29th AIM International Workshop

Assessment of Climate Change Impact on South Korea's Electricity Demand

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I. Introduction

Korea Adaptation Center for Climate Change(KACCC)

- Established on July 1, 2009.
- Specialized in researching climate change adaptation policies.
- Study policies addressing the climate crisis and mainstreaming climate adaptation

KACCC aims to secure Korean from
the climate crisis by minimizing the impact of climate change through a
systematic and scientific approach.

- Support climate change adaptation polices and develop adaptation tools
- Assist with climate change impact and vulnerability assessments
- Support in developing the National Adaptation Plan(NAP)
- Assist local governments in developing detailed action plans for adaptation measures
- Facilitate international cooperation on climate change adaptation
- Build a network of professionals focused on climate change adaptation at the national and international levels

〈Adaptation Report〉

〈National Adaption Plan〉

〈UNFCCC Global Adaptation Week〉

KACCC | Nation | Local gov. | Public agencies | Science | Domestic and International collaboration

What do we do?

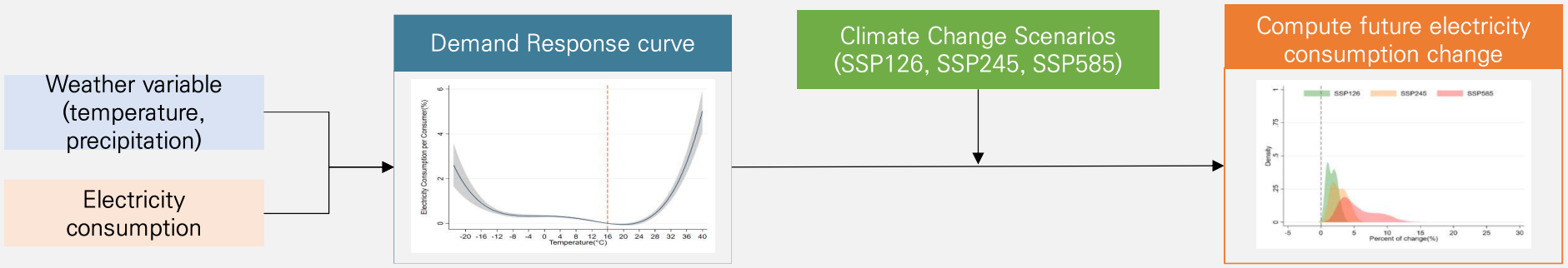
Object

➢ Estimating the impact of climate change on electricity consumption in South Korea

Data

Variable		Spatial unit	Time unit	Source
Past weather information	temperature, precipitation	County	2011–2018, daily	Korea Meteorological Administration
Past electricity consumption	residential sector, general sector	County	2011–2018, monthly	Korea Electric Power Corporation
Future weather information	temperature, precipitation	County	2021–2100, daily	Korea Meteorological Administration, Integrated Watershed Management Institute

Method



$$y_{i,t} = \beta_0 + \beta_j \cdot f_j\left(h, Tbin_{i,t}^{h}\right) + P(prcp) + \delta_i + \tau_t + \varepsilon_{i,t}$$

Features of this study

- Use the latest climate change scenarios

Scenarios	Projected Period	Global Climate Models
Shared Socioeconomic Pathways(SSP) (SSP126, SSP245, SSP585)	2021~2040, 2041~2060, 2081~2100	CanESM5 (CAN), GFDL-ESM4 (USA), ASSESS-ESM1-5 (AUS), 5ENSEM (KOR)

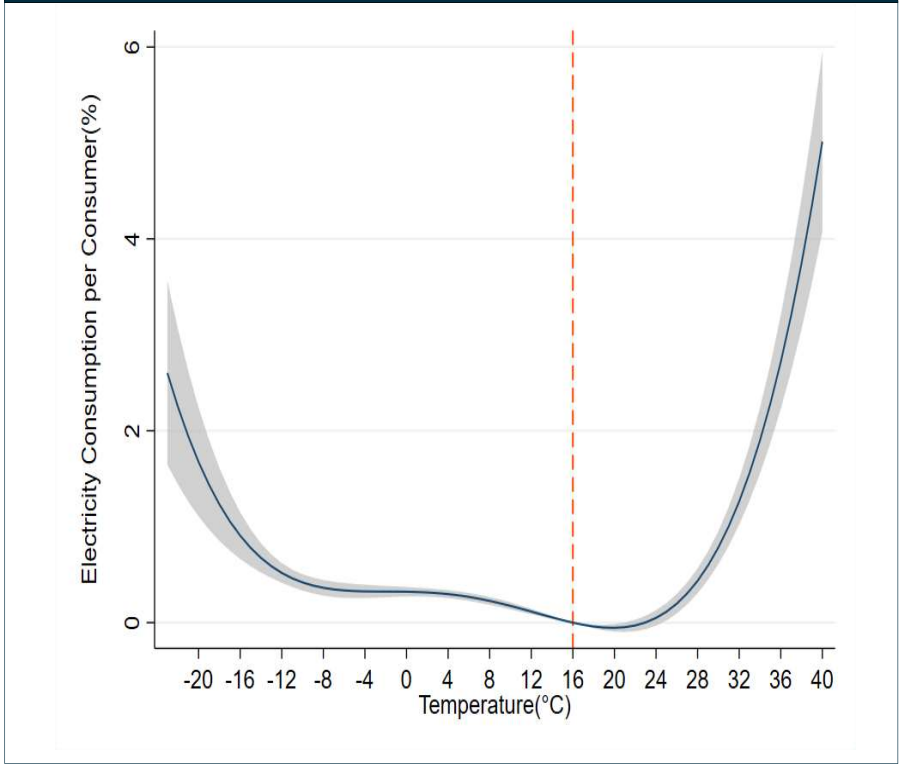
- Consider the uncertainty of climate change impacts
  - Uncertainty from global climate models
  - Uncertainty from econometrics analysis
  - Randomized simulation

- Estimate the precise demand response curve
  - Used 4^{th}-order polynomial to capture nonlinearity
  - Employed the fixed effect panel analysis to control omitted variable bias

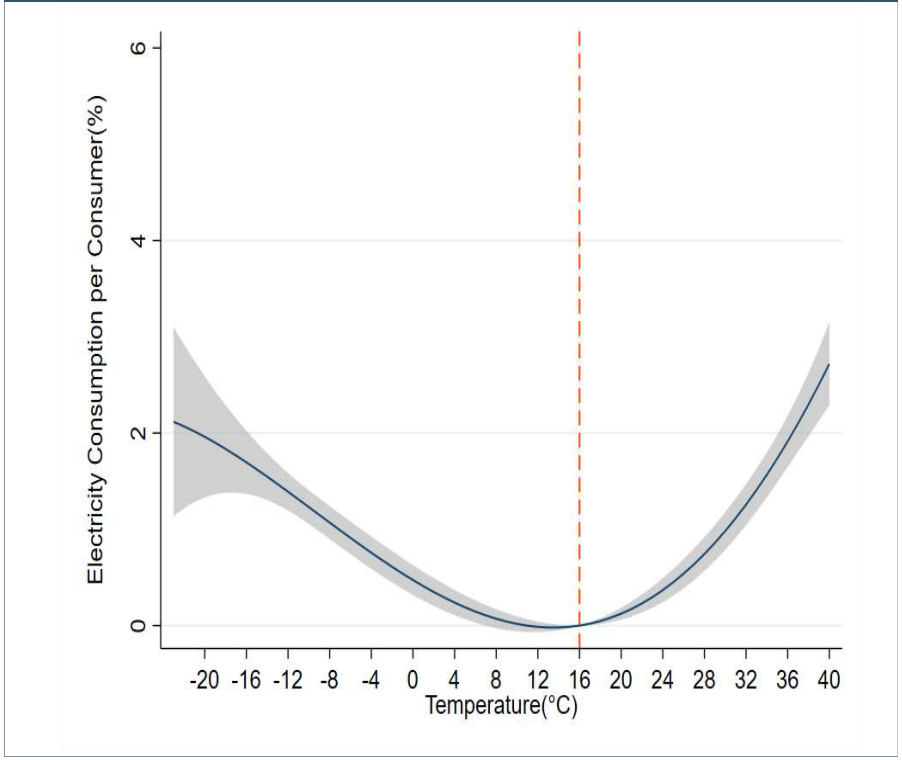
II. Result

Demand response curves

Residential sector



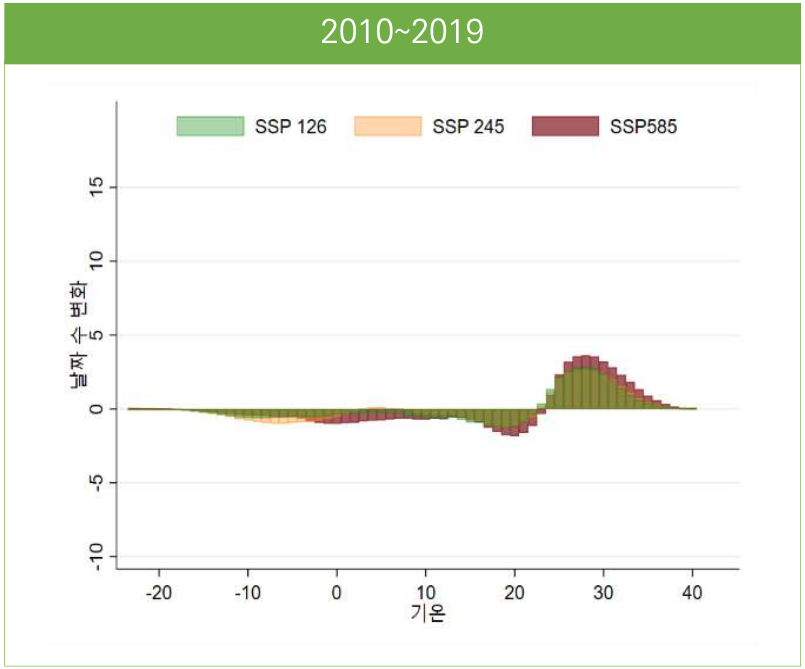
General sector



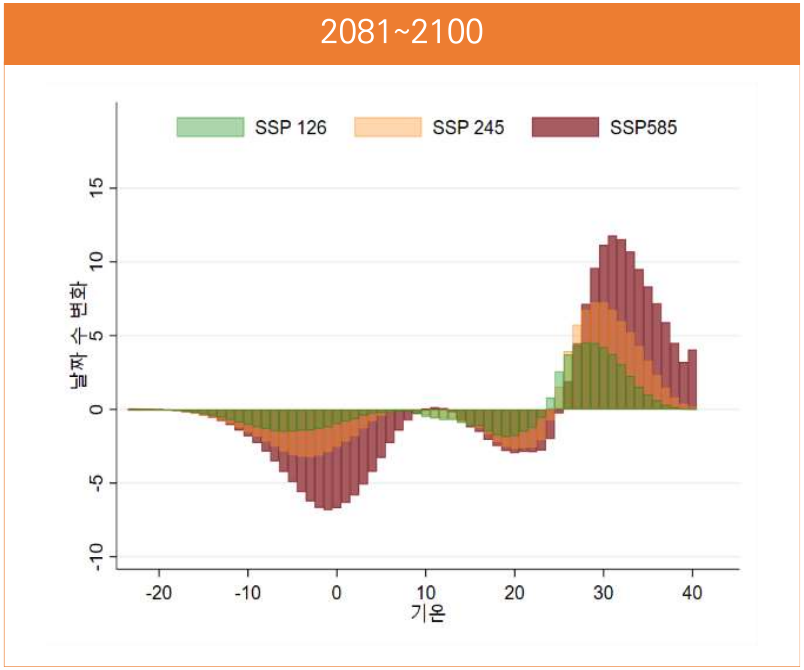
- The demand response curve of both sectors is U-shaped
- Replacing a 16 ℃ day with 40 ℃ increases residential electricity consumption by 5%.
- Replacing a 16 ℃ day with 40 ℃ increases general sector electricity consumption by 3%.
- Residential consumption increases more on hot days than on cold days.
- General consumption increases on both hot and cold days.

Change in Temperature Bin due to Climate Change(GCM: CanESM5)

2010~2019



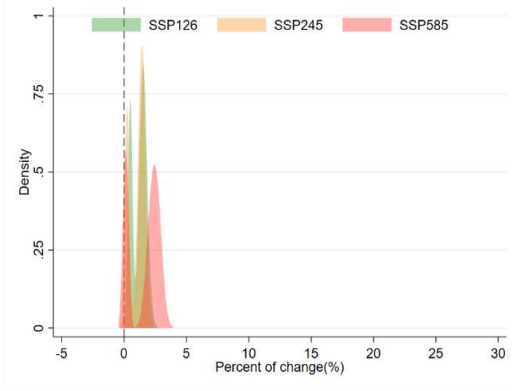
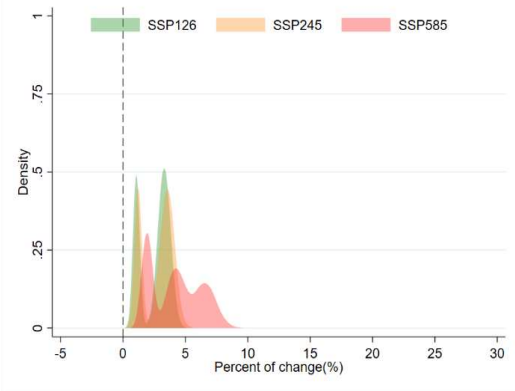
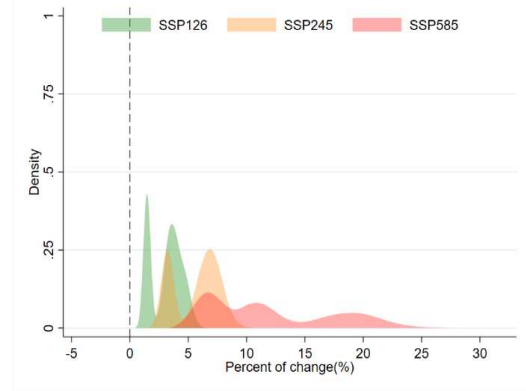
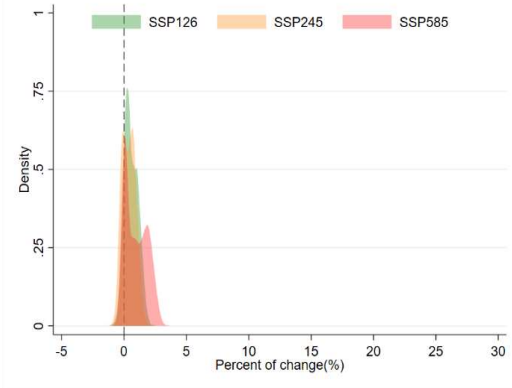
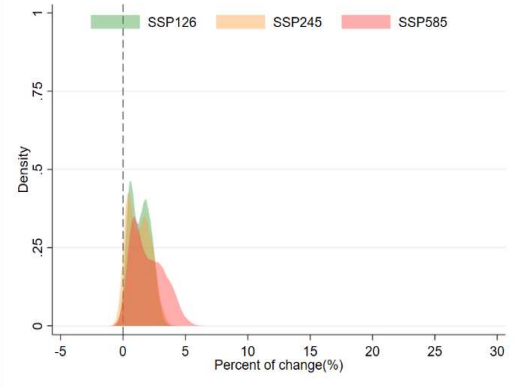
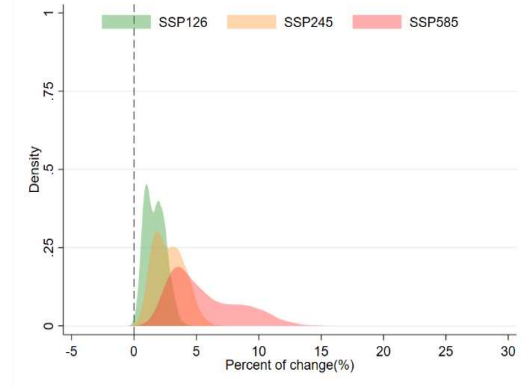
2081~2100



- Due to climate change, expect more frequent hot days.
- Days with temperatures above 30℃ will increase, while those below 30 ℃ will decrease.
- Under the SSP585 scenario, anticipate 5 more days with temperatures reaching 40℃ compared to the present

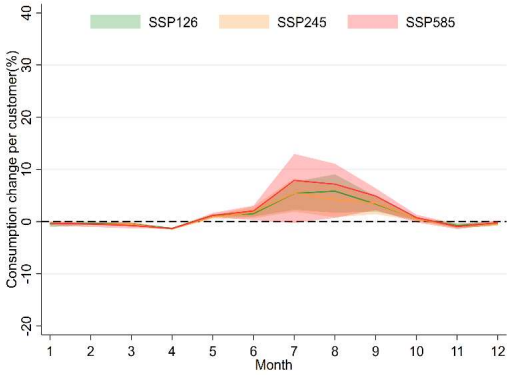
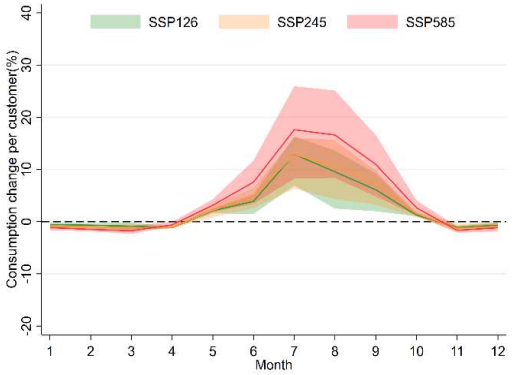
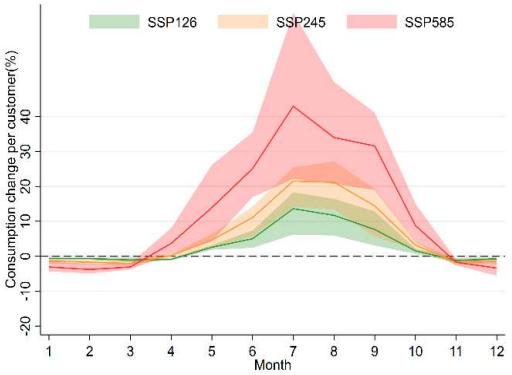
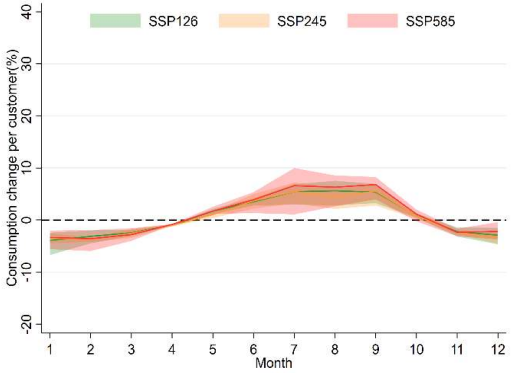
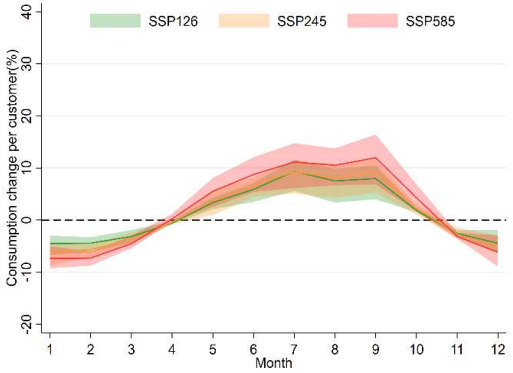
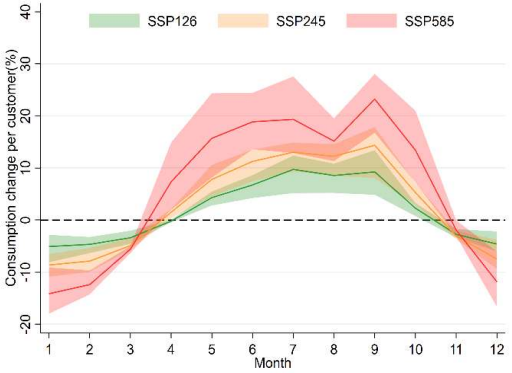
How these changes affect the electricity consumption in South Korea?

Future Electricity Consumption Change due to Climate Change

	2021~2040	2041~2060	2081~2100
Residential sector			
General sector			

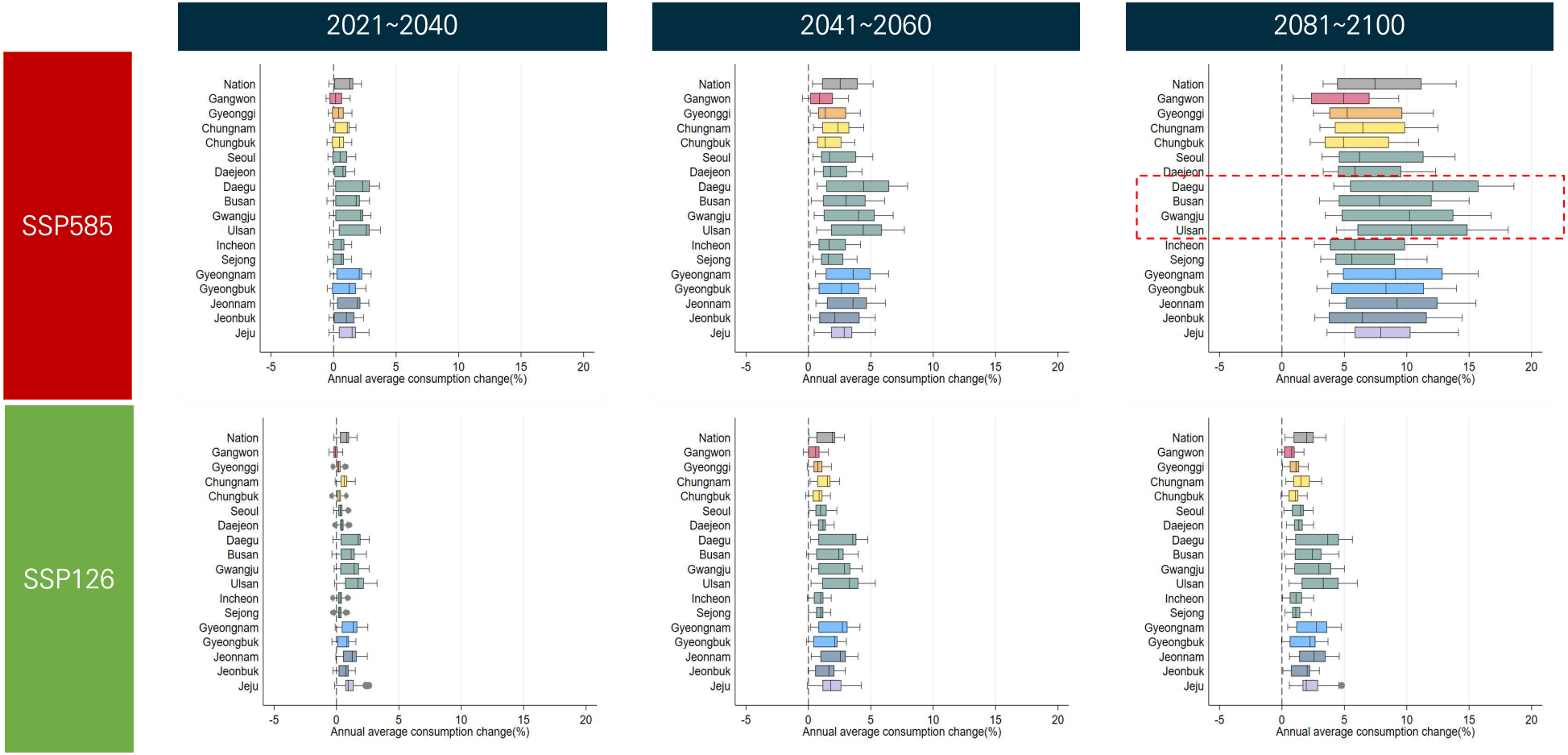
- Both sectors' electricity consumption will increase in the future.
- The magnitude of changes depends on the period and SSP scenarios.
- Uncertainty will grow over time.
- The highest increase in electricity consumption is projected under SSP585 during 2081–2100

Future Electricity Consumption Change in Different Months

	2021~2040	2041~2060	2081~2100
Residential sector			
Commercial sector			

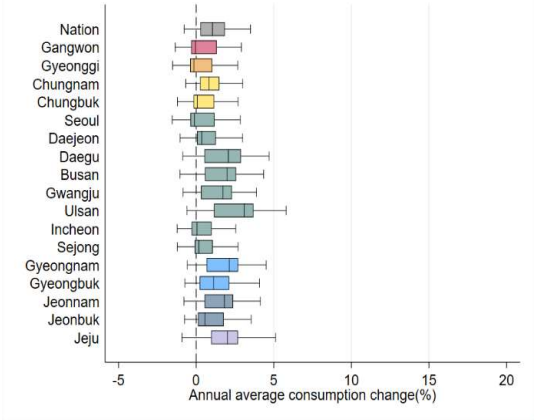
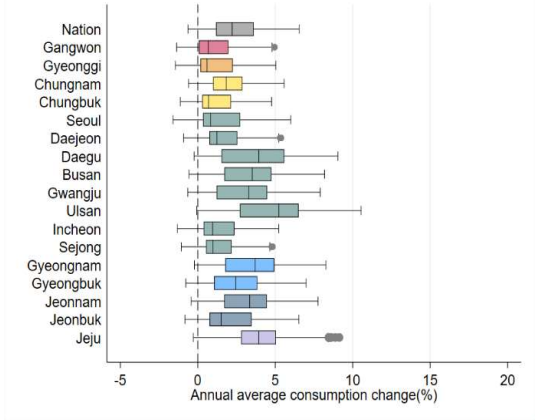
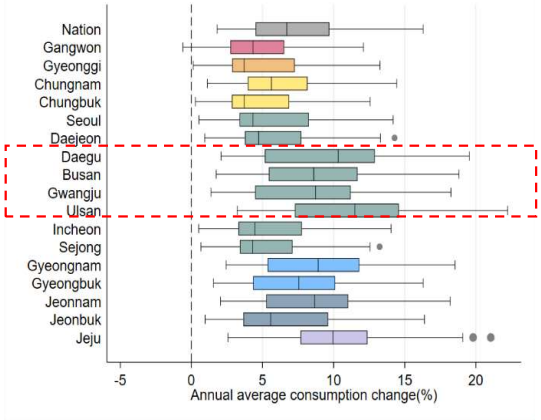
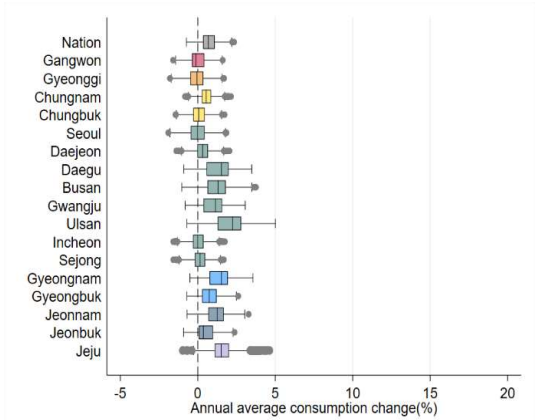
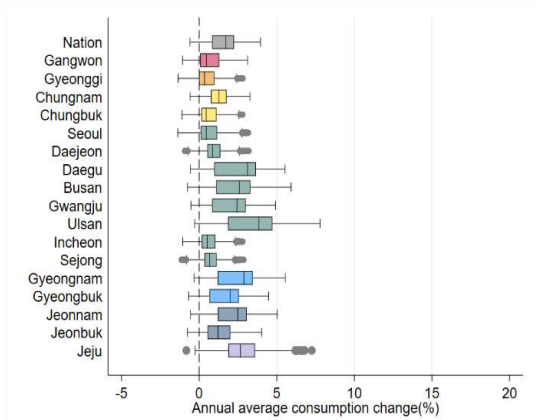
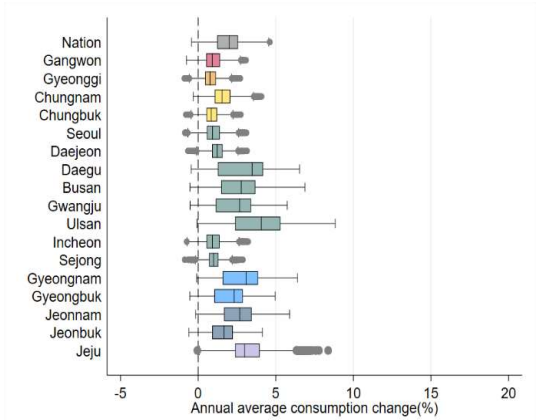
- The electricity consumption between April and October are expected increase in the future
- The electricity consumption in winter will decrease in the future

Future Electricity Consumption Change in Different Regions (Residential Sector)



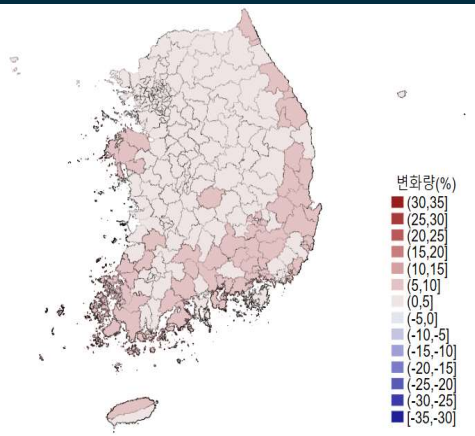
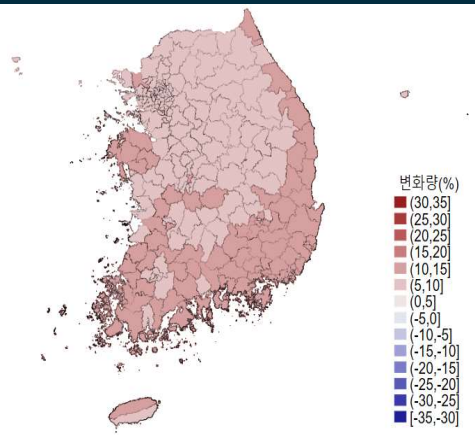
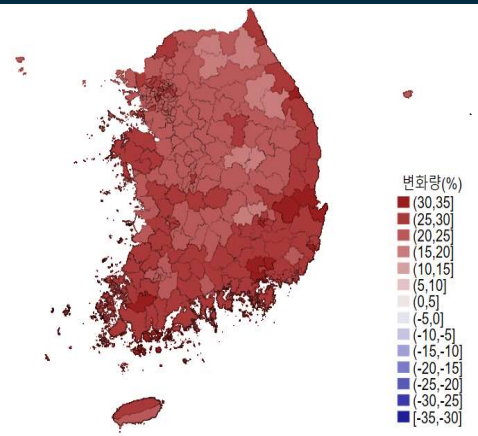
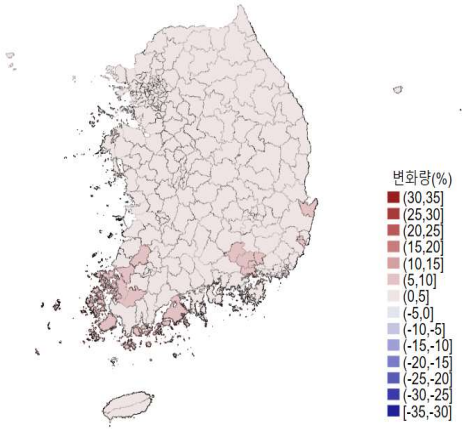
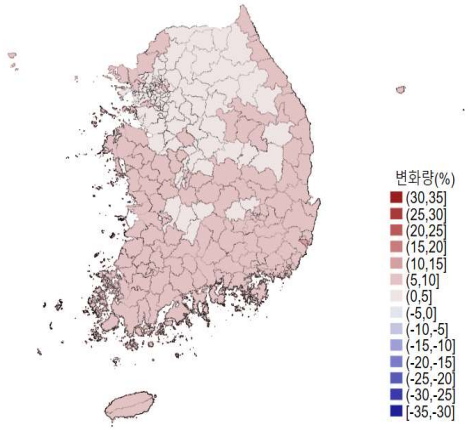
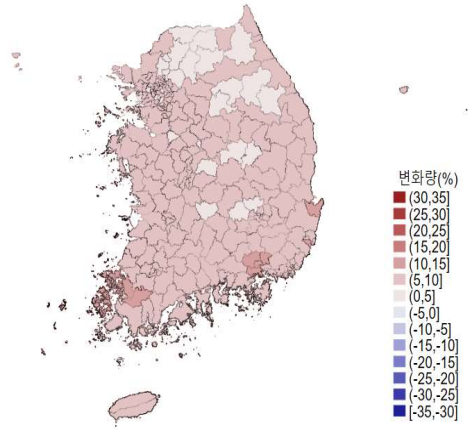
- Daegu, Busan, Gwangju, and Ulsan shows higher electricity consumption increases than national average
- The demand of electricity consumption in Jeju, Gyongnam, Jeonnam is also higher than national average
- The provinces and cities located in northern part of S.Korea are expected to have lower consumption increases than the national average

Future Electricity Consumption Change in Different Regions (General Sector)

	2021~2040	2041~2060	2081~2100
SSP585			
SSP126			

- The results are the similar with that of the residential sector

Electricity Consumption Change in August (Residential Sector)

	2021~2040	2041~2060	2081~2100
SSP585			
SSP126			

III. Conclusion

Conclusion

- Residential and general electricity consumption are temperature-sensitive
- Climate change will raise electricity consumption in South Korea

Sectors	Period	SSP126	SSP245	SSP585
Residential sector	2081~2100	1~7%	2~10%	4~27%
General sector	2081~2100	1~4%	1~8%	1~15%

- The impacts of climate change on electricity consumption have a seasonality
  - Increasing summer consumption and decreasing winter consumption
- The consumption gap between peak and off-peak season will expand in the future

V. Appendix

Method(1)

1.Construct temperature bin

- Convert daily temperature to hourly temperature
- Construct monthly temperature bin by using hourly temperature

$$Tbin_{t,j}^{temp} = \sum_{d=1}^{D} x_{d,j}^{temp} \qquad \forall\, t = \sum_{d=1}^{D\in\{30,31\}} d$$

2. Estimate the demand response curve

- Analyze the relationship between electricity consumption and temperature bin
  - Use the fixed effects to control omitted variable bias
  - Use 4th–order polynomial to reflect the nonlinearity

$$y_{i,t} = \beta_0 + \beta_j \cdot f_j\left(h, Tbin_{i,t}^{h}\right) + P(prcp) + \delta_i + \tau_t + \varepsilon_{i,t}$$

$$f_j\left(h, Tbin_{i,t}^{h}\right) = f_j\left(\sum_{h=-20}^{40} h \times Tbin_{i,t}^{h}\right) \qquad P(prcp) = \gamma_1 \cdot prcp_{i,t} + \gamma_2 \cdot prcp_{i,t}^{2}$$

- $y_{i,t}$: county–level monthly electricity consumption per customer
- β_j : coefficient of each order in function f
- δ_i : county–level fixed effect
- τ_t : time fixed effect
- $\varepsilon_{i,t}$: error

Method(2)

3. Compute future electricity consumption change with climate change scenarios

- Compute the change of temperature bin in each scenario
- Compute the change of electricity consumption by using the demand response curve and future temperature bin change

$$\Delta y_{i,t+1} = \sum_{h=-20}^{40} \alpha_h \times \underbrace{\left(Tbin_{i,t+1}^{h} - Tbin_{i,t}^{h}\right)}_{\text{change in temperature bin between t and t+1}} \times y_{i,t}$$

- $\Delta y_{i,t+1}$: the change in electricity consumption per customer in county-level
- α_h : coefficient of temperature bin h
- $Tbin_{i,t+1}^{h}$: the exposed time in each temperature bin at time t+1
- $Tbin_{i,t}^{h}$: the exposed time in each temperature bin at time t
- $y_{i,t}$: the electricity consumption of county i at time t

4. Consider uncertainty

- Uncertainty of econometrics

$$N \sim (\alpha_h, \delta_h)$$

- Uncertainty of Global Climate Model(GCM)

$$P(GCM_i) = p$$

$$\sum P(GCM_i) = 1$$