

The Effect of the Energy Price Increase on the Energy Poverty in Korea

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Abstract

The energy poverty in Korea has been generally increasing regardless of the oil price fluctuations, but there were almost no fluctuations in the ratios from 2011 to 2013. Several implications emerge from the empirical findings. First, social minorities, like the elderly, the handicapped, and single-parent families, as well as low-income families are more vulnerable to energy poverty. This is supported by the logit regression results. Second, one of the causes of low-income households falling into energy poverty may be that they cannot afford energy-efficient electronic appliances. The energy poverty ratio can be alleviated by energy welfare programs; thus, government intervention is required.

Keywords: Determinants of Energy Poverty, Energy Poverty, Logit Regression, Oil Price Hike

1. Introduction

In July 2007, the world experienced a drastic increase in the oil price, which continued until mid-2008 and had a significant influence on the economy (Figure 1). However, the price dropped sharply at the beginning of 2009 and, after that, showed a moderate increase. Once again, the oil price began to increase in early 2011 and stayed at the record level of 2008 until the end of 2014.

These kinds of oil price hikes inevitably have a negative effect on households' standard of living. Significantly, they rarely hurt high-income households, while they affect low-income households severely. In particular, low-income households cannot afford adequate home heating during the winter and thus are likely to be subject to health risks.

Now, we focus on how many households suffer due to the oil price hikes. In this context, we apply our interest to the concept of energy poverty. An energy-poor household is defined as one that spends more than 10% of its income on basic energy needs, such as heating, cooking, and lighting⁶. Therefore, our study examines the change in the percentage of households in energy poverty from

2006 to 2013, using the "Household Survey" of 2006–2013 released by Statistics Korea.

The paper is structured as follows. Section 2 explains the data to be used in our study, that is, the Household Survey. Section 3 introduces the concept of energy poverty and its trends. In addition, the analytic results by household characteristics are discussed with reference to several tables. Section 4 illustrates the factors that affect energy-poor households with the logit regression model. Finally, section 5 summarizes the empirical findings and suggests several implications.

2. Data to be Used

This work uses the Household Survey of 2006 through 2013 released by Statistics Korea. The survey was conducted among households residing in sixty-nine cities (excluded the households of farmers and fishermen), including one-person households.¹ The survey participants kept a household budget and expenditure diary, provided by Statistics Korea, every month.

First, the survey includes the following household information: the household types, number of household

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Figure 1. Trends of the Monthly Dubai Oil Price (2004–2014) (Unit: US Dollars).

Source: IMF Cross Country Macroeconomic Statistics.

members, number of income earners, marital status, yearly income, income sources, housing type, and number of vehicles owned. The personal information on the household members consists of their sex, age, education level, and labor status, such as their employment, occupation, and industry.

Secondly, the survey contains information on the following ten expenditure segments: food and beverages, housing, utilities, furniture and utensils, footwear and apparel, medical care, education, culture and recreation, transportation and telecommunication, and others. We obtain the energy expenditure by subtracting water expenses from utility expenditures, since the utility expenditures in the survey are the sum of water expenses and energy expenditures.

3. The Concept of Energy Poverty, its Trends and Analytic Results

3.1 Concept

The term “energy poverty” was first introduced in the United Kingdom by Boardman¹, as mentioned above. He defines energy poverty as a household that spends more than 10% of its income on the total fuel used to heat the house to an adequate temperature.² For reference, the World Health Organization (DTI/DEFRA, 2001) recommends that an adequate temperature should be considered as 21 °C in the main living room and 18 °C in other rooms during daytime hours (with lower temperatures at night).

An energy-poor household is defined as one that spends more than 10% of its income on basic energy

needs, such as heating, cooking, and lighting. Actually, this differs from the definition used in the UK in that the UK considers an adequate temperature in the house.³ It is known that our definition has the weakness of not considering low-income households as non-energy-poor households that cut back on their energy expenditure ratio while maintaining sufficient warming and it can underestimate the number of energy-poor households. However, this work uses a definition in accordance with this concept since the Korean Household Survey provides only the energy expenditures actually spent by a household.

3.2 Trends of Energy Poverty in Korea in 2006–2013

Table 1 shows the trends of the energy poverty ratios during the period from 2006 to 2013. It reports that the energy poverty has been increasing regardless of the oil price fluctuations since 2007, the ratio of which dropped a little lower than the previous year. Though the price in the second half of 2008 fell, the ratio on an annual basis rose higher than in 2007. After that, the energy poverty ratio increased to 11.3% in 2010 by 1%p more or less. There were almost no fluctuations in the ratios from 2011 to 2013.

3.3 Analytic Results of Energy Poverty by Household Characteristics

We discuss the energy poverty trends by diverse household characteristics, such as the income decile, the age groups, the education levels, and the number of household members.

Let us begin with the income decile, especially the four lowest decile, which are considered to be poor

Table 1. Trends of the energy poverty ratio in Korea

Year	2006	2007	2008	2009	2010	2011	2012	2013
Energy Poverty Ratio (%)	9.5	8.2	9.0	10.2	11.3	11.6	12.3	12.5
Disparity (%)	-	-1.3	0.8	1.2	1.1	0.3	0.7	0.2

¹The ratio of one-person households to total households was surveyed as 12.5% in 1995 and 23.89% in 2010 by the Population Census in Korea.

²Note that this definition does not take account the amount that a household actually spends on fuel for heating.

³The sharp rise in fuel prices between 2007 and 2008 doubled the number of energy-poor families in the UK. A study showed that the percentage of energy-poor families increased by 0.05% as energy prices rose by 1% (City of Liverpool, 2007).

households. Better information is obtained by examining energy poverty by income decile (see Table 2).

The percentage of energy-poor households for the first decile increased from 51.3% in 2006 to 66.6% in 2013. The percentage for the second decile climbed from 19.1% in 2006 to 30.5% in 2013, showing the steepest rise among the ten income decile. The third decile observed an increase from 8.5% to 12.3% and the fourth income decile increased from 3.2% to 5.3% during the same period. In contrast, the percentage of energy-poor households in the higher income decile, except for the highest decile, decreased or remained stable. This implies that the energy price increases hurt low-income households; thus, many of them fell into energy poverty as anticipated.

Next, we investigate how the energy poverty from 2006 to 2013 changed for the household head age groups and the number of household members. Table 3 shows how the age of the household head is related to the increase in energy poverty. The energy poverty percentage increased from 26.5% in 2006 to 39.3% in 2013 for those over 70 years old and from 7.5% in 2006 to 8.1% in 2013 for those below 29 years old. However, the energy poverty percentage decreased for the other age groups. These results tell

Table 2. Energy poverty ratio by income decile in Korea (Unit: %)

Decile	2006	2007	2008	2009	2010	2011	2012	2013
Decile 1	51.3	48.4	53.9	63.1	66.7	66.5	68.3	66.6
Decile 2	19.1	18.3	22.5	24.0	31.4	29.1	31.7	30.5
Decile 3	8.5	6.1	8.4	10.8	11.9	10.6	11.2	12.3
Decile 4	3.2	1.9	3.5	4.4	3.7	4.4	5.3	5.3
Decile 5	2.0	0.8	1.6	1.6	2.0	2.0	1.3	1.6
Decile 6	0.7	0.3	0.6	0.5	0.6	0.7	0.5	1.4
Decile 7	0.4	0.6	0.2	0.3	0.7	0.4	0.3	0.2
Decile 8	0.3	0.1	0.2	0.4	0.4	0.2	0.2	0.3
Decile 9	-	-	-	-	-	-	-	-
Decile 10	-	-	-	-	-	-	-	-

Table 3. Energy poverty ratio by age group (Unit: %)

Age	2006	2007	2008	2009	2010	2011	2012	2013
-29	7.5	5.5	6.5	7.2	11.2	9.4	10.1	8.1
30-39	5.3	3.0	3.5	4.1	4.8	4.3	4.5	4.2
40-49	5.2	4.5	4.4	5.4	5.4	4.8	4.4	4.3
50-59	8.3	6.8	7.2	8.0	8.2	8.8	7.0	7.2
60-69	20.0	15.5	17.9	16.8	20.0	20.1	19.2	19.6
70	26.5	27	28.7	35.8	35.7	36.4	41.2	39.3

us that the income is relatively low for the households with the youngest and oldest heads.

In addition, a large increase in energy poverty for households with one, two, six, and seven or more family members was observed. The energy poverty percentage for one-person households increased from 19.3% in 2006 to 28.7% in 2013 (see Table 4). Furthermore, the energy poverty ratio for two-person, six-person, and seven-person and more households increased from 14.0%, 4.5%, and 10.8% in 2006 to 18.0%, 6.8%, and 12.5% in 2013, respectively. This implies that many old people live alone or with a spouse and then the energy poverty percentage by age coincides with the energy poverty ratio by the number of household members. Our study reports that the energy price hikes severely affected single- or two-person elderly households.

Now we discuss the results regarding the education level. Table 5 shows that those who graduated from

Table 4. Energy poverty ratio by the number of household members (Unit: %)

	2006	2007	2008	2009	2010	2011	2012	2013
1 person	19.3	17.4	18.6	22.5	26.7	26.8	28.1	28.7
2 persons	14.0	12.9	14.6	16.4	16.6	17.1	18.6	18.0
3 persons	6.7	5.0	5.3	6.1	6.8	6.8	6.1	5.7
4 persons	3.5	2.4	3.0	3.6	4.1	3.3	2.9	3.3
5 persons	5.0	3.0	2.4	2.2	2.5	4.2	4.9	2.2
6 persons	4.5	4.2	5.0	1.7	4.5	3.8	3.5	6.8
Over 7 persons	10.8	8.3	3.2	7.9	5.9	8.0	10.0	12.5

Table 5. Energy poverty ratio by the education level (Unit: %)

Education Level	2006	2007	2008	2009	2010	2011	2012	2013
Graduated from elementary school	21.2	20.8	22.0	25.2	28.1	30.8	32.1	33.0
Graduated from middle school	11.5	10.0	12.1	13.6	14.7	14.3	16.6	17.9
Graduated from high school	7.5	5.4	6.4	7.7	8.7	9.2	9.3	9.4
Graduated from college	3.8	2.7	3.8	3.7	4.7	2.6	4.2	3.3
Graduated from university	4.4	3.7	3.8	4.6	4.3	3.8	4.4	3.9

elementary school experienced a large increase in energy poverty from 21.2% in 2006 to 33.0% in 2013, a rise of 11.8%p. In addition, those who graduated from middle school and high school experienced the energy poverty ratio increasing from 11.5% in 2006 to 17.9% in 2013, by 6.4%p, and 7.5% to 9.4%, by 1.9%p, respectively. On the other hand, the other two groups dropped by 0.5%p altogether for the energy poverty ratio. These results report that the lower the education level, the severer the problems the households faced as a result of the energy price hikes.

Now we compare the income and expenditure trends between the energy-poor and the non-energy-poor households (Table 6). The households in the lowest income decile, the second decile, and the third decile of the energy poor always experience a deficit, because their expenditure exceeds their current income. The fourth decile has shown a surplus since 2008. However, non-energy-poor families are not always in deficit for the periods analyzed. These results partly support the analytic results in Table 3.

Table 6. Income and expenditure of energy-poor households by decile and year (Unit: 10 Thousand Korean Won/Month, %)

Income Decile		2006			2007			2008			2009		
		A	B	C	A	B	C	A	B	C	A	B	C
D1	Energy poverty	28	75	24.66	29	80	24.22	31	81	23.50	28	73	25.33
	Non-energy poverty	45	48	5.60	44	46	5.49	45	49	5.76	42	43	5.78
	Subtotal	36	62	13.17	37	63	12.64	37	66	13.57	33	62	16.24
D2	Energy poverty	84	106	14.72	86	120	14.00	83	111	14.66	82	108	15.14
	Non-energy poverty	88	84	5.11	89	83	5.07	89	82	5.16	85	80	5.36
	Subtotal	87	89	6.87	88	90	6.66	87	89	7.20	84	87	7.63
D3	Energy poverty	129	140	13.16	132	145	13.05	131	146	14.24	133	139	13.44
	Non-energy poverty	132	112	4.58	135	117	4.54	136	118	4.74	135	117	4.90
	Subtotal	132	114	5.29	135	118	5.05	135	121	5.52	135	120	5.81
D4	Energy poverty	168	168	12.83	182	190	12.56	182	164	12.94	184	162	12.74
	Non-energy poverty	172	139	4.12	179	144	3.95	183	147	4.14	185	147	4.32
	Subtotal	172	140	4.40	179	144	4.11	183	148	4.44	185	148	4.68
D5	Energy poverty	209	187	11.85	219	200	12.05	220	220	13.03	230	206	12.62
	Non-energy poverty	211	161	3.79	221	168	3.59	226	173	3.67	232	173	3.73
	Subtotal	211	162	3.95	221	169	3.66	226	173	3.82	232	174	3.87
D6	Energy poverty	249	214	11.92	272	475	13.29	267	291	16.42	280	210	14.27
	Non-energy poverty	253	178	3.40	264	184	3.21	272	192	3.34	280	191	3.41
	Subtotal	253	178	3.45	264	185	3.24	272	193	3.42	280	191	3.47
D7	Energy poverty	294	376	11.88	312	229	10.95	309	242	10.71	334	262	10.56
	Non-energy poverty	300	205	3.11	312	212	2.95	323	216	3.00	333	220	3.09
	Subtotal	300	206	3.15	312	212	2.99	323	216	3.01	333	220	3.11
D8	Energy poverty	340	234	10.76	343	189	10.23	399	426	12.95	395	242	12.44
	Non-energy poverty	358	227	2.79	372	233	2.54	386	241	2.65	396	250	2.66
	Subtotal	358	227	2.81	372	233	2.55	386	241	2.67	396	250	2.70
D9	Energy poverty	-	-	-	-	-	-	-	-	-	-	-	-
	Non-energy poverty	434	255	2.40	456	273	2.23	478	276	2.24	482	281	2.28
	Subtotal	434	255	2.40	456	273	2.23	478	276	2.24	482	282	2.30
D10	Energy poverty	-	-	-	-	-	-	-	-	-	-	-	-
	Non-energy poverty	643	326	1.84	684	331	1.65	722	344	1.69	722	352	1.72
	Subtotal	643	326	1.84	684	331	1.65	722	344	1.69	722	352	1.72

Note: A - current income, B - total expenditure, C - proportion of fuel for the house of the current income.

Table 6. Income and expenditure of energy-poor households by decile and year (continued) (Unit: 10 Thousand Korean Won/Month, %)

Income Decile		2010			2011			2012			2013		
		A	B	C	A	B	C	A	B	C	A	B	C
D1	Energy poverty	29	78	28.06	31	82	29.18	35	78	26.43	33	78	27.57
	Non-energy poverty	42	45	5.43	45	52	5.80	47	51	5.47	48	49	5.50
	Subtotal	33	67	18.52	36	72	19.30	39	69	18.32	38	68	18.31
D2	Energy poverty	87	111	15.43	92	115	15.91	95	128	15.32	93	117	15.50
	Non-energy poverty	91	86	5.58	97	91	5.44	102	92	5.49	103	90	5.45
	Subtotal	90	94	8.58	95	98	8.37	100	104	8.47	100	98	8.30
D3	Energy poverty	139	153	13.57	150	160	13.33	159	173	13.97	160	151	13.25
	Non-energy poverty	145	123	4.99	156	130	4.86	162	135	5.07	166	134	4.92
	Subtotal	144	127	5.97	155	133	5.73	161	139	6.05	165	136	5.91
D4	Energy poverty	199	188	12.61	211	199	12.96	217	215	13.56	226	210	13.24
	Non-energy poverty	200	158	4.46	211	165	4.39	223	165	4.42	230	171	4.32
	Subtotal	200	159	4.76	211	166	4.76	223	168	4.89	230	173	4.78
D5	Energy poverty	248	195	13.79	265	241	13.05	279	234	11.93	283	342	12.86
	Non-energy poverty	251	182	3.92	267	196	3.92	281	201	3.89	290	203	3.87
	Subtotal	250	182	4.12	267	197	4.10	281	202	4.00	290	205	4.01
D6	Energy poverty	300	226	12.07	312	240	13.94	332	263	12.27	336	290	12.79
	Non-energy poverty	300	210	3.65	318	227	3.62	336	226	3.60	343	220	3.48
	Subtotal	300	210	3.70	318	227	3.69	336	226	3.64	343	221	3.60
D7	Energy poverty	349	335	11.69	372	286	12.78	407	182	11.39	383	233	10.49
	Non-energy poverty	352	230	3.21	374	243	3.21	395	257	3.16	404	254	3.09
	Subtotal	352	231	3.27	374	243	3.25	395	256	3.18	404	253	3.10
D8	Energy poverty	416	277	11.54	459	222	14.00	458	234	11.28	464	207	12.49
	Non-energy poverty	419	259	2.83	441	281	2.78	468	282	2.71	478	289	2.74
	Subtotal	419	259	2.87	441	281	2.81	468	282	2.73	478	288	2.77
D9	Energy poverty	-	-	-	526	614	14.49	-	-	-	-	-	-
	Non-energy poverty	510	296	2.48	537	306	2.41	573	313	2.36	585	311	2.42
	Subtotal	510	296	2.48	537	306	2.42	573	313	2.36	585	311	2.42
D10	Energy poverty	716	476	14.97	-	-	-	-	-	-	-	-	-
	Non-energy poverty	755	365	1.89	811	385	1.74	846	390	1.78	872	404	1.78
	Subtotal	754	365	1.92	811	385	1.74	846	390	1.78	872	404	1.78

Note: A - current income, B - total expenditure, C - proportion of fuel for the house of the current income.

Lastly, we discuss the causes of the energy poverty in Korea. First, the energy expenditures are quite large relative to the income during the sharp increase in the oil price for low-income households. The energy expenditure ratio, which is the ratio of energy expenditure to income, increases as the energy prices rise and it results in a greater possibility of facing energy poverty. The energy consumption is generally moving rigidly downward even with a

high energy price, because an increase in the energy prices causes the energy expenditures to increase and energy poverty becomes more prevalent. Second, insufficient access to cheap energy sources leads to energy poverty. Therefore, it occurs primarily in places where low-income households live. According to the Fuel Poverty Strategy in the UK (2001), a household that does not use LNG fuel spends 40% more than one that does use LNG.

4. Empirical Results from the Logit Regression

Now we examine the factors that affect energy poverty. We use the following logit regression model:

$$y_i^* = \beta_0 + \sum_{j=1}^k \beta_j x_{ij} + u_i \quad (1)$$

where y_i^* is the unobservable latent variable and x_{ij} are dependent variables that affect energy poverty. As we know, the logit regression or the logit model is a type of probabilistic statistical classification model. It is also used to predict a binary response from a binary predictor, for forecasting

the consequence of a categorical dependent variable based on one or more predictor variables. Generally, the logistic regression is used to refer specifically to a problem in which the dependent variable is binary.

In our paper, we use the following independent variables: the age of the household head, the number of households, the number of employees in the family, a dummy for an apartment, and a dummy for income poverty. The dependent variable is a dummy for energy poverty. In other words, the dummy variable is equal to “1” if the household falls into the energy poverty category and “0” otherwise.

We analyze the summary statistics before discussing the empirical findings (Table 7). The age of the household head is about 48 years and increases by 1 year up to 52.2 in 2013. The number of household members is 2.9, showing that a standard household may be a 3-person family. Additionally, the number of employees is approximately 1.2. The ratio of an apartment house type is 45.1% in 2006 but increases year by year. Lastly, the poverty ratio based on the income is 11.8% and increases immediately after the global financial crisis; it can be said that the ratio increases generally even though there are fluctuations year by year.

Now we examine the empirical results of the logit regression (Table 8). First, two variables, the head of the household's age and a poor household due to a lower

Table 7. Summary Statistics

Year	Energy Poverty Ratio (%)	Head Age (years)	Number of Household Members	Number of Employees	Dummy for Apartment (apartment = 1)	Absolute Income Poverty Ratio (%)
2006	9.5	47.9	2.90	1.24	0.451	11.8
2007	8.2	48.7	2.86	1.23	0.449	11.4
2008	9.0	48.8	2.87	1.23	0.474	11.6
2009	10.2	49.2	2.89	1.30	0.474	13.0
2010	11.3	49.8	2.89	1.31	0.473	12.5
2011	11.6	50.5	2.85	1.29	0.491	13.1
2012	12.3	51.3	2.80	1.27	0.499	13.0
2013	12.5	52.2	2.75	1.26	0.494	13.8

Table 8. Logit regression results

Variables	2006	2007	2008	2009	2010	2011	2012	2013
Head age	0.004 (1.568)	0.006** (1.965)	0.006** (2.117)	0.009*** (3.028)	0.009*** (3.199)	0.010*** (3.485)	0.013*** (4.449)	0.016*** (5.136)
Number of household members	-0.104*** (-2.969)	-0.104** (-2.474)	-0.162*** (-3.848)	-0.153*** (-3.758)	-0.155*** (-3.881)	-0.119*** (-2.970)	-0.134*** (-3.199)	-0.097** (-2.253)
Number of employees	-0.774*** (-11.745)	-0.912*** (-11.425)	-0.729*** (-9.685)	-0.703*** (-10.481)	-0.774*** (-12.052)	-0.747*** (-11.430)	-0.823*** (-12.351)	-0.830*** (-12.351)
Dummy for apartment	-0.216*** (-2.691)	-0.313*** (-3.297)	-0.272*** (-3.022)	-0.341*** (-3.914)	-0.431*** (-5.136)	-0.646*** (-7.708)	-0.444*** (-5.297)	-0.562*** (-6.644)
Dummy for income poverty	2.696*** (32.822)	2.643*** (28.189)	2.846*** (30.871)	2.825*** (31.817)	2.669*** (30.786)	2.682*** (30.891)	2.710*** (30.990)	2.541*** (28.961)
Constant	-2.209*** (-11.787)	-2.409*** (-10.921)	-2.377*** (-10.869)	-2.372*** (-10.949)	-2.033*** (-9.533)	-2.144*** (-9.825)	-2.257*** (-9.636)	-2.419*** (-10.151)
Log likelihood	-2607.955	-2017.085	-2108.830	-2224.330	-2360.735	-2373.834	-2317.518	-2295.627
χ^2	2608.822	2241.448	2449.689	2743.273	2790.025	2940.763	3108.131	2983.675
Observations	12458	11040	11012	10881	10667	10721	10401	10046

income, have a positive impact on the probability of falling into energy poverty with statistical significance for all the periods analyzed. In contrast, the number of household members, the numbers of employees in the household, and those who live in the apartment decrease the probability of facing energy poverty. These almost conform to the analytic findings regarding household characteristics in Tables 2–4 and Table 6.

5. Summary and Concluding Remarks

We examined how the percentage of households that sank into energy poverty changed from 2006 to 2013 with the “Household Survey” of 2006–2013. Several additional points should be noted from the empirical findings. First, the above-mentioned analytic findings highlight that social minorities, such as the elderly, the handicapped, and single-parent families, including low-income families, are more vulnerable to energy poverty. Second, energy poverty is blamed on energy-inefficient home appliances. The low level of energy efficiency of all the devices in the house may be caused by excessive energy consumption, obsolete boiling systems, and inadequate insulation. In fact, the prices of energy-efficient electronic appliances are generally higher than those of energy-inefficient ones. This means that low-income households cannot afford them. Third, a household with limited access to information about energy welfare programs is less likely to pull itself out of an energy-poor situation. Fourth, both the head age and the income-poor household have a positive impact,

but the number of household members, the number of the employees in the household, and those who live in the apartment decrease the probability of facing energy poverty.

In this context, the energy poverty ratio can be alleviated by energy welfare programs; thus, government intervention is required.

6. Acknowledgement

This work was supported by the research grant of Chungbuk National University in 2013. Also, this work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2014S1A3A2044456).

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