

# Estimating the effects of climate change on food consumption pattern in South Korea



**Yena Suh**

*Master Student / Seoul National University*

*South Korea*

*suh1231@snu.ac.kr*

**Heeyeun Yoon**

*Associate Professor / Seoul National University*

*South Korea*

*hyyoon@snu.ac.kr*

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# I. Introduction

CLIMATE CHANGE / RESEARCH BACKGROUND / QUESTION

# Climate Change

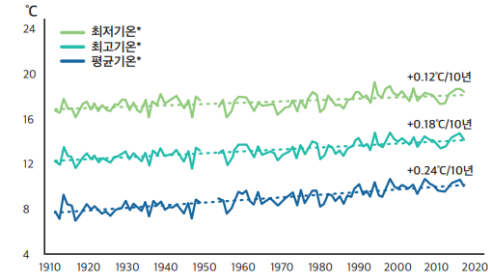
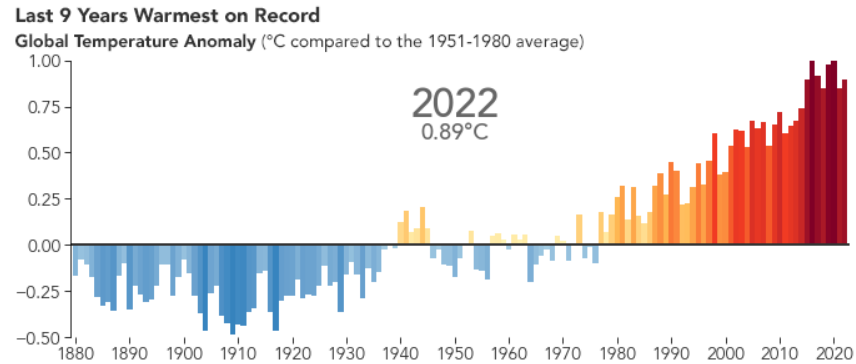
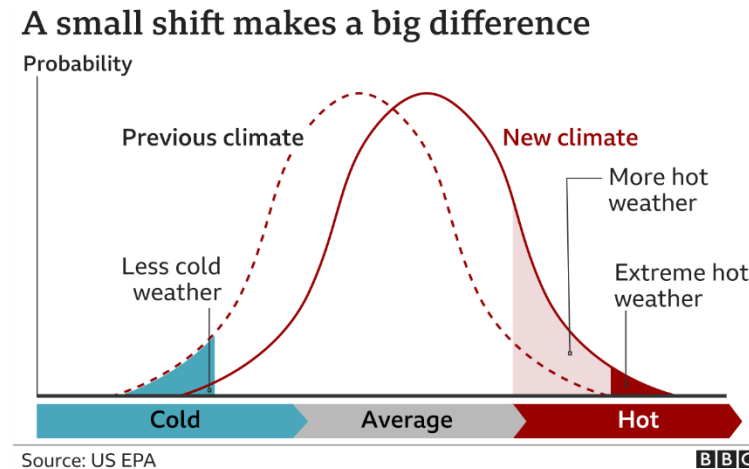
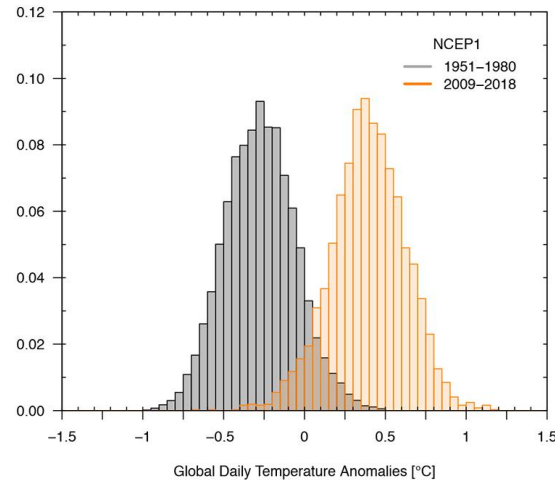


Fig. 2.2. Time series of annual maximum, mean, and minimum temperature in South Korea for 1912~2017 (NIMR, 2018).

## Climate change trends

- Since pre-industrial era, there has been a notable increase in accumulated heat, as evidenced by the global average surface temperature rising by 1°C (NOAA, 2023).
- yearly surface temperature compared to the 20<sup>th</sup> century average from 1880 to 2022, blue bars indicate cooler while red bars show warmer than average. The frequency of warmer average temperature is consistently increasing last 40 years.
- South Korea also experiences a persistent warming trend over the past century, since the increasing trend in annual maximum, mean, and minimum temperatures appeared from 1912 to 2017 (KMA, 2020).

# Climate Change



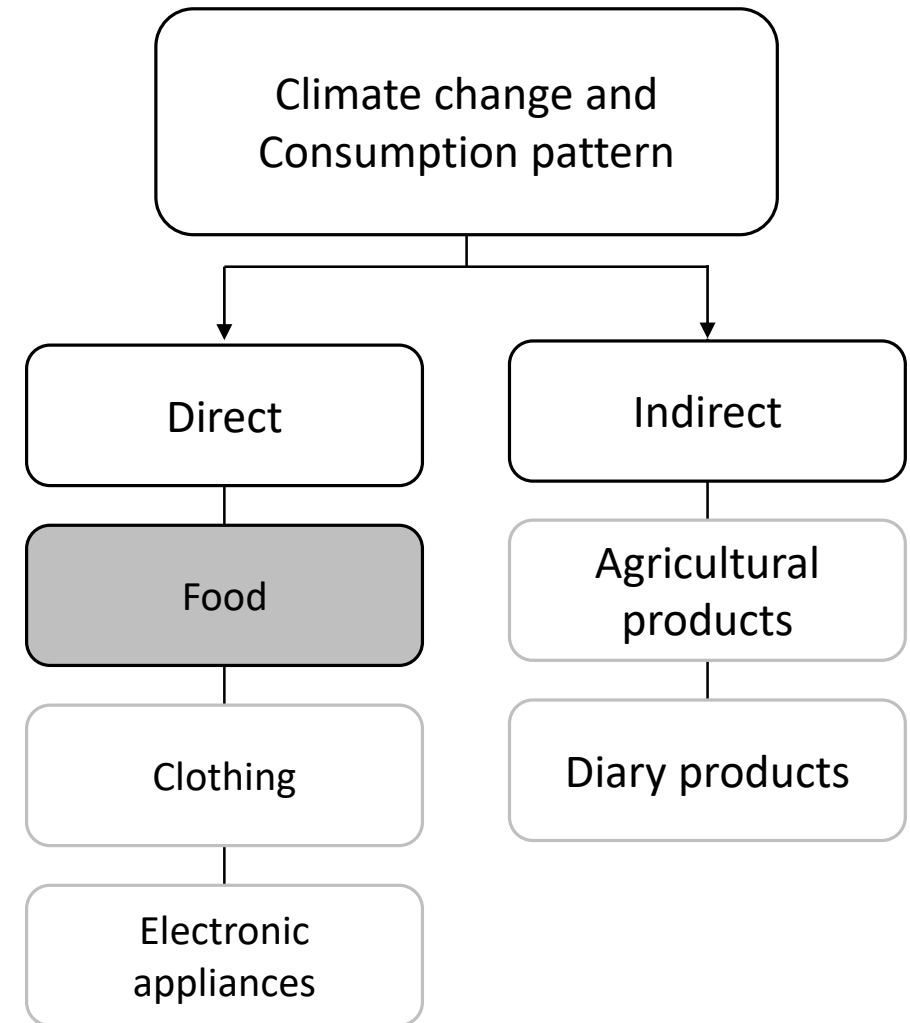
## Weather and Climate change

- While weather and climate are distinct concepts, recent research indicates that evidence of climate change can be identified in daily global weather data (Sippel S. et al, 2020).
- Comparing the distribution of global daily mean temperature from 1951 to 1980 with those from 2009 to 2018, the two curves barely overlap, indicating that weather can detect climate change trend
- Rising global average temperature is associated with widespread changes in daily weather patterns as well, since extreme weather events are become more frequent and intense (EPA, 2022).

# Research Background

## Climate change and food consumption pattern

- Based on literature reviews, this research classifies the impacts of climate change on consumption pattern into direct and indirect
  - Direct impacts; consumers adjust their consumption patterns in response to weather conditions as a means of adaptation
  - Indirect impacts; consumers are compelled to modify their consumption behaviors in response to fluctuations in product price or quality
- Among these various sectors, food is a product that consumers must purchase on a daily basis, and highly vulnerable to weather variations



# Research Background



## Ready-to-Eat

Can be consumed immediately after purchase, without any cooking (e.g., lunch boxes, hamburgers, sandwiches)



## Ready-to-Heat

Require brief heating in a microwave or hot water (e.g., instant curry, instant rice, soup)



## Ready-to-Cook

Require cooking tools, a relatively long heating time or a simple cooking process (e.g., frozen fried rice, stew, steamed foods)

## Home Meal Replacement

- Home Meal Replacement(HMR) is a food prepared in a store and consumed at home which require little or no preparation on the part of the consumer
- HMR can be categorized into ready-to-eat, ready-to-heat, and ready-to-cook products (Ji Y. et al, 2022)

# Research Background

**Due to the heat wave, 'fire-free' home appliances and convenience foods are popular:**

Kim Da-ran | Input 2018.08.12 18:19 | Comment 0

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press release Home > Policy promotion > new news > press release

**Agricultural Development Administration analyzes changes in agricultural purchases during summer heat wave**

Manager 2019-07-30 - Main Office -

**CJ CheilJedang "Simple Cold Noodles Sold Over KRW 10 Billion in July"**

Sales of more than 10 billion won in July for the first time in the convenient cold noodle industry due to the record heat wave...Record Monthly Sales 25 billion won in sales during the peak season (May-July) this year...It has grown 30% in two years, establishing itself as Korea's representative "simple cold noodles."

"Dongchimi Mulnaengmyeon," which is different from Jeju winter radish, is sold out as it hits consumers' appetite tired of the heat wave.

news provision CJ CheilJedang. (COSPI 097950)  
2018-08-07 09:06

CJ 제일제당

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- Although many news articles show that rising temperature and extreme weather events make consumers to purchase more HMR products, limited studies have been conducted to identify this relationship
  - Soyeong Kim et al.(2018) state single-person household rate positively effects the consumption of HMR products
  - Yunho Ji et al.(2022) indicate increased participation of women in the economy attributed to growth of HMRs



# Research Question

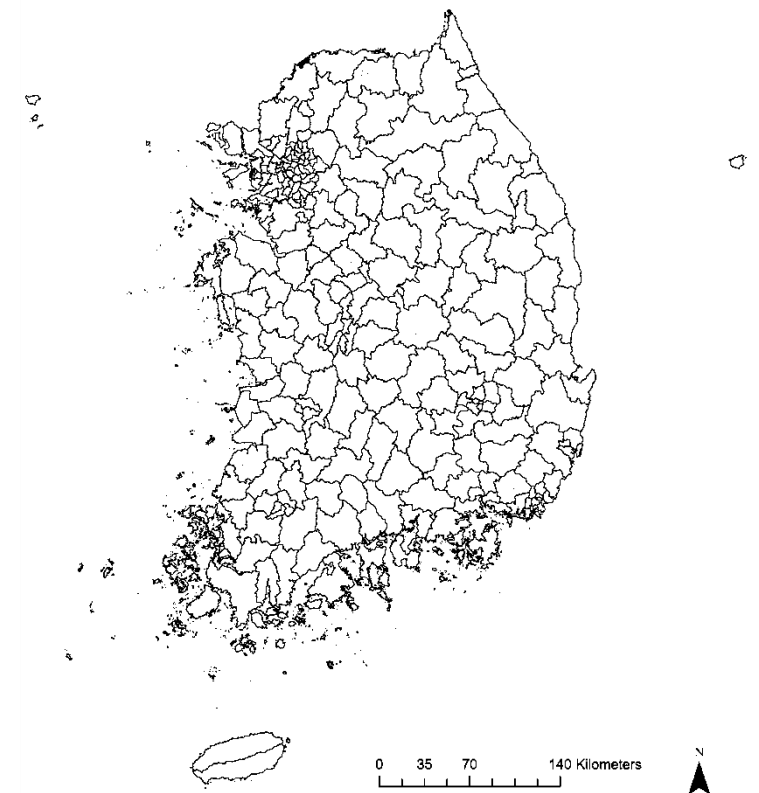
- Aim to analyze the relationship between the change in weather conditions and the number of purchased Home Meal Replacement products
- Hypothesize that climate variables will affect the consumption of HMR products

# II. Analytical Design

STUDY SITE / DATA / VARIABLE / METHOD

# Study Site and Data

- Spatial scope: South Korea
  - 250 Si-gun-gu administrative districts level
- Temporal scope: 2 years
  - Time wave: a week
- Research data: 71,600,000 number of credit card purchases data



# Variables

	Variables	Definition
<b>Dependent Variables</b>	Frozen and Fridge products	Number of frozen, fridge, canned, meal replacement, ready meal products purchased
	Canned products	
	Meal replacement products	
	Ready meal products	
<b>Independent Variables</b>	Average Temperature	Average temperature per a week
	Average Humidity	Average humidity per a week
	Total Precipitation	Total precipitation per a week
<b>Extreme weather</b>	Heat wave	If a heat wave occurs during a week = 1, or not = 0
	Cold wave	If a cold wave occurs during a week = 1, or not = 0
<b>Demographic</b>	One Person Rate	One person household rate by 250 Si-Gun-Gu level
	Agri. Job	People with agricultural related jobs rate by 17 Si-Do level
	Gen. Job Rate	People with general, technique, and labor service jobs rate by 17 Si-Do level
<b>Socio-economic</b>	Price Index Rate	Price index rate of home meal replacement products
	Financial Independency	Financial independency of each Si-Gun-Gu level
<b>Date</b>	Holiday	If Chuseok or New Year included during a week = 1, or not = 0

# Method

## Spatial Panel Error Regression Model

- The spatial error regression model is a method that takes into account the dependency of error values of an area with errors in other areas associated with in (D R S Saputro et al., 2019)
- SER model is used to include a function of unexplained error and that of its neighbors

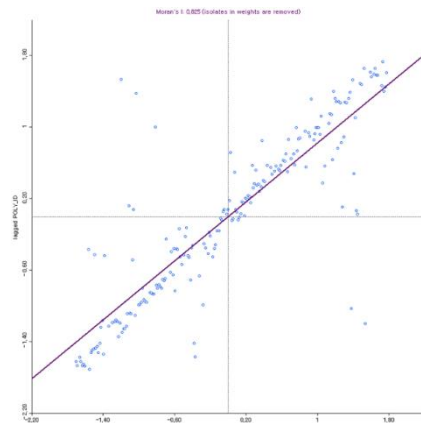
# III. Results

MORAN'S I / SPATIAL PANEL ANALYSIS

## RESULTS

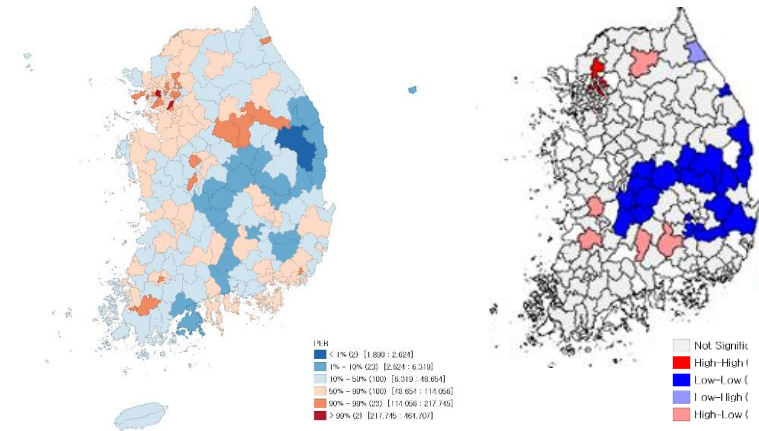
# Moran's I Analysis

## GLOBAL MORAN'S I



- Consumption pattern of HMR products shows spatial autocorrelation due to Moran's I value is 0.8
  - Positive Moran's I value indicates that similar values cluster together
  - Since global Moran's I value is closer to 1, spatial analysis method is selected

## HIGH AND LOW CLUSTERING



- High consumption patterns tend to cluster at Seoul and Metropolitan areas, whereas low consumption patterns concentrate at Gyeongsangbuk-do area

RESULTS

# Spatial Panel Analysis

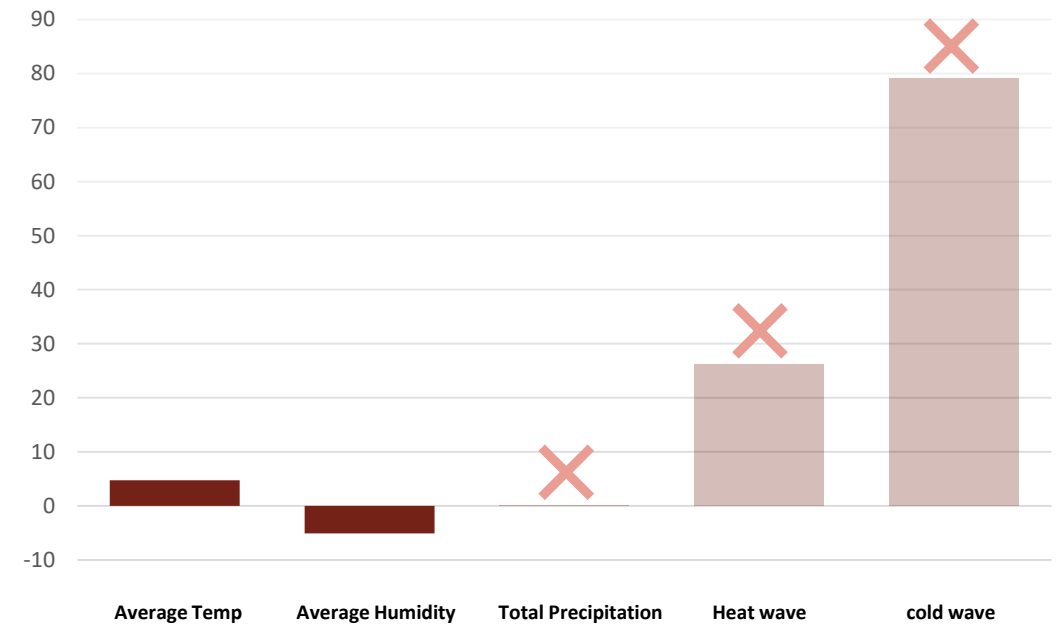


Frozen and fridge products

	Estimated	Std. Error	t-value	Pr(> t )	
<b>Average Temp</b>	4.745	1.372	3.457	0.0005	***
<b>Average Humidity</b>	-5.082	0.904	-5.621	1.891e-08	***
<b>Total Precipitation</b>	0.184	0.229	0.803	0.421	
<b>Heat wave</b>	26.242	30.886	0.849	0.395	
<b>Cold wave</b>	79.095	45.628	1.733	0.083	.
Holiday	-75.954	51.537	-1.473	0.140	
One Person Rate	-3.524	0.479	-7.353	1.926e-13	***
Price Index Rate	-24.779	8.196	-3.023	0.002	**
Agri. Job Rate	-39.679	1.172	-33.827	< 2.2e-16	***
Gen. Job Rate	4.060	0.247	16.403	< 2.2e-16	***
Financial Independency	28.201	0.893	31.574	< 2.2e-16	***

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FROZEN AND FRIDGE PRODUCTS





RESULTS

# Spatial Panel Analysis

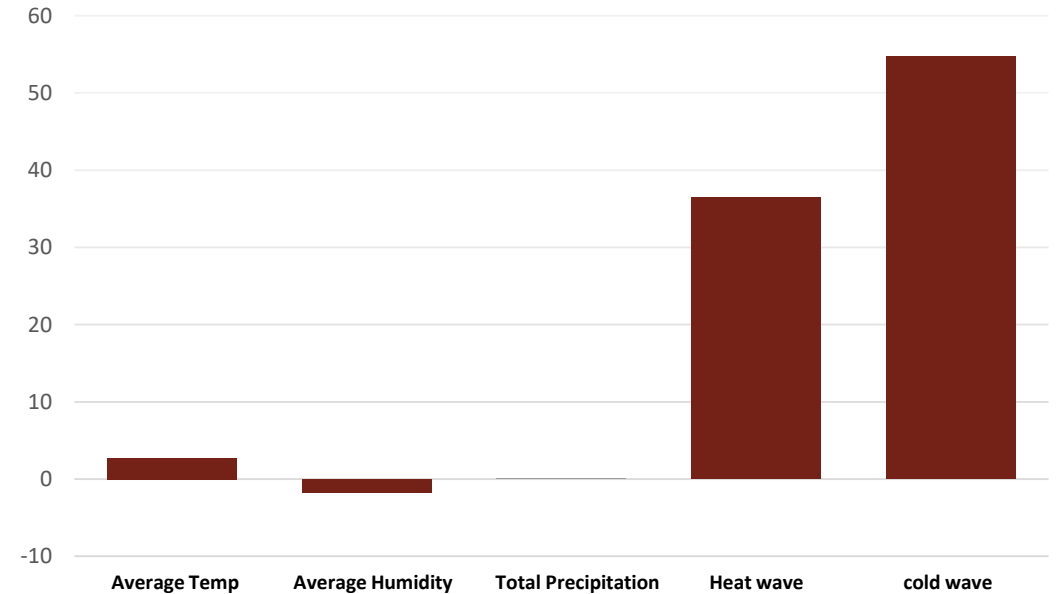


**Meal replacement products**

	Estimated	Std. Error	t-value	Pr(> t )	
<b>Average Temp</b>	2.721	0.319	8.518	< 2.2e-16	***
<b>Average Humidity</b>	-1.693	0.209	-8.092	5.852e-16	***
<b>Total Precipitation</b>	0.106	0.053	2.006	0.044	*
<b>Heat wave</b>	36.508	7.152	5.104	3.323e-07	***
<b>Cold wave</b>	54.744	10.534	5.196	2.029e-07	***
Holiday	-18.712	12.049	-1.552	0.12	
One Person Rate	-0.804	0.108	-7.446	9.564e-14	***
Price Index Rate	-7.177	1.918	-3.741	0.000	***
Agri. Job Rate	-9.258	0.267	-34.658	< 2.2e-16	***
Gen. Job Rate	0.543	0.056	9.629	< 2.2e-16	***
Financial Independency	6.581	0.203	32.304	< 2.2e-16	***

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**MEAL REPLACEMENT PRODUCTS**



RESULTS

# Spatial Panel Analysis

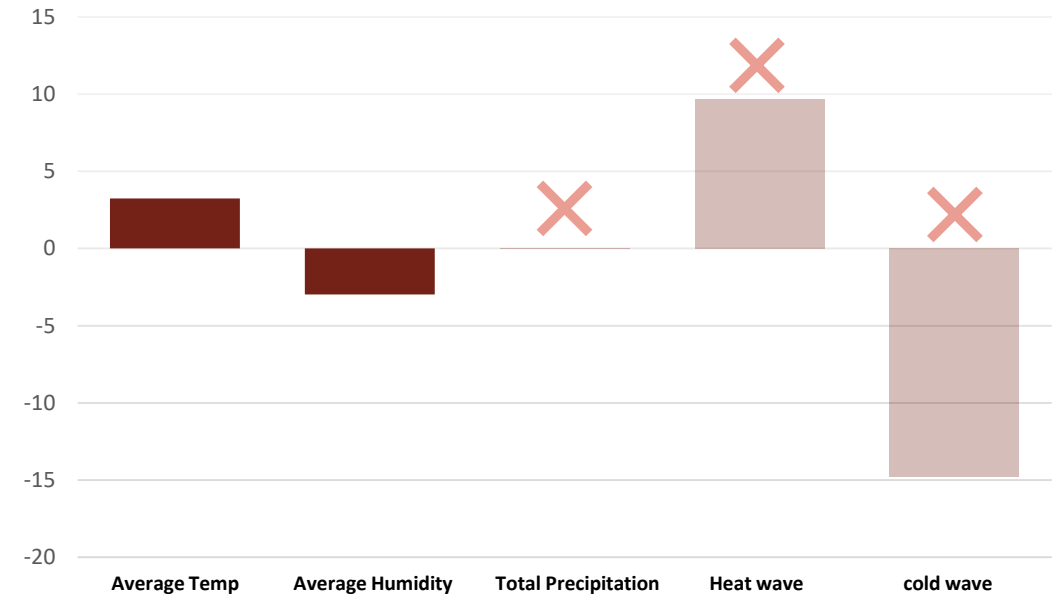


**Canned products**

	Estimated	Std. Error	t-value	Pr(> t )	
<b>Average Temp</b>	3.233	0.613	5.273	1.336e-07	***
<b>Average Humidity</b>	-2.967	0.396	-7.488	6.983e-14	***
<b>Total Precipitation</b>	-0.054	0.101	-0.533	0.59407	
<b>Heat wave</b>	9.693	13.552	0.715	0.47447	
<b>Cold wave</b>	-14.776	19.837	-0.744	0.45635	
Holiday	-75.954	51.537	-1.473	0.1405422	*
One Person Rate	-0.942	0.193	-4.872	1.104e-06	***
Price Index Rate	-19.1	3.727	-5.124	2.987e-07	**
Agri. Job Rate	-15.603	0.488	-31.915	< 2.2e-16	***
Gen. Job Rate	0.759	0.103		2.287e-13	***
Financial Independency	12.121	0.373	32.438	< 2.2e-16	***

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**CANNED PRODUCTS**



RESULTS

# Spatial Panel Analysis

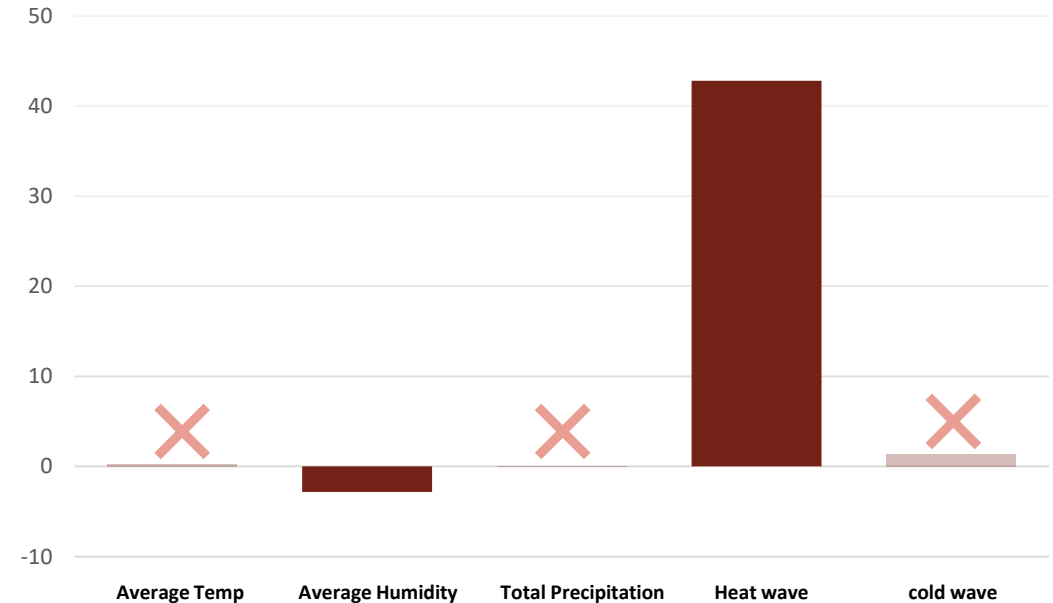


**Ready meal products**

	Estimated	Std. Error	t-value	Pr(> t )	
<b>Average Temp</b>	0.274	0.473	0.58	0.561	
<b>Average Humidity</b>	-2.846	0.309	-9.194	< 2.2e-16	***
<b>Total Precipitation</b>	0.076	0.079	0.963	0.335	
<b>Heat wave</b>	42.821	10.581	4.046	5.190e-05	***
<b>Cold wave</b>	1.404	15.57	0.09	0.928	
Holiday	-81.865	17.877	-4.579	4.665e-06	***
One Person Rate	-1.121	0.158	-7.07	1.549e-12	***
Price Index Rate	-14.728	2.847	-2.316	0.021	*
Agri. Job Rate		1.172	-33.827	< 2.2e-16	***
Gen. Job Rate	0.711	0.083	8.561	< 2.2e-16	***
Financial Independency	11.923	0.3	39.739	< 2.2e-16	***

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**READY MEAL PRODUCTS**

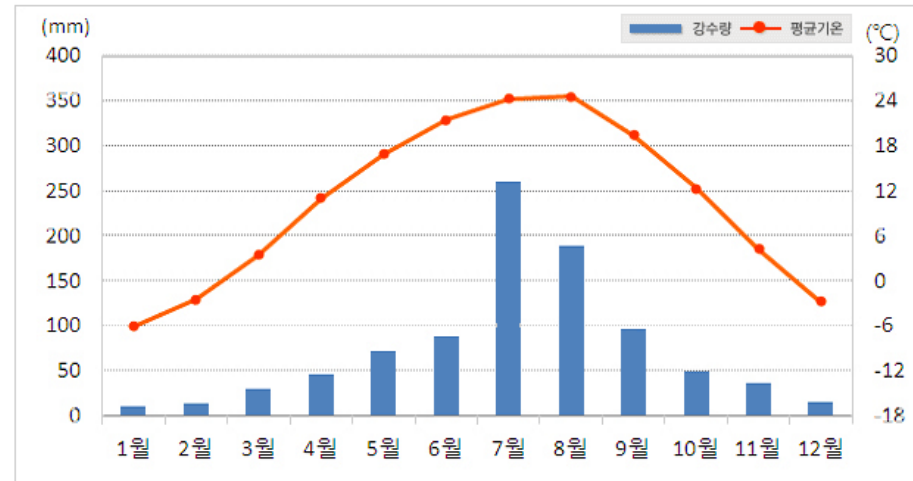


# IV. Conclusion

FINDINGS

## CONCLUSION

# Findings



- Consumers tend to purchase *more* HMR products when the average temperature increases
  - Perhaps consumers purchase more HMR products to reduce burden of cooking process when the weather is hot
- Consumers tend to purchase *less* HMR products when the average humidity increases
  - Temperature and Humidity are generally moving together. So the consumers behaviors against temperature and humidity might be the same. However, the reasons for this diverging result of humidity and temperature might be due to multi-collinearity between two variables. The correlation is about 0.5, which is not very large, so we included these two variables in the model. Thus we need to refine the model to address this issue.

## CONCLUSION

# Findings

- The overall consumption of HMR products is not significantly impacted by the total amount of precipitation
- Consumptions of meal replacement and ready meal products are increased when heat wave happened
- Regions with high financial independency consume more HMR products compared to regions with less financial independency
- One person household rate negatively associated with HMR consumption pattern
  - This result is different from the previous researches, since data of this study include single household rate not only from urban regions but also from rural areas
- Consumer occupation is also a significant determinant of consumption patterns, with individuals employed in general labor and service industries exhibiting a greater propensity for purchasing HMR products compared to those employed in agriculture-related occupations

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**Yena Suh**

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*South Korea*

suh1231@snu.ac.kr