Household vulnerability and energy conservation behavior: do the poor save less?[1]

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Abstract

The ability of consumers to use energy efficiently is a determinant factor for the success of policies aiming at limiting the progression of the energy consumption in the household segment. The development of fuel poverty policies which aim at improving energy efficiency among vulnerable households raises the question whether this particular group of households is consuming their energy in an efficient manner. The present paper investigates the specificities of energy conservation behavior of a set of households living in a deprived area of Paris. In addition to determinants which are included in most analyses of energy conservation behavior, like economic motivations and information, we therefore analyze the effect of several "poverty" variables.

Keywords : energy saving behavior, fuel poverty, capabilities

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1. INTRODUCTION

The discussion on the reduction of fuel poverty often puts the emphasis either on the insufficiency of households' incomes or on the role of poor housing conditions in explaining the difficulties of households facing fuel poverty. However, as fuel poverty has many dimensions, income and/or housing conditions are not the only factors contributing to it. In a series of interviews we conducted with consumer associations and charities in contact with vulnerable households (Dubois, 2008) one additional aspect appeared, which has not received much attention in the literature on fuel poverty: the fact that some households could be lacking the basic skills to use their energy consuming devices efficiently, and therefore have higher energy consumption levels than they should have if they used energy in the most efficient way. This raises the question of the determinants of energy consumption behavior of vulnerable households.

Various studies analyze the adoption of energy efficiency measures by households (Healy and Clinch (2004), Mills and Schleich (2010)). There are fewer analyses on households' day-to-day energy saving behaviors (Barr et al (2005), Ek and Söderholm (2010)). And there is even less evidence on the day-to-day energy saving behavior of vulnerable households.

Among the factors which play a role in adoption of day-to-day energy saving behavior, many studies mention the role of information (Ek and Söderholm, 2010). This information is not only related to the benefits of energy conservation for the household itself. It also includes aspects related to the environment, which can be interpreted as the fact that customers are valuing the "production of a public good" aspect of energy conservation.

However, the role of information is an imperfect one: not all households who are informed of potentially beneficial effects of a given behavior are adopting it. The literature analyzing households' energy conservation behavior from a psychological point of view has for example shown that consumers' *values*[4] play a role in adopting energy saving behaviors (Oikonomou et al., 2009). Especially *altruistic* and *biospheric* values seem to play an important role.

The economics literature has also discussed why, among those households who are informed about the potential benefits of energy savings, only a small proportion is actually adopting energy saving behaviors. According to Heinrich and Neuhoff (2006) for example, this can be explained by a complex "*consumer choice chain*". The representation of consumer choices they propose aims at opening the *"black box"* of individual choices, in order to identify those consumers who actually *"receive, understand, and internalise the message of facing up to climate change through their own actions. Moreover, analysis of the consumers' residency at each of the stages also helps us to understand which phases of the take-up process are under-utilised or ignored under current conditions and/or policies. Finally, the 'consumer choice chain' clarifies that it takes different efforts or policies to influence individuals' decision process, and to move individuals along the chain from one stage to the next"*.

This type of approach, while providing information about the reasons why not all informed households do actually undertake energy saving measures, is however not telling us what are the mechanisms behind the consumer choice chain, i.e. what determines the rate of consumers who will finally adopt energy saving behaviors. If it can be assumed that households are not all equal in transforming information into behavior, then the factors explaining this transformation should be identified.

This is particularly important for our question, the question whether vulnerable households have particular patterns of energy saving behavior. Several studies analyzing the difficulties of fuel poor households suggest that this "transformation function" could be less efficient in the case of vulnerable households. For example, vulnerable households

[4] As indicated by Oikonomou et al. (2009), "such values are categorized in egoistic (concern for own self), altruistic (concern for others), and biospheric (concern for the biosphere). Based on this theory, energy saving measures are accepted by the public when they have strong altruistic and biospheric values (…). More specifically, values influence awareness of energy problems and the extent to which individuals feel responsible for these problems, which in turn influence feelings of moral obligation to do something about it and increase the acceptability of energy policies (…)."

with low levels of literacy or numeracy seem to adopt particular "coping strategies" when they are facing fuel poverty (Gibbons and Singler, 2008) or in handling energy-related complaints (George et al., 2007).

Most of these difficulties can be related to limited "capabilities" of these households, which seem to play a role in their energy consumption behavior. The influence of these capabilities on energy saving, as an aggravating factor in situations of fuel poverty, has however not been analyzed so far. This is why our paper tries to explore the role of capabilities in energy conservation behavior, in order to contribute to a better understanding of the specific difficulties faced by vulnerable households in managing their energy consumption.

2. POSSIBLE EXPLANATORY FACTORS OF ENERGY CONSERVATION BEHAVIOR

There is an extensive literature on energy conservation behavior, mainly in the field of psychology, but also in economics. The objective of our review is to highlight those elements which are most relevant to understand the specificities of energy conservation behavior of vulnerable households. We first discuss the role of economic motivations (2.1) and the role of information (2.2). We then analyze what could be the role of poverty in that kind of analysis (2.3). Finally, we present the other socio-demographic indicators which are generally associated with energy consumption and energy conservation behavior (3.4).

2.1. Economic motivations

A first set of variables that may influence an individual's decision to adopt energy saving behaviors relates to economic considerations. Indeed, decisions to adopt energy saving measures may result from considerations based on the relative importance of gains from adopting such behavior and costs related to such behavior (Oikonomou et al,2009). In this paper, we focus on "habitual" behavior, which can be distinguished from energy saving measures which require large amounts of investment (like buying more efficient electrical appliances or heating systems, or insulations measures). This habitual behavior includes switching off the lights when no one is in a room, limiting the indoor temperature and also using compact fluorescent lamps (CFL). This last element is included in the analysis because the price for these lamps is now very limited and thus we consider that this does not involve an investment decision.

In a part of the literature, the adoption of energy-saving measures is related to environmental considerations, i.e. the gains considered are mostly of a "non-monetary nature (e.g., personal satisfaction from contributing to a reduction in negative environmental impacts)" (Ek and Söderholm, 2010). However, as mentioned by Barr et al. (2005), the "habitual actions", that require less conscious thought, do not necessarily reflect activities that are undertake with a single environmental motivation. And costs of energy may be a significant factor.

On the other hand, it can be argued that the magnitude of economic gains is relatively limited. As mentioned by Ek and Söderholm (2010) the monetary savings that can be achieved by, for instance, turning off the lights are often comparatively low. Therefore, when individuals "are confronted with these low potential savings their willingness to undertake the associated measures declines".

The limited impact of economic gains has also been highlighted by Abrahamse et al. (2005) in their review of intervention studies aimed at household energy conservation. Some of these studies introduced financial rewards for those households who were adapting their behavior in order to use less energy. In practice however, the effect of these rewards was considered as limited: "rewards have effectively encouraged energy conservation, but with rather short-lived effects" (Abrahamse et al., 2005), i.e. economic rewards induced a change in behavior only as long as financial incentives were provided. One possible explanation for the limited effect of economic motivations they mentioned is that the economic effects of energy consumption are not visible to households.

The gains from adopting energy saving behavior are compared with the costs that an end-user must sustain in order to reduce his consumption. These costs represent the "disutility associated with 'virtuous behaviors' of energy saving, essentially in terms of opportunity cost of time (the time necessary to acquire information and apply it to individual behaviors and organizational practices), as well as costs of effort, discomfort, and reduced status" (Oikonomou et al, 2009). These costs also comprise direct monetary costs (e.g., the purchase of energy-efficient light bulbs). The loss (actual or perceived) of comfort seems to play an important role in the decision to adopt energy saving behaviors. As revealed by the study of Barr et al. (2005) on "habitual" energy saving behaviors, those "behaviors that related to personal comfort and consequential sacrifice (such as wearing more clothes instead of turning up the heating) were less popular (and) may be more difficult to encourage."

To summarize, it seems that economic gains associated with energy saving behavior are relatively limited and not visible to the consumer. In addition, households adopting energy saving behaviors are also facing some costs, which include the (actual or fear of) loss of thermal comfort. Therefore, we expect that economic motivations will not play the same role for all types of customers. Economic motivations should play a more important role (1) for those households who are well informed about the potential benefits of energy-saving behavior, (2) for the households whose incomes are relatively low (because they may value more the small monetary gains associated with energy saving) and (3) for households which have sufficient "capabilities" in order to understand the potential gains associated with energy conservation and adapt their behavior accordingly.

2.2. Information

Information is given a central place in the literature on energy conservation behavior. It appears as the necessary condition for households to adopt energy saving behaviors. This can be explained by the fact that individuals have a preference for the status quo and information may play a role in breaking that status quo (Ek and Söderholm, 2010). But the manner of providing information to the households seems to matter a lot: there is some evidence that information needs to be put in an appropriate "format" in order to produce some effects on behavior. Finally, information in itself is not sufficient to induce a change of behavior: the individuals who receive it need also to be convinced that it is true, and they must be willing to adopt new behaviors.

The role of information in the adoption of energy saving measures is a central one. Providing information increases households' awareness of energy consumption issues and their knowledge about possibilities to reduce their level of consumption. Clinch and Healy (2000) have for example examined the role of information in the adoption of energy efficiency measures in Ireland. For them, the "market failure" in that field is clearly related to a lack of information. They asked households "why they do not invest in energy saving measures when the benefits clearly outweigh the costs. (…) The result of the survey demonstrate an enormous 'information gap' in the market for domestic energy efficiency. Some 32.3 % of energy inefficient households were not aware of the benefits of energy-saving measures, while a further 19 % did not know of their existence. This implies that over half of Irish households are unaware of the benefits of retrofitting these measures into their homes, despite on-going information and awareness campaigns funded by the Irish government." (Healy and Clinch, 2004).

If information matters for the adoption of energy saving measures, the format and content of information seem to matter a lot. It can take the form of general information about energy-related problems, or specific information about possible solutions, such as information about various energy-saving measures households can adopt (Abrahamse et al., 2005). Also, information about energy savings can be conveyed in several ways, from general mass media campaigns to information which is specifically tailored to the specificities of each household.

This explains why the impact of information on adoption of energy saving behavior is difficult to assess. According to Steg (2008), "information campaigns (generally) result in only modest behavioral changes. But there are some information al strategies that appear to be successful in promoting household energy conservation. They include prompts,

individualized social marketing approaches in which information is tailored to the needs, wants and perceived barriers (…), commitment strategies, eliciting implementation intentions (…) and modeling and providing information about the behavior of others (…). Informational strategies are especially effective when pro-environmental behavior is relatively convenient and not very costly in terms of money, time, effort or social disapproval, and when individuals do not face severe constraints on behavior."

The role of the "format" of information is also confirmed by Ek and Söderholm (2010), who test "whether information about available savings measures that is presented in a more concrete and specific way is more likely to affect (stated) behavior than more general information is. The differences in the level of detail of the information provided (…) had a statistically significant impact on the reported willingness to be more active. However, additional information in terms of the (potential) monetary savings associated with the different electricity saving activities did not increase the willingness to undertake electricity saving measures further."

Finally, one must take into account the fact that the information is not always sufficient to induce a change of behavior. As highlighted by Heinrich and Neuhoff (2006) "domestic consumers do not chose cost effective options that induce net savings for (them) as well as benefits to society from reduced energy consumption. This is frequently referred to as the 'energy-efficiency paradox' or the 'cost perception gap' ". They explain that paradox by presenting a "consumer choice chain" which takes into account that individuals also need to be able to treat the information in order to be convinced of the potential benefits of such a behavior. And even for those who are convinced of the benefits, there exist some barriers to the take-up of new behaviors.

This is why we want to go beyond the role of economic motivations and information, to examine some additional factors which could contribute to explaining the inter-individual differences in energy saving behaviors. As our focus is on vulnerable households, our objective is to include in the analysis a set of indicators which could give an indication about individuals' "poverty" levels.

2.3. Poverty indicators

Poverty has not been a central element in analyses on adoption of energy saving measures. This can partly be explained by the focus of some of these studies of "adopters" of energy saving measures, where the emphasis is placed on pro-environmental orientations rather than on poverty issues. However, some studies test the effect of incomes on the use of energy or on the adoption of energy saving measures.

Regarding the role of income for *"energy use"*, Abrahamse and Steg (2009) found a positive correlation between income and use of energy (which was analyzed separately from the decision to *"save energy"*, i.e. to change the use of energy). It could seem self-evident that households with higher incomes use more energy. However, there could also be an opposite effect, i.e. households with higher incomes having relatively more possibilities to adopt (costly) energy-saving measures (Abrahamse and Steg, 2009).

Regarding the effect of income on the acceptability of energy-saving measures, Poortinga et al. (2003) found that income has a significant impact, "behavioral measures aimed at reducing direct energy" being the least acceptable for high incomes.

These results suggest that households with lower incomes would have a higher tendency to save energy than households with higher incomes. However, focusing on income might not be sufficient to explain energy saving behaviors. As mentioned by Sen (1997), economic inequality relates more generally to a series of difficulties which do not only cover income. Therefore, our poverty indicators should include more information than the only income variable. In order to build a proper set of poverty indicators, we rely on the "capability" approach that has been proposed by Amartya Sen.

In Sen's definition of poverty, inequalities between individuals cannot be reduced to income inequalities for several reasons, which include personal heterogeneities (problems of disabilities, illness, age, or gender), environmental diversities (which can influence what a person gets out of a given level of income) and differences in relational perspectives (like

being relatively poor in a rich community) (Sen, 1997). He suggests that the poverty level of individuals should be assessed both in terms of "functionings" (i.e. the level of realized welfare) and in terms of "capabilities" (i.e. the level of potential and feasible welfare) (Kuklys and Robeyns, 2004). This capability approach is justified by the fact that individuals derive utility both from the range of options in the choice set, as well as from the possibility to perform the act of choice themselves (Sen, 1985).

Functionings are defined as "an achievement of a person, i.e. what he or she manages to do or to be: an individual's activities and states of being." (Kuklys and Robeyns, 2004). The functioning space is related to the goods and characteristics spaces through a personal conversion function.

Capabilities reflect the various combinations of functioning a person can achieve, i.e. the person's freedom to choose between different ways of living (Kuklys and Robeyns, 2004). The capability space is related to the functioning space in that it comprises all functionings an individual can potentially achieve.

If we want to test the impact of "poverty" using Sen's capability approach, we need to take into account not only income, but also a series of other functionings (like having access to a stable employment, or having a decent accommodation) and the capabilities, i.e. the "menu of choices" of individuals. Defining a list of relevant capabilities is not an easy task. In the literature on capabilities listings, there is still a debate whether there exists "one" list of capabilities or whether the set of relevant capabilities is case specific. However, according to Sen (2004), there cannot be one final and fixed list of capabilities and capability indicators should be adapted to the problems which are analyzed in each case. In our capability indicators, we will include for example the level of education of individuals, their insertion in social networks, and also whether they have access to Internet[5].

Even though capabilities have not been explicitly taken into account in previous analyses of energy saving behaviors, some elements of capabilities are sometimes included. For example, Ek and Söderholm (2010) mention the role of interactions with the social environment : "(…) interactions with and/or perceived expectations from friends, neighbors, family or other households in general (…) can also help highlight the potential importance of electricity saving behavior.". These social interactions can for example play a role in providing information or reducing uncertainty : "if an individual is uncertain about the future cost savings or environmental effects associated with increased electricity saving efforts, beliefs about others' behavior and/or opinions may be used as a compass and thus play an important role in the decision-making process" (Ek and Söderholm, 2010).

2.4. Other socio-demographic variables

In addition to variables on economic motivations, information and "capabilist" poverty, our analysis will also test the role of several socio-demographic variables. In many analyses of energy conservation behavior, socio-demographic variables appear to play a significant role.

This role is however varying with the type of behavior considered. While factors like household size seem to play an important role in *"energy use"* (Abrahamse and Steg, 2009), their role appear to be less important when analyzing *"changes in energy use"* like for example changes of energy consumption behavior in order to save energy. This literature then distinguishes the determinants of *energy consumption behavior* from the determinants of *changes of energy consumption behavior*: energy consumption behavior is supposed to be linked with socio-demographic characteristics of the households, while

[5] This element has been specifically mentioned by Sen (2004) as an important capability: *"social conditions and the priorities they suggest may vary. For example, given the nature of poverty in India as well as the nature of available technology, it was not unreasonable in 1947 (...) to concentrate on elementary education, basic health, and so on, and not worry too much about whether everyone can effectively communicate across the country and beyond. However, with the development of the Internet and its wide-ranging applications, and the advance made information technology (...), access to the web and the freedom of general communication are now parts of a very important capability that is of interest and relevance to all Indians."*

changes of energy consumption behavior are supposed to be linked to psychological variables.

Abrahamse and Steg (2009) tested the impact of household size on energy consumption and found a significant positive effect. They also tested the impact of age and gender on energy consumption and found no significant effect.

Barr et al. (2005) higher age groups were more likely to be energy savers. "The variables that were significant included gender, household size, education and political allegiance and activity". "Those groups which require the greatest focus are young people, on lower incomes, who tend to rent rather than own (…)"

Poortinga et al. (2003) investigated the acceptability of several energy-saving measures like for example "*switching off lights in unused rooms*", "*compact fluorescent light bulbs*" and "*thermostat maximally 18°C*". They found a significant effect of the age of individuals : home measures (as compared with transport measures) were relatively more acceptable for respondents aged 20 through 39 years, while respondents aged 65 years and older found home measures to be least acceptable.

3. AN EMPIRICAL ANALYSIS OF THE DETERMINANTS OF ENERGY SAVING OF HOUSEHOLDS LIVING IN A DEPRIVED AREA

To analyze households' energy saving behaviors, we conducted a survey during the summer of 2009 in the 19th district of Paris, which is an area of the city of Paris with a high proportion of vulnerable households. In the following empirical analysis, we seek to determine the factors that may lead an agent to adopt energy saving measures. As we have already pointed out in our previous discussion, economic and social science theories provide a wide array of factors that could explain why an individual may adopt energy saving measures. An econometric analysis may be helpful in order to disentangle and understand the contribution of various factors determined in the literature. We first present some general characteristics of the "Flandre" area (3.1) which reveal that a high proportion of households living in that area are facing economic difficulties. We then briefly present the survey me conducted in that area in the summer of 2009 (3.2), our methodology (3.3), the variables used in the estimation (3.4), and our results (3.5).

3.1. Household vulnerability in the « Flandre » area of Paris

The "Flandre" area of Paris is one of the most deprived areas of the French capital. It is located in the 19th district, in the north-east of Paris. Because of an enduring gap between that area and the remainder of Paris, it has been part of the "priority areas" of the municipality[6] for several years.

In comparison with the whole of Paris, the "Flandre" area is characterized by high levels of poverty (one household out of four) and of unemployment (almost 20 %). The percentage of immigrants is particularly high as well as the proportion of people without any qualification (20 % in the "Flandre" area, while this figure is only 11.4 % for the whole of Paris). This area groups a high number of families, especially families with several children. The young people are particularly vulnerable to academic failure and unemployment and have little access to recreational facilities. Table 1 presents some deprivation indicators characterizing this area.

[6] The municipality has selected a total of 14 areas of Paris which are subject to specific attention. These areas group a total of 330 000 people, of which a high proportion can be considered as vulnerable: 23 % of these households are below the poverty line (compared with 12 % for the whole of Paris), 21 % of people are without any qualification (this figure is 112 % for the whole of Paris) and the proportion of immigrants is of 29 % (compared with 20 % for Paris).

Table 1: deprivation indicators of the "Flandre" area of Paris

	"Flandre" area	19th district	Paris
Total population [1]	40 867	172 587	2 125 851
Average income per household (€ per year) [2]	25 902 €	30 190 €	41 617 €
Unemployment rate	18,8%	16,3%	12,0%
People aged between 15 and 24 years and without any qualification [1]	8,4%	6,5%	3,9%
Number of households [1]	16 646	79 022	1 110 912
Proportion of low-income households [3]	27%	21%	13%
Proportion of families with 3 children or more [1]	18,2%	13,1%	8,5%
Proportion of single parent families [1]	17,4%	15,7%	13,0%

[1] source : INSEE (1999)

[2] source : DGI (2004)

[3] source : CAF (2006)

In terms of housing, there is a large proportion of big blocks, most of them having been built between the 1950s' and the 1970s'. There is also a high proportion of older buildings in the south of the area, where a large proportion of the immigrant population is living. All these characteristics explain why this area has been chosen as a field of investigation to analyze energy consumption behaviors of a vulnerable population.

3.2. The design of the survey

In order to explore the determinants of energy saving behavior, we rely on a original database obtained through a survey conducted during the summer 2009 in the "Flandre" are of Paris. The survey was randomly administered to 297 inhabitants of the area through face-to-face interviews in the street or at the individuals' home.

These 297 individuals are representative of the population of the "Flandre" area on the following criteria: (1) gender, (2) age - we defined three age categories: less than 35 years, 35 to 60 years, and 60 years and more and (3) the property rights of the lodging (owner, tenant in social housing and tenant in private housing).

As the area was chosen among the most deprived areas of Paris, we assume that households on low incomes are over-represented in comparison with the population of Paris. Also, we assume that people with lack of interest or knowledge in energy-related issues are over-represented.

The formulation of the questions included in the questionnaire as well as the content of the questions was designed after taking into account comments from the Association EDIF which has an activity of advising households of the Flandre area on their energy use and from an association of tenants in social housing in the same area.

The survey has allowed us to obtain various information on personal and household characteristics of respondents, as well as information on their energy consumption and telecommunications consumption behavior. Our empirical analysis in this paper relies on a final sample of 141 usable observations due to missing information[7].

[7] This is essentially due to respondents' reluctance to disclose information on their income.

3.3. The methodology

Our dependent variable is a binary variable EnSave, which takes the value 1 when an individual has undertaken at least one energy saving measures. Energy saving measures is defined as following in our survey:

- Using compact fluorescent lamps
- Switching off the lights when nobody is in the room
- Reducing the temperature
- Not heating certain rooms
- Switching off the heating when there is nobody at home
- Switching off the heating even when there is someone at home
- Reducing the use of hot water
- Reduction the consumption of other devices

Therefore, we will treat all energy saving measure in the same way, because all of them can be considered as simple gestures which do not require an investment from the household. Using compact fluorescent lamps is one exception, but given the low amount of investment required (the price for these lamps is now very low) we chose to include this item in the "simple gesture"[8].

In our final sample, 71% of respondents replied positively to having undertaken at least one energy saving measure.

Given the binary nature of our dependent variable, our empirical strategy consists in estimating the following limited dependent variable model:

$$\text{Prob}[\text{EnSave}_i = 1] = \text{Prob}[\text{EnSave}_i^* \geq 0] = \text{Prob}[\mathbf{x}_i'\beta + u_i \geq 0], \qquad u_i \rightsquigarrow \mathcal{N}(0, \sigma^2)$$

where EnSave*$_i$ is a continuous latent variable that could be taken to approximate the utility of individual i with respect to energy saving measures, x_i is a vector of explanatory variables that may have an impact on the utility of an individual to undertake energy saving measures, □ is the vector of coefficient, and u_i is an error term. Hence, an individual i will undertake measures to save energy if the utility of doing so is greater than a certain threshold, which we normalize to 0 without loss of generality. We assume that the error term is distributed as a normal variable with zero mean and with variance □². Following standard practice in the literature, the variance of u_i is normalized to 1. The last two assumptions yield a Probit regression model.

3.4. The variables used in the investigation

We are able to theoretically identify various factors that may motivate an individual to adopt energy saving measures. In order to relate the theoretical aspects of energy saving behavior with our data, we need to identify variables that capture the various aspects discussed above. We present the variables that will be used as explanatory variables in our regression analysis in the following, and clarify how they relate to the various concepts discussed above.

Economic motivations

Among economic motivations, we analyze the sensitivity of the respondents to variations in price. This sensitivity was tested through two questions. The first one examines the (stated) sensitivity of the consumption of heating in case of a price increase of energy of 10 %. Individuals surveyed were asked how they would react in terms of their behavior (heat less or leave the heating unchanged). The second question examines the (stated) sensitivity of electricity consumption in case of a price increase of energy of 10 %. Individuals surveyed were asked how they would react in terms of their behavior (consume less electricity or leave their electricity consumption unchanged). As the energy

[8] Motivations to undertake these different types of energy saving measures may differ. Some of them could be undertaken to use energy in the most efficient way, while others could be interpreted as a rationing behavior. However, since our empirical analysis is preliminary, we will not distinguish among various energy-saving measures. We intend to explore how motivations for different forms of energy saving may vary in the near future.

conservation behaviors we analyze relate both to the use of electricity and to the use of energy for heating purposes, both price sensitivities needed to be examined. We expect individuals who are more sensitive to changes in prices to be more inclined to adopt energy saving measures, as such measures may reflect in lower energy bills.

This is why we include in the analysis the effect of personal income, as well as individual's subjective appreciation of their income. Hence, we include in our regression the declared personal income of the individual (Income) as well as the individual's subjective appreciation of his/her income (Subjective appreciation of current income). The latter reflects whether an individual is satisfied with his/her current income. As we mentioned in our previous discussion, the effect of economic motivation could be more important for low-income individuals. Therefore we expect individuals with lower incomes to be more inclined to adopt energy saving measures.

Access to information

Another important block of factors that may motivate individuals to adopt energy saving measures relates to whether individuals may have access to information. We have therefore included 4 different variables reflecting whether an individual can easily access information concerning energy saving measures. The first variable that we include relates to whether an individual has knowledge on the possibility of changing his/her energy supplier. The underlying idea is that an individual who has this knowledge this may be more sensitive with respect to energy consumption issues, and may therefore be more proactive in looking for information on energy saving measures. The second variable captures whether an individual is aware of insulation properties in his/her lodgings. The third and fourth variables give an indication on the access to general purpose information on energy conservation on the one hand and to personalized advice on energy use on the other hand. Therefore, we include the question whether the respondent has got access to general information on energy conservation (information campaigns in his building). And finally the question whether the respondent has benefitted from personalized advice on the efficient use of energy.

Poverty indicators

Another block of factors that may lead an individual to adopt energy saving measures concerns an individual's capabilities as defined by Sen (1985). According to Sen, poverty indicators may be distinguished to include factors relating to an individual's "functionings" and "capabilities". In order to examine how these aspects may drive an individual's decision to save energy we will use various information in our database to proxy for both functionings and capabilities.

The former is captured by a set of variables that reflect realized welfare:

- The main occupation of the respondent,
- Being owner of his home or tenant,
- Living in a decent accommodation,
- The ratio of numbers of persons in a lodging,
- The difficulties in terms of energy use (i.e. living in a home which is too cold, too warm, or having difficulties of payment of energy).

These various types of functionings allow us to test the different levels of welfare, from the most general (income) to the more energy-specific ones (characteristics of the home, difficulties in the use of energy).

We expect owners of their homes to be benefit from a higher level of functionings, which could allow them to be more inclined to adopt energy saving measures, while a lower density in the lodging may well reflect the living comfort of an individual, hence a higher level of functionings.

The individuals' capabilities relate to potential welfare. They are measured by the following variables:

- The level of education of the respondent
- His insertion in social networks
- Access to Internet
- Access to mobile phone

We use an individual's level of education as a capability indicator. An individual with a higher level of education may be more knowledgeable, and may therefore be more aware of various options available to him/her. We expect that individual with a higher level of education may therefore be more inclined to adopt energy saving measures.

An individual's social network may also reflect the extent of an individual's capabilities. It may have an impact on his/her decision to undertake energy saving measures. Social network may influence on a individual's decision to adopt energy saving measures through two channels: firstly, social network may be a means by which an individual may obtain information on energy saving measures. Hence, social network may play a role in allowing an individual to easily access information. Secondly, peer pressure may lead an individual to adopt energy saving measures. This is the case when the social network to which an individual belongs places an string emphasis on such issues. To assess the importance played by social network in an individual's decision to adopt energy saving measures, we include two variables relating to an individual's social environment: the Number of persons in contact with an individual, and the Number of persons that an individual will contact in case of illness. The latter variable seeks to measure the size of an individual's more intimidate social network, while the former may include acquaintances such as colleagues. While both variables measures the intensity of an individual's social network, we are unable to identify the precise characteristics of the individual's social network. Hence, in our work, we are only able to focus on the informational channel and not on the peer pressure explanation on how social network may have an influence on an individual's decision to adopt energy saving measures. We expect both variables to have a positive impact on an individual's tendency to adopt energy saving measures. Finally, we also use an individual's employment as a means to capturing the individual's social network. Indeed, one may expect unemployed individuals to be more isolated than those who are employed in terms of social network. Furthermore, the social network of an employed individual may be more diversified, hence leading to a richer and more diversified access to information. We therefore expect individuals who have an occupation to be more inclined to adopt energy saving measures.

Lastly, we have also included in our capability variables information on whether an individual owns a mobile phone and has access to the Internet as means of measuring the facility with which individuals may have access to information related to energy saving.

Other socio-demographic variables

Finally, we also include a set of control variables in our regression. These variables include an individual's family status, his/her profession, his/her age, and information the type of heating system. Variables such as age will influence an individual's decision to adopt energy saving measures because younger person may be more sensitive to environmental issues, and hence, be more receptive to adopting such measures. In the same way, family with children may also be more receptive towards such issues, and may therefore be more inclined to adopt energy saving measures. An individual's profession may lead him/her to be more sensitive to energy saving issues, and therefore, may have an impact on his/her motivations to adopt energy saving measures.

The following table shows the definition and some simple descriptive statistics of the variables that we use in our analysis.

Table 2: Descriptive statistics of variables used in our analysis

Variable	N	Mean	Std. Dev.	Min	Max
EnSave	141	0.71	0.46	0	1
Income					
<900 euros per month	141	0.16	0.36	0	1
From 901 to 1800 euros per month	141	0.57	0.50	0	1
>1800 per month	141	0.28	0.45	0	1
Subjective appreciation of current income					
Life is difficult with current income	141	0.48	0.50	0	1
No income difficulties	141	0.52	0.50	0	1
Price sensitivity of the individual					
Price effect : Heat less	141	0.17	0.38	0	1
Price effect : Consume less	141	0.36	0.48	0	1
Access to information					
Change in energy supplier	141	0.77	0.42	0	1
Mobile phone	141	0.89	0.31	0	1
Access to internet	141	0.70	0.46	0	1
dexistenceisolation1	141	0.09	0.28	0	1
Social network					
# of people to contact in case of illness	141	2.99	3.69	0	30
# of people in contact	141	10.75	10.75	0	80
Employment status					
Others	141	0.03	0.17	0	1
Unemployed	141	0.08	0.27	0	1
Employed	141	0.79	0.41	0	1
Retired	141	0.10	0.30	0	1
Property rights of the lodgings					
Tenant in social housing	141	0.41	0.49	0	1
Tenant in private housing	141	0.35	0.48	0	1
Owner of the lodging	141	0.23	0.42	0	1
Others	141	0.01	0.08	0	1
Number of inhabitants per room in lodging					
Education					
No eduation	141	0.06	0.25	0	1
Primary school	141	0.04	0.20	0	1
Collège, CAP, BEP	141	0.24	0.43	0	1
Secondary School	141	0.20	0.40	0	1
University	141	0.45	0.50	0	1
Age	141	39.65	15.19	19	90
Type of family					
Single Woman	141	0.17	0.38	0	1
Single Man	141	0.07	0.26	0	1
Couple w/o children	141	0.16	0.37	0	1
Couple with children	141	0.29	0.46	0	1
Monoparent family	141	0.11	0.31	0	1
Complexe family	141	0.20	0.40	0	1
Difficulties					
Not sufficiently warm in lodging	141	0.20	0.40	0	1
Too warm in lodging	141	0.13	0.34	0	1
Payment difficulty	141	0.00	0.00	0	0
Heating system					
Individual electric heating	141	0.66	0.48	0	1
Individual gaz heating	141	0.28	0.45	0	1
Collective heating system	141	0.66	0.48	0	1
Profession					
Ouvrier	141	0.17	0.38	0	1
Employé	141	0.09	0.28	0	1
Artisan, commercial, entrepreneur	141	0.63	0.48	0	1
Cadre, profession intellectuelle	141	0.04	0.19	0	1
Intermediary profession	141	0.12	0.33	0	1

3.5. Estimation results

Estimates for our Probit model are computed using the pseudo maximum likelihood method. This method allows us to obtain standard errors that are robust to heteroskedasticity for our estimates. Results for our estimations are reported in table 3 below. Estimations results from 3 specifications are produced in table 2: column (A) shows estimates for the general model, in which we include all explanatory variables discussed in the previous subsection; column (B) shows estimates obtained when objective personal income is not included in the set of explanatory variables.

As one may see from table 3, objective personal income does not seem to play a role in an individual's decision to adopt energy saving measures. Indeed, as column (A) shows, estimates for various personal income categories turn out to be non significant. This implies that the probability for an individual to adopt energy saving measures is not significantly affected by the individual's personal income[9]. Moreover, a comparison of estimates from column (A) and (B) does not show any important differences. We are therefore quite confident that objective personal income does not have a significant impact on the probability of adopting energy saving measures.

On the other hand, our estimations show that subjective evaluation of personal income contributes to the probability that an individual decides to undertake energy saving measures, ceteris paribus. The estimated coefficient for this variable is significant in all our three specifications, and suggests that individuals who believe that their income is insufficient to sustain their lifestyle are more unlikely to adopt energy saving measures than those who are satisfied with their current income. This observation is interesting in two ways: firstly, it suggests that objective income may not be as important as subjective appreciation of income by individuals to understand the adoption of energy saving measures. One may therefore doubt whether policy based on monetary incentives to promote energy saving measures would work. Secondly, this observation is somewhat paradoxical, as one may expect those individuals who find that their income to insufficient may have a bigger incentive to undertake energy saving measures. A potential explanation to this paradoxical observation may lie in the fact that energy saving measures may be perceived as costly for those individuals.

Table 3: Estimation results

[9] We have also tried running regressions using finer categories of personal objective income. As it turns out, the coefficients are very often non significant.

	(A)		(B)	
	Coef.	Std. Error	Coef.	Std. Error
Income				
<900 euros per month	0.113	(0.606)		
From 901 to 1800 euros per month	-0.222	(0.361)		
>1800 per month		Ref.		
Subjective appreciation of current income				
Life is difficult with current income	-0.587+	(0.313)	-0.559+	(0.315)
No income difficulties		Ref.		
Price sensitivity of the individual				
Price effect : Heat less	0.407	(0.503)	0.330	(0.494)
Price effect : Consume less	0.877*	(0.373)	0.891*	(0.372)
Access to information				
Change in energy supplier	0.797*	(0.374)	0.765*	(0.373)
Mobile phone	0.381	(0.541)	0.272	(0.536)
Access to internet	1.315***	(0.388)	1.358***	(0.386)
dexistenceisolation1	-1.046*	(0.495)	-1.080*	(0.489)
Social network				
# of people to contact in case of illness	0.027	(0.036)	0.033	(0.037)
# of people in contact	0.011	(0.015)	0.010	(0.015)
Employment status				
Others		Ref.		
Unemployed	-1.068	(1.070)	-1.166	(1.058)
Employed	-0.989	(0.799)	-1.173	(0.781)
Retired	-1.399	(0.935)	-1.395	(0.874)
Property rights of the lodgings				
Tenant in social housing	4.578***	(0.706)	4.734***	(0.687)
Tenant in private housing	4.613***	(0.674)	4.756***	(0.637)
Owner of the lodging	3.583***	(0.825)	3.732***	(0.766)
Others		Ref.		
Number of inhabitants per room in lodging	0.134	(0.367)	0.163	(0.347)
Education				
No eduation		Ref.		
Primary school	2.677*	(1.173)	2.538*	(1.160)
Collège, CAP, BEP	1.400	(1.027)	1.301	(0.951)
Secondary School	1.073	(1.006)	0.938	(0.932)
University	0.233	(1.060)	0.093	(0.969)
Age	0.032	(0.020)	0.029+	(0.017)
Type of family				
Single Woman		Ref.		
Single Man	0.076	(0.750)	-0.047	(0.748)
Couple w/o children	-0.545	(0.567)	-0.685	(0.556)
Couple with children	-0.086	(0.573)	-0.188	(0.548)
Monoparent family	-0.946+	(0.548)	-0.998+	(0.542)
Complexe family	-0.527	(0.580)	-0.641	(0.575)
Difficulties				
Not sufficiently warm in lodging	0.872*	(0.394)	0.882*	(0.375)
Too warm in lodging	-0.092	(0.489)	-0.194	(0.456)
Payment difficulty	.	.	.	.
Heating system				
Individual electric heating	-1.051	(0.684)	-0.943	(0.684)
Individual gaz heating	-0.382	(0.660)	-0.358	(0.672)
Collective heating system		Ref.		
Profession				
Ouvrier	-1.689+	(0.908)	-1.895*	(0.876)
Employé	-1.337*	(0.527)	-1.416**	(0.505)
Artisan, commercial, entrepreneur	-0.295	(0.699)	-0.238	(0.690)
Cadre, profession intellectuelle	-0.134	(0.547)	-0.066	(0.553)
Intermediary profession		Ref.		
Constant	-4.624*	(2.050)	-4.350*	(1.896)
Pseudo R^2	0.387		0.384	
N	141		141	

*Robust standard errors within parentheses. Significance stars : + 10% * 5% ** 1% *** 0.1%*

Table 3 also shows that an individual's sensitivity to changes in price plays a role in determining the probability of adopting energy saving measures. This is true for those individuals who have declared to choose to consume less electricity in the event of a 10% increase in energy price. These individuals are significantly more likely to adopt energy saving measures than those who do not react in such a manner to energy price increases. On the other hand, individuals who react to a change in price through their heating behavior do not seem to be significantly more likely to adopt energy saving measures than those who do not react in such a way to an increase in energy prices.

According to our estimation results, information plays an important role in the probability that an individual opts to implement energy saving measures. Three of out 4 of our explanatory variables are significant and are consistent with what we expected. Hence, one can see that those individuals who have access to the Internet, as well as those who are informed about the possibility of changing their energy supplier, are more likely to adopt energy saving measures, ceteris paribus. This is consistent with the idea that those individuals who have sufficient information, or who can easily access the relevant information, may find it in their best interest to adopt energy saving measures. Individuals who are unaware of insulation properties of their lodgings, on the other hand, have a significantly lower probability of adopting energy saving measures. One explanation that is consistent with this is that such individuals who do not have access to this information may have more difficulties to decide on how to save energy.

Our results also find only mild support for the influence of an individual's capabilities on the probability of adopting energy saving measures. Indeed, while the proprietor status of an individual's lodging plays a significant role in determining his/her probability of adopting energy saving measures, one may see that the coefficients of various configurations that we consider here is quite similar. Moreover, the coefficient of "Owner of the lodging variable" is lower in in the two cases considered. This may imply that owners do not tend to have a higher probability of adopting energy saving measures than tenants. Hence, if ownership of one's lodging may be taken as a proxy of a higher degree of liberties, our results show that a higher degree of liberties does not lead to a higher probability of adopting energy saving measures. Along the same line, neither the density within the lodging, nor the level of education of an individual seem to play an important role in determining an individual's probability of adopting energy saving measures. As our estimates show, individuals who have a primary school education are more likely to adopt energy saving measures, but those with a higher level of education do not behave differently from individuals who have received no education.

Finally, our estimations do not find any support that an individual's social network play a role in his/her decision to adopt energy saving measures. As it turns out, all of our explanatory variables that relate to this dimension (number of contacts, number of contacts in case of illness, and employment status) are all non significant. This may be due to the fact that we have not been able to adequately measure specific characteristics of an individual's social network. This dimension calls for further exploration.

In a nutshell, we find some support for some of the economic motivations and informational explanation in explaining an individual's decision to adopt energy saving measures. However, our estimations seem to suggest that factors related to capabilities à la Sen and social network do not have a strong impact on the probability of adopting energy saving measures. An interesting result that arise from our study is that subjective appreciation of income is a more important determinant than objective personal income to explain individuals' decision to adopt energy saving measures. Note, however, that our results are quite preliminary, and given our sample size and the specificities of our survey, generalization of these results should be subject to caution.

4. CONCLUSION

The aim of this paper was to investigate whether vulnerable households tend to save less energy than those households who are not vulnerable. To examine this question, we used data from a survey we realized during the summer of 2009 in a deprived area of Paris. We developed a number of indicators of vulnerability, based on Sen's capability approach,

which allowed us to elaborate more precise information on vulnerability than the simple indicator of monetary poverty or of subjective poverty.

Our estimations of the determinants of energy conservation behavior do not give support to the idea that vulnerable households are globally less willing (or able) to save energy than the non vulnerable, which suggests that the appreciation of the ability of households to use energy efficiently should be done carefully.

While the (objective) level of income does not influence significantly the willingness to save energy, the subjective appreciation of income has an influence: individuals who find life difficult with their current income are less willing to save, maybe because they fear that energy saving could cause a loss of comfort.

Knowledge about energy related questions and more generally access to Internet influence significantly the willingness to undertake energy saving measures, which suggests that there could be some links between "digital poverty" and a reduced ability or willingness to save energy.

As suggested by our estimations, there is a big difference in terms of energy saving behavior between individuals without formal education and individuals with primary education, those with primary education having a high willingness to save energy. Similarly, there is also a big difference between intermediary professions and low-skilled workers (manual and non manual), the low-skilled workers being much less willing to save.

These preliminary results suggest that the most "careful" energy users are in the medium-low social categories (people with primary education and in intermediary professions), while the "non-savers" are limited to the lowest social groups (i.e. people with no formal education and non-skilled workers). Public policies aimed at promoting energy conservation among households at risk of fuel poverty should therefore be specifically targeted towards this category of population with very limited basic skills. This result also raises the question of the most appropriate policy options to prevent these households to be in fuel poverty.

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