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Determinants of Household Energy Consumption in France: Behavior Approach

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Overview

French residential consumption takes a significant part of 26.5% (including wood) in the total final energy consumption [1]. Many recent policies either mandate or promote energy reduction in residential sector, but the residential energy consumption decrease too slowly. The renewal of the building stock is low and the level of renovation works is not sufficient to reduce the consumption in accordance with an ambitious target. Otherwise the level of household consumption per m² varies according to quality of dwelling insulation, to the type of energy systems and to the energy source. For this reasons it is important to understand and to explain at first the household choices in dwellings. The recent works on this topic study the determinant of household choice using discrete choice models and calculate the expected energy consumption. They try to take into account the constraints such as access to natural gas in the U.S. [7], regional differences in Germany [3], choice of multi energy heating system in Norway [9] etc. The number of studies in France is limited and is more regional that national [4]. The purpose of this paper is twofold. First, we take into account the supply side restrictions and the interdependence between energy systems for different home services. Second, we focus on clustering the household in groups for energy systems choice instead interesting in level consumption. The result might be helpful for politics and energy managers to better target their energy policies.

Methods

We adapt the econometric approach based on the Random Utility Model (RUM) to study household energy choices in their dwellings. The RUM concept was initially proposed by the psychologist Thurston [11] and after adapted to economics by McFadden [8]. The random utility function is decomposed in two parts. One is observable by the researcher and can be estimated, the other one is considered to be random. The RUM allows us to obtain the probability by choice alternative and by household. Based on data from French housing surveys in the years 2006 and 2013 we estimate two models using Multinomial Logit. The first model provides as output the utility function by energy source (electricity, gas, fuel oil, wood and LPG[1]) for dwelling energy services: space heating, sanitary hot water and cooking. The second model provides the utility function for choice of heating system (direct electric heating, heat pump, boiler, wood-burning stove). Besides the probabilities, these models estimate the marginal elasticity of probability and allow us to cluster households in group with similar behavior.

[1] Liquefied Petroleum Gas

Results

The services choice model by energy shows that the access to natural gas is the most important determinant of choice. If the dwelling is connected to the gas grid, the probability to use the electricity for space heating and sanitary hot water is divided by 22, divided by 60 for using electricity for all home services, divided by 28 in the case of LPG use for cooking and divided by 6 in the case of fuel oil or wood use for space heating and hot water, *ceteris paribus*. Three other variables have a large impact on the level of probabilities: the occupancy status (owner or tenant), the type of dwelling (house or apartment) and the dwelling age. However the marginal elasticity never goes beyond the absolute value of 2. For example, if the household move from a house to an apartment, the probability to use the electricity for all services is multiplied by 1.05, by 0.63 for gas and by 0.06 for LPG. The dwelling surface, number of occupant and the age of household's reference person have a very limited impact. The second model, choice of heating system, highlights the importance of double glazing and house age on choice of heating system, especially in the cases of electricity heating choice (convector and heat pump). The variation of household income and the sociological variables do not appear significant in the models. This is explained by structure of our model which takes into account the dwelling characteristics linking to socio-economic variables. Both models were estimated for the years 2006 and 2013. We did not find any significant differences in household choice.

Conclusions

This study allows us to quantify the energy choices for each household, as well as the groups of household after the post estimation clustering. We were able to determine the main drivers of energy choices in dwellings. These quantitative results are consistent with the qualitative knowledge of experts from energy sector in France. We intend to use these results in the model that describes the home renovation market: insulation and replacement of space heating system. This type of model can be also used to calibrate energy models [10] or calculate expected energy consumption [3], [4], [9]. We use the revealed preferences data which is related to actual choices in real-world situations, but do not give the information on the no selected choice alternatives. To improve our study, we indeed to conduct the choice experiment on French household. This will give us the stated preferences data set which is enable to take into account the attributes of all choice alternatives, calculates the willingness-to-pay [5] or considers the taste heterogeneity of consumer's behavior [6]. The two types of data can be combined to make the choice experiment more realistic [2].

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