5C-2

How Climate Change Affects Household Electricity Consumption in Taiwan

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1. Introduction

- Electricity has always been regarded as one of the important energy sources affecting national economic development and national security.
- After the Fukushima disaster in 2011, Taiwan introduced the "New Energy Policy" to ensure stable power supply, reasonable electricity prices, and international carbon reduction commitments.
- Taiwan enacted the "Greenhouse Gas Reduction and Management Act" in 2015 to align with the "Paris Agreement" and focus on greenhouse gas reduction.

1. Introduction

- Taiwan heavily relies on energy imports, with 98% of its energy being imported, and has a high dependence on fossil fuels.
- Literatures on power supply side and demand analysis in Taiwan has progressed, but more research is needed on climate change's impact on household electricity demand.
- Climate change, such as rising temperatures and sea levels, will affect household electricity demand and potentially lead to energy shortages.

1. Introduction

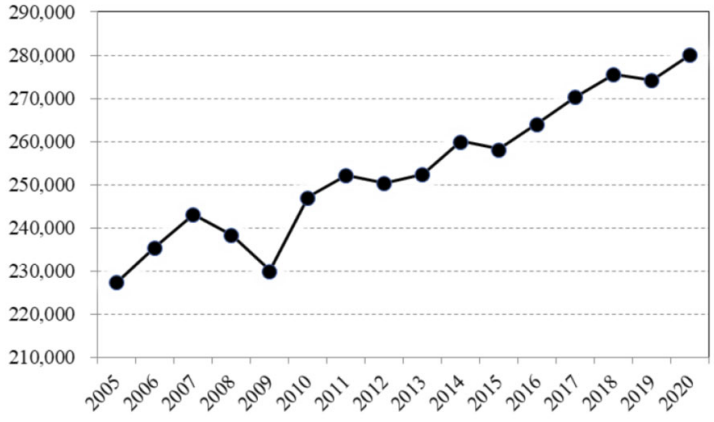

Figure 1-1 Total power consumption in Taiwan from 2005 to 2020（Unit：million kWh）

1. Introduction

- This study aims to analyze the factors affecting household electricity consumption from the perspective of climate change using panel data from 20 counties and cities in Taiwan.
- The research objectives are to analyze long-term household electricity consumption, explore relevant literature, analyze the impact of climate change on household electricity consumption, and provide policy recommendations to the government.

2. Literatures review

Studies from individual data:

- Tiwari (2000) indicates that factors such as housing structure, demographic characteristics, sociocultural differences, and appliance usage significantly influence power consumption.
- Filippini and Pachauri (2004) finds that price elasticity of electricity varies across regions, with different areas and seasons impacting consumption differently. Larger households and younger household heads tend to have lower electricity consumption.

2. Literatures review

Studies on electricity price elasticity and demand function:

- Holtedahl and Joutz (2004) suggests that short-term behavior change is more challenging, as short-term income and price elasticity are smaller than long-term elasticity.
- Yoo et al. (2007) finds that price and income elasticity are generally inelastic, indicating that price increases may not drastically reduce demand, and income increases may not lead to significant demand increases.

2. Literatures review

Studies from macro data:

- Bernarda et al. (2011) demonstrates that electricity and natural gas are substitutes, while electricity and fuel oil are complementary. Factors such as electricity price, natural gas price, oil price, income, and cold weather significantly influence electricity consumption, while house size has no significant impact.
- Fan et al. (2015) finds that the increase in the number of households leads to higher electricity demand, and independent houses consume twice as much electricity as apartments.

2. Literatures review

Studies on climate change and electricity consumption:

- Mansur, Mendelsohn, and Morrison (2008) and Mendelsohn (2003) endogenize fuel choice, which is usually assumed to be exogenous. They find that warming will result in fuel switching toward electricity.
- Deschênes and Greenstone (2007) find a U- shaped response function where electricity consumption is higher on very cold and hot days.

3. Methodology

Data and variable

- The main purpose of this study is to analyze the influence of climate change on the household electricity consumption in Taiwan.
- Therefore, this study uses an official county-level panel data of 20 counties and cities over the 2012-2020 period in Taiwan.

Table 1: Descriptive Statistics and Definitions of Variables

Variables	Definitions	Mean (S.D.)	Min (Max.)	Expected Sign
A. Dependent Variables				
POWER	Electricity sales of residential sector (million kWh)	191.23 (196.60)	9.60 (1043.57)	
B. Explanatory Variables				
TEMP	The monthly average temperature (°C)	20.64 (4.83)	9.44 (29.98)	+
TEMPVAR	The variance of the monthly average temperature in the first 36 months	18.66 (4.78)	8.45 (28.71)	+
INCOME	Average disposable income per capita (unit: NT)	25,454.2 (3,906.0)	19,631.61 (38,536.98)	+
AGEING	The population over the age of 65	152,716.9 (136,200.4)	14,011 (618,261)	+
HOLIDAY	January, July, and August=1 Other months=0	0.25 (0.43)	0.00 (1.00)	+
SUMMER	June, July, August and September=1 Other months=0	0.33 (0.47)	0.00 (1.00)	+

Sources: *Report on the Survey of Family Income and Expenditure,* and statistical database of Bureau of Meteorology, Taiwan.

3. Methodology

Model Specifications

$$POWER_{i,t} = \alpha_i + \beta_0 TEMP_{i,t} + \beta_1 TEMPVAR_{i,t} + \beta_2 INCOME_{i,t} + \beta_3 INCOME^2_{i,t} + \beta_4 AGEING_{i,t} + \beta_5 HOLIDAY_{i,t} + \beta_6 SUMMER_{i,t} + \beta_7 TIME_{i,t} + \varepsilon_{it}$$

4. Estimation Results

- This study adopts the pair-wise correlation coefficients and the R-square of auxiliary regression to deal with this issue. It is shown that none of the pair-wise correlation coefficients are greater than 0.8 and thus concluding that there is no collinearity between any of two explanatory variables.

Table 2: The Estimation Results of Fixed-effect Models

Variables	MODEL 1 ALL	MODEL 2 NORTH	MODEL 3 CENTRAL	MODEL 4 SOUTH	MODEL 5 EAST
TEMP	4.68*** (11.33)	5.81*** (6.65)	3.82*** (6.73)	3.19*** (4.59)	0.79*** (4.58)
TEMPVAR	10.66*** (3.07)	9.01 (1.33)	12.43** (2.58)	13.59** (2.22)	1.91 (1.12)
INCOME	0.03* (1.72)	0.01 (0.09)	0.31*** (5.39)	-0.01 (-0.17)	0.02 (1.46)
$INCOME^2$	-6.54×10^{-7}** (-2.14)	-2.25×10^{-7} (-0.31)	-7.08×10^{-6}*** (-5.57)	9.38×10^{-8} (0.11)	-4.91×10^{-7} (-1.63)
AGEING	0.05*** (12.04)	0.05*** (7.37)	0.06*** (9.66)	0.04*** (5.88)	0.06*** (6.11)
HOLIDAY	8.67*** (2.98)	9.12 (1.40)	10.45** (2.55)	9.53** (2.05)	0.77 (0.76)
SUMMER	23.18*** (6.09)	36.30*** (4.08)	22.27*** (4.29)	26.18*** (4.46)	5.91*** (4.30)
TIME	0.09** (2.20)	0.01 (0.12)	0.12** (2.28)	0.11* (1.81)	0.04** (2.25)
Observations	2140	749	535	642	214
Adjusted R^2	0.58	0.64	0.57	0.45	0.35
Hausman test	1,094.04***	45.08***	3,798.09***	2300.72***	409.19***
F-statistics	201.68***	153.39***	353.75***	281.08***	354.99***

Notes: 1. The standard errors are corrected for heteroskedasticity.
2. *t*-values are in parentheses.
3. ***, ** and * indicate the 1%, 5% and 10% significance levels, respectively

5. Concluding Remarks

- The major finding is that higher temperatures and temperature variations lead to increased household electricity consumption.
- The study highlights that the electricity consumption of households is mainly influenced by the population over the age of 65 due to factors such as limited mobility, increased elevator usage, and higher air conditioner usage among the elderly.
- It is also observed that higher household income is associated with increased electricity consumption.

5. Concluding Remarks

- Contrary to expectations, the implementation of summer electricity prices did not decrease electricity consumption but instead led to an increase.
- The study recommends that governments should consider the impact of climate change on energy consumption and suggests policy measures such as providing incentives for energy-saving improvements in building envelopes, referencing practices from advanced countries, and utilizing tax credits, subsidies, low-rate loans, and reimbursement methods to encourage energy efficiency improvements in existing buildings.
- These measures aim to reduce power consumption, particularly from air-conditioning, and mitigate the increase in electricity consumption caused by climate change.