Fuel poverty in residential housing: Providing financial support vs. combatting substandard housing

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Dorothée Charlier[1], Berangère Legendre[2] and Anna Risch[3]

Abstract

Between 50 and 125 million Europeans are unable to afford the energy needed for adequate heating, cooking, light, and use of appliances in the home. Tackling fuel poverty has thus become a public policy challenge. In this paper, we assess the effectiveness of social energy subsidies and social housing to reduce fuel poverty. The literature reports that rising fuel prices, low incomes, and energy-inefficient housing are the main causes of fuel poverty. Existing public policies focus mainly on price- and income-based measures to reduce fuel poverty, such as social energy subsidies. This type of policy is palliative as it does not permit to sustainably eradicate fuel poverty. Other policies aim to encourage renovation in order to improve energy efficiency. Those policies are curative as they sustainably reduce one cause of fuel poverty : energy inefficiency. In this paper, we focus on another public policy to tackle fuel poverty : social housing. We believe that this policy could be preventive, as the literature reports the better energy efficiency of social housing. We use matching methods and find that living in social housing decreases fuel poverty by 5.4% to 9.1%. On the contrary, social energy subsidies have no effect on fuel poverty.

Keywords: Fuel poverty; social housing; social energy subsidy; matching method

JEL codes: Q41, C52, Q51

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Introduction

An estimated 50 to 125 million people in Europe are fuel poor[4] (Bird et al., 2010; European Fuel Poverty and Energy Efficiency, 2006), and 8.8% of EU27 households were in arrears on their utility bills in 2011 (European University Institute, 2011). In France, in 2006, 8,4% of the 30% lowest income households were fuel poor. This figure increased to 10,4% in 2013 and 14% in 2016.

Fuel poverty is an aspect of multidimensional poverty. Poverty is indeed a multidimensional phenomenon, made up of several factors constituting poor's people deprivation experience. Fuel poverty combines several key aspects of poverty. Fuel poor households lack the means to improve the energy efficiency of their often-substandard homes: financial hardships are often combined with low energy efficiency of the home and can lead to heating restriction behavior to meet household budget constraints.

Three factors are clearly identified as fuel poverty causes in the literature: rising fuel prices, low incomes, and energy-inefficient housing (EPEE, 2006; IEA, 2011; Rappel, 2011; Palmer et al., 2008). Poor housing conditions such as noise or damp (EPEE, 2006; Phimister et al., 2015) impact well-being at home, and when combined with rising fuel prices, lead to increasing energy bills and problems paying them.

There are several approaches to measuring the phenomenon of fuel poverty, each focusing on different aspects. (i) Three monetary indicators are commonly used in the literature. First, fuel poverty can be measured as the ratio of energy expenditures to household income. A household can be defined as experiencing fuel poverty if its energy expenditures make up more than 10% of its income (Hills, 2011; Hills, 2012). The second approach is very similar to the well-known indicator of relative poverty : the fuel poor are those with a residual income (i.e. after housing and fuel costs) below a poverty line defined as 60% of the median national equalised income. Finally, "the low income high cost approach" covers households with both low income (residual income below 60% of the national median level) and relatively high energy needs (energy expenditures above the national median level). (ii) Another approach is based on household

[4] Fuel poverty occurs when a household is unable to afford the most basic levels of energy for adequate heating, cooking, light, and use of appliances in the home.

behavior. A household is considered as fuel poor if its effective energy consumption is lower than the theoretical amount needed to guarantee a standard level of comfort and an appropriate use of heating, cooking, and light. In this case households are seen as restricting their energy consumption in order to afford their energy bill, by setting lower indoor temperatures, for example.

Fuel poverty and monetary poverty are inextricably linked: according to Palmer et al. (2008), nearly three-quarters of the fuel poor in England in 2005 were also income poor, showing the multidimensional aspect of poverty.

Poverty is often measured as a relative phenomenon, implying that such deprivation phenomenon is also representative of the inequality level on a territory. Many reasons justify to design policies in order to reduce inequalities and poverty, from a normative and a positive point of view (Atkinson, 2015). Moral sense and collective interest are both normative reasons to fight inequalities. But from a positive point of view, policy makers also focus on relieving poverty to reduce inequality which creates negative externalities (Ehrlich, 1973; Becker, 1968; Kelly, 2000; Kang, 2016), damaging for social cohesion (Runciman, 1966; Wodon and Yithzaki, 2002) and economic growth (Cingano14).

Different public policies are then implemented to tackle the multiple aspects of poverty, including fuel poverty. Decreasing fuel poverty and mitigating its social issues have become a target for the French government. The current French fuel poverty policy was established in 2010 during the French environment roundtables called ‘‘Grenelle de l’environnement’’, resulting in the law “Grenelle 2” n° 2010-788[5]. The law defines a person suffering from fuel poverty as *“*anyone who encounters, in their home, particular difficulties in obtaining the energy required to meet their basic energy needs due to insufficient resources or housing conditions”.

In response of the fuel poverty challenges, three types of policies are commonly cited as measures to reduce fuel poverty: price-based, income-based and energy-efficiency improvement policies (Legendre and Ricci, 2015). Price-based policies consist of social energy subsidies.

[5] Loi n° 2010-788 du 12 juillet 2010 portant sur l’engagement national pour l’environnement [Law passed on July 12, 2010 defining France’s commitment to the environment].

These were introduced to offer discounted energy bills to those vulnerable to or already in fuel poverty, with special price plans from individual energy suppliers. Price-based policies have given these households the right to a reduction in electricity bills since 2005 and natural gas bills since 2008. This policy is expected to bring some households out of fuel poverty by reducing the relative cost of their consumed energy. In September 2017, the French Ministry of ecology decided to transform the social energy price reduction to energy vouchers and to extend this program to all fuel-poor households.

Poorer households can also receive income-based assistance in the form of allowances to help them cover their expenditures on housing (housing allowances), energy, and water.

Implementing these price- and income-based policies is supposed to reduce fuel poverty by impacting the two first causes of fuel poverty identified in the literature: rising fuel prices and low incomes (Keirstead, 2008). Price-based and income based policies are palliative measures as such policies reduce ex-post exposure to fuel poverty but does not eradicate the phenomenon.

Energy-efficiency policies, on the contrary, aim to decrease energy consumption in order to reduce vulnerable households' energy bills and thus reduce exposure to fuel poverty over the long term. They are curative measures designed to tackle fuel poverty ex ante.

Another public policy, less commonly cited as a measure to reduce fuel poverty, is the development of social housing. Many years ago, the French government began to develop policies to support low-income households and help them to live in decent housing by providing social housing. This measure aims at being preventive and is primarily seen as a social policy designed to reduce the vulnerability of low-income earners, especially given the weight of housing expenditures in the households' budget.

However, social housing may also reduce fuel poverty, which results from both a lack of resources and unfavorable housing characteristics. In France, 70% of the households experiencing fuel poverty belong to the lowest quartile of standard of living, and 87% were private housing tenants in 2015 (*Ministère de l'Environnement de l'Énergie et de la Mer,* 2015). Social housing is consequently intended to aid these households by impacting the third cause of fuel poverty, energy-inefficient housing. Social housing could be a powerful policy instrument in reducing fuel poverty as this housing sector is highly regulated and heavily influenced by government policies (Reeves et al., 2010).

This article investigates whether social housing and social energy subsidies significantly impact fuel poverty in France, assuming these policies impact two causes of this phenomenon identified in the literature. The first policy affects housing energy efficiency and the second one impacts the cost of energy. These policies being respectively defined as preventive and palliative measures against fuel poverty. In 2016, the cost of social energy subsidies has been estimated at around €394 million per year (or €102 million for gas and €292 million for electricity) according to the energy regulation and in 2018, 85 millions euros are devoted to social housing renovations. Since these policies are costly and given that multidimensional poverty appears harmful for social cohesion, evaluating their effectiveness seems necessary.

Based on an innovative recent French survey specially dedicated to energy consumption (PHEBUS), this assessment of public housing policy in keeping poor households out of fuel poverty is conducted using matching methods. Considering that fuel poverty still lacks a commonly agreed-upon definition, we use different measures of fuel poverty.

Our results show that living a social housing leads to a 5.4-9.1% decrease in fuel poverty depending on the fuel poverty definition. On the contrary, social energy subsidies have no impact on fuel poverty. We conclude then that preventive measures are much more efficient to tackle fuel poverty. Palliative measures (income-based policies) have only a one-off impact on fuel poverty unless repeated, and do not permit to eradicate the phenomenon. Preventive policies, social housing, seem to be a more complete approach to tackling fuel poverty: it directly impacts housing quality, one cause of fuel poverty, as this housing stock is directly managed by the public sector.

The rest of the paper is organized as follows: the first part discusses social housing and social energy subsidies in France and the second presents the data used. In the third part, we explain our method. Finally, the results are reported and analyzed in the last part before concluding.

I. Social housing and social energy subsidies in France

Social housing in France offers decent, low-rent housing to persons whose income does not exceed certain thresholds. Rented public housing units can be created following a public or private initiative. More than 10 million French people are tenants in the 4.7 million public housing units (*Ministère du logement et de l'habitat durable*, 2015). In France there are 69.2 social housing units for every 1,000 inhabitants, but large disparities exist among European countries, such as Spain with 3 social housing units for every 1,000 inhabitants or Netherlands with 147 social housing units for every 1,000 inhabitants (J.CH, 2008).

Social housing is likely to pollute less than private rental housing. Some studies have indeed demonstrated that social housing offers better energy performance (Devalière et al., 2011) because it is managed by public policies (Keirstead, 2008) and thus offers better opportunities for carbon reduction (Teli et al., 2015) or installation of energy-saving devices (Reeves et al., 2010). Social housing thus has the potential to fight housing energy inefficiency, which is one cause of fuel poverty.

In its investment plan for housing, the French government committed to introducing financial support (such as a reduced rate of value-added tax on the construction of social housing) in order to promote the construction and renovation of social housing. The objective is set at 150,000 new social housing units and 120,000 renovations a year by 2017.

Social energy price reductions were introduced in 2005 for electricity and then extended to gas consumers in 2008. This program is dedicated to helping low-income households reduce their energy burden. This measure is meant to have an impact on monetary causes of fuel poverty. In 2012, 1,662,000 households benefitted from a social energy price reduction. In 2013 the income threshold determining the eligibility for this measure was raised. Since then, the number of households benefitting from these social energy price reductions increased to 3,531,000 in 2014 (2,465,000 households for electricity and 1,066,000 households for gas, respectively) (*Ministère de l'Environnement de l'Énergie et de la Mer*, 2015). In September 2017, this measure was turned into a subsidy voucher and extended to all low-income households.

For electricity, a lump sum deduction is granted based on the number of people in the household and the power contract and corresponds to a discount of between €71 and €140 per year. This social price reduction was founded by the French public electricity company EDF. For gas, a lump sum deduction is also applied depending on the size of households and their energy consumption, leading to a discount from €23 to €185 per year. The discount is given by the gas suppliers. In 2016, the cost of the measure has been estimated at around €394 million per year (or €102 million for gas and €292 million for electricity) according to the energy regulation commission (*Ministère de l'Environnement de l'Énergie et de la Mer*, 2015).

Social energy subsidies will be extended to the use of all fuels beginning 2018. The price reduction program will be replaced by an energy subsidy voucher of €48 to €227 a year, depending on the household income and composition. Households will use this voucher to help pay their energy bill. The number of beneficiaries is estimated at 4 million for a total cost of €600 million a year.

Given the cost and the potential extensions of these social policies, our objective is to assess their effectiveness in mitigating fuel poverty, in terms of their effects on fuel poverty causes (monetary causes for the social energy subsidies and energy efficiency for social housing).

II. Data

i. Data description

To study the effect of social housing and social energy subsidies on fuel poverty, we use the 2013 *PHEBUS* (*Housing performance, equipment, needs, and uses of energy survey*) database.

The *Housing performance, equipment, needs, and uses of energy survey* is a new French government survey[6]. This random survey consists of two parts conducted separately: a face-to-face interview with the occupants of the home about their energy consumption expenditures and attitudes, and an energy performance diagnosis of the housing[7]. The survey aims to provide

[6] The Operation Managers of the survey are: Ministry of Ecology, Sustainable Development and Energy (MEDDE); General Commission for Sustainable Development (MEDDTL); Service Observation and Statistics (SOeS); under the direction of housing and construction statistics; under the direction of energy statistics

[7] The energy performance diagnosis is a document that provides an estimate of the energy consumption and greenhouse gas emissions of a dwelling, and gives it an energy label. It is part of the technical diagnostics record, which also includes asbestos diagnostics, termites, lead, and the status of indoor facilities for electricity and gas. This diagnosis has been mandatory since 1 November 2006 when a dwelling is sold and since 1 July 2007 when a unit is leased. The display of the unit's energy performance rating in real estate agencies has been mandatory since 1 January 2011. The diagnosis, which is valid for 10 years, was provided

information about the energy performance of the housing stock, allowing for analysis according to household characteristics (such as disposable income per adult equivalent or household size) and household appliances, as well as their energy use and consumption. Attitudes towards energy consumption are also available through this survey (we know, for example, the household's indoor temperature and the beginning and the end of the heating period).

This survey provides very detailed information on energy consumption by type of fuel, energy costs, and energy subsidies. We know if households live in social or private housing and if they are eligible for a social energy subsidy for gas and electricity.

We group variables into 3 main categories: socio-demographic household characteristics (socio-professional category, disposable income, and behavioral and preference variables), building characteristics (period of construction, type of housing, type of heating system, type of fuel, and renovations), and location (climate area and urban area size).

The present paper studies fuel poverty using not only disposable income but also information about energy expenditures and attitudes towards energy consumption. To our knowledge, this dataset is one of the most precise and richest surveys in this field of research. Our sample contains 3,786 households including 1,051 tenants[8] and is representative of the French population (the sample is weighted to ensure representativeness).

ii. Fuel poverty and descriptive statistics

A widely used measure of fuel poverty is the energy-income ratio (De Quero and Lapostolet, 2009). Boardman (2010) considers that a "household is in fuel poverty if it needs to spend more than 10% of its income on fuel to maintain a satisfactory heating regime and all other energy services". Today, while there are numerous criticisms of this 10% ratio approach and more generally to the exclusive cost/income approach, these definitions remain commonly used.

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free to the participant at the end of the survey.

[8] We exclude from the sample households using a collective heating system and who thus do not declare the amount of their collective charges dedicated to heating or hot water use. Indeed, we cannot calculate accurate energy expenditures for these households. Consequently, we slightly underestimate households using collective heating in our sample: in France 46% of tenants living in social housing have collective heating (against 32,4% in our sample), as do 19% of tenants living in private sector (against 17,5% in our sample) (Devalière et *al*. 2011)

The *Low Income-High Costs* (LIHC) indicator is an alternative measurement framework focusing on the overlap of high costs and low income (Hills, 2011). This definition is the one used by French national entities such as *ONPE (Observatoire National de la Précarité Energétique)*. According to the low-income high-costs approach, a household is considered energy poor if (i) its income minus housing and energy expenditures per adult equivalent is below 60% of the national median level, and (ii) its energy expenditure per square meter is higher than the national median level. In our analysis, we retain these two definitions.

In addition to the financial approach, household behavior can be a good indicator of fuel poverty (Charlier et al., 2015). A household is considered fuel poor if its effective energy consumption is lower than the theoretical level needed to guarantee a standard level of comfort. In this case, households restrict their heating consumption in order to afford their energy bill. From the database, we know if households restricted their heating consumption during the last winter as well as the average annual indoor temperature. We use these two indicators to complete our analysis. Therefore, we capture several dimensions of fuel poverty, based on both financial constraints and household behavior.

According to the *PHEBUS* survey, the percentage of fuel poor in France, according to the 10% ratio approach, is 9.96%; 10.73% according to the Hills definition, while 4.39% of French households are considered fuel poor if we consider both definitions[9]. Tenants are more vulnerable: The share of fuel-poor households is significantly higher among tenants according to the low income – high cost definition (23.3% vs. 4.8% for homeowners) and the perception of discomfort in their housing seems more widespread among tenants (31.2% of tenants reported suffering from cold in their housing as opposed to 12.2% of homeowners) (Table 7 of Appendix A). Considering these observations and the fact that social policy concerns mainly tenants (only 1% of homeowners benefit from social energy subsidies vs. 8% of tenants) we exclude homeowners from our analysis.

The main summary statistics about fuel-poor tenants according to each definition are presented in Table 8 of Appendix A. Fuel-poor tenants restrict their energy consumption to reduce their bills

[9] The *PHEBUS* survey is conducted one time; therefore we study fuel poverty in one year. We cannot measure the sensitivity of fuel poverty according to the variability of energy prices. However, heating with electricity and gas are the most common in our sample, and the prices of electricity and gas are less variable than that of oil products.

(41% on average vs. 32% for the total sample). Their disposable income is almost two times lower than the average (around €15,000 a year vs. €26,400). More than the half of fuel-poor tenants live in the coldest climate area (area H1) and prefer saving energy rather than using their heating system to obtain a comfortable temperature, which seems to be consistent with their financial situation.

In the database, 40.4 % of tenants live in social housing (or 480 households). The rent is on average €385.64 (or €5.77 per square meter) a month as opposed to €563.06 (or €10.56 per square meter) for tenants in the private sector. Moreover, 8.05% of tenants (or 81 households) are eligible for a social energy subsidy for gas or electricity. The amount of the deduction due to the social energy subsidy is 115.93 €/year, which represents 14.42% of the total energy bill of eligible households in our data. 58 households benefit from both social housing and social energy subsidies.

Generally speaking, households who are eligible for social housing and social energy subsidies are almost the same : they have a lower disposable income than households which do not benefit from any public policy. More households report suffering from cold in the housing even if the percentage of households which restrict their energy consumption is lower (see Table 8 in Appendix A). Overall, on average, households who live in social housing live in more recent units than tenants living in private housing (Figure 1), which is consistent with the literature (Keirstead, 2008). Energy expenditures per square meter are also slightly lower in social housing than for tenants in private housing on average (17.28 €/m^2 vs. 18.88 €/m^2) (Table 1). The share of energy expenditures included in collective charges is higher in social housing (as collective heating is more commonly used) (Table 9 in appendix A).

[Insert Figure 1]

[Insert Table 1]

Among low-income households, only some experiencing fuel poverty live in social housing or benefit from social energy subsidies. Around 36% of fuel-poor households have access to social housing, and between 12 and 16% of fuel-poor households, depending on the definition used, have access to a social energy subsidy (Table 9 in appendix A).

For a similar indoor temperature, 29.6% of fuel-poor households benefitting from social energy subsidies report restricting their heating consumption during the winter, as opposed to 44.9% of the fuel poor who do not benefit from a social program (Table 2).

[Insert Table 2]

III. Method

We are interested in estimating the causal effect of social housing on fuel poverty. To do this, we use matching methods, which allow us to evaluate the effect after controlling for the observable characteristics of each observation.

Based on our data, we form three groups of households. The first one, the control group, includes 552 tenants who do not benefit from any social program (they live in private housing and do not benefit from the social energy subsidy). The second one is treatment group 1, composed of tenants who benefit only from social housing. We remove the sample households that benefited from both social housing and social energy subsidies (58 households)[10], in order to isolate and measure the effect of social housing on fuel poverty. The 422 tenants in treatment group 1 live in social housing and do not receive the social energy subsidy. The third group, treatment group 2, includes 81 tenants who benefit from social energy subsidies. Considering the size of this sample, we are not able to exclude households living in social housing (they represent 71.6% of tenants benefitting from the social energy subsidy). This means that we cannot isolate the effect of the social energy subsidy on fuel poverty. However, it is still possible to study whether this policy strengthens the effect of social housing on fuel poverty.

A vector x of control variables represents personal attributes and housing characteristics. The binary variable (the treatment variable) denoted R indicates first, whether the household lives in

[10] Consequently, we remove from the sample households that do not declare if they benefit from social energy subsidies for electricity or gas.

social housing or not, and second, whether the household benefit from social energy tariff. For the treated sample, $R = 1$ and for the control group, $R = 0$.

Only a perfectly randomized evaluation can avoid selection bias in the estimate. In that case, comparing the outcome variable difference between treated and untreated individuals provides the impact of the treatment (Rubin, 1974). However, in most cases independence between the probability of being treated and personal attributes can absolutely not be assumed. In our case, benefitting from a public policy is undoubtedly strongly linked with household characteristics including housing conditions. The present study is based on non-experimental data, so we use a non-experimental method to estimate the impact of public policies on fuel poverty. The impact of public policy ($\beta(x)$) should ideally be the difference between the outcome variable for the treated households (Y_1) and this variable if the household had not been treated (Y_0):

$$\beta(x) = E[Y_1/ R = 1, X = x] - E[Y_0/ R = 1, X = x] \qquad [2]$$

where:

$$Y = RY_1 + (1 - R)Y_0 \qquad [3]$$

Y_0 and Y_1 cannot be observed simultaneously; therefore the counterfactual situation (i.e. $E[Y_0/ R = 1, X = x]$) must be estimated. We use matching estimators, which requires matching each treated household with households from the control group. The control group includes all households lacking access to public programs (i.e. tenants living in private housing with no social energy subsidies). Our first objective is to measure the effect of social housing on fuel poverty. Treatment group (1) includes households that benefit from social housing (except those that also benefit from social energy subsidies, in order to measure only the effect of social housing on fuel poverty). We then focus on social energy subsidies with treatment group (2), which includes all households benefitting from social energy subsidies. Considering the size of the sample, we are not able to exclude households living in social housing. This means that we cannot isolate the effect of social energy subsidies on fuel poverty. However, our results will indicate whether social subsidies strengthen the effect of social housing on fuel poverty (Figure 2).

[Insert Figure 2]

Rubin (1974) proposes matching observations by observable characteristics. Each beneficiary of public policy is matched to a non-beneficiary on the basis of the probability of living in social housing (or benefitting from social energy subsidies) conditionally on the different observed characteristics x. This conditional probability is the propensity score (Rosembaum and Rubin, 1983). Rosembaum and Rubin (1983) show that matching on estimated $R(x)$ is as good as matching on x. Key assumptions for identification of the constraint effect are conditional independence –or *unconfoundedness*- and the presence of a propensity score density common support (Heckman et al., 1999). Under those assumptions, the average treatment effect is then equal to the mean difference in fuel poverty rate, over the common support. We assess the sensitivity of the results compared to the conditional independence assumption in part 5 of the paper.

A nonparametric matching estimator, kernel matching, is used to construct a counterfactual match for each treated unit by using the weighted average of all untreated units. The weights ($\omega(.)$) for kernel matching are given by:

$$\omega(i.j) = \frac{K\left(\frac{P_j - P_i}{a_n}\right)}{\sum_{k \in C}\left(\frac{P_k - P_i}{a_n}\right)} \qquad [4]$$

where P_i is the propensity score for a constrained household and P_j the propensity score for an untreated household included in the control sample (C). K(.) is a kernel function and a_n a bandwidth parameter. Robust standard errors are calculated using bootstrapping, as the estimators are asymptotically linear. Bootstrapping standard errors also takes into account the variance due to the derivation of the propensity score matching and the determination of the common support (Efron and Tibshirani, 1993; Heckman et al., 1997; Horowitz, 2003).

IV. Results

i. Propensity scores

To estimate the effect of these social measures, we first match households from the treatment and control groups on the basis of their propensity scores–the probability of 1) living in social housing and 2) benefitting from social energy subsidies. In our analysis, we consider household characteristics, building characteristics, and location. We estimate these probabilities using logit models; our results are presented in Tables 3a and 3b. Several control variables have an impact on the probability of being eligible for this social policy.

[Insert Table 3a]

[Insert Table 3b]

The propensity score of a household living in social housing is significantly influenced by disposable income. The estimate also shows that period of construction and agglomeration are strongly significant and positive. Results suggest that social housing is renovated significantly more often, which is in line with the literature on the energy efficiency of social housing. The propensity score of social energy subsidies is significantly influenced by disposable income and the number of people in the household, which conforms to the allocation criteria.

The propensity scores allow us to match a household from the treatment group with an equivalent household from the control group. The balancing assumption between the characteristics of the treatment and control groups is valid in both cases.

Moreover, to verify that the household characteristics of the treatment and control groups are similar after matching, we use two indicators: the standardized percentage bias (Rosenbaum and Rubin, 1983) and overall explanatory power of the propensity score estimates (Table 4)[11]. (i) The overall bias decreases significantly after matching, from 18.2% to 1.5% for social housing and from 16.0% to 2.6% for social energy subsidies. The deviation of household characteristics of the control group from those of the treatment group, before and after matching, is largely reduced after matching (See Figures 3a, 3b and 4a, 4b in appendix B1). (ii) We study the overall

[11] See appendix B for a more detailed presentation of these indicators.

explanatory power of the propensity score estimates using the likelihood ratio (LR) chi-square test. This test enables us to conclude that before matching, at least one of the regression coefficients in the model is not equal to zero. In contrast, all regression coefficients are simultaneously equal to zero after matching. Considering these results, we can use the matched sample to estimate the effect of social housing.

[Insert Table 4]

ii. Causal effects

We first estimate the impact of social housing using the kernel-matching estimator, which enables us to assess the differential of fuel poverty rate between similar treated (i.e. households living in social housing) and control households (Table 5). We also consider behavioral indicators.

[Insert Table 5]

Living in social housing led to a 5.4% decrease in fuel poverty with the 10% ratio approach and a 9.1% decrease with the low income-high cost definition, *ceteris paribus*. However, households living in social housing do not restrict their heating consumption more. On the contrary, the indoor temperature is slightly higher in social housing, by 0.29 Celsius degrees, all things being equal. These results suggest that the development of social housing will have a significant effect on fuel poverty.

Second, we estimate the impact of social energy subsidies on fuel poverty indicators (Table 6).

[Insert Table 6]

Receiving a social energy subsidy does not prevent a household from being fuel poor. Indeed, the effect of benefitting from social energy subsidies has no effect on fuel poverty indicators, even though a large part of the sample (71.6% of tenants in this treatment group) also live in social housing. Thus, the French government's recent extension of the measure should be debated.

Our results show that providing energy-efficient housing to low-income households is a more efficient means of reducing fuel poverty than providing them financial support to pay their energy bills. Considering that fuel-poor households do not necessarily live in social housing, promoting social housing seems a more effective policy for decreasing fuel poverty than energy subsidies, under the constraint of ensuring equality of social housing allocation according to income criteria.

The sensitivity of the results to a deviation from the assumption of conditional independence of potential outcomes (CIA) is presented in the following section (Table 10a and 10b in appendix B).

V. Sensitivity analysis

Matching is based on the conditional independence assumption (CIA), which means that given the observable characteristics, fuel poverty is independent of the probability of living in social housing. This assumption is not satisfied when unobserved characteristics of the treatment group differ from unobserved characteristics of the control group. In this section, we observe the sensitivity of the results to a deviation from this assumption. This enables us to appraise the extent to which the results can be altered by unobserved factors.

We use Ichino et al.'s (2008) approach: We test the impact of an unobserved binary variable u that affects the potential outcome Y (i.e. fuel poverty) and eligibility for first social housing and second for social energy subsidies (T = 1). The conditional independence given the set of variables x is not valid, but this assumption holds given x and u. In other words,

$$Pr(T = 1|Y_0, Y_1, x) \neq Pr(T = 1|x) \quad [5]$$

and

$$Pr(T = 1|Y_0, Y_1, x, u) = Pr(T = 1|x, u), \qquad [6]$$

where u is assumed to be binary.

First, we characterize the distribution of u, which depends on the choice of four parameters. In the case of a binary outcome (fuel poverty), the distribution of u is defined by:

$$\Pr(u = 1|T = i, Y = j, x) = \Pr(u = 1|T = i, Y = j) \equiv P_{ij} \qquad [7]$$

where i, j ∈ {0,1}, which gives the probability that $u = 1$ in each of the four groups defined by the treatment status (i = 0 or 1) and the outcome value (j = 0 or 1).

We assign arbitrary values to the parameter Pij. We consider the neutral confounder Pij = 0.5, and then we can let u mimic the behavior of some important covariates. We choose variables that we assume to have an effect on the outcome.

Second, we simulate u, which is considered like any other variable and is used to estimate the propensity score and the kernel-matching estimates.

Results are presented in Table 10a and 10b in appendix B. The first four columns contain probabilities Pij. For each value we give at u, the next two columns present, respectively, the outcome effect (i.e., the effect of u on the untreated outcome, controlling for observables x) and the selection effect (i.e., the effect of u on eligibility for social housing or social energy subsidies, controlling for observables x). When the outcome and the selection effects are higher than 1, this means that u has a positive effect on the probability of being fuel poor, given that households are ineligible for social housing, and a positive effect on the probability of living in social housing. The last column provides the effect and the standard error of social housing, controlling for observable x and unobservable u.

To focus on the effect of social housing on fuel poverty, we assume that u follows the same distribution as the variable "Construction 1991 and after". For the 10% ratio approach, P11 equals 0.18, i.e. 18% of fuel-poor households living in social housing live in dwellings built in 1991 and after. The effect of social housing, controlling for x and u, is slightly lower than the situation without a confounder (-0.0483). For the low income high cost approach, if we consider that u has the same distribution as the "2nd income decile" variable, the impact of social housing is significant and close to the situation without a confounder reaching -0.0886. The sensitivity analysis confirms the robustness of the results concerning the effect of social housing on the fuel poverty rate.

Discussion

Using an innovative recent French survey specially dedicated to energy consumption (PHEBUS), we empirically evaluated two social public policies (social housing and social energy tariff) by estimating their causal effect on fuel poverty. We conclude that developing social housing is an efficient public policy to tackle fuel poverty whereas social energy subsidies do not seem to impact it.

Our results confirm that palliative measures are not efficient to reduce the phenomenon, as they do not permit to eradicate sustainably one of the fuel poverty sources. Palliative measures need to be repeated to relieve only temporarily households of the energy burden.

Living in social housing led to a 5.4-9.1% decrease in fuel poverty depending on the fuel poverty definition. Whereas price- and income-based policies suffer from important limitations, social housing seems to be a more complete approach to tackling fuel poverty: it impacts housing quality, one cause of fuel poverty. The public sector directly manages this housing stock, and given that efficient housing are promoted by the government, this policy can also be viewed as a curative policy.

These results could have strong implications and offer new perspectives. Implementing effective policies to reduce fuel poverty – social housing- could also help reach environmental objectives. Social housing consumes indeed 30% less energy than private housing in France.

The Investment Plan for Housing, announced in March 2013 by the President of France, aims to mobilize considerable resources for social housing. The objective is to promote the creation and renovation of social housing. The goal is to renovate 500,000 units per year, including 120,000 social housing units *(République Française*, 2013). If this objective is reached, living in social housing will become a driver of fuel poverty alleviation. The average cost of a renovation during the period 2009-2014 amounted to € 30,500 per housing. Of these 30,500 euros, 32% were spent on energy renovation. For example, the 394 millions devoted to social energy subsidies would represent about 12900 housing renovations.

However, for public housing to become an effective alleviator of fuel poverty, the image and social reality of public housing needs to be seriously examined. Social exclusion[12] is a particularly relevant topic in many countries, especially in a period in which there is increased evidence that housing circumstances relate to and contribute to problems of social disadvantage. Housing situations are not simply products of poverty but themselves contribute to the difficulties facing households and affect social integration. Yet some definitions and measures of social exclusion imply that all social housing tenants are necessarily socially excluded, or at least are at particular risk of exclusion (Hills et al., 2010). Given our results, there is an urgent need to rehabilitate the image of social housing. Policy makers cannot afford to exclude a policy instrument that could impact efficiently fuel poverty.

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Appendix

A. Descriptive statistics

Table 7: Comparison homeowners and tenants

	Homeowners	Tenants	ttest
<u>Fuel poverty indicators</u>			
Energy expenditure / Income > 10%	0.0928	0.1030	ns
Low income – High cost approach	0.0483	0.2331	***
Report restriction on heating consumption	0.2061	0.3210	***
Temperature in the housing (Celsius degree)	19.97	19.98	ns
Perception of cold in the housing	0.1219	0.3118	***
<u>Monetary information</u>			
Annual energy expenditure (€/m^2)	16.67	18.11	**
Disposable income per adult equivalent (€)	25,954	18,434	***
<u>Housing characteristics</u>			
Year of construction 1970 or before	0.4607	0.4904	*
Renovations since the five last years	0.5085	0.3041	***
<u>Public policy</u>			
Social housing	/	0.4043	***
Social energy subsidies	0.0105	0.0805	***
Observations	2,851	1,055	

Note: *** significant at 1%, ** significant at 5%, * significant at 10%, ns non-significant
Statistics for the ‘temperature’ concern only 2,841 homeowners and 1,026 tenants.

Table 8: Characteristics of fuel-poor tenants

	All Sample		Energy-income ratio > 10%		Low income – High cost	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Annual disposable income in euros	26,374.17	16,834.40	14,462.96	5,846.49	16,383.85	6,375.78
Annual disposable income per adult equivalent (in euros)	18,430.68	10,089.69	11,725.00	4,018.53	11,791.23	3,118.63
Retired	0.2093	0.4070	0.2906	0.4567	0.1763	0.3820
Preference for energy savings concerning heating system use	0.4739	0.4996	0.4357	0.4985	0.5143	0.5010
Reported restricted energy consumption	0.3210	0.4671	0.4057	0.4937	0.4168	0.4942
Temperature (Celsius degree)	19.98	1.88	19.81	1.93	19.94	2.04
Perception of cold in the housing	0.3118	0.4635	0.3332	0.4739	0.3544	0.4794
Year of construction before 1970	0.2363	0.4250	0.2996	0.4606	0.2624	0.4410
Year of construction between 1946-1970	0.2541	0.4355	0.3451	0.4780	0.3169	0.4664
Year of construction between 1971-1990	0.2418	0.4284	0.1819	0.3879	0.1985	0.3998
Year of construction 1991 and after	0.2678	0.4430	0.1733	0.3805	0.2222	0.4167
Individual housing unit	0.2861	0.4521	0.3516	0.4800	0.2652	0.4425
Surface (in square meters)	66.65	26.72	67.82	25.86	59.02	25.12
Collective heating system	0.1860	0.3893	0.1361	0.3448	0.1699	0.3765
Energy expenditures (excluding collective charges) (€)	1,034.44	685.84	1,814.81	970.21	1,321.76	815.19
Heating and hot water expenditures included in collective charges (€)	114.73	302.05	141.46	410.84	116.50	322.41
Percent of households using gas	0.4195	0.4937	0.4311	0.4979	0.4206	0.4948
Percent of households using fuel oil	0.0429	0.2028	0.1449	0.3539	0.0560	0.2305
Percent of households using wood	0.0331	0.1789	0.0315	0.1757	0.0241	0.1537
Renovations during the last five years	0.3041	0.4602	0.3145	0.4668	0.3007	0.4596
Paris agglomeration	0.2006	0.4006	0.1187	0.3252	0.2194	0.4148
Climate area H1 (the coldest area)	0.5979	0.4905	0.6087	0.4907	0.6410	0.4808
Social energy subsidy	0.0805	0.2721	0.1156	0.3214	0.1554	0.3631
Social housing	0.4043	0.4910	0.3691	0.4852	0.3626	0.4819
Observations	1.051		94		214	

Note: France is divided into 3 climate areas: H1 is the coldest and H3 the warmest. Statistics on ‘temperature’ and ‘retired’ variables are based on 1,026 observations.

Table 9: Pre-treatment characteristics

	Households with no policy (i.e. control group)	Households living in social housing (i.e. treatment group 1)	Households which benefit from social energy subsidies (i.e.

		treatment group 2)				
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Annual disposable income in euros	28,188.96	19,098.19	25,333.45	13,454.79	18,069.60	7,793.25
1st income decile	0.3589	0.4801	0.3476	0.4768	0.6589	0.4770
2nd income decile	0.2345	0.4241	0.3339	0.4722	0.2421	0.4310
3rd income decile	0.2097	0.4075	0.2093	0.4073	0.0789	0.2712
4th income decile	0.1177	0.3226	0.0830	0.2762	0.0201	0.1412
5th income decile	0.0792	0.2703	0.0262	0.1600	0.0000	0.0000
Annual disposable income per adult equivalent (in euros)	20,329.05	11,869.63	16,930.98	6,180.77	11,570.61	4,602.44
Retired	0.1906	0.3931	0.2643	0.4415	0.1022	0.3049
Preference for energy savings concerning heating system use	0.4672	0.4994	0.4643	0.4993	0.5628	0.4991
Reported restricted energy consumption	0.3300	0.4706	0.3057	0.4613	0.3242	0.4710
Temperature (Celsius degree)	19.93	1.73	20.17	1.96	19.53	2.41
Perception of cold in the housing	0.2814	0.4501	0.3613	0.4809	0.3119	0.4661
Year of construction before 1945	0.3263	0.4693	0.0853	0.2797	0.2577	0.4401
Year of construction between 1946-1970	0.2123	0.4093	0.3152	0.4652	0.2828	0.4532
Year of construction between 1971-1990	0.1860	0.3894	0.3339	0.4722	0.2357	0.4271
Year of construction 1991 and after	0.2754	0.4471	0.2655	0.4421	0.2238	0.4194
Individual housing unit	0.3203	0.4670	0.2325	0.4229	0.2772	0.4504
Surface (in square meters)	64.71	30.26	69.20	19.15	69.31	27.37
Collective heating system	0.0890	0.2850	0.3245	0.4687	0.2698	0.4466
Energy expenditures (excluding collective charges) (€)	1,094.71	743.88	968.68	583.44	894.52	600.70
Heating and hot water expenditures included in collective charges (€)	48.95	209.47	202.00	357.99	200.08	444.54
Percent of households using gas	0.2616	0.4399	0.6571	0.4752	0.5024	0.5031
Percent of households using fuel oil	0.0723	0.2593	0.0050	0.0705	0.0000	0.0000
Percent of households using wood	0.0504	0.2189	0.0080	0.0890	0.0198	0.1402
Renovations during the last five years	0.2721	0.4454	0.3674	0.4827	0.2543	0.4382
Paris agglomeration	0.1829	0.3869	0.2531	0.4353	0.0973	0.2982
Climate area H1 (the coldest area)	0.5502	0.4979	0.6935	0.4616	0.5195	0.5027
Energy-income ratio > 10%	0.1049	0.3067	0.0896	0.2859	0.1479	0.3572
Low income – High cost	0.2330	0.4231	0.1834	0.3875	0.4501	0.5006
Observations	452		422		81	

Note: In the treatment group 1 (i.e. households living in social housing) we remove the sample households that benefited from social energy subsidies. However. in treatment group 2 (i.e. households which benefit from social energy subsidies) 71.6% of households benefit also from a social housing.

B. Matching quality

B1: Quality of the propensity score distribution

Figure 3a Propensity score distribution by treatment status – Social housing

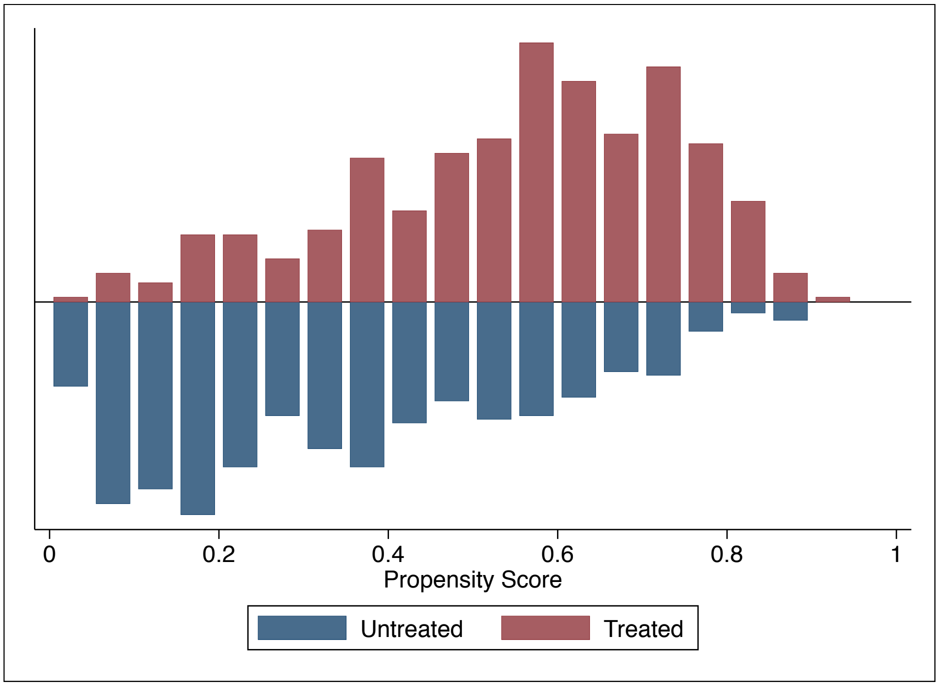


Figure 3b Propensity score distribution by treatment status – Social energy subsidies

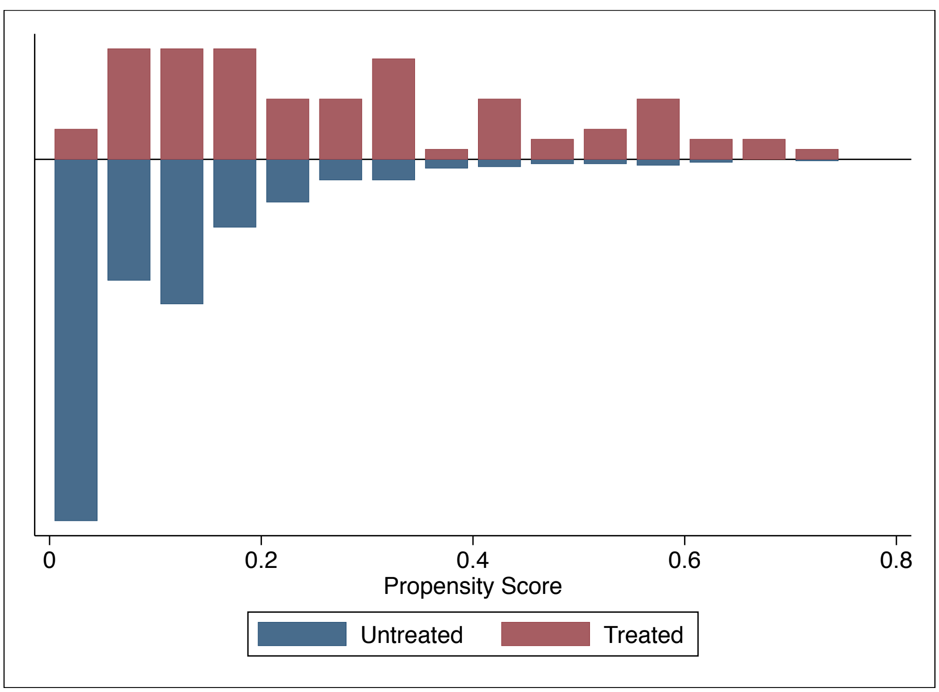


Figure 4a Standardized percentage bias before and after matching – Social housing

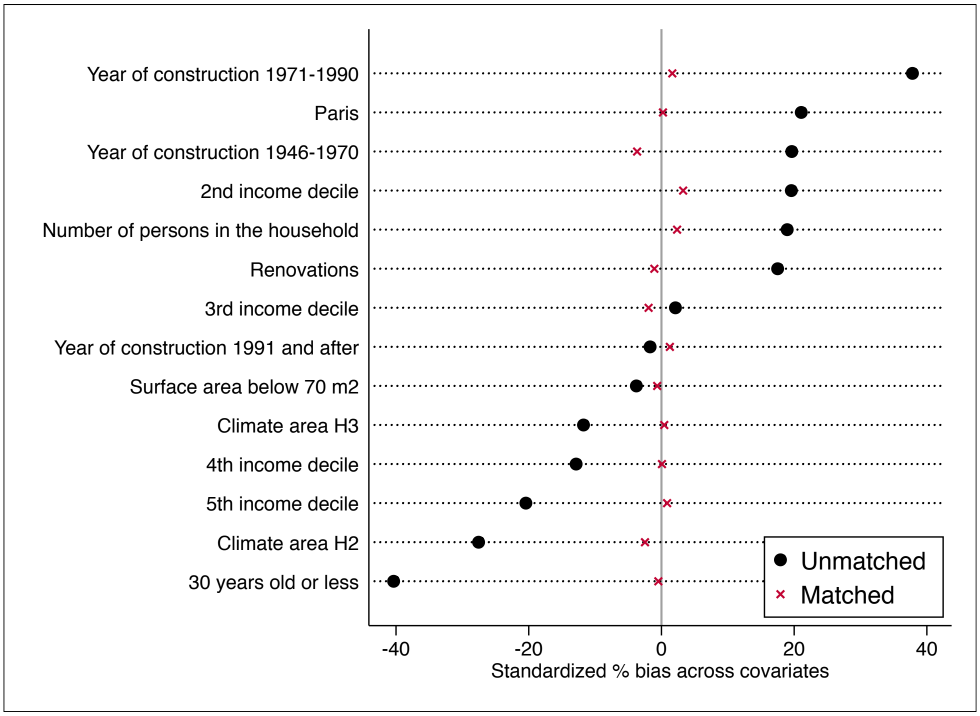
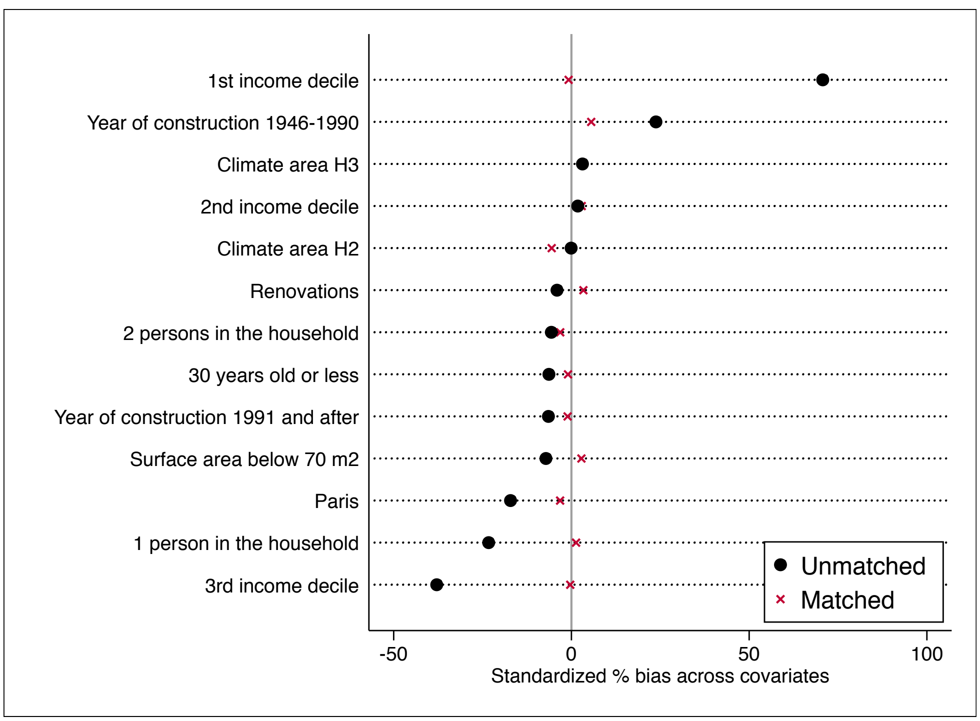


Figure 4b Standardized percentage bias before and after matching – Social energy subsidies



B2: Sensitivity analysis

Table 10a: Sensitivity analysis – Impact of social housing on fuel poverty

	Fraction *u* =1 by treatment/outcome				Outcome effect	Selection effect	Social housing effect	SE
	P_{11}	P_{10}	P_{01}	P_{00}				
Fuel poverty: According to 'Energy expenditure / Income' ratio								
No confounder	0	0	0	0	-	-	-0.0541	0.0250**
Neutral confounder	0.5	0.5	0.5	0.5	1.035	0.996	-0.0482	0.0247*
Confounder like:								
2nd income decile	0.04	0.35	0.17	0.24	0.676	1.645	-0.0476	0.0228**
Construction 1991 and after	0.18	0.27	0.16	0.29	0.458	0.958	-0.0483	0.0234**
Climate area H3	0.07	0.07	0.09	0.10	0.839	0.647	-0.0486	0.0234**
Fuel poverty: According to Low income – High cost approach								
No confounder	0	0	0	0	-	-	-0.0910	0.0311***
Neutral confounder	0.5	0.5	0.5	0.5	1.024	1.013	-0.0860	0.0299***
Confounder like:								
2nd income decile	0.39	0.31	0.21	0.24	0.921	1.624	-0.0886	0.0310***
Construction 1991 and after	0.26	0.27	0.22	0.29	0.697	0.981	-0.0862	0.0301***
Climate area H3	0.09	0.07	0.11	0.10	1.309	0.640	-0.0858	0.0302***
Restriction								
No confounder	0	0	0	0	-	-	0.0044	0.0378
Neutral confounder	0.5	0.5	0.5	0.5	1.011	1.008	0.0041	0.0356
Confounder like:								
2nd income decile	0.30	0.34	0.24	0.23	1.081	1.642	0.0026	0.0353
Construction 1991 and after	0.33	0.24	0.27	0.28	1.010	0.959	0.0041	0.0370
Climate area H3	0.06	0.07	0.12	0.09	1.468	0.685	0.0064	0.0357
Average annual indoor temperature								
No confounder	0	0	0	0	-	-	0.2917	0.1436**
Neutral confounder	0.5	0.5	0.5	0.5	1.009	0.993	0.2934	0.1468**
Confounder like:								
2nd income decile	0.32	0.33	0.25	0.21	1.280	1.632	0.3000	0.1446**
Construction 1991 and after	0.27	0.27	0.27	0.28	0.995	0.998	0.2947	0.1412**
Climate area H3	0.09	0.02	0.12	0.08	1.726	0.712	0.3006	0.0139**

Table 10b: Sensitivity analysis – Impact of social energy subsidies on fuel poverty

	Fraction *u* =1 by treatment/outcome				Outcome effect	Selection effect	Energy subsidies effect	SE
	P_{11}	P_{10}	P_{01}	P_{00}				
Fuel poverty: According to 'Energy expenditure / Income' ratio								
No confounder	0	0	0	0	-	-	-0.0795	0.0634
Neutral confounder	0.5	0.5	0.5	0.5	1.078	0.992	-0.0606	0.0582
Confounder like:								
2nd income decile	0.15	0.26	0.17	0.25	0.710	1.127	-0.0613	0.0609
Construction 1991 and after	0.15	0.26	0.17	0.29	0.585	0.929	-0.0630	0.0608
1 person in the household	0.46	0.28	0.51	0.41	1.657	0.588	-0.0581	0.0596
Fuel poverty: According to Low income – High cost approach								
No confounder	0	0	0	0	-	-	-0.0115	0.0680
Neutral confounder	0.5	0.5	0.5	0.5	1.040	1.028	0.0217	0.0593
Confounder like:								

2nd income decile	0.15	0.32	0.23	0.24	0.944	1.153	0.0210	0.0643
Construction 1991 and after	0.18	0.30	0.23	0.29	0.764	0.943	0.0167	0.0622
1 person in the household	0.29	0.32	0.45	0.41	1.239	0.592	0.0216	0.0623
Restriction								
No confounder	0	0	0	0	-	-	-0.0429	0.0723
Neutral confounder	0.5	0.5	0.5	0.5	0.969	1.052	-0.0347	0.0648
Confounder like:								
2nd income decile	0.16	0.29	0.25	0.23	1.083	1.049	-0.0350	0.0688
Construction 1991 and after	0.36	0.20	0.27	0.28	1.009	0.879	-0.0349	0.0705
1 person in the household	0.40	0.27	0.41	0.42	0.973	0.625	-0.0351	0.0630
Average annual indoor temperature								
No confounder	0	0	0	0	-	-	-0.4657	0.3295
Neutral confounder	0.5	0.5	0.5	0.5	1.036	1.028	-0.3973	0.3204
Confounder like:								
2nd income decile	0.27	0.22	0.25	0.22	1.215	1.072	-0.3914	0.3302
Construction 1991 and after	0.18	0.33	0.27	0.28	0.989	0.828	-0.3983	0.3217
1 person in the household	0.24	0.39	0.41	0.44	0.910	0.624	-0.3977	0.3132

Tables

Table 1 Energy expenditures and public policy

	Tenants which do not benefit from social policy	Tenants living in social housing	Tenants which benefit from social energy subsidies
Energy expenditures (in €)	1,141	1,164	1,095
Energy expenditures per square meter (in €/m2)	18.88	17.28	16.30
Energy expenditure / income			
>10 %	0.105	0.090	0.148
Low income High cost	0.233	0.183	0.450
Observations	552	422	81

Table 2 Fuel poverty and public programs

	Fuel poor who do not benefit from social programs	Fuel poor living in social housing	Fuel poor with access to social energy subsidies
Restriction	0.449	0.401	0.296
Temperature (Celsius degree)	20.0	19.9	19.8
Observations	121	75	35

Note 1: In this table, we consider households to be fuel poor according to either the energy expenditure income ratio, or the low income high cost indicator.

Note 2: Statistics on the temperature variable are based on a smaller sample due to missing values. We have information for 116 fuel-poor households with no program, 72 fuel poor living in social housing, and 34 households benefitting from social energy subsidies.

Table 3a Propensity score – Social Housing

	Social Housing		
Variables	Marginal effects	Standard errors	
Household characteristics			
1st income decile	ref		
2nd income decile	-0.0165	0.0474	
3rd income decile	-0.1343	0.0488	***
4th income decile	-0.2397	0.0502	***
5th income decile	-0.3284	0.0404	***
Number of persons in the household	0.0676	0.0174	***
Reference person aged 30 years old or less	-0.2746	0.0405	***
Building characteristics			
Year of construction 1945 or before	ref		
Year of construction between 1946-1970	0.4148	0.0492	***
Year of construction between 1971-1990	0.4979	0.0440	***
Year of construction 1991 and after	0.4068	0.0506	***
Renovations since the five last years	0.0829	0.0393	**
Surface area below 70 m2	-0.0170	0.0400	
Location			
Paris	0.1040	0.0544	*
Climate area H1 (the coldest)	ref		
Climate area H2	-0.1861	0.0491	***
Climate area H3 (the warmest)	-0.1801	0.0377	***
Number of observations	974		
Number of treated	422		
Correct prediction rate	70.53%		
Pseudo-R2	0.1695		

Note: ***significant at 1%; **significant at 5%; *significant at 10%.

Table 3b Propensity score – Social Energy Subsidies

	Social Energy subsidies		
Variables	Marginal effects	Standard errors	
Household characteristics			
1st income decile	0.5059	0.1065	***
2nd income decile	0.3625	0.1293	***
3rd income decile	0.1375	0.1014	
4th or 5th income decile	ref		
1 person in the household	-0.1265	0.0258	***
2 persons in the household	-0.0553	0.0168	***
3 persons or more	ref		
Reference person aged 30 years old or less	-0.0255	0.0197	
Building characteristics			
Year of construction 1945 or before	ref		
Year of construction between 1946-1990	0.0451	0.0235	*
Year of construction 1991 and after	0.0240	0.0301	
Renovations since the five last years	0.0017	0.0199	
Surface area below 70 m2	-0.0101	0.0206	
Location			
Paris	-0.0318	0.0222	
Climate area H1 (the coldest)	ref		
Climate area H2	-0.0197	0.0229	
Climate area H3 (the warmest)	-0.0189	0.0196	
Number of observations	633		
Number of treated	81		
Correct prediction rate	87.84%		
Pseudo-R2	0.1969		

Note: ***significant at 1%; **significant at 5%; *significant at 10%.

Table 4 Matching quality

	Social Housing		Social energy subsidies	
	Standardized percentage bias	**LR χ^2**	**Standardized percentage bias**	**LR χ^2**
Before matching	18.2	225.37 $p > \chi^2 = 0.000$ ***	16.0	94.50 $p > \chi^2 = 0.000$ ***
After matching	1.5	0.84 $p > \chi^2 = 1.000$ ns	2.6	0.68 $p > \chi^2 = 1.000$ ns

Table 5 Causal effect of social housing on fuel poverty, according to definitions of fuel poverty

	Financial indicators		**Behavioral indicators**	
	Energy expenditure / Income > 10%	**Low income – High cost approach**	**Restriction**	**Indoor temperature**
Effect of social housing	-0.0541	-0.0910	0.0044	0.2907
Standard error	0.0250**	0.0311***	0.0368	0.1426**
Number of controls	552			
Number of treated	422			

Note 1: Bootstrapped standard errors are obtained after 10,000 replications.
Note 2: ***significant at 1%; **significant at 5%; *significant at 10%.
Note 3: Estimation on indoor temperature is conducted on a smaller sample due to missing values (12 missing values in the treatment group and 11 in the control group)

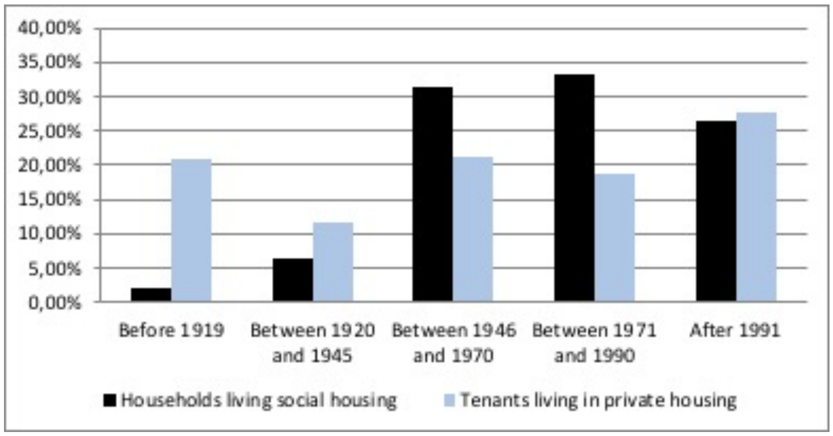
Table 6 Causal effects of social energy subsidies on fuel poverty, by fuel poverty definition[13]

	Financial indicators		**Behavioral indicators**	
	Energy expenditure / Income > 10%	**Low income – High cost approach**	**Restriction**	**Indoor temperature**
Effect of social housing	-0.0785	-0.0105	-0.0419	-0.4647
Standard error	0.0634	0.0680	0.0723	0.3285
Number of control	552			
Number of treated	81			

Note 1: Bootstrapped standard errors are obtained after 10,000 replications.
Note 2: ***significant at 1%; **significant at 5%; *significant at 10%.
Note 3: Estimation of indoor temperature is conducted on a smaller sample due to missing values (5 missing values in the treatment group and 10 in the control group)

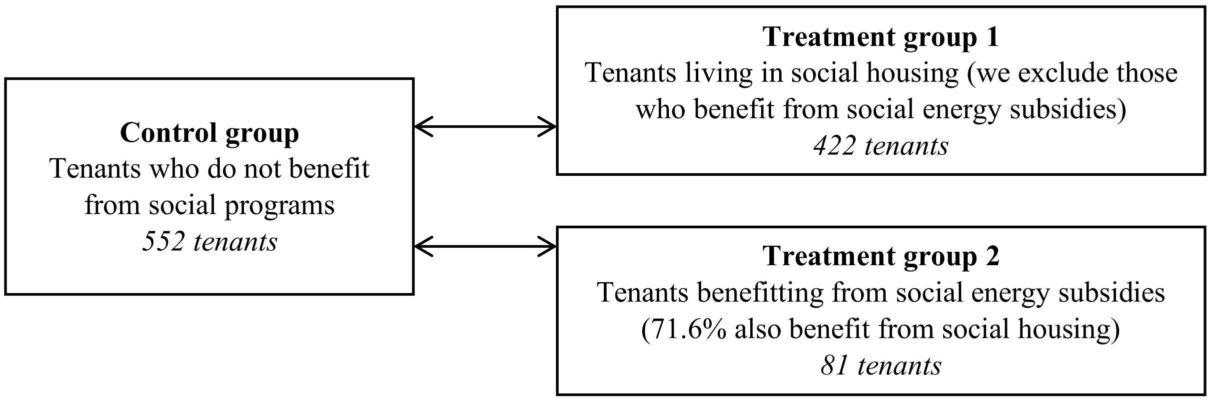
[13] Results are similar if we consider only the 58 households which benefit from both policies (i.e. social housing and social energy subsidies). Results are available on request.

Figure 1 Periods of construction and social housing



Note: This figure is based on 422 social housing units (treatment group 1) and 552 private housing units (control group)

Figure 2 Control and treatment groups



List of figures

Figure 1 Periods of construction and social housing

Figure 2 Control and treatment groups