag{23}$$

It is assumed to be homogeneous and constant across households of this quantile.

Our control group is composed of three sub-groups so we estimate our triple differences model at each quantile instead of the mean. We assume that, conditionally on T, C_1 and C_2, each quantile is:

$$\begin{aligned} Q_{Y^N_{C_1,C_2,t}}(\tau) = \ & \max\{0, \alpha(\tau) + \beta_1(\tau)C_1 + \beta_2(\tau)C_2 + \beta_3(\tau)C_1C_2 \\ & + \beta_4(\tau)C_1T + \beta_5(\tau)C_2T + \delta_T(\tau)C_1C_2T\} \end{aligned} \tag{24}$$

The treatment effect on the expenditures of the treated for the quantile τ of the distribution of Y is given by $\delta_T(\tau)$.

The identification conditions are (Athey and Imbens, 2006):

- the distribution of unobserved variables is identical in all sub-groups of the population;
- group and time effects are additive;
- the treatment is rank-preserving.

As in the Tobit model, we assume two first assumptions are verified by the latent quantile.

The rank preserving assumption imposes that the rank of each household in the distribution is independent of its treatment status: even if they had not been treated, the households' rank in the distribution of expenditures would be the same. It is a strong assumption because it implies that the relative value of the potential outcome of a given individual is the same if the individual is in the treatment group or in the control group. If the assumption that the treatment is rank preserving holds, then the results can be interpreted at the individual level: a positive estimate at the lowest quantile means that small energy efficiency investors who are eligible to 40% tax credit rate have increased their expenditures after the treatment, all else being equal.

On the contrary, if the "treatment rank preserving" assumption is not verified, the results can only be interpreted in terms of changes in the whole distribution of expenditures. A positive estimate at the lower quantiles means that average expenditures reported at the lowest quantiles by treated households have increased after the tax credit rate increase. The estimated effect corresponds to shifts in the whole distribution. In other words, eligible households who undertake the lowest investments for a 40% tax credit rate invest more than households who undertake the lowest investments for a 25% tax credit rate. It cannot be interpreted as the fact that households who used to undertake small investments before the reform (lower quantiles without treatment) now invest more after treatment than otherwise.

The rank preserving assumption cannot be tested. We assume it is verified but leave the reader free to reject this assumption and interpret the results accordingly.

5 Results

5.1 Treatment effect

Results from both censoring models indicate that eligible households did adjust upward their energy efficiency expenditures after the 15 percentage point tax credit rate increase and that this effect is increasing with time. As a remainder we control for inflation in the housing repair sector so our results are net of most of the price effect. The increase in energy efficiency can be interpreted as both a quantity effect (increase in the number of items) and a quality effect (more efficient item).

The results of the Tobit DDD are reported in table 12, panel A. They are fairly robust to matching specifications: the conditional mean of the energy efficiency expenditures of the treated was 7 to 14% higher in 2006 to what would have been observed if the tax credit rate had not changed, 28% to 33% in 2007 and 23% to 34% in 2008 (columns 1 and 2). As a robustness check, covariates used to define cells of the other specifications are added in the Tobit equation. Results of the augmented equations give slightly larger estimates (columns 3 to 4). The difference-in-difference (DD) Tobit estimates are larger than the DDD Tobit estimates (table 12, panel B): not controlling for the impact of the two eligibility criteria on the average expenditures would have led to overestimate the treatment effect on the treated. The ordinary least-square DDD estimations (table 12, panel C) are downward biased and not significant: not correcting for censoring would have led to underestimate the treatment effect on the treated. The selection bias seems to be small: the Tobit DDD without matching only slightly over-estimates the treatment effect on the treated, especially in 2006. As a robustness check we estimate the impact of the tax credit rate increase on the expenditures of new homeowners of dwellings built between 1977 and 1982. In this group no household benefited from the 40% tax credit rate so no impact should be observed. The estimated effect is close to null in 2006 and 2007 and lower than the estimated effect of the real treatment in 2008 (table 21 in annex C). These results confirm that the effect we estimated can be attributed to the tax credit rate increase and not to another factor.

Due to computational limits we were not able to include covariates in the censored quantile regressions (CQR), nor to estimate the matching model. Still, to gain some insights on the heterogeneity of the treatment effect depending on the level of investment, we run the DDD censored quantile regressions with no covariate (results in figure 5 and annex B, tables 18, 19, 20, panel A). Then to partially control for structural effects, we run separate CQR with no covariate on various clusters (results in figure 6 to 8 and annex B, tables 18, 19, 20, panel B). As a reminder due to heavy censoring it is not possible to robustly estimate coefficients for quantiles smaller than the censoring point (96^{th} for the whole estimation sample for example). The CQR results on the whole estimation sample confirm the previous findings: the 2006 tax credit rate increase had a positive and significant impact on the distribution of the expenditures reported by the eligible households, and this effect is increasing with time. The order of magnitude of the treatment effect is consistent with the Tobit results with no covariate (column 1 in table 12, panel A). Nevertheless the CQR estimates provide strong evidence of a high heterogeneity in the treatment effect across quantile. If the treatment effect were homogenous, we would observe a translation to the right of the entire distribution of expenditures and the estimated coefficients would be equal for all quantiles. On the contrary we observe that the bottom of the distribution adjusted more to the tax credit rate increase than the top of the distribution: in 2006, the 40% tax credit rate implementation led to a 17% increase in expenditures at the 96^{th} quantile, a 10% increase at the 97^{th} but only a 6% increase at the highest quantiles. In 2007 and 2008 the impacts were almost as twice as important at each percentile but still decreasing at the highest percentiles.

The same regularity in the results holds when the CQR are estimated on clusters of the population: when significant, the treatment effect is positive, decreasing at the larger quantiles and increasing with time. Nevertheless, the results greatly differ across dwelling types, households' age, composition, fiscal income and dwelling location clusters. The tax credit rate increase had no significant impact on the energy efficiency investments when CQR are estimated on the apartment cluster, whereas it always had a positive and significant impact when estimated on the house cluster. On the house cluster, the smallest investments were highly sensitive to the tax credit rate increase. The estimated treatment effect on the expenditures of the treated is close to 100% at the lowest positive quantile (+ 73% in 2006, + 100% in 2007 and + 108% in 2008 at the 95^{th} quantile of expenditures). At the largest quantiles, the treatment effect is more moderate and lower than 25%. The tax credit rate increase had no impact on the distribution of expenditures reported when estimated on the youngest households cluster (20 to 30 year-old), on the eldest households cluster (75 year old and more) nor on the more modest households (1^{st} and 2^{nd} deciles of fiscal revenue). On the contrary, the treatment effect is strong and significant when estimated on the 40 to 75 year old households cluster, and starting in 2007 on the distribution of expenditures reported by households in the second to fourth quintile of fiscal revenue. The results on the various clusters based on households' composition give insights on the impact of the ceiling level (8,000 for a single person, 16,000 for a couple, plus 400 euros per child). The treatment effect is significant and high at the lowest quantiles for the households with the highest ceilings (couples). On the contrary we observe almost no impact of a highest tax credit rate on the distribution of energy efficiency investments of single persons with no child. Single persons tend to live more often in apartments and are more frequently below 30 or above 75 year-old so this result may also be driven by composition effects.

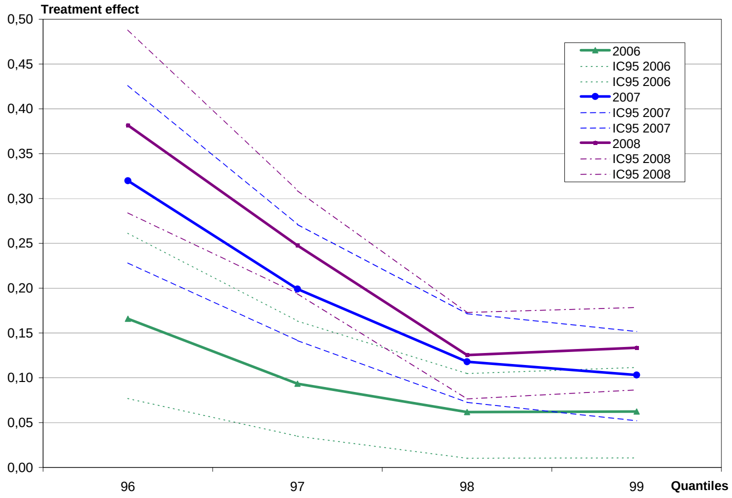
To control for composition effect, we select clusters of the most representative household types among tax credit claim filers, depending on their composition location, their fiscal standard of living, the type of the housing unit (apartment or house) and its location. In 2006, the treatment effect is not significant when estimated on the clusters of rural and urban households living in houses by household's composition, except for the relatively well-off 30 to 49 year-old couples with children and living in Paris or Île de France (in figure 9 and annex B, tables 18, 19, 20, panel C and D). After the tax credit increase, the 93^{th} quantile of the expenditures of the treated was 56% higher than it would have been without the tax credit increase, and the 98^{th} 24% higher. It is worth noting that this is the only cluster on household's composition for which the treatment is significant each year and for which the estimated treatment effect is the largest (close to 1 at the lowest quantiles above the censoring point).

Table 12: Treatment effect on treated expenditures - censored Tobit

	2006				**2007**				**2008**			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Panel A: DDD Tobit												
Specif A	0,13	0,14	0,19	**0,15**	0,32	0,33	0,39	**0,34**	0,32	0,34	0,48	**0,34**
	[0, 00; 0, 27]	[0, 01; 0, 28]	[0, 11; 0, 41]	[0, 01; 0, 28]	[0, 20; 0, 46]	[0, 22; 0, 46]	[0, 30; 0, 61]	[0, 23; 0, 47]	[0, 16; 0, 42]	[0, 20; 0, 44]	[0, 25; 0, 56]	[0, 20; 0, 45]
Specif B	0,12	0,12	**0,28**		0,30	0,31	**0,38**		0,23	0,25	**0,29**	
	[−0, 04; 0, 25]	[−0, 05; 0, 27]	[0, 07; 0, 38]		[0, 14; 0, 46]	[0, 16; 0, 46]	[0, 25; 0, 58]		[0, 06; 0, 35]	[0, 09; 0, 37]	[0, 14; 0, 45]	
Specif C	0,05	**0,07**			0,28	**0,31**			0,23	**0,27**		
	[−0, 41; 0, 18]	[−1, 87; 0, 18]			[0, 02; 0, 43]	[0, 09; 0, 43]			[−0, 01; 0, 32]	[−0, 01; 0, 36]		
No matching	0,18	0,19	0,69	0,20	0,34	0,35	0,38	0,36	0,37	0,38	0,38	0,39
	[0, 08; 0, 29]	[0, 09; 0, 29]	[0, 08; 0, 74]	[0, 09; 0, 30]	[0, 23; 0, 45]	[0, 24; 0, 47]	[0, 25; 0, 74]	[0, 25; 0, 48]	[0, 24; 0, 47]	[0, 27; 0, 49]	[0, 27; 0, 48]	[0, 27; 0, 49]
Panel B: DD Tobit												
Specif A	0,19	0,19	0,19	0,19	0,28	0,28	0,29	0,29	0,20	0,22	0,34	0,23
	[0, 14; 0, 25]	[0, 14; 0, 25]	[0, 14; 0, 25]	[0, 14; 0, 25]	[0, 23; 0, 33]	[0, 23; 0, 33]	[0, 24; 0, 34]	[0, 24; 0, 34]	[0, 13; 0, 24]	[0, 15; 0, 26]	[0, 16; 0, 27]	[0, 16; 0, 27]
Specif B	0,26	0,26	0,19		0,37	0,37	0,29		0,31	0,32	0,23	
	[0, 21; 0, 32]	[0, 20; 0, 31]	[0, 20; 0, 31]		[0, 32; 0, 43]	[0, 32; 0, 42]	[0, 32; 0, 42]		[0, 24; 0, 35]	[0, 25; 0, 36]	[0, 26; 0, 37]	
Specif C	0,27	0,27			0,39	0,39			0,34	0,35		
	[0, 19; 0, 33]	[0, 06; 0, 33]			[0, 30; 0, 44]	[0, 22; 0, 44]			[0, 26; 0, 39]	[0, 21; 0, 39]		
No matching	0,21	0,21	0,21	0,54	0,30	0,31	0,30	0,31	0,23	0,24	0,24	0,23
	[0, 16; 0, 28]	[0, 16; 0, 28]	[0, 16; 0, 28]	[0, 17; 0, 28]	[0, 26; 0, 36]	[0, 26; 0, 36]	[0, 26; 0, 36]	[0, 27; 0, 37]	[0, 16; 0, 27]	[0, 18; 0, 28]	[0, 18; 0, 28]	[0, 19; 0, 29]
Panel C: DDD OLS												
Specif A	0,03	0,03	0,04	**0,04**	0,07	0,07	0,08	**0,08**	0,07	0,07	0,07	**0,07**
	[−0, 06; 0, 11]	[−0, 05; 0, 12]	[−0, 05; 0, 12]	[−0, 05; 0, 12]	[−0, 02; 0, 16]	[−0, 01; 0, 16]	[−0, 01; 0, 17]	[−0, 01; 0, 17]	[−0, 02; 0, 15]	[−0, 02; 0, 15]	[−0, 01; 0, 16]	[−0, 01; 0, 16]
Specif B	0,03	0,03	**0,03**		0,08	0,09	**0,09**		0,07	0,07	**0,07**	
	[−0, 10; 0, 16]	[−0, 10; 0, 16]	[−0, 10; 0, 16]		[−0, 05; 0, 21]	[−0, 05; 0, 22]	[−0, 05; 0, 22]		[−0, 06; 0, 21]	[−0, 06; 0, 21]	[−0, 05; 0, 21]	
Specif C	0,03	**0,03**			0,08	**0,08**			0,08	**0,08**		
	[−0, 22; 0, 28]	[−0, 22; 0, 28]			[−0, 17; 0, 33]	[−0, 17; 0, 34]			[−0, 18; 0, 33]	[−0, 17; 0, 33]		
No matching	0,03	0,03	0,04	0,04	0,08	0,09	0,09	0,09	0,07	0,07	0,07	0,07
	[−0, 02; 0, 07]	[−0, 01; 0, 08]	[−0, 01; 0, 08]	[−0, 01; 0, 08]	[0, 04; 0, 12]	[0, 04; 0, 13]	[0, 05; 0, 13]	[0, 05; 0, 13]	[0, 03; 0, 11]	[0, 03; 0, 11]	[0, 03; 0, 12]	[0, 04; 0, 12]
Controls		x	x	x		x	x	x		x	x	x
Augmented regression:												
House			x				x				x	
Household's composition			x	x			x	x			x	x

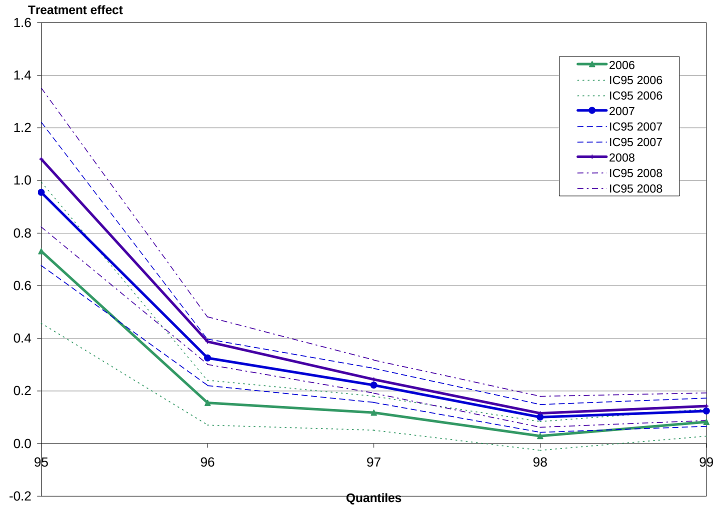
Note: 95% Confidence intervals are reported in brackets below the coefficient. They are calculated by bootstrap (100 replications) .
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982.
Authors' own calculation.

Figure 5: Results of the DDD censored quantile regression



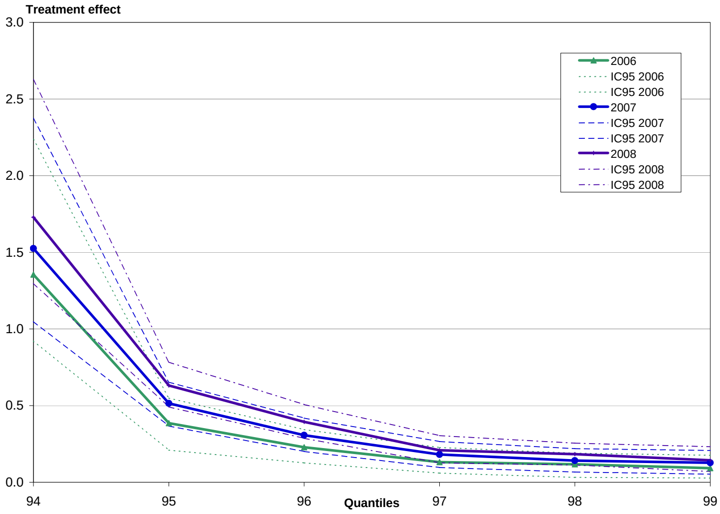
Note: 95% confidence intervals are reported in dashed lines. They are calculated by bootstrap (500 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982, author's calculations.
Estimation sample: households who purchased in the past 5 years a dwelling constructed between 1969 and 1988.

Figure 6: Results of the DDD censored quantile regression on the cluster of private houses



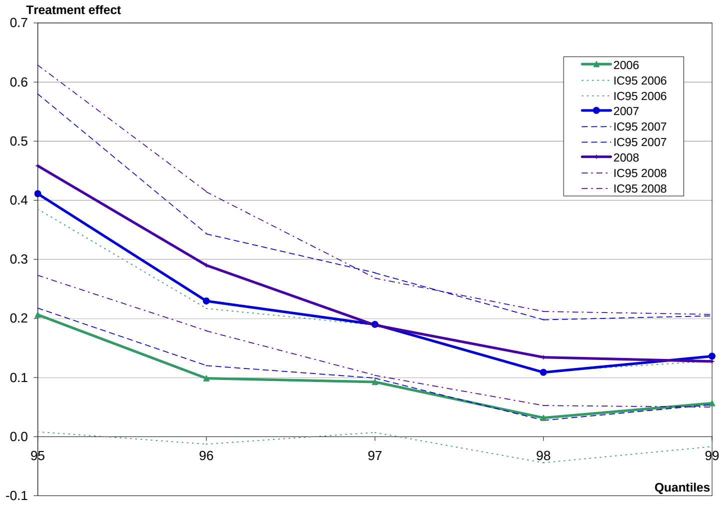
Note: 95% confidence intervals are reported in dashed lines. They are calculated by bootstrap (500 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982, author's calculations.
Estimation sample: households who purchased in the past 5 years a private house constructed between 1969 and 1988.

Figure 7: Results of the DDD censored quantile regression on the cluster of couples with children



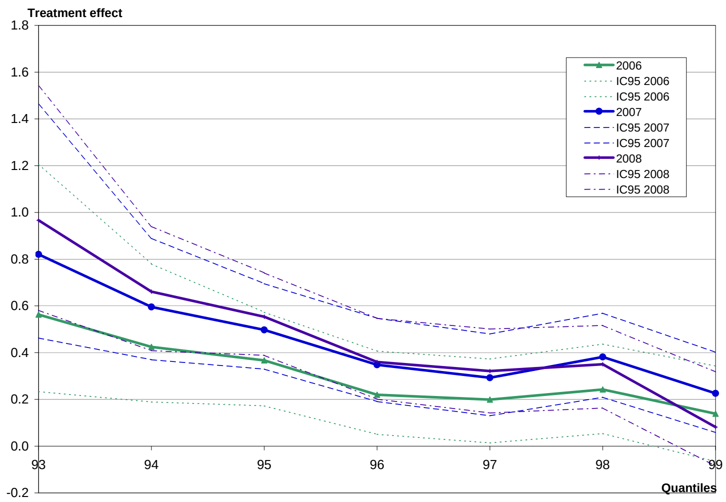
Note: 95% confidence intervals are reported in dashed lines. They are calculated by bootstrap (500 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982, author's calculations.
Estimation sample: couples with children who purchased in the past 5 years a dwelling constructed between 1969 and 1988.

Figure 8: Results of the DDD censored quantile regression on the cluster of households belonging to the highest quintile of fiscal standard of living



Note: 95% confidence intervals are reported in dashed lines. They are calculated by bootstrap (500 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982, author's calculations.
Estimation sample: households in the 20^th richest who purchased in the past 5 years a dwelling constructed between 1969 and 1988.

Figure 9: Results of the DDD censored quantile regression on the cluster of 30 to 49 year-old couples with children, living in Paris or Île de France, in the 2 top quintiles of fiscal standard of living



Note: 95% confidence intervals are reported in dashed lines. They are calculated by bootstrap (500 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982, author's calculations.
Estimation sample: households in the $20^t h$ richest who purchased in the past 5 years a dwelling constructed between 1969 and 1988.

5.2 Discussion

Mauroux (2012) suggests that a majority of households would have undertaken home renovation updates even if the tax credit rate were 25% but our results show that they adjusted their investment choices and increased their expenditures. They either installed more equipments (quantity effect) or chose even more efficient ones (quality effect).

Like Nauleau (2013) we observe a small latency in the impact of the tax credit rate increase. According to the Open database, the maturation period of a renovation project lasts more than 6 months. As a consequence the impact of a larger fiscal incentive may also take time to translate into actions and effective retrofit investments. This pattern is also consistent with the increase in the knowledge of the existence of the tax credit. In 2005, only 53% of the households were aware of it existence but they were 63% in 2006, 74% in 2007 and 78% en 2008 (survey "Maîtrise de l'énergie" Ademe-TNS-SOFRES 2008, on all households, including tenant). Moreover, the rapid increase in the number of households undertaking CIDD works fostered the diffusion of this information through word of mouth, the better understanding of its conditions and learning effects. Lastly, since the mid-2000 the survey "Maîtrise de l'énergie" reports a growing sensitivity of households to financial incentives (Ademe-TNS-SOFRES, 2008. The share of households stating that they undertake retrofitting investment to reduce their energy bill doubled between 2002 and 2008. It became the first reason to retrofit, before the historically more cited reason, improving indoor comfort).

The heterogeneity in the treatment effect, and in particular the smaller impact at the highest percentile of the distribution, may be caused by the existence of the ceiling. Only the first 8,000 euros reported by a single person and the first 16,000 euros reported by a couple (plus 400 euros per child) enter the refund calculation. When total expenditures are larger than this cap the tax credit is equivalent to a lump sum transfer. The larger the expenditures, the less sensitive to the level of tax credit rate the household should be. This theoretical results is confirmed by our estimation: at the 98^{th} and the 99^{th} quantiles, the estimated treatment effects are rather low (between 6 and 18%) and systematically lower than the estimated value for the first quantile above the censoring point. Moreover due to the nature of the expenditures (insulation material, double-glazing windows, boilers, ...), when the level of investment is already high it is not always possible to increase the quantity nor the quality of the equipments installed.

5.2.1 Impact on the final cost for households

We calculate AFC the average final cost for treated household as the average expenditures reported on the tax credit claim net of the tax credit refund :

$$AFC(\tau) = (1 - \tau)\bar{w}_\tau \tag{25}$$

The difference on the average final cost with and without treatment is equal to:

$$\Delta AFC = AFC(40) - AFC(25) \;=\; (1-0.40)\bar{w}_{40} - (1-0.25)\bar{w}_{25} \qquad (26)$$
$$= (1-0.40)(1+\hat{\delta})\bar{w}_{25} - (1-0.25)\bar{w}_{25}$$
$$= \underbrace{\left((1-0.40)\hat{\delta}\right)\bar{w}_{25}}_{\text{net additional cost}} - \underbrace{(0.40-0.25)\bar{w}_{25}}_{\text{windfall profit}}$$

where $\bar{w}_\tau$ is the average expenditures of the treated for a tax credit rate equal to τ and $\hat{\delta}$ is the treatment effect on the treated.

When the estimated treatment effect on the treatment is null (meaning that the households did not increase their expenses, $\hat{\delta} = 0$), their final cost decreases and they benefit from windfall profits ($\Delta AFC = -0.15\bar{w}_{25} < 0$).

When the estimated increase in expenditures is equal to 25%, the net additional cost is equal to the windfall profits and on average the households final expenses are unchanged.[6] Households adjust upward their expenditures but only to match the same final cost they would have spent if the tax credit rate had been 25%. In this case the reform is neutral with respect to the households renovation budget but leads to additional investments and, in the end, improves the final energy efficiency of the dwellings of the treated. When $\hat{\delta}$ is greater than 25%, the reform led to an increase on the average thermal renovation budget because the final cost is higher than what treated households would have spent if the tax credit rate had been unchanged at 25%.

Our results suggest a great variety of profiles. In 2006, the estimated treatment effect on the conditional mean expenditures is lower than 25%. Nevertheless, it is larger in 2007 and 2008, meaning that the budget spent by the treated households on thermal renovation, net of the tax credit, is equal to or slightly larger to what it would have been if the tax credit rate had remained 25%. This is consistent with the idea that households are price sensitive but face budgetary constraints. Even if just after the purchase of a new dwelling the time horizon for returns on energy efficiency investments is the longest, some households may have reached their maximal financial or debt capacity. Even if the investments would be profitable, they may not be able to increase their final budget dedicated to home renovation, even after the increase of the subsidy rate.

Looking at the CQR results, coefficients at the lowest quantile of expenditures appear to be large and almost always greater than 25%. It suggests that on average the final cost of the lower investments increased greatly after the reform. As a remainder we estimate only a gross intensive margin (increase on the average expenditures) and not a strict intensive margin (increase in expenditures of households who would have invested

[6] If the energy efficiency were all caped by the ceiling, this threshold would be 15%.

even at the 25% rate). At the lowest quantile the estimated treatment effect may capture the impact of the reform on the extensive margin: the expenditures of households who would not have invested at the 25% rate go from 0 to $w(40)$ so their adjustment ratio $w(40)/w(25)$ is theoretically infinite. The CQR results reflect this non-linearity in the expenditures.

On the contrary, when significant the 98^{th} and 99^{th} quantiles are always lower than 25%. Again this may be due to the nature of the expenditure and to the ceiling effect: when total expenditures exceed the ceiling, the tax credit is equivalent to a lump-sum transfer and the incentive effect is diluted.

5.2.2 Multiplicative effect

Reconciling the results of Mauroux (2012) on the extensive margin and our results on the gross intensive margins, we estimate a multiplicative effect of the public expenditures on the private expenses. We define it as the ratio between the total increase in private energy efficiency improvement investment ΔPI by the treated and the consequential increase in the budgetary cost ΔBC:

$$\begin{aligned} M &= \frac{\Delta PI}{\Delta BC} \\ &= \frac{\sum_{i=1}^{N_{40}} w_i(40) - \sum_{i}^{N_{25}} w_i(25)}{0.40 \sum_{i}^{N_{40}} w_i(40) - 0.25 \sum_{i=1}^{N_{25}} w_i(25)} \\ &= \frac{N_{40}\bar{w}(40) - N_{25}\bar{w}(25)}{0.40 N_{40}\bar{w}(40) - 0.25 N_{25}\bar{w}(25)} \end{aligned} \tag{27}$$

where N_τ is the number of treated households who undertake home repairs and $\bar{w}(\tau)$ is the average expenditures when the tax credit rate is equal to τ. N_{40} and $\bar{w}(40)$ are observed in the data, $N_{40} - N_{25}$ is the extensive margin estimated by Mauroux (2012) and $\bar{w}(40) - \bar{w}(25)$ is the gross intensive margin we estimate. N_{25} and $\bar{w}(25)$ are not observed because they correspond to an hypothetical situation but they can be recovered using the definition of the treatment effect:

$$N_{40} = (1 + \delta_{Ext}) N_{25} \tag{28}$$

$$\bar{w}(40) = (1 + \delta_{Int}) \bar{w}(25) \tag{29}$$

Calculations based on the Tobit estimations are provided in table 13 for the three matching specifications. It is not possible to conclude on the magnitude of the reform multiplier in 2006 but, in 2007 and 2008, each euro of budgetary expenditures generated 1.5 euro of private investment. Based on the results of simulations by ADEME on the total private investment in home renovation with and without CIDD in 2008 (Report of the comité d'évaluation des dépenses fiscales et des niches sociales, 2011), we compute the budgetary multiplier of the whole CIDD. In 2008, a euro of budgetary expenditures generated 2.2 euros of private investment. The leverage effect of the 2006 reform we estimated is lower so the 15 point increase in the tax credit appears to be less efficient than the overall policy. It is not surprising given that it was only a marginal increase in the tax credit.

Our estimates of a greater than one budgetary multiplier is not inconsistent with our previous finding of a constant average final cost because of the impact of the reform on the extensive margin. The aggregate final cost for households is equal to the difference between the total private investment and the total budgetary expenditures and as shown is the equation 30 even if the average final cost is constant, the increase in total private investments is greater than the increase in the budgetary cost if $N_{40} > N_{25}$:

$$
\begin{aligned}
\Delta PI - \Delta BC &= \sum_{N_{40}} AFC(40) - \sum_{N_{25}} AFC(25) \\
&= N_{40} AFC(40) - N_{25} AFC(25) \\
&= N_{40}(AFC(40) - AFC(25)) + (N_{40} - N_{25}) AFC(25)
\end{aligned}
\tag{30}
$$

Table 13: Impact of the 2006 reform on private investment and public finance

	2005	2006			2007			2008		
		Lower bound	Mean value	Upper bound	Lower bound	Mean value	Upper bound	Lower bound	Mean value	Upper bound
(1) ***Extensive margin***										
(A) **Impact on the tax credit claim filling rate.** ($\hat{\delta}_{Ext}$) in percentage point		0.52	0.79	1	1.2	1.48	1.73	1.09	1.49	1.72
(B) Number of treated households in the population	1,530,000	1,520,000	1,500,000	1,440,000	1,500,000	1,500,000	1,500,000	1,440,000	1,440,000	1,440,000
(C) Number of treated households in the evaluation (N_E)	287,262	283,315	283,315	283,315	278,591	278,591	278,591	266,442	266,442	266,442
(D) Number of tax credit claim fillers among the treated (N_{40})	24,705	30,315	30,315	30,315	32,038	32,038	32,038	33,039	33,039	33,039
(E) **Additional tax credit claim fillers among the treated** ($N_{40} - N_{25}$)		1,473	2,238	2,833	3,343	4,123	4,820	2,904	3,970	4,583
(2) ***Gross intensive margin***										
(F) **Impact on the average expenditures (in %)** ($\hat{\delta}_{Int}$)		1	15	28	23	34	47	27 *	34	41 *
(G) Average expenditures of the treated (w_{40})	4,134	4,543	4,543	4,543	4,956	4,956	4,956	5,043	5,043	5,043
(H) **Average additional investment. in euros** ($\bar{w}_{40} - \bar{w}_{25}$)		45	593	994	927	1,257	1,585	1,066	1,280	1,471
(I) **Impact on private investment (in million euros)** ($W_{40} - W_{25}$)		8	27	40	43	56	67	47	57	65
(3) ***Average final cost***										
(J) ΔAFC in %		-19.2	-8	2.4	-1.6	7.2	17.6	1.4	7.2	13.0
(K) ΔAFC in euros		-648	-237	64	-48	200	445	43	203	347
(4) ***Budgetary impact***										
(L) Total budgetary cost of the tax credit (in million euros)	900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900
(M) **budgetary cost of the tax credit of the treated**, in million euros ($BC(40)$)		55.1	55.1	55.1	63.5	63.5	63.5	66.6	66.6	66.6
(N) **Impact of the reform on budgetary cost** ($BC(40) - BC(25)$)		22.7	27.4	30.7	34.6	37.7	40.6	36.7	39.3	41.2
(O) **Multiplicative effect** (M)		0.3	1.0	1.8	1.1	1.5	1.9	1.1	1.5	1.8

Sources:
(A) Mauroux (2012), matching specification C (dwelling type, age in 4 modalities, climate zone in 3 modalities, town size in 5 modalities, fiscal standard of living in 8 modalities, household's composition in 4 modalities).
(B), (C), (D), (G), (L): fiscal data from 2005 to 2008
(E) Calculation: $(A)/100 * (C)$ (because by definition $N_{40}/N_E = N_{25}/N_E + \delta_{Ext}$)
(F) Results of the study: DDD Tobit for the matching specif A, augmented regression (table 12, panel A, column 4).
(H) Calculation: $(E) - (E)/(1 + (F))$
(I) Calculation: $(D) * (G) - (D - E) * (G - H)$
(J) Calculation: $(1 - 0.4)/(1 - 0.25)(1 + (F)) - 1$
(K) Calculation: $(1 - 0.4) * (G) - (1 - 0.25)(G - H)$
(M) Calculation: $0.4 * (I)$
(N) Calculation: $(M) - 0.25 * (D - E) * (G - H)$
(O) Calculation: $(I)/(N)$

6 Conclusion

In this paper we study the sensitivity of residential energy efficiency investments to the level of fiscal incentives, here the tax credit dedicated to sustainable development. Our results suggest that French households did adjust upward their housing improvement expenditures after an increase of the fiscal incentive, even if many of them would have undertaken home repairs anyway. Indeed, the 2006 tax credit rate increase had a positive and significant impact on the distribution of the expenditures reported by the eligible households, and this effect is increasing with time. The DDD Tobit estimations suggest that the average final private cost would have been the same with or without the 2006 reform. As we control for inflation in the housing repair sector, households either installed a more efficient version of the same equipment, or installed more equipment than what they would have done for a 25% tax credit rate. This result comforts the intuition that households face strong budgetary constraints for their home renovation. On several clusters of the populations Censored Quantile Regressions suggest that there is a high heterogeneity in the treatment effect across the distribution of expenditures and across categories of households.

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A Additional statistics

Table 14: Main characteristics of French households (in %)

	2005	2006	2007	2008
Household's characteristics				
Status and housing unit				
Tenant of an apartment	31.4	31.3	31.1	31.0
Tenant of a private house	11.2	11.2	11.2	11.1
Homeowner of an apartment	12.2	12.3	12.4	12.4
Homeowner of a private house	45.2	45.2	45.3	45.4
Age				
Less than 30 year old	9.8	9.7	9.7	9.7
30 to 39 year-old	18.0	17.6	17.3	17.1
40 to 49 year-old	19.6	19.6	19.4	19.4
50 to 59 year-old	19.4	19.3	19.1	18.9
60 to 74 year-old	19.3	19.5	19.9	20.3
75 year-old and more	14.0	14.2	14.5	14.6
Household's composition				
Single persons	40.1	40.3	40.6	40.8
Couples with no child enfant	24.2	24.1	24.1	24.1
Single persons with children	13.0	13.2	13.2	13.3
Couples with children	22.0	21.6	21.2	21.0
Others	0.7	0.7	0.8	0.8
Dwelling's characteristics				
Size				
Smaller than 30 m^2	3.7	3.7	3.7	3.6
30 to 59 m^2	21.0	20.9	20.8	20.7
60 to 89 m^2	38.1	37.9	37.7	37.5
90 to 119 m^2	22.5	22.5	22.6	22.6
Greater than 119 m^2	14.7	15.0	15.3	15.6
Housing unit construction year				
Before 1948	30.7	32.3	31.8	31.3
1949-1975	28.7	30.1	29.5	29.0
1976-1982	10.2	10.7	10.5	10.4
1983-1989	7.6	8.0	7.8	7.7
1990-2000	11.3	11.9	11.7	11.6
2001-2005	5.3	6.0	6.2	6.2
after 2005	0.0	1.0	2.4	3.8
Town size				
Rural town	25.6	25.5	25.6	25.7
Less than 20,000 inhabitants	18.2	18.3	18.3	18.3
Between 20,000 and 99,999 inhabitants	13.9	13.9	13.9	13.9
100,000 inhabitants and more	28.1	28.1	28.1	28.0
Paris	14.2	14.2	14.1	14.0
Thermal regulation climate zone				
H1 (ex. Paris)	58.3	58.3	58.1	58.0
H2 (ex. Nantes)	28.6	28.6	28.7	28.7
H3 (ex. Marseille)	11.1	11.1	11.2	11.2

(*) Fiscal standards of living are defined as the net fiscal income of the households divided by the number of consumption units in the household.
Source: fiscal data from 2006 to 2009, authors' own calculation.

Table 15: Main characteristics of French households filling a tax credit claim (in %)

	2005	2006	2007	2008
Household's characteristics				
Status and housing unit				
Tenant of an apartment	1.7	1.7	1.7	1.5
Tenant of a private house	2.7	2.8	2.8	2.6
Homeowner of an apartment	18.3	17.2	17.2	16.7
Homeowner of a private house	77.3	78.3	78.3	79.1
Age				
Less than 30 year old	3.7	4.0	4.1	3.8
30 to 39 year-old	17.0	17.0	16.7	15.6
40 to 49 year-old	19.7	19.3	19.0	18.3
50 to 59 year-old	24.2	23.0	22.4	22.3
60 to 74 year-old	25.8	26.4	26.9	28.4
75 year-old and more	9.7	10.4	10.9	11.7
Household's composition				
Single persons	23.9	24.1	24.7	24.8
Couples with no child enfant	37.3	36.9	36.8	37.9
Single persons with children	8.7	9.1	9.2	8.8
Couples with children	29.5	29.1	28.7	27.8
Others	0.6	0.7	0.7	0.7
Fiscal Standards of living (*)				
1^{st} decile	1.1	1.4	1.6	1.6
2^{nd} decile	2.7	3.2	3.5	3.5
3^{rd} decile	4.5	5.1	5.4	5.6
4^{th} decile	6.6	6.9	7.2	7.2
5^{th} decile	8.9	9.0	9.0	8.9
6^{th} decile	11.3	11.1	10.9	10.9
7^{th} decile	13.5	13.1	12.9	12.8
8^{th} decile	15.8	15.1	14.9	14.8
9^{th} decile	17.8	17.2	16.9	16.9
10^{th} decile	18.1	18.0	17.8	17.8
Dwelling's characteristics				
Size				
Smaller than 30 m^2	0.4	0.4	0.4	0.4
30 to 59 m^2	7.9	7.7	7.6	7.4
60 to 89 m^2	34.9	34.2	34.0	33.4
90 to 119 m^2	32.3	32.4	32.3	32.6
Greater than 119 m^2	24.5	25.4	25.7	26.1
Housing unit construction year				
Before 1948	33.6	34.2	33.8	33.6
1949-1975	37.0	36.3	35.4	35.0
1976-1982	15.9	15.5	15.4	15.7
1983-1989	7.3	7.2	7.5	7.9
1990-2000	4.8	4.9	5.0	5.1
2001-2005	1.5	1.4	1.6	1.5
after 2005	0.0	0.6	1.2	1.3
Town size				
Rural town	28.8	29.1	29.6	30.1
Less than 20,000 inhabitants	19.3	19.6	19.4	19.5
Between 20,000 and 99,999 inhabitants	13.5	13.6	13.7	13.7
100,000 inhabitants and more	26.3	26.4	26.4	25.8
Paris	12.1	11.2	10.9	10.8
Thermal regulation climate zone				
H1 (ex. Paris)	57.9	57.7	57.4	57.7
H2 (ex. Nantes)	31.9	32.5	33.2	33.4
H3 (ex. Marseille)	10.1	9.7	9.3	8.8

(*) Fiscal standards of living are defined as the net fiscal income of the households divided by the number of consumption units in the household.
Source: fiscal data from 2006 to 2009, authors' own calculation.

Table 16: Expenditures on energy efficiency of tax credit claimants (in current euros)

	2005	2006	2007	2008
Average	3,598	3,761	3,747	3,869
Household's characteristics				
Status and housing unit				
Tenant of an apartment	3,644	3,917	3,992	4,170
Tenant of a private house	4,095	4,747	4,326	4,479
Homeowner of an apartment	2,828	3,032	3,129	3,225
Homeowner of a private house	3,761	3,883	3,856	3,978
Age				
Less than 30 year old	3,275	3,428	3,502	3,528
30 to 39 year-old	3,734	3,857	3,836	3,885
40 to 49 year-old	3,790	3,989	4,009	4,169
50 to 59 year-old	3,779	3,975	3,943	4,052
60 to 74 year-old	3,472	3,653	3,634	3,803
75 year-old and more	2,971	3,109	3,123	3,294
Household's composition				
Single persons	3,153	3,233	3,262	3,349
Couples with no child enfant	3,624	3,790	3,757	3,928
Single persons with children	3,581	3,812	3,782	3,876
Couples with children	3,917	4,131	4,125	4,233
Others	4,268	4,427	4,419	4,522
Fiscal Standards of living (*)				
1^{st} decile	4,052	4,273	4,202	4,250
2^{nd} decile	3,606	3,768	3,722	3,757
3^{rd} decile	3,431	3,515	3,495	3,627
4^{th} decile	3,448	3,458	3,432	3,508
5^{th} decile	3,236	3,391	3,379	3,446
6^{th} decile	3,255	3,434	3,419	3,472
7^{th} decile	3,347	3,490	3,468	3,570
8^{th} decile	3,484	3,589	3,583	3,707
9^{th} decile	3,663	3,786	3,835	3,926
10^{th} decile	4,278	4,611	4,558	4,826
Dwelling's characteristics				
Size				
Smaller than 30 m^2	2,595	2,575	2,737	2,705
30 to 59 m^2	2,810	2,919	2,939	2,993
60 to 89 m^2	3,297	3,410	3,421	3,490
90 to 119 m^2	3,645	3,778	3,774	3,880
Greater than 119 m^2	4,216	4,467	4,382	4,586
Housing unit construction year				
Before 1948	3,635	3,769	3,707	3,837
1949-1975	3,608	3,801	3,803	3,899
1976-1982	3,819	3,956	3,970	4,094
1983-1989	3,488	3,641	3,722	3,877
1990-2000	3,026	3,213	3,283	3,455
2001-2005	3,364	3,062	3,129	3,213
after 2005		4,975	3,938	3,881
Town size				
Rural town	3,763	3,903	3,865	4,031
Less than 20,000 inhabitants	3,722	3,908	3,805	3,902
Between 20,000 and 99,999 inhabitants	3,520	3,667	3,685	3,749
100,000 inhabitants and more	3,425	3,574	3,578	3,669
Paris	3,476	3,762	3,896	4,067
Thermal regulation climate zone				
H1 (ex. Paris)	3,608	3,805	3,813	3,964
H2 (ex. Nantes)	3,630	3,710	3,647	3,715
H3 (ex. Marseille)	3,440	3,668	3,700	3,837

(*) Fiscal standards of living are defined as the net fiscal income of the households divided by the number of consumption units in the household.
Source: fiscal data from 2006 to 2009, authors' own calculation.

Table 17: Share of households filling a tax credit claim (in %)

	2005	2006	2007	2008
Average	2.7	3.1	3.3	3.6
Household's characteristics				
Status and housing unit				
Tenant of an apartment	0.1	0.2	0.2	0.2
Tenant of a private house	0.6	0.8	0.8	0.9
Homeowner of an apartment	4.0	4.4	4.5	4.9
Homeowner of a private house	4.6	5.4	5.7	6.3
Age				
Less than 30 year old	1.0	1.1	1.4	1.4
30 to 39 year-old	2.5	3.3	3.2	3.3
40 to 49 year-old	2.7	3.3	3.2	3.4
50 to 59 year-old	3.3	3.3	3.9	4.3
60 to 74 year-old	3.6	4.4	4.4	5.1
75 year-old and more	1.8	2.2	2.5	2.9
Household's composition				
Single persons	1.6	1.9	2.0	2.2
Couples with no child enfant	4.1	4.8	5.0	5.7
Single persons with children	1.8	2.2	2.3	2.4
Couples with children	3.6	4.2	4.4	4.8
Others	2.3	2.8	2.9	3.2
Fiscal Standards of living (*)				
1^{st} decile	0.3	0.4	0.5	0.6
2^{nd} decile	0.7	1.0	1.1	1.3
3^{rd} decile	1.2	1.6	1.8	2.0
4^{th} decile	1.7	2.2	2.4	2.6
5^{th} decile	2.4	2.8	2.9	3.3
6^{th} decile	3.0	3.5	3.6	4.0
7^{th} decile	3.6	4.1	4.2	4.6
8^{th} decile	4.2	4.7	4.9	5.4
9^{th} decile	4.7	5.4	5.6	6.1
10^{th} decile	4.8	5.6	5.8	6.5
Dwelling's characteristics				
Size				
Smaller than 30 m^2	0.3	0.4	0.4	0.4
30 to 59 m^2	1.0	1.2	1.2	1.3
60 to 89 m^2	2.5	2.8	3.0	3.3
90 to 119 m^2	3.9	4.5	4.7	5.3
Greater than 119 m^2	4.5	5.3	5.6	6.2
Housing unit construction year				
Before 1948	2.8	3.4	3.5	4.0
1949-1975	3.3	3.8	4.0	4.5
1976-1982	4.0	4.6	4.9	5.6
1983-1989	2.4	2.9	3.2	3.8
1990-2000	1.1	1.3	1.4	1.6
2001-2005	0.7	0.8	0.9	0.9
after 2005	0.0	1.8	1.7	1.3
Town size				
Rural town	3.3	3.9	4.1	4.6
Less than 20,000 inhabitants	3.1	3.6	3.7	4.1
Between 20,000 and 99,999 inhabitants	2.8	3.3	3.5	3.8
100,000 inhabitants and more	2.7	3.2	3.3	3.6
Paris	2.5	2.7	2.7	3.0
Thermal regulation climate zone				
H1 (ex. Paris)	2.6	3.1	3.2	3.6
H2 (ex. Nantes)	3.0	3.6	3.8	4.2
H3 (ex. Marseille)	2.4	2.7	2.7	2.8

(*) Fiscal standards of living are defined as the net fiscal income of the households divided by the number of consumption units in the household.
Source: fiscal data from 2006 to 2009, authors' own calculation.

B Censored quantile regressions results

Table 18: Treatment effect on treated expenditures 2006 - Quantile regressions on various clusters

2005-2006 Quantiles	93	94	95	96	97	98	99
Panel A: no covariates. estimation on the cluster of:							
Homeowners (whole sample)				**0.17**	**0.09**	**0.06**	**0.06**
				[0.08; 0.26]	[0.03; 0.16]	[0.01; 0.10]	[0.01; 0.11]
Panel B: no covariates. estimation on the cluster of:							
Apartments					−0.06	0.00	0.01
					[−0.73; 0.52]	[−0.17; 0.16]	[−0.11; 0.12]
Private houses			**0.73**	**0.15**	**0.12**	0.03	**0.08**
			[0.46; 0.99]	[0.07; 0.24]	[0.05; 0.18]	[−0.03; 0.08]	[0.03; 0.13]
Less than 30 years old				0.05	0.01	0.01	−0.02
				[−0.59; 0.62]	[−0.40; 0.44]	[−0.29; 0.29]	[−0.25; 0.24]
30 to 49 year-old			**0.36**	**0.15**	**0.14**	0.04	**0.10**
			[0.18; 0.58]	[0.05; 0.25]	[0.05; 0.21]	[−0.03; 0.11]	[0.03; 0.16]
50 to 74 year-old				**0.24**	0.10	0.07	**0.09**
				[0.08; 0.48]	[−0.01; 0.20]	[−0.01; 0.15]	[0.01; 0.16]
75 year-old and more						−0.02	−0.20
						[−0.65; 1.02]	[−0.49; 0.12]
Single persons					0.18	0.03	0.00
					[−0.09; 0.50]	[−0.12; 0.17]	[−0.10; 0.09]
Couples with no child				0.09	0.04	0.05	0.04
				[−0.25; 0.50]	[−0.19; 0.23]	[−0.06; 0.18]	[−0.11; 0.18]
Single persons with children			**0.82**	0.05	0.05	0.01	0.09
			[0.31; 1.51]	[−0.11; 0.22]	[−0.07; 0.16]	[−0.08; 0.12]	[0.00; 0.18]
Couples with children		**1.35**	**0.39**	**0.23**	**0.13**	**0.12**	**0.09**
		[0.92; 2.24]	[0.21; 0.55]	[0.13; 0.34]	[0.06; 0.23]	[0.03; 0.19]	[0.03; 0.18]
Rural towns				**0.27**	**0.24**	**0.12**	0.06
				[0.05; 0.47]	[0.10; 0.37]	[0.02; 0.21]	[−0.02; 0.15]
Less than 20,000 inhabitants			0.50	0.00	−0.01	−0.03	0.06
			[−0.03; 0.99]	[−0.21; 0.21]	[−0.15; 0.12]	[−0.15; 0.09]	[−0.05; 0.17]
Between 20,000 and 99,999 inhabitants				−0.01	−0.03	−0.08	0.01
				[−0.26; 0.24]	[−0.23; 0.15]	[−0.20; 0.08]	[−0.15; 0.16]
100,000 inhabitants and more			**0.72**	**0.27**	**0.19**	**0.16**	**0.17**
			[0.39; 1.23]	[0.11; 0.42]	[0.07; 0.31]	[0.07; 0.26]	[0.07; 0.27]
Paris and Île-de-France				0.12	0.02	0.04	−0.02
				[−0.38; 0.56]	[−0.21; 0.24]	[−0.12; 0.20]	[−0.14; 0.14]
1^{st} quintile of fiscal standard of living							0.09
							[−0.19; 0.39]
2^{nd} quintile of fiscal standard of living						0.09	0.08
						[−0.10; 0.29]	[−0.06; 0.21]
3^{nd} quintile of fiscal standard of living				**0.33**	0.14	**0.14**	0.06
				[0.04; 0.58]	[−0.01; 0.30]	[0.03; 0.26]	[−0.05; 0.16]
4^{nd} quintile of fiscal standard of living			0.17	0.05	0.03	−0.01	0.01
			[−0.06; 0.44]	[−0.09; 0.18]	[−0.06; 0.14]	[−0.09; 0.07]	[−0.08; 0.11]
5^{nd} quintile of fiscal standard of living			**0.21**	0.10	**0.09**	0.03	0.06
			[0.01; 0.39]	[−0.01; 0.22]	[0.01; 0.19]	[−0.04; 0.11]	[−0.02; 0.13]
Panel C: no covariates. estimation on the cluster of private houses in until 20,000 inhabitants' towns and:							
Couples with no child			0.33	0.18	0.19	0.14	0.14
+ 50 to 74 year-old + Q4-Q5			[−0.02; 0.72]	[−0.06; 0.42]	[−0.04; 0.34]	[−0.05; 0.31]	[−0.03; 0.34]
Couples with children					0.28	0.14	0.09
+ 30 to 49 year-old + Q1-Q2					[−0.21; 0.93]	[−0.19; 0.45]	[−0.18; 0.38]
Couples with children			0.41	0.29	0.10	0.17	0.09
+ 30 to 49 year-old + Q3			[−0.10; 0.93]	[−0.06; 0.66]	[−0.17; 0.44]	[−0.12; 0.47]	[−0.19; 0.37]
Couples with children	0.25	0.18	0.10	0.02	−0.04	0.06	0.00
+ 30 to 49 year-old + Q4-Q5	[−0.09; 0.70]	[−0.13; 0.51]	[−0.13; 0.32]	[−0.19; 0.20]	[−0.22; 0.16]	[−0.14; 0.20]	[−0.18; 0.21]
Panel D: no covariates. estimation on the cluster of private houses in Paris and Île de France and:							
Couples with no child			−0.06	0.01	−0.04	0.02	0.02
+ 50 to 74 year-old + Q4-Q5			[−0.54; 0.34]	[−0.36; 0.32]	[−0.31; 0.27]	[−0.25; 0.32]	[−0.34; 0.32]
Couples with children					−0.08	−0.02	0.22
+ 30 to 49 year-old + Q1-Q2					[−0.76; 0.41]	[−0.54; 0.46]	[−0.20; 0.66]
Couples with children	**0.56**	**0.42**	**0.37**	**0.22**	**0.20**	**0.24**	0.14
+ 30 to 49 year-old + Q4-Q5	[0.23; 1.21]	[0.19; 0.78]	[0.17; 0.57]	[0.05; 0.41]	[0.01; 0.37]	[0.05; 0.44]	[−0.07; 0.34]

Note: 95% Confidence intervals are reported in brackets below the coefficient. They are calculated by bootstrap (500 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982.

Table 19: Treatment effect on treated expenditures 2007 - Quantile regressions on various clusters

2005-2007 Quantiles	93	94	95	96	97	98	99
Panel A: no covariates. estimation on the cluster of:							
Homeowners (whole sample)				**0.32**	**0.20**	**0.12**	**0.10**
				[0.23; 0.43]	[0.14; 0.27]	[0.07; 0.17]	[0.05; 0.15]
Panel B: no covariates. estimation on the cluster of:							
Apartments					0.18	0.07	0.04
					[−0.26; 0.73]	[−0.10; 0.24]	[−0.09; 0.14]
Private houses			**0.95**	**0.33**	**0.22**	**0.10**	**0.12**
			[0.68; 1.22]	[0.22; 0.40]	[0.16; 0.29]	[0.04; 0.15]	[0.07; 0.17]
Less than 30 years old				−0.01	−0.03	−0.06	−0.03
				[−0.56; 0.54]	[−0.41; 0.38]	[−0.40; 0.23]	[−0.27; 0.20]
30 to 49 year-old			**0.56**	**0.29**	**0.20**	**0.11**	**0.16**
			[0.37; 0.79]	[0.19; 0.39]	[0.13; 0.28]	[0.03; 0.17]	[0.09; 0.23]
50 to 74 year-old				**0.41**	**0.24**	**0.14**	**0.10**
				[0.24; 0.61]	[0.14; 0.35]	[0.05; 0.21]	[0.03; 0.18]
75 year-old and more						0.17	−0.06
						[−0.37; 1.20]	[−0.33; 0.25]
Single persons					**0.31**	0.10	0.04
					[0.11; 0.58]	[−0.03; 0.24]	[−0.05; 0.15]
Couples with no child				**0.42**	0.21	**0.15**	0.07
				[0.10; 0.78]	[−0.01; 0.39]	[0.02; 0.27]	[−0.05; 0.19]
Single persons with children			**1.06**	**0.21**	**0.17**	0.07	**0.13**
			[0.59; 1.74]	[0.05; 0.39]	[0.04; 0.28]	[−0.04; 0.17]	[0.04; 0.22]
Couples with children		**1.53**	**0.51**	**0.31**	**0.18**	**0.14**	**0.13**
		[1.05; 2.37]	[0.37; 0.65]	[0.20; 0.42]	[0.10; 0.27]	[0.07; 0.22]	[0.05; 0.21]
Rural towns				**0.46**	**0.38**	**0.17**	**0.14**
				[0.24; 0.68]	[0.25; 0.51]	[0.06; 0.26]	[0.05; 0.22]
Less than 20,000 inhabitants			**0.82**	**0.23**	0.12	0.04	0.09
			[0.31; 1.25]	[0.02; 0.42]	[−0.02; 0.25]	[−0.07; 0.14]	[−0.01; 0.21]
Between 20,000 and 99,999 inhabitants				0.11	0.05	−0.01	0.12
				[−0.12; 0.34]	[−0.13; 0.24]	[−0.15; 0.13]	[−0.02; 0.26]
100,000 inhabitants and more			**0.81**	**0.29**	**0.23**	**0.17**	**0.17**
			[0.45; 1.26]	[0.14; 0.45]	[0.13; 0.36]	[0.07; 0.25]	[0.08; 0.26]
Paris and Île-de-France				0.32	0.15	0.09	0.09
				[−0.13; 0.69]	[−0.06; 0.34]	[−0.07; 0.27]	[−0.07; 0.24]
1^{st} quintile of fiscal standard of living							0.20
							[−0.11; 0.45]
2^{nd} quintile of fiscal standard of living						0.20	**0.18**
						[−0.01; 0.41]	[0.01; 0.30]
3^{nd} quintile of fiscal standard of living				**0.43**	**0.21**	**0.18**	**0.13**
				[0.16; 0.71]	[0.06; 0.38]	[0.07; 0.30]	[0.02; 0.24]
4^{nd} quintile of fiscal standard of living			**0.35**	**0.17**	**0.14**	0.02	0.04
			[0.13; 0.57]	[0.04; 0.30]	[0.04; 0.25]	[−0.08; 0.11]	[−0.04; 0.14]
5^{nd} quintile of fiscal standard of living			**0.41**	**0.23**	**0.19**	**0.11**	**0.14**
			[0.22; 0.58]	[0.12; 0.34]	[0.10; 0.28]	[0.03; 0.20]	[0.05; 0.20]
Panel C: no covariates. estimation on the cluster of private houses in until 20,000 inhabitants' towns and:							
Couples with no child			**0.78**	**0.50**	**0.34**	**0.26**	**0.25**
+ 50 to 74 year-old + Q4-Q5			[0.41; 1.14]	[0.31; 0.73]	[0.11; 0.49]	[0.08; 0.43]	[0.08; 0.40]
Couples with children					0.33	0.11	0.14
+ 30 to 49 year-old + Q1-Q2					[−0.16; 0.91]	[−0.19; 0.42]	[−0.19; 0.43]
Couples with children			**0.71**	**0.52**	**0.36**	**0.37**	**0.36**
+ 30 to 49 year-old + Q3			[0.34; 1.23]	[0.22; 0.86]	[0.12; 0.65]	[0.02; 0.63]	[0.10; 0.55]
Couples with children	0.24	0.08	0.00	−0.06	−0.09	0.03	−0.02
+ 30 to 49 year-old + Q4-Q5	[−0.14; 0.67]	[−0.18; 0.43]	[−0.23; 0.27]	[−0.26; 0.14]	[−0.25; 0.11]	[−0.14; 0.20]	[−0.20; 0.20]
Panel D: no covariates. estimation on the cluster of private houses in Paris and Île de France and:							
Couples with no child		0.32	0.18	0.27	0.08	0.02	−0.07
+ 50 to 74 year-old + Q4-Q5		[−0.32; 1.47]	[−0.22; 0.60]	[−0.12; 0.61]	[−0.19; 0.40]	[−0.29; 0.33]	[−0.38; 0.27]
Couples with children					−0.10	**0.19**	0.11
+ 30 to 49 year-old + Q1-Q2					[−0.70; 0.58]	[0.39; 0.55]	[−0.37; 0.56]
Couples with children	**0.82**	**0.60**	**0.50**	**0.35**	**0.29**	**0.38**	**0.23**
+ 30 to 49 year-old + Q4-Q5	[0.46; 1.46]	[0.37; 0.89]	[0.33; 0.70]	[0.19; 0.55]	[0.13; 0.48]	[0.21; 0.57]	[0.06; 0.40]

Note: 95% Confidence intervals are reported in brackets below the coefficient. They are calculated by bootstrap (500 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982.

Table 20: Treatment effect on treated expenditures 2008 - Quantile regressions on various clusters

2005-2008 Quantiles	93	94	95	96	97	98	99
Panel A: no covariates. estimation on the cluster of:							
Homeowners (whole sample)				**0.38**	**0.25**	**0.13**	**0.13**
				[0.28; 0.49]	[0.19; 0.31]	[0.08; 0.17]	[0.09; 0.18]
Panel B: no covariates. estimation on the cluster of:							
Apartments					0.17	0.06	0.14
					[−0.22; 0.68]	[−0.09; 0.24]	[0.00; 0.24]
Private houses			**1.08**	**0.39**	**0.24**	**0.11**	**0.14**
			[0.82; 1.35]	[0.30; 0.48]	[0.19; 0.32]	[0.06; 0.18]	[0.09; 0.19]
Less than 30 years old				0.09	0.00	−0.02	−0.08
				[−0.52; 0.68]	[−0.32; 0.38]	[−0.35; 0.24]	[−0.28; 0.14]
30 to 49 year-old			**0.66**	**0.37**	**0.27**	**0.12**	**0.18**
			[0.50; 0.87]	[0.27; 0.46]	[0.20; 0.36]	[0.05; 0.18]	[0.12; 0.24]
50 to 74 year-old				**0.51**	**0.27**	**0.16**	**0.13**
				[0.36; 0.71]	[0.19; 0.38]	[0.07; 0.22]	[0.06; 0.22]
75 year-old and more						0.12	0.04
						[−0.44; 1.30]	[−0.34; 0.24]
Single persons					**0.31**	0.11	0.04
					[0.12; 0.60]	[−0.02; 0.23]	[−0.05; 0.12]
Couples with no child				**0.56**	**0.37**	**0.18**	**0.13**
				[0.22; 0.94]	[0.15; 0.54]	[0.02; 0.27]	[0.11; 0.24]
Single persons with children			**1.15**	0.26	**0.19**	0.11	**0.13**
			[0.63; 1.74]	[−0.08; 0.44]	[0.07; 0.31]	[0.00; 0.21]	[0.04; 0.23]
Couples with children		**1.73**	**0.63**	**0.39**	**0.21**	**0.18**	**0.14**
		[1.30; 2.63]	[0.49; 0.78]	[0.29; 0.51]	[0.13; 0.30]	[0.11; 0.26]	[0.07; 0.23]
Rural towns				**0.52**	**0.40**	**0.21**	**0.17**
				[0.35; 0.72]	[0.28; 0.53]	[0.11; 0.31]	[0.09; 0.28]
Less than 20,000 inhabitants			**0.84**	**0.25**	0.10	0.06	**0.12**
			[0.38; 1.36]	[0.06; 0.45]	[−0.01; 0.23]	[−0.09; 0.13]	[0.01; 0.22]
Between 20,000 and 99,999 inhabitants				**0.23**	0.14	0.02	0.06
				[0.04; 0.48]	[−0.02; 0.30]	[−0.11; 0.17]	[−0.08; 0.20]
100,000 inhabitants and more			**0.76**	**0.27**	**0.24**	**0.16**	**0.16**
			[0.40; 1.21]	[0.13; 0.43]	[0.14; 0.36]	[0.07; 0.25]	[0.07; 0.26]
Paris and Île-de-France				**0.76**	**0.36**	**0.16**	**0.15**
				[0.38; 1.15]	[0.18; 0.57]	[0.01; 0.31]	[0.02; 0.30]
1^{st} quintile of fiscal standard of living							0.22
							[−0.05; 0.52]
2^{nd} quintile of fiscal standard of living						0.20	**0.16**
						[0.00; 0.42]	[0.03; 0.29]
3^{nd} quintile of fiscal standard of living				**0.57**	**0.33**	**0.22**	**0.16**
				[0.31; 0.80]	[0.21; 0.48]	[0.12; 0.33]	[0.05; 0.27]
4^{nd} quintile of fiscal standard of living			**0.47**	**0.26**	**0.17**	0.03	0.06
			[0.24; 0.68]	[0.16; 0.41]	[0.08; 0.27]	[−0.05; 0.11]	[−0.03; 0.14]
5^{nd} quintile of fiscal standard of living			**0.46**	**0.29**	**0.19**	**0.13**	**0.13**
			[0.27; 0.63]	[0.18; 0.41]	[0.10; 0.27]	[0.05; 0.21]	[0.05; 0.21]
Panel C: no covariates. estimation on the cluster of private houses in until 20,000 inhabitants' towns and:							
Couples with no child			**0.68**	**0.39**	**0.28**	**0.24**	0.15
+ 50 to 74 year-old + Q4-Q5			[0.36; 1.02]	[0.16; 0.59]	[0.06; 0.43]	[0.08; 0.42]	[−0.02; 0.31]
Couples with children					0.37	0.18	**0.31**
+ 30 to 49 year-old + Q1-Q2					[−0.06; 1.00]	[−0.07; 0.50]	[0.02; 0.54]
Couples with children			**0.70**	**0.46**	0.24	0.30	0.25
+ 30 to 49 year-old + Q3			[0.22; 1.14]	[0.11; 0.82]	[−0.01; 0.55]	[−0.02; 0.55]	[−0.10; 0.49]
Couples with children	**0.53**	**0.39**	**0.25**	0.10	0.07	0.12	0.03
+ 30 to 49 year-old + Q4-Q5	[0.14; 0.90]	[0.10; 0.73]	[0.01; 0.50]	[−0.08; 0.28]	[−0.09; 0.27]	[−0.06; 0.32]	[−0.17; 0.22]
Panel D: no covariates. estimation on the cluster of private houses in Paris and Île de France and:							
Couples with no child		**0.72**	**0.39**	0.25	0.10	0.11	−0.03
+ 50 to 74 year-old + Q4-Q5		[0.01; 1.95]	[0.02; 0.80]	[−0.09; 0.59]	[−0.22; 0.44]	[−0.13; 0.39]	[−0.36; 0.27]
Couples with children					−0.40	−0.10	−0.18
+ 30 to 49 year-old + Q1-Q2					[−0.93; 0.26]	[−0.66; 0.29]	[−0.60; 0.32]
Couples with children	**0.97**	**0.66**	**0.55**	**0.36**	**0.32**	**0.35**	0.08
+ 30 to 49 year-old + Q4-Q5	[0.58; 1.54]	[0.41; 0.94]	[0.39; 0.74]	[0.20; 0.55]	[0.14; 0.50]	[0.16; 0.52]	[−0.09; 0.32]

Note: 95% Confidence intervals are reported in brackets below the coefficient. They are calculated by bootstrap (500 replications). Source: fiscal data from 2006 to 2009 on households owning for 5 years or less a dwelling constructed between 1969 and 1982.

C Placebo test results

Table 21: Robustness check - Placebo DDD

	2006				2007				2008			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
DDD TOBIT Placebo												
Dwelling constructed between 1977 and 1988												
Specif A	−0,02	−0,01	0,30	**0,13**	−0,01	−0,02	0,14	**0,12**	0,18	0,18	0,39	**0,19**
	[−0,22;0,13]	[−0,22;0,12]	[0,01;0,46]	[−0,23;0,13]	[−0,19;0,14]	[−0,20;0,13]	[−0,03;0,39]	[−0,22;0,14]	[−0,03;0,35]	[−0,02;0,35]	[0,10;0,53]	[0,07;0,35]
Specif B	−0,03	−0,04	**0,25**		0,02	0,07	**0,20**		0,22	0,15	**0,41**	
	[−0,21;0,14]	[−0,21;0,13]	[0,03;0,38]		[−0,21;0,16]	[−0,22;0,15]	[−0,05;0,34]		[−0,05;0,32]	[−0,05;0,31]	[0,07;0,46]	
Specif C	−0,10	**-0,09**			−0,01	**-0,04**			0,12	**0,10**		
	[−0,57;−0,02]	[−4,80;−0,03]			[−0,41;0,15]	[−0,76;0,10]			[−0,40;0,28]	[−0,93;0,27]		
No matching	−0,08	−0,08	0,52	−0,08	0,02	0,01	0,56	0,02	0,15	0,15	0,29	0,15
	[−0,25;0,08]	[−0,25;0,07]	[−0,07;0,63]	[−0,07;0,50]	[−0,17;0,18]	[−0,19;0,16]	[0,14;0,66]	[−0,18;0,17]	[−0,03;0,27]	[−0,03;0,27]	[0,10;0,70]	[−0,03;0,27]
Controls		x	x	x		x	x	x		x	x	x
Augmented regression												
House			x				x				x	
Household's composition			x	x			x	x			x	x

Note: 95% Confidence intervals are reported in brackets below the coefficient.
They are calculated by bootstrap (100 replications).
Source: fiscal data from 2006 to 2009 on households owning for 5 years or less.
Authors' own calculation.

D Difference in differences in non linear models

We take the Rubin framework of potential outcomes. Let Y_t^I be the potential investment of the treated if they are treated and Y_t^0 if they are not treated, with $Y_t^I = w(40)$ and $Y_t^0 = w(25)$. We assume potential outcomes are linear:

$$Y_t^I = \alpha + \beta_t + \beta_{C1} + \beta_{C2} + \beta_{C1C2} + \delta + \theta X + \epsilon$$
$$Y_t^0 = \alpha + \beta_t + \beta_{C1} + \beta_{C2} + \beta_{C1C2} + \theta X + \epsilon$$

where β_k is the fixed effect of the dummy k, X is a vector of covariates and ϵ is an error term.

We observe

$$Y_t = I.Y_t^I + (1 - I).Y_t^0$$

where $I = 1$ if the household is treated in t. We are interested in the difference of potential outcome of the treatment group with and without treatment:

$$\delta = E[Y^1|T = 1, G = 1] - E[Y^0|T = 1, G = 1] \tag{31}$$

where $T = 1$ for periods after the treatment and $G = 1$ if the households is in the treatment group. $TG = I$. In linear model (and under identifying conditions), it can be simply computed as differences in conditional expectations and estimated with ordinary least squares. In non-linear models the treatment effect is not equal to the interaction term coefficient (Ai and Norton 2003, Puhani 2012). Indeed the treatment effect is equal to:

$$\begin{aligned} \delta &= E[Y^1|T = 1, G = 1] - E[Y^0|T = 1, G = 1] \\ &= \Phi(\alpha + \beta_T + \beta_G + \gamma + X\beta) - \Phi(\alpha + \beta_T + \beta_G + X\beta) \end{aligned}$$

where $\Phi(.)$ is the conditional distribution function of the residuals. When X_k is a dummy, the coefficient β_k can be calculated as the difference between the conditional expectation taken at $X_k = 1$ and $X_k = 0$. Here the interaction term coefficient is equal to the cross difference of the conditional expectation of Y with respect to T and G:

$$\begin{aligned} \frac{\Delta^2 E[Y|Y, G, X]}{\Delta T \Delta G} &= [\Phi(\alpha + \beta + \gamma + X\theta) - \Phi(\beta + X\theta)] - [\Phi(\alpha + X\theta) - \Phi(X\theta)] \\ &\neq \delta \end{aligned}$$

The treatment effect δ is zero if and only if γ is equal to zero and have the same sign as γ ($\Phi(.)$ strictly monotonic).

Puhani (2012) showed that the treatment effect can be computed as the difference between the cross difference of the conditional expectation of the observed outcome Y and the cross difference of the conditional expectation of the counterfactual outcome Y_0. Noting that:

$$\frac{\Delta^2 E[Y^0|Y,G,X]}{\Delta T \Delta G} = [\Phi(\alpha+\beta+X\theta) - \Phi(\beta+X\theta)] + [\Phi(\alpha+X\theta) - \Phi(X\theta)]$$

He deducts,

$$\begin{aligned}\frac{\Delta^2 E[Y|Y,G,X]}{\Delta T \Delta G} - \frac{\Delta^2 E[Y^0|Y,G,X]}{\Delta T \Delta G} &= \Phi(\alpha+\beta+\gamma+X\theta) - \Phi(\alpha+\beta+X\theta) \\ &= \delta\end{aligned}$$

This result holds for to all non linear models with a parametric structure where $\Phi(.)$ is a nonlinear strictly monotonic transformation function.

Following this, the difference in difference Tobit treatment effect is:

$$\begin{aligned}\delta =& E[Y^1|T=1.G=1] - E[Y^0|T=1.G=1] \\ =& \alpha+\beta_T+\beta_G+\gamma+X\theta+\sigma\lambda\left(\frac{\alpha+\beta_T+\beta_G+\gamma+X\beta}{\sigma}\right) \\ & - \left[\alpha+\beta_T+\beta_G+\gamma+X\theta+\sigma\lambda\left(\frac{\alpha+\beta_T+\beta_G+\gamma+X\beta}{\sigma}\right)\right] \\ =& \gamma+\sigma\left[\lambda\left(\frac{\alpha+\beta_T+\beta_G+\gamma+X\beta}{\sigma}\right) - \lambda\left(\frac{\alpha+\beta_T+\beta_G+X\beta}{\sigma}\right)\right]\end{aligned}$$

where $\lambda(x)$ is the inverse Mills ratio. From this we see that γ is a biased estimate of the treatment effect.

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