MULTIVARIATE MODEL FOR THE USAGE OF RENEWABLE ENERGIES IN A RURAL AREA

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Within Hungary, the Koppányvölgye rural area was chosen due to its unique natural circumstances with its broad green nature, concerning the inhabitants' habit for the usage and knowledge of renewable energy for residential heating. Through quota-based sampling method we collected the demographic, social and economic variables to examine their level of influence on wood for residential heating usage. We received the Likert scale values through the questionnaire, which had to be recoded for the binomial logistic regression model that we chose to use because of the indicator variable's trait, and in aim to examine the explanatory variables' significance. As a result, for the wood indicator variable, the age of the respondent turned out to be a significant variable, the higher age compared to lower age is a chance decreasing category for wood usage, employed compared to unemployed increased the likelihood, thereby rejected the energy ladder phenomenon, as well as more people in one household increased the chance for wood usage. The higher education, environmental awareness and insulation level of a house turned out to be non-significant for wood usage. Therefore, we strengthened those statements from the earlier studies, that in this rural region, the change of the residential heating technology is more likely to be supply driven than demand driven.

Keywords: renewable energy; rural development; environmental awareness; residential heating; wood heating

INTRODUCTION

The difficulty of choosing the residential heating technology wisely is rooted in the phenomenon of the regional area's ability of self-preservation concerning heating source. If we examine wood as the most commonly used renewable energy source in our studied area, we need to look at the conflicting part. While wood is renewable, it has serious health effects on human existence and on the atmosphere's balance of gases, while it can solve the local self-preservation problem from energy source point of view. There is the interest in understanding the detailed consumption representative attributes of the residential sector in an effort to make regional development decisions promote maintenance, efficiency, technology application and energy source switching. This article aims to examine it by relationship analysis of the connection of wood with the chosen demographic, economic and social variables to understand the influencing factors of inhabitants' decisions about the residential heating technology. According to Lissowska's (2005) results, one lifestyle factor associated with urbanization is the usage of cleaner fuels for domestic cooking and heating. In the case of urbanized areas, it is more likely to use modern fuels and energy sources, such as kerosene, gas, and electricity. In opposition, rural areas in poor countries still rely heavily or completely on biomass fuels, such as wood and dung. Among the four components of indoor pollution (combustion products, chemicals, radon, and biologic agents), combustion-originated pollutants, particularly those from solid fuels (wood, charcoal, crop residues, dung, and coal) are generic (Lissowska, 2005). By analyzing the link between households' energy consumption and human development index, Rahut and Behera's (2016) article stated that the representation of strong association for income, education, and life expectancy with energy consumption is present in Bhutan. Separately from the quantity, the type of energy used also changes with income, with a shift towards modern fuels, particularly electricity. Besides the access for affordable, low-cost sources of energy, the income and level of education influence the quantity of households' energy consumption. A large part of empirical studies have documented the presence of energy ladder (energy ladder means that fuel process as income increases, or in other words, where wood is much more likely to be used by the lowest-income categories in income), and factors affecting a households' decision to change for cleaner fuel with growth in households' income. Furthermore, household demographic attributes, consumption habits play an important role in energy-choice decisions of households. The share of wood consumed by total households' energy consumption is more than 50% for those households with no education in the years 2003, 2007 and 2012, and it drops with the raise of education level. The share of expenditures on wood was below 5% through the years for the households of those who have completed university education. But not just exclusively for wood; the overall the energy consumption lowers with the increase of households' income level. By increasing income, there is a precipitous growth in the households' proportion using electricity, and a sharp downfall in the proportion of those households using wood and kerosene. The chance to choose electricity and gas as energy sources expands with income (Rahut and Behera, 2016). Lillemo and Halvorsen's (2013) article also emphasizes the education and income level's impact on fuelwood consumption in Norway. Education level presents negative correlation with firewood consumption as well; besides, this negative correlation is highly significant (Lillemo and Halvorsen, 2013). The education has a role in fuel switching as concluded by Hine (2007), but educational campaigns may fail if they only focus information on risks but do not try to influence the positive image of wood combustion. Many associate wood combustion at home with innate feelings of comfort, goodness, happiness and warmth (Hine, 2007). According to Lillemo and Halvorsen (2013), the standard deviation increases in case of price of firewood, meanwhile 18% decrease can be seen in acquired sack of firewood's presumed number. This explains that cheapness of firewood is one of the most important factors for firewood utilization for residential heating in Norwegian households. We could propose that in this case income has weight as a variable, but in the article the income variable turns out as a non-significant variable, indicating that the usage of firewood is divided over all income classes. The following demographic factor is the age of households' main income gainer. In this situation, the demand for firewood decreases with the age of the households' main income gainer. The result differs from Huei-Chu and Tsai-Feng's (2002) article's result, where in the US

they found on the one hand that residential heating energy requisition grows by the respondents' age, nevertheless, the natural gas and fuel oil increase as a substitution for electricity as well (Huei-Chu and Tsai-Feng, 2002) (Lillemo and Halvorsen, 2013). Vaage's (2000) study also states (where the examined area in this study is Norway) that high household income seems to heighten the probability of selecting electricity as the only heating source. Compositions with solid fuels such as wood are principally unpopular within high-income households. Additionally, type and age of buildings seem to have significant impacts on the heating appliance choice. The estimates of the study report that households more likely to choose electric heating are those living in blocks. Moreover, heating technology based entirely on electricity occurs to be more regular in new buildings. Keep in mind that 'new' in Vaage's (2000) study is defined as built in 1975 or later (Vaage, 2000). However, Stéphane's (2012) analysis seems to confirm the opposite to the earlier mentioned energy ladder theory. Furthermore, those are the highest income households, which are more likely to use wood as an extension source of heating energy next to other heating devices, or for pleasure (Stéphane, 2012). Israel's (2002) study also mentions that based on several studies, the economic development generally directs for transformation from traditional into modern type of heating technology. At the end of Arabatzis and Malesios' (2011) research the results have proved that economically weaker population is more likely to use conventional heating sources (Israel, 2002) (Leach, 1987). In García-Maroto's (2015) study we can see that environmental awareness influences the decision to switch for more environmentally friendly techniques. While environmental concern may bear some weight in the decision to adopt these heating systems, the existence of subsidies for their purchase was more important in consumers' ultimate decisions (I. García-Maroto, 2015). As it is stated by Guta's (2014) study, a cross-country study in Sub-Saharan Africa as well found that fuel-switching behaviour of households is more likely supply side driven comparatively to demand factors, which means less importance of income's influence on heating device (Guta, 2014). Results of Bartecchi's (2006) study, increasing the observation of health risks associated with solid fuel heating can be one motivation to change attitude, although awareness of risks does not exclusively lead to beneficial changes in behaviour (Bartecchi, 2006). WHO (2015) stated as well that in order to reach heating technique switch, the outsider financial support has a bigger weight than the environmental effects' awareness (WHO, 2015).

Material and methods

Data collection method

We have examined 10 settlements concerning the inhabitants' habit for the usage and knowledge of renewable energy in residential heating, depending on demographic, social and economic variables. Our ten settlements are Törökkoppány, Fiad, Kisbárapáti, Bonnya, Somogyacsa, Somogydöröcske, Szorosad, Kara, Miklósi, and Koppányszántó in the Koppányvölgye region, within Hungary. The examined energy type as a heating source is wood. Our variables are age, settlement of the respondents, the educational level, employment status, and the number of people of the respondents' household for examination about likelihood of the usage of wood. These mentioned variables are the so called demographic variables, while the social attributes are the trust in their mayor, their consciousness about biogas concerning its climate change influence, and the person's standard for contribution toward green energy, in the form of act, or financial support. The number of filled questionnaires is 310, which were distributed and filled in May 2018. The survey contains 3 main sections, which are the general information about the respondents, awareness regarding renewable energy sources, and biomass related questions. For question-answer types, the survey contains one-option questions-answers, likert scale answers, and multi-optional questions-answers. The questionnaire was distributed quota based on settlements' population within the settlements, with random selection of respondents.

Variables

Our variables were divided into two groups, the indicator variable, and explanatory variables.

❒ Indicator variable

Our indicator variable is wood. Wood is in the renewable energy source category, but it has serious health effects through its indoor and outdoor emissions.

❒ Explanatory variables

Our explanatory variables were divided into three groups. The first group is the sum of demographic variables, which consists of age (age), settlement (settl), education (edu), employment status (job) and household size (hh_size) of respondents. The second group is the sum of social variables, composed from the trust level toward mayor (trust), the consciousness about biogas' environmental effect (consbiogas), willingness to collect bio waste (consact), and the willingness to financially support green energy (consmat). The third group is the sum of economic variables, which are the insulation level (insul) and the age of the house (hou_yr).

Logistic regression model

Our examined indicator variable is wood as a residential heating source. Two answers are available for the usage of wood, which are yes (1) or no (0) answers. Because of the indicator variable's trait, we chose to use the logistic regression model. The logistic regression model is a form of binomial regression (Walker and Duncan, 1967). In the logistic model, the logarithm of the odds for the value 1 is a linear combination of one or more explanatory variables, where the variables can be binary variables or continuous variables (Equation 1). This model shows which examined explanatory variables are significant (or not significant) for the indicator variable. The level of the odds ratio within the explanatory variables' category gives the level of multiply (to increase or decrease compared to the explanatory variable's base class) the usage of the indicator variable. Expressed in equation form, the odds of result variable is the exponential combination of the explanatory variables (Equation 2). The calculation was accomplished via Stata software.

$$\log it\,(p) = \log\,(odds) = \log\frac{p}{1-p}\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k \qquad (1)$$

$$odds = e^{\beta_0} e^{\beta_1 x_1} e^{\beta_2 x_2} ... e^{\beta_k x_k} \qquad (2)$$

Research question and hypothesis

❒ Research question

Which demographic, social and economic variables influence the likelihood of the usage of wood residential heating devices? Specifically, our demographic variables are age, settlement, educational level, employment status and household size of the respondents. Besides, the social variables are trust in mayor, consciousness about biogas, consciousness about action towards

green energy, and consciousness about financial support to gain green energy. Our economic variables in details are insulation level and the age of the house.

❒ **Hypothesis**

Due to the conducted data analysis I was seeking to prove the following hypotheses. Age of the respondent was contested during literature review as a significant variable, as well as employment status and size of the household and their significance. Besides, settlement's size and educational level had a negative correlation with wood usage for residential heating. Social variables can be taken as environmental awareness measures, but we could see in the literature review that consciousness was contested, due to the renewable energy and emission quality contradiction. The insulation level is expected to have a significance and a negative correlation with wood usage. For the age of the house variable a significance, positive correlation with wood is awaited.

Results and discussion

In the next chapter the resulting significant and non-significant explanatory variables are detailed. After we examined the Variance Inflation Factor (VIF) to avoid multicollinearity, we used the logistic regression model for the examination of the explanatory variables' significance.

We can see the significant and non-significant explanatory variables for our indicator variable.

Summed significant explanatory variables for wood indicator variable

Table 1 shows the significant variables in case of wood.

Table 1 Significant variables for wood indicator variable

Age of the people	Employment state	Household size	Consciousness in form of action
age is between 19 and 30 years old	employed	■ 2 persons ■ at least 3 persons	unsure

Age variable is debated in the literature review among the researchers' results. Our result says that among maximum 30 years old inhabitants, who are between 19 and 30 years old there is lower probability of using wood (0.37 times), than for those under 18. Employed status seems to increase the chance for wood usage by 2.92 times compared to unemployed and students, which seems to reject the energy ladder phenomenon, and supports those studies, which rejected the energy ladder. The literature review mentioned that the more people live in one household, the more stack of wood they use, while our research means that if at least 2 people live in the same household, the chance to use wood multiplies by 5.25–5.51. Those who were unsure about collecting organic waste for biogas plant are more likely to use wood compared to those, who disagree. They can be influenced by education, which is based in the literature review.

Non-significant explanatory variables for wood indicator variable

Within the educational level variable "higher education" category, no trust in the mayor, those, who agreed with the biogas' environmental benefits (consbiogas), and insulation level's both category, the partly and non-insulated are neither significant categories within the variables with higher, than 0.7 P value. The ratio of people with no trust is 90%. Table 6 shows the non-significant variables in case of wood indicator variable.

Table 2 Non-significant variables for wood indicator variable

Educational level	Trust in the mayor	Consciousness about biogas' environmental effects	Insulation level
higher education	no	agree with the statement	■ partly insulated ■ not insulated

Higher educational level was expected to be a significant variable, but in our case, the opposite phenomenon took place.

Lissowska (2005) stated that in rural area the ratio of wood users is significantly higher, which we could confirm with our results. Rahut and Behera (2016) also stated that demographic factors are significant in case of residential heating technology. The wood users' ratio is undoubtedly higher than the modern technologies users' ratio. As we could see in Rahut and Behera's (2016) research, and in Lillemo and Halvorsen's (2013) article, higher education level has a significant role in case of choice of modern or traditional type of heating. Our results show no significance for higher education level for wood as a residential heating source. Income had contradictory results in the literature review by the different researchers. Rahut and Behera (2016) stated the significance of income, supported the energy ladder, such as Vaage (2000) and Barnes (2002) with the same state, while Stéphane (2012) rejected the energy ladder, besides Lillemo and Halvorsen's (2013) result stated that income is a non-significant variable. Based on our results, in wood indicator case it became a significant variable. We can support a statement by Stéphane (2012), by the reason that our result rejected the energy ladder. The likelihood increased for wood usage with the employment status compared to unemployed/student status. The age of the respondent became a significant variable, where the older age decreased the likelihood of wood usage. It accepts Lillemo and Halvorsen's (2013) statement, which says that the demand for firewood decreases with age. We did not examine directly the consequences of renewable energy education in the area, but to mention, the governments of the area's villages have already organized educational campaigns, but those seemed to be unsuccessful. It can be a result of the trust in the local government, which we could see as significantly low with the high ratio of no answers towards the trust in mayor. In case of wood the trust level did not generate any change. If the respondent agrees with the great benefit of renewable energy (biogas question, consbiogas), it does not have any significant influence on the odds to wood usage at all. Therefore, Hine's (2007) hypothesis established with our results in this situation, according to the researcher, the positive effect of wood heating (warmness, comfort) has to be contradicted with the negative effects. Israel (2002), Leach (1987) and also García-Maroto (2015) stated, that environmental awareness influences the usage of conventional and modern heating type choice, but our results support Hine's (2007) hypothesis. Our result also strengthens Guta's (2014) result, where the researcher's statement is that fuel switching is more likely to be supply driven than demand driven. WHO (2015) stated as well, that in order to reach heating technique switch, the outsider financial support has a bigger weight than the environmental effects' awareness. García-Maroto (2015) likewise mentioned that the environmental awareness works combined

with financial support switching technology. As specified in the literature review by the WHO (2015), economic downturns can increase the ratio of wood residential heating, and higher level of economic background of the inhabitant (as higher income) can expand the usage of modern type heating. Vaage (2000) also stated that the greater quality of houses means more modern heating technique, besides, the age of the house effects with the same positive correlation the modern heating appliances. In Koppányvölgye's case, our economic variable of insulation showed that partly insulated and non-insulated houses do not influence the chance for wood usage. For the age of the house we did not receive any significant result.

Conclusions

In Conclusions Sub-chapter we answer the research question, as well as evaluate our hypotheses.

Answer for the research question, hypothesis evaluation

In our examined area, the higher the age of the respondent, the less wood they tend to use. The likelihood increased for wood usage with the employment status compared to unemployed/student status. We can observe the same phenomenon for the number of people in one household, the more people live in the same household, the higher the chance they use wood. For wood usage, we did not receive any significant category within settlement size variable. For educational level, in opposite to our expectations based on the literature review, it became a non-significant variable for wood usage. The fact that the respondents did not trust their mayor did not affect the habit of wood usage. Those respondents, who were not sure about social responsibility willingness to collect organic waste, were more likely to use wood, compared to those, who did not show any willingness to collect organic waste. Even the awareness about biogas' positive effects did not influence the respondents' heating technology choice. Likewise in insulation level and age of the house cases, these did not have any effect on wood usage. Therefore, our initial hypothesis is partly verifiable, while some other parts of it are clearly rejected. What we can see clearly is the change of the residential heating technology as more likely to be supply driven than demand driven.

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