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Analysis of Households' Electricity Consumption with Ordered Logit Models: Example of Turkey

Erkan ARI[1], Noyan AYDIN[2] Semih Karacan[3] Sinan Saracli[4]
[1,2,3]Dumlupınar University, Faculty of Economics and Administrative Sciences, Department of Econometrics, Center Campus, 43100, Turkey,
[4] Afyon Kocatepe University, Science and Literature Faculty, Department of Statistics, Ahmet Necdet Sezer Campus, 03200, Turkey,

ABSTRACT: *Percentage of households' electricity demand in total energy demand of households is increasing day by day. However, households' electricity consumption fails to provide the added value to Gross National Product unlike industry sector. Therefore, the factors that increase the energy consumption of households should be analyzed and in this respect, required energy saving policies should be generated. In this paper, the ordered logit models examined the variables affecting the electricity consumption of households in Turkey. According to goodness of fit indicators, Partial Proportional Odds Model was determined as the best model that fits into our dataset. The results obtained from model show that electrically powered items and their quantities, household size, income, housing type and properties are important factors that increase households' electricity consumption.*

Keywords: *Household Electricity Consumption, Ordered Logit Models, Assumption of Parallel Lines , Partial Proportional Odds Model.*
JEL Classification: *C35, C46, Q43, Q47, R22*

I. Introduction

Energy is an indispensable reality of industrial and daily life, and its place and importance in the socio-economic structure of countries is increasing day by day, due to developments in technology and changes in living standards. Because technological advances and increased welfare changes both production structures of industries and households' consumption habits as end-users. Increasing energy demand in this direction is shifting toward more environmentally friendly energy sources that are easier to obtain and use, such as solar and electricity.

Turkey is a country with the highest energy demand growth in the OECD countries for the last decade and energy demand is expected to rise to 2 times for the next decade (MENR 2015). On the other hand, demand for primary energy sources which are non-renewable and rapidly depleted resources such as wood, coal and crude oil, give place to greener secondary energy sources such as electricity and hydrogen which are transformed from renewable primary energy sources such as water, wind and solar in many sectors. 45% of planned 37.4 trillion $ energy investment in OECD countries until 2035 was reserved only to obtain electrical energy, and this planning approach confirms this situation. Population growth, industrialization, urbanization, technological development, increase in greenhouse gas emissions, and increasing diversity in consumer behavior play an important role in increasing share of electricity consumption in total energy consumption. In addition, this situation leads to an increase in electricity demand in all sectors. Demand forecasts made by MENR for next ten years indicate that electricity demand in Turkey will increase by 7.5% (TETC 2015). In particular, due to technological advances and increased welfare, individuals and families prefer to use electricity, which is clean, continuous, and easily accessible source of energy, for needs such as communication, transportation, nutrition, shelter, heating, lighting and entertainment.

In the figure 1, households' percentages in total electricity consumption for the period 1970-2013 in Turkey are given. In 2013, share of households' electricity consumption in total electricity consumption in Turkey is 22.7% and comes in second place after the industry sector (47.1). Besides, it can be seen that the share of households' electricity consumption in total electricity consumption has an upward trend.

Figure 1: Household electricity consumption in total electricity consumption in Turkey

Source: *TSI, Distribution of net electricity consumption by sector* (http:/ /www.tuik.gov.tr/ PreIstatistikTablo .do?istab_id=1579)

Demand dynamics should be investigated in detail and demand forecasts should be made to meet the increasing electricity demand, to reduce dependence on foreign and to increase security of supply. In this way, identification of factors affecting the electricity consumption and calculating the impact on electricity demand levels of these factors are becoming very important for all sectors, especially household. Analyses to be made, especially for the household sector, which has a lower added value than industry sector for economy, are becoming more important to determine the causes of the increase in the electricity consumption and to produce the savings-oriented policy.

Various studies have been made to examine the factors affecting the energy preferences and the electricity consumption of households in countries. Özcan et al. (2013) analyzed factors that affect the choice of energy consumption in households for Turkey using TSI Household Budget Survey (2006) with multinomial logit model. The findings showed that household income, age of household head, employment status and education of household head, being in urban or rural, household type and number of rooms affected the choice of household energy.

In the study of Güloğlu (2014), partial proportional odds model, which is a special kind of generalized ordered logit model, was used to determine the factors affecting the household electricity consumption in Turkey via TSI Household Budget Survey (2008). The results of the study showed that households vary according to housing type, housing size, the structure, and the real income of households, and the availability of electrical household appliances such as air conditioning, freezer, microwave, and washing machine.

Rahut et al. (2014) used multinomial logit model to analyze factors that determine the choice of energy use for heating, enlightenment and cooking of households using Bhutan Living Standards Survey (2007). According to the findings in this study, when disposable income level, education level, age and level of ease in access to electricity increase, households prefer greener energy sources such as natural gas and electricity. Besides, this preference is more preferable for households living in urban areas, women, and families with small populations.

Tewathia (2014) used multivariate regression model to determine the variables affecting monthly and seasonal average electricity consumption for households living in the city of Delhi, India. The results of the study show that there is a relationship between the average electricity consumption of households with monthly incomes of households, number of people in household, the number of electrical appliances and areal size of the household used in the same direction, but, with educational level of the household head in the opposite direction.

Fan et al. (2015) studied multivariate regression model to estimate monthly electricity consumption values for Chinese households and various sectors. In addition, significant relationship was found between monthly electricity consumption values and the real price of electricity, climatic conditions, and holidays.

In this paper, ordered logit models using TSI micro data set (2012) will analyze factors affecting the household electricity consumption for Turkey. Because the data set collected by TSI is very comprehensive, a large number of variables that may affect the electricity consumption were included.

II. Methodology And Data

Ordered logit models are used in cases where the dependent variable has three categories at least and an ordered (sequential) structure. Although ordered logit models are similar to Multinomial logit model, it differs from that due to the parallel lines assumption. Multinomial logit models are used as enlarged version of binary logit model in cases where the dependent variable has more than two categories, where categories are nominal, and where categories have not ordered structure (Lemeshow 2000).

In this paper, factors affecting the electricity consumption of households in Turkey will be analyzed using STATA software package and Turkey Statistical Institute (TSI)'s Household Budget Survey (2012) dataset by ordered logit models. This survey was applied to the 8683 households by TSI. At first, 22 variables thought to affect the consumption of electricity were tested by Chi-square test of independence, and then the variables, which are unrelated to electricity consumption, were removed from the data set and the remaining 19 independent variables were included to multicollinearity analysis. Variance inflation factor (VIF) was used in determining of multicollinearity and all independent variables were included in the logit analysis because VIF values of 19 dependent variables is smaller than 10. In the next step, different ordered logit models were established for household electricity consumption variable that has ordered categorical structure in order to determine what the most appropriate model for the data set. Then, maximum likelihood estimators obtained the odds ratios for studied models. Finally, the validity of the models was tested by likelihood ratio test, and Pseudo , deviation measure, AIC and BIC information criteria as goodness of fit indicators were used to compare alternative logit models. In this way, most appropriate ordered logit model for the data set could be determined by obtained values of goodness of fit.

Table 1: Levels of Independent Variables

Independent variables	Levels of independent variables
X1: Annual real income	1: 0-10.500 2: 10.500-20.500 3: 20.500-27.500 4: 27.500-33.000 5: 33.000+
X2:Housing size	1: 0-75 2: 75-100 3:100-1254: 125
X3: Heating system	1: stove 2: central heating 3:combi 4: air conditioner 5: other
X4: Cable or satellite TV	0: no 1: yes
X5: Computer	0: no 1: yes

X6: LCD TV	0: no	1: yes
X7: Refrigerator	0: no	1: yes
X8: Deep freeze	0: no	1: yes
X9: Dishwasher	0: no	1: yes
X10: Microwave oven	0: no	1: yes
X11: Washing machine	0: no	1: yes
X12: Dryer	0: no	1: yes
X13: Air conditioning	0: no	1: yes
X14: Property ownership	0:tenant	1: host
X15: Household size	1: family with an only one child 2: family with two children 3: family with three or more children 4: childless couple 5: big family 6: family with an only one adult 7: persons living together	
X16: Housing type	0: apartment	1: single house
X17: Natural gas	0: no	1: yes
X18: Hot water	0: no	1: yes
X19: Rural / urban life	0: rural	1: urban

In this paper, ordered categorical dependent variable is household electricity consumption level. The levels of electricity consumption per household have an ordered structure in the form of (1**:** 0-10 KWh, 2: 40-60 KWh, 3: 60-100 KWh, 4: 60 KWh+). The variables, which are thought to affect the level of household electricity consumption, are real income, housing size, heating system, cable or satellite TV, computer, LCD TV, refrigerator, deep freeze, dishwasher, microwave oven, washing machine, dryer, air conditioning, property ownership, household size, housing type, natural gas, hot water, rural or urban life. All independent variables are categorical and are determined in different levels as shown in Table 1.
Different models are used for category comparisons of dependent variable in ordered logistic regression model. In these models, models that can be applied and interpreted easily are ordered logit models that are based on cumulated probability. These models are proportional odds model, non-proportional odds model, partial proportional odds model and constrained / unconstrained partial proportional odds models.

2.1 Proportional Odds Model

Proportional odds model (POM) is an ordered logistic regression model, which is based on the estimate of the cumulative probabilities and used commonly in studies, when dependent variable is categorical and parallel lines assumption is met between categories (Brant 1990; Bender and Grouven 1998; Fullerton 2009). McCullagh and Nelder (1989) put this model forward based on using the logit link function.

(1)

Proportional odds model is established using cumulated probabilities as in the following equation 1 (Kleinbaum and Ananth 1997

(2)

(3)

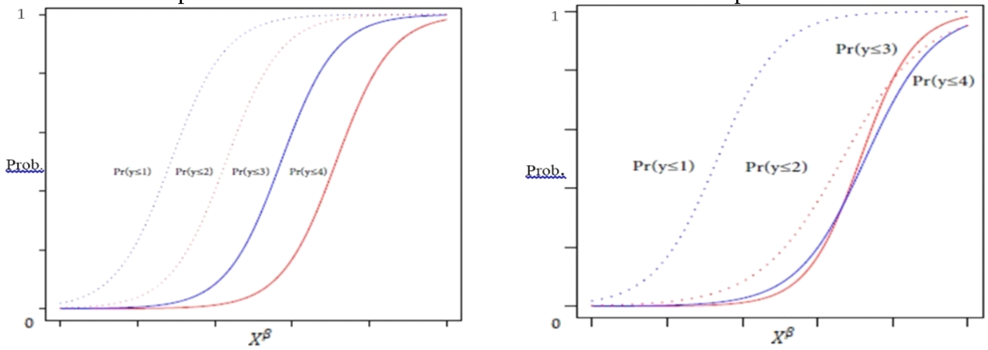
This equation can be written as follows by taking the natural logarithm of the odds ratio of models:
In equation 1 and 3, is ordered categorical dependent variable, is vector of independent variables, are breakpoints corresponding to estimators (. In addition, = is a vector of logit coefficients of regression corresponding to . In here, these β coefficients are independent of the dependent variable categories, namely, related β coefficients for kth independent variable are equal to each other in all cumulative logits (McCullagh 1980 and Gagea 2014). In the literature, the status of equality of *β* coefficients at each breakpoint is known as parallel lines assumption in logistic regression. In other words, parameter estimates for logit models do not vary according to the breakpoints if parallel lines assumption is met.

2.2 Parallel Lines Assumption

Parallel lines assumption is an important assumption of the ordered logit models. According to this assumption, the relationship between independent variables and the dependent variable does not change according to the dependent variable categories. In other words, the parameter estimates do not show changes according to the cut points (Fullerton and Xu 2012). This assumption expresses that categories of the dependent variable is parallel to each other and there are unit cut points and only 1 unit *β* parameter for comparison of *J-1* unit logit in dependent variable has j category.

Figure 2: Cases where the assumption is violated and met for probabilities of categories

Assumption meets — Assumption violated



In case of violation of the assumption, parallelism belonging to categories breaks down. In this instance, generalized ordered logit model (non-proportional odds model "non-POM") and partial proportional odds model (PPOM) can be used as the alternative models. Violation and fulfilling of the assumptions is shown in figure 2 (Fullerton and Xu 2012). Brant test (Brant, 1990), Wald test (Williams 2006) or other similar tests are used to test the parallel lines assumption.

2.3 Non-Proportional Odds Model

In non-Proportional Odds Model (non-POM), which is also known as the Generalized ordered logit model and suggested by Fu (1998), the effect of independent variables is not same on the odds of the dependent variable and β coefficients are different for each category of the dependent variable. Equation 4 expresses this model (Maddala 1986; McCullagh and Nelder 1989; Williams 2006; Fullerton and Xu 2012).

(4)

In here, is an estimator of unknown parameters and threshold value representing estimators (is a vector of the regression coefficients representing . This model can be expressed in linear form as Equation 6 by taking the logarithm of the odds ratio (eq. 5) (Fullerton and Xu 2012).

(5)

(6)

2.4. Partial Proportional Odds Model

Partial Proportional Odds Model (PPOM), which is suggested by Peterson and Harrell (1990), is used when the parallel lines assumption is met for some variables but is not met for the others. In addition, this model is a model that loosens the assumption and has a characteristic of models that are proportional and non-proportional at the same time. PPOM has been identified in two ways by Peterson and Harrell (1990), namely constrained, and unconstrained. The general form for unconstrained model (UPPOM) is as follows:

(7)

This model can be expressed in linear form as Eq. 8 by taking logarithm of odds ratio:

(8)

In here, is an estimator of unknown parameters representing estimators, is a dimensional vector of variables that are met the parallel lines assumption and k is a dimensional vector of variables that are not met the parallel lines assumption. On the other hand, parameter gives the increase change in the logit for non-proportional variable. Parallel lines assumption is met and the model (UPPOM) transforms into POM when (Peterson and Harrell 1990).

Unconstrained model becomes constrained model by multiplying a fixed predetermined scalar and the coefficients at changing breakpoints. Fewer parameters are needed compared to UPPOM and non-POM because parallelism is met between the coefficients of variables in the model that becomes constrained model (Peterson and Harrell 1990; Kleinbaum and Annath 1997). This model can be expressed as follows:

(9)

III. Results

POM that is one of the ordered logit models was applied to data set and the results in Table 2 have been reached.

Table 2: The results of POM

Electricity consumption level	Variable	Coef.	Std. Error	Odds Ratio	value
Category 2,3,4 against Category 1	Threshold 1	2,177	0,213	---	---

(comparison 1)					
Category 3,4 against Category 1,2 (comparison 2)	Threshold 2	3,883	0,216	---	---
Category 4 against Category 1,2,3 (comparison 3)	Threshold 3	5,690	0,220	---	---
	Real income	0,193	0,016	1,212	0,000*
	Housing size	0,054	0,022	1,055	0,001*
	Heating system	0,256	0,029	1,292	0,000*
	Cable or satellite TV	0,206	0,099	1,228	0,039*
	Computer	0,320	0,040	1,377	0,000*
	LCD television	0,186	0,041	1,205	0,000*
	Refrigerator	0,764	0,176	2,148	0,000*
	Deep freeze	0,517	0,059	1,677	0,000*
	Dishwasher	0,441	0,050	1,554	0,000*
	Microwave oven	0,156	0,057	1,169	0,007*
	Washing machine	0,364	0,126	1,440	0,004*
	Dryer	0,172	0,184	1,187	0,350
	Air conditioning	0,363	0,041	1,438	0,000*
	Property ownership	0,028	0,042	1,028	0,511
	Household size	0,231	0,013	1,260	0,000*
	Housing type	-0,190	0,053	0,830	0,001*
	Natural gas	-0,650	0,060	0,522	0,000*
	Hot water	0,382	0,073	1,466	0,000*
	Rural or urban life	-0,220	0,056	0,801	0,000*

The likelihood ratio test examined POM's validity and the model is significant. Although POM is significant, parallel lines assumption should also be tested to use this model. In this context, to test whether this assumption is met, whether the β coefficients of independent variables for each categories are equal was tested by likelihood ratio test . According to the test results, the null hypothesis was rejected and it was reached the conclusion that the parallel lines assumption is not met.

Non-POM that is one of the ordered logit models was applied to data set and the results in Table 3 have been reached. The validity of Non-POM was tested by likelihood ratio test and according to the result, it is seen that the model was significant . Although Non-POM is significant, parallel lines assumption should also be tested to use this model. According to likelihood ratio test (= 2582,05; , the null hypothesis was rejected and it was reached the conclusion that the parallel lines assumption is not met.

***Table 3:* T**he results of non-POM

Electricity consumption level	Variable	Coeff.	Std. Error	Odds Ratio	value
Category 2,3,4 against Category 1 (comparison 1)	Threshold 1	-2,732	0,027	---	---
	Real income	0,212	0,024	1,236	0,000*
	Housing size	0,090	0,032	1,094	0,006*
	Heating system	0,258	0,050	1,295	0,000*
	Cable or satellite TV	0,673	0,189	1,069	0,722
	Computer	0,569	0,066	1,767	0,000*
	LCD television	0,118	0,069	1,125	0,088
	Refrigerator	0,903	0,241	2,467	0,000*
	Deep freeze	0,640	0,107	1,897	0,000*
	Dishwasher	0,599	0,071	1,820	0,000*
	Microwave oven	0,147	0,106	1,158	0,166
	Washing machine	0,309	0,138	1,362	0,025*
	Dryer	-0,284	0,352	0,752	0,419
	Air conditioning	0,207	0,078	1,230	0,008*

	Property ownership	0,039	0,062	1,040	0,525
	Household size	0,262	0,019	1,299	0,000*
	Housing type	-0,046	0,075	0,954	0,0541
	Natural gas	-0,041	0,100	0,659	0,000*
	Hot water	0,286	0,085	1,332	0,001*
	Rural or urban life	-0,153	0,075	0,857	0,041*
Category 3,4 against Category 1,2 (comparison 2)	Threshold 2	-3,739	0,281	---	---
	Real income	0,198	0,018	1,220	0,000*
	Housing size	0,044	0,026	1,045	0,088
	Heating system	0,255	0,036	1,291	0,000*
	Cable or satellite TV	0,263	0,106	1,288	0,013*
	Computer	0,344	0,048	1,410	0,000*
	LCD television	0,246	0,049	1,279	0,000*
	Refrigerator	0,909	0,238	2,482	0,000*
	Deep freeze	0,616	0,071	1,851	0,000*
	Dishwasher	0,376	0,058	1,457	0,000*
	Microwave oven	0,219	0,069	1,245	0,002*
	Washing machine	0,215	0,155	1,240	0,165
	Dryer	0,187	0,234	1,206	0,423
	Air conditioning	0,342	0,052	1,409	0,000*
	Property ownership	0,035	0,050	1,035	0,484
	Household size	0,223	0,015	1,250	0,000*
	Housing type	-0,249	0,063	0,779	0,000*
	Natural gas	-0,068	0,073	0,523	0,000*
	Hot water	0,307	0,086	1,360	0,000*
	Rural or urban life	-0,210	0,065	0,810	0,001*
Category 4 against Category 1,2,3 (comparison 3)	Threshold 3	-4,279	0,324	---	---
	Real income	0,150	0,024	1,162	0,000*
	Housing size	0,041	0,034	1,042	0,226
	Heating system	0,234	0,039	1,264	0,000*
	Cable or satellite TV	0,263	0,106	1,384	0,013*
	Computer	0,184	0,057	1,202	0,001*
	LCD television	0,222	0,058	1,249	0,000*
	Refrigerator	0,488	0,239	1,629	0,042*
	Deep freeze	0,373	0,080	1,452	0,000*
	Dishwasher	0,314	0,080	1,369	0,000*
	Microwave oven	0,139	0,080	1,149	0,084
	Washing machine	0,218	0,220	1,243	0,323
	Dryer	0,452	0,217	1,572	0,038*
	Air conditioning	0,434	0,050	1,544	0,000*
	Property ownership	0,053	0,066	1,054	0,421
	Household size	0,183	0,018	1,200	0,000*
	Housing type	-0,359	0,082	0,698	0,000*
	Natural gas	-0,964	0,087	0,318	0,000*
	Hot water	0,254	0,121	1,289	0,037*
	Rural or urban life	-0,299	0,083	0,741	0,000*

*

This means that the β coefficients take different values for each category in the model and so, the odds ratios of the variables are changing for each categories. For example, the coefficient of real income variable takes different values (0,212; 0,198; 0,150) for each category of the dependent variable because parallel lines assumption is not met. The similar situation is also valid for other variables affecting the power consumption.

In non-POM, the effects of each independent variables on dependent variable are different for each categories. The effect on dependent variable of independent variable is expressed by when category 1 of dependent variable electricity consumption levels is compared with category 2, 3, and 4 of dependent variable electricity consumption levels based on logit. Similarly, the effect on dependent variable of independent variable is expressed by when category 1 and 2 of the dependent variable is compared with category 3 and 4 of dependent variable; and the effect on dependent variable of independent variable is expressed by when category 1, 2, and 3

of dependent variable is compared with category 4 of dependent variable. In this way, slopes (β coefficients) in the obtained ordered regression model are different from each other.
Odds ratios can be interpreted as follows because non-POM is significant:

Category 2, 3, and 4 against category 1: This comparison is to answer the question: "How Category 2, 3 and 4 increase or decrease the odds compared to category 1 due to change in the category of each independent variable." Two examples are given below for two independent variables affecting the consumption of electricity.
Computer: In terms of electricity consumption levels, the probability in a higher category instead of being in category 1 for a family with a computer is more than 1.767 times compared to a family without a computer.
Deep Freeze: In terms of electricity consumption levels, the probability in a higher category instead of being in category 1 for a family with a deep freeze is more than 1.897 times compared to a family without a deep freeze.

Category 3 and 4 against category 1 and 2: This comparison is to answer the question: "How Category 3 and 4 increase or decrease the odds compared to category 1 and 2 due to change in the category of each independent variable." Two examples are given below for two independent variables affecting the consumption of electricity.
Computer: In terms of electricity consumption levels, the probability in a higher category instead of being in category 1, and 2 for a family with a computer is more than 1.410 times compared to a family without a computer.
Deep Freeze: In terms of electricity consumption levels, the probability in a higher category instead of being in category 1 for a family with a deep freeze is more than 1.851 times compared to a family without a deep freeze.

Category 4 against category 1, 2, and 3: This comparison is to answer the question: "How Category 4 increase or decrease the odds compared to category 1, 2, and 3 due to change in the category of each independent variable." Two examples are given below for two independent variables affecting the consumption of electricity.
Computer: In terms of electricity consumption levels, the probability in a higher category instead of being in category 1 for a family with a computer is more than 1.202 times compared to a family without a computer.
Deep Freeze: In terms of electricity consumption levels, the probability in a higher category instead of being in category 1 for a family with a deep freeze is more than 1.452 times compared to a family without a deep freeze.

Table 4: The results of PPOM

Electricity consumption level	Variable	Coeff.	Std. Error	Odds Ratio	value
Category 2,3,4 against Category 1 (Comparison 1)	Threshold 1	-2,437	0,217	---	---
	Real income	0,189	0,016	1,208	0,000*
	Housing size	0,056	0,022	1,058	0,012*
	Heating system	0,246	0,029	1,279	0,000*
	Cable or satellite TV	0,253	0,103	1,288	0,014*
	Computer	0,568	0,064	1,766	0,000*
	LCD television	0,212	0,042	1,236	0,000*
	Refrigerator	0,746	0,175	2,108	0,000*
	Deep freeze	0,637	0,107	1,891	0,000*
	Dishwasher	0,615	0,069	1,850	0,000*
	Microwave oven	0,180	0,059	1,198	0,002*
	Washing machine	0,280	0,124	1,324	0,024*
	Dryer	0,279	0,191	1,322	0,144
	Air conditioning	0,204	0,075	1,227	0,007*
	Property ownership	0,042	0,043	1,043	0,325
	Household size	0,269	0,018	1,309	0,000*
	Housing type	-0,023	0,072	0,976	0,743
	Natural gas	-0,389	0,085	0,677	0,000*
	Hot water	0,298	0,072	1,348	0,000*
	Rural or urban life	-0,212	0,217	0,808	0,000*
Category 3,4 against Category 1,2 (Comparison 2)	Threshold 2	-3,628	0,218	---	---
	Real income	0,189	0,016	1,208	0,000*
	Housing size	0,056	0,022	1,058	0,012*
	Heating system	0,246	0,029	1,279	0,000*
	Cable or satellite TV	0,253	0,103	1,288	0,014*
	Computer	0,360	0,047	1,433	0,000*

	LCD television	0,212	0,042	1,236	0,000*
	Refrigerator	0,746	0,175	2,108	0,000*
	Deep freeze	0,617	0,071	1,853	0,000*
	Dishwasher	0,388	0,057	1,474	0,000*
	Microwave oven	0,180	0,059	1,198	0,002*
	Washing machine	0,280	0,124	1,324	0,024*
	Dryer	0,279	0,191	1,322	0,144
	Air conditioning	0,352	0,051	1,422	0,000*
	Property ownership	0,042	0,043	1,043	0,325
	Household size	0,222	0,015	1,249	0,000*
	Housing type	-0,239	0,061	0,786	0,000*
	Natural gas	-0,623	0,068	0,536	0,000*
	Hot water	0,298	0,072	1,348	0,000*
	Rural or urban life	-0,212	0,218	0,808	0,000*
Category 4 against Category 1,2,3 (Comparison 3)	Threshold 3	-4,777	0,229	---	---
	Real income	0,189	0,016	1,208	0,000*
	Housing size	0,056	0,022	1,058	0,012*
	Heating system	0,246	0,029	1,279	0,000*
	Cable or satellite TV	0,253	0,103	1,288	0,014*
	Computer	0,155	0,055	1,168	0,005*
	LCD television	0,212	0,042	1,236	0,000*
	Refrigerator	0,746	0,175	2,108	0,000*
	Deep freeze	0,364	0,079	1,440	0,000*
	Dishwasher	0,255	0,077	1,290	0,001*
	Microwave oven	0,180	0,059	1,198	0,002*
	Washing machine	0,280	0,124	1,324	0,323
	Dryer	0,279	0,191	1,322	0,144
	Air conditioning	0,412	0,047	1,510	0,000*
	Property ownership	0,042	0,043	1,043	0,325
	Household size	0,175	0,018	1,191	0,000*
	Housing type	-0,415	0,077	0,659	0,000*
	Natural gas	-0,999	0,082	0,368	0,000*
	Hot water	0,298	0,072	1,348	0,000*
	Rural or urban life	-0,212	0,217	0,808	0,000*

*

The partial proportional odds model (PPOM) that is one of the ordered logit models was applied to data set and the results in Table 6 have been reached. PPOM is used in cases where some of variables meet the parallel lines assumption but some of them do not meet the assumption. The main objective of this model is to minimize the number of variables by assigning a common coefficient or odds.

In PPOM, variables were tested at 5% significance level by putting constraints to variables in order to decide whether the variables meet the parallel line assumption or not. It has been reached to the conclusion that these constraints, which is placed to meet the assumption for each variable, did not meet the parallel lines assumption at 5% significance level for computer, deep freeze, dishwasher, air conditioning, household size, type of housing and natural gas variables It has been concluded that the variables meet the parallel lines assumption (=25,14; and obtained PPOM is also significant =2558,15; when Brant Wald test is applied for other variables except for variables that meet parallel lines assumption.

When referring table 4, it can be seen that the coefficients do not differ according to the dependent variable categories and they meet parallel lines assumption for real income, housing size, heating system, cable/satellite TV, LCD TV, refrigerator, microwave oven, washing machine, dryer, property ownership, hot water, rural-urban life variables.

CPPOM that is one of the ordered logit models was applied to data set and the results in Table 5 have been reached. In this model, it was tested at 5% significance level that whether the parallel lines assumption is met by putting constraints on all variables. After constraints were put on variables in order to ensure the parallel lines assumption for each variable, it could be concluded that parallel lines assumption was met for each variables and obtained CPPOM is significant (=2269,90;). Thus, the assumption was met by obtaining a single parameter instead of a separate parameter in each category for all variables.

Table 5: The results of CPPOM

Electricity consumption level	Variable	Coeff.	Std. Error	Odds Ratio	value
Category 2,3,4 against Category 1 (Comparison 1)	Threshold 1	-2,177	0,213	---	---
	Real income	0,193	0,016	1,212	0,000*
	Housing size	0,054	0,022	1,055	0,001*
	Heating system	0,256	0,029	1,292	0,000*
	Cable or satellite TV	0,206	0,099	1,228	0,039*
	Computer	0,320	0,040	1,377	0,000*
	LCD television	0,186	0,041	1,205	0,000*
	Refrigerator	0,764	0,176	2,148	0,000*
	Deep freeze	0,517	0,059	1,677	0,000*
	Dishwasher	0,441	0,050	1,554	0,000*
	Microwave oven	0,156	0,057	1,169	0,007*
	Washing machine	0,364	0,126	1,440	0,004*
	Dryer	0,172	0,184	1,187	0,350
	Air conditioning	0,363	0,041	1,438	0,000*
	Property ownership	0,028	0,042	1,028	0,511
	Household size	0,231	0,013	1,260	0,000*
	Housing type	-0,185	0,053	0,830	0,001*
	Natural gas	-0,649	0,060	0,522	0,000*
	Hot water	0,382	0,073	1,466	0,000*
	Rural or urban life	-0,221	0,056	0,801	0,000*
Category 3,4 against Category 1,2 (Comparison 2)	Threshold 2	-3,883	0,216	---	---
	Real income	0,193	0,016	1,212	0,000*
	Housing size	0,054	0,022	1,055	0,001*
	Heating system	0,256	0,029	1,292	0,000*
	Cable or satellite TV	0,206	0,099	1,228	0,039*
	Computer	0,320	0,040	1,377	0,000*
	LCD television	0,186	0,041	1,205	0,000*
	Refrigerator	0,764	0,176	2,148	0,000*
	Deep freeze	0,517	0,059	1,677	0,000*
	Dishwasher	0,441	0,050	1,554	0,000*
	Microwave oven	0,156	0,057	1,169	0,007*
	Washing machine	0,364	0,126	1,440	0,004*
	Dryer	0,172	0,184	1,187	0,350
	Air conditioning	0,363	0,041	1,438	0,000*
	Property ownership	0,028	0,042	1,028	0,511
	Household size	0,231	0,013	1,260	0,000*
	Housing type	-0,185	0,053	0,830	0,001*
	Natural gas	-0,649	0,060	0,522	0,000*
	Hot water	0,382	0,073	1,466	0,000*
	Rural or urban life	-0,221	0,056	0,801	0,000*
Category 4 against Category 1,2,3 (Comparison 3)	Threshold 3	-5,690	0,220	---	---
	Real income	0,193	0,016	1,212	0,000*
	Housing size	0,054	0,022	1,055	0,001*
	Heating system	0,256	0,029	1,292	0,000*
	Cable or satellite TV	0,206	0,099	1,228	0,039*
	Computer	0,320	0,040	1,377	0,000*
	LCD television	0,186	0,041	1,205	0,000*
	Refrigerator	0,764	0,176	2,148	0,000*
	Deep freeze	0,517	0,059	1,677	0,000*
	Dishwasher	0,441	0,050	1,554	0,000*
	Microwave oven	0,156	0,057	1,169	0,007*
	Washing machine	0,364	0,126	1,440	0,004*
	Dryer	0,172	0,184	1,187	0,350
	Air conditioning	0,363	0,041	1,438	0,000*

	Property ownership	0,028	0,042	1,028	0,511
	Household size	0,231	0,013	1,260	0,000*
	Housing type	-0,185	0,053	0,830	0,001*
	Natural gas	-0,649	0,060	0,522	0,000*
	Hot water	0,382	0,073	1,466	0,000*
	Rural or urban life	-0,221	0,056	0,801	0,000*

*

The unconstrained partial proportional odds model (UPPOM) that is one of the ordered logit models was applied to data set and the results in Table 6 have been reached. UPPOM is a model is that loosens the parallel lines assumption. However, an undesirable feature of this model is that it forms many coefficients for the variables. When looking at the coefficient values in Table 11, it can be seen that coefficients of variables are different for each category. In addition, UPPOM is significant at 5% significance level (=2269,9; .

Table 6: The results of UPPOM

Electricity Consumption Level	Variable	Coeff.	Std. Error	Odds Ratio	value
Category 2,3,4 against Category 1 (Comparison 1)	Threshold 1	-2,732	0,276	---	---
	Real Income	0,212	0,024	1,236	0,000*
	Housing Size	0,090	0,032	1,094	0,006*
	Heating System	0,258	0,050	1,295	0,000*
	Cable or Satellite TV	0,673	0,189	1,069	0,722
	Computer	0,569	0,066	1,767	0,000*
	LCD Television	0,118	0,069	1,125	0,088
	Refrigerator	0,903	0,241	2,467	0,000*
	Deep Freeze	0,640	0,107	1,897	0,000*
	Dishwasher	0,599	0,071	1,820	0,000*
	Microwave Oven	0,147	0,106	1,158	0,166
	Washing Machine	0,309	0,138	1,362	0,025*
	Dryer	-0,284	0,352	0,752	0,419
	Air Conditioning	0,207	0,078	1,230	0,008*
	Property Ownership	0,039	0,062	1,040	0,525
	Household Size	0,262	0,019	1,299	0,000*
	Housing Type	-0,046	0,075	0,954	0,0541
	Natural Gas	-0,041	0,100	0,659	0,000*
	Hot Water	0,286	0,085	1,332	0,001*
	Rural or Urban Life	-0,153	0,075	0,857	0,041*
Category 3,4 against Category 1,2 (Comparison 2)	Threshold 2	-3,739	0,281	---	---
	Real Income	0,198	0,018	1,220	0,000*
	Housing Size	0,044	0,026	1,045	0,088
	Heating System	0,255	0,036	1,291	0,000*
	Cable or Satellite TV	0,263	0,106	1,288	0,013*
	Computer	0,344	0,048	1,410	0,000*
	LCD Television	0,246	0,049	1,279	0,000*
	Refrigerator	0,909	0,238	2,482	0,000*
	Deep Freeze	0,616	0,071	1,851	0,000*
	Dishwasher	0,376	0,058	1,457	0,000*
	Microwave Oven	0,219	0,069	1,245	0,002*
	Washing Machine	0,215	0,155	1,240	0,165
	Dryer	0,187	0,234	1,206	0,423
	Air Conditioning	0,342	0,052	1,409	0,000*
	Property Ownership	0,035	0,050	1,035	0,484
	Household Size	0,223	0,015	1,250	0,000*
	Housing Type	-0,249	0,063	0,779	0,000*
	Natural Gas	-0,068	0,073	0,523	0,000*
	Hot Water	0,307	0,086	1,360	0,000*
	Rural or Urban Life	-0,210	0,065	0,810	0,001*
Category 4 against	Threshold 3	-4,279	0,324	---	---

Category 1,2,3 (Comparison 3)	Real Income	0,150	0,024	1,162	0,000*
	Housing Size	0,041	0,034	1,042	0,226
	Heating System	0,234	0,039	1,264	0,000*
	Cable or Satellite TV	0,263	0,106	1,384	0,013*
	Computer	0,184	0,057	1,202	0,001*
	LCD Television	0,222	0,058	1,249	0,000*
	Refrigerator	0,488	0,239	1,629	0,042*
	Deep Freeze	0,373	0,080	1,452	0,000*
	Dishwasher	0,314	0,080	1,369	0,000*
	Microwave Oven	0,139	0,080	1,149	0,084
	Washing Machine	0,218	0,220	1,243	0,323
	Dryer	0,452	0,217	1,572	0,038*
	Air Conditioning	0,434	0,050	1,544	0,000*
	Property Ownership	0,053	0,066	1,054	0,421
	Household Size	0,183	0,018	1,200	0,000*
	Housing Type	-0,359	0,082	0,698	0,000*
	Natural Gas	-0,964	0,087	0,318	0,000*
	Hot Water	0,254	0,121	1,289	0,037*
	Rural or Urban Life	-0,299	0,083	0,741	0,000*

*

IV. Conclusions

In this paper, factors affecting household electricity consumption were tried to determine by POM, Non-POM (GOLOGIT), PPOM, CPPOM, and UPPOM logit models. For this purpose, these models were compared with some goodness of fit indicators. Although POM, Non-POM and PPOM are statistically significant, POM failed to provide the parallel lines assumption that is required to use this model (Therefore, the cumulative odds that are calculated for electricity consumption level are different in each category. In this respect, odds ratios given in Table 2 do not reflect the real situation in the dataset due to the violation of the assumption of parallel lines.

In Non-POM, odds estimates that reflect the actual state of the data could be obtained for all three categories because cumulated odds calculated without the assumption of parallel lines. On the contrary, it was tested whether or not variables violate the parallel lines assumption putting constraints to variables in PPOM. The findings in this model showed that parallel lines assumption did not meet at significance level of 5% for computer, freezer, dishwasher, air conditioning, household size, type of housing and natural gas variables but met for other variables

On the other hand, CPPOM and UPPOM were built for PPOM. CPPOM is being used to achieve a common coefficient and to meet the assumption of parallel lines putting constraints for all independent variables in PPOM in the case of a violation of parallel lines assumption. According to the findings, both CPPOM and UPPOM are significant at level of 5% It can be seen from table 5 that all the odds ratios for variables in comparison 1, 2 and 3 are equal, when CPPOM is applied. For instance, the odds ratio of real income is 1,212 for comparison 1, 2 and 3. A similar situation is also valid for other variables. When CPPOM is applied, a single parameter can be obtained instead of obtaining separate parameters for variables in each category. Thus, CPPOM turned into POM. In this context, it can be seen from Table 2 and Table 5 that the odds ratios obtained for the variables from POM and CPPOM are equal.Different odds ratios are obtained for each variables in comparison 1, 2 and 3 when UPPOM is applied (table 6). For instance, the odds ratio of real income is 1,236 in comparison 1, is 1,220 in comparison 2, and is 1,162 in comparison 3. A similar situation is also valid for other variables. Referred to Table 3 and Table 6, it can be seen that the odds ratio coefficients in each category for non-POM and UPPOM are equal. Thus, UPPOM turned into non-POM.Ordered logit models were compared in terms of goodness of fit indicators and the results in Table 7 was reached.

Table 7: Comparison of ordered logit models by goodness of fit indicators

Goodness of Fit Indicator	Model				
	POM	Non-POM	PPOM	CPPOM	UPPOM
Mac Fadden	0,096	0,109	0,108	0,096	0,109
Deviation Measure	21225,2	20912,9	20936,9	21225,2	20912,9
AIC	21269,2	21033,0	21008,9	21269,2	21033,0
BIC	21424,7	21457,1	21263,4	21424,7	21457,1

Within the framework of the goodness of fit indicators, the most appropriate model between alternative models for the data set is the model that has the highest Pseudo value and the lowest Deviance Measure, AIC and BIC values. When compared POM and Non-POM according to the goodness of fit indicators in table 7, it is seen that non-POM provides a better fit to the data set (except for BIC value). These findings indicate that non-POM is more appropriate model than POM when POM does not meet parallel line assumption.

When compared POM and PPOM according to the goodness of fit indicators in table 7, it is seen that PPOM provides a better fit to the data set. These findings indicate that PPOM is more appropriate model than POM when POM does not meet parallel line assumption.

When compared non-POM and PPOM according to the goodness of fit indicators in table 7, it is seen that, Mac Fadden value as Pseudo is almost the same; non-POM is a more appropriate model according to indicator of Deviation Measure and PPOM is a more appropriate model according to indicators of AIC and BIC. On the other hand, it can be said that PPOM is a more appropriate model to the data set than non-POM. Because variables that provide parallelism in PPOM are represented by common odds coefficients (by a smaller number of variables) and so PPOM can be more easily interpreted as statistically according to non-POM. In addition, goodness of fit indicators (table 7) indicates that POM and CPPOM have the same goodness of fit values and conversely non-POM and UPPOM have the same goodness of fit values. These results support that odd ratios obtained for models are equal.

As a result, this paper shows that PPOM exhibits a better fit to the data set than POM and non-POM when parallel lines assumption is not met. Besides, according to the results obtained from the analyzed models, the type and amount of the household electric appliances, household size, household income, housing type, and ownership of LCD TV are important factors that increase the household's electricity consumption.

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