VII部門：環境・エネルギー
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[VII-10] Evaluation of the Impact of Climate Change on Ski Resorts' Business Probabilities -under Climate Model MRI-ESM2-0-

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キーワード：Climate change, Ski resorts, Panel data, Coupled model intercomparison project phase 6 (CMIP6), Representative Concentration Pathways (RCPs) , Shared socioeconomic pathways (SSPs)

In this study, 71 ski resorts in Hokkaido, Japan, famous for ski resorts in Asia, are taken as the case studies. We built a logit model to evaluate climate change’ s influence on ski resorts’ business status. In this model, the business status of every ten-day period from 2006 to 2020 was taken as the dependent variable (dummy), and comprehensive meteorological and socioeconomic data were treated as independent variables. The results show that per degree increase in temperature will reduce the probability of a ski resort opening by 40.35%, and every 1mm increase in precipitation will reduce the probability of a ski resort opening by 6.95 %.

Evaluation of the Impact of Climate Change on Ski Resorts' Business Probabilities -under Climate Model MRI-ESM2-0-

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1. Background and Purpose

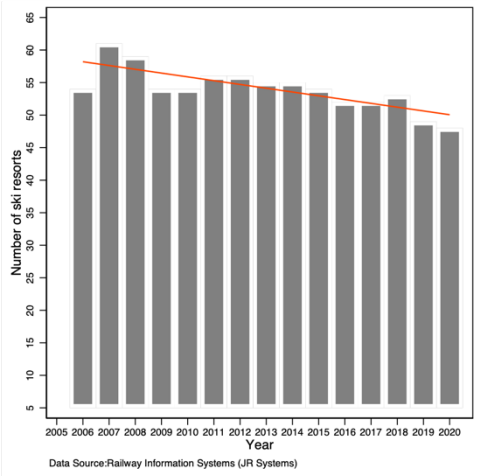
Observations by Japan Meteorological Agency show that the average annual temperature in Japan rises 1.19℃ per 100 years in the long term, and by the end of the 21st century (2070-2100), the average annual temperature in Japan is projected to increase by 0.5℃ to 1.7 ℃, and 3.4℃ to 5.4℃ under two different greenhouse gases (GHG) concentration scenarios: RCP2.6 and RCP8.5. Research on its effects is progressing in various fields, and various effects on the natural environment are being clarified. While quantitative assessment of how changes in winter temperature and other climate factors affect ski resorts' business probabilities remains an important and urgent issue. The main purpose of this study is to build a logistic regression model by collecting and organizing a panel data of 71 objects over 15 years, to assess the degree of influence of various conditions that affect the business status of ski resorts, so as to provide insights into the future impact on operation continuation of ski resorts under the risk of climate change.

2. Research Objectives and Data collection

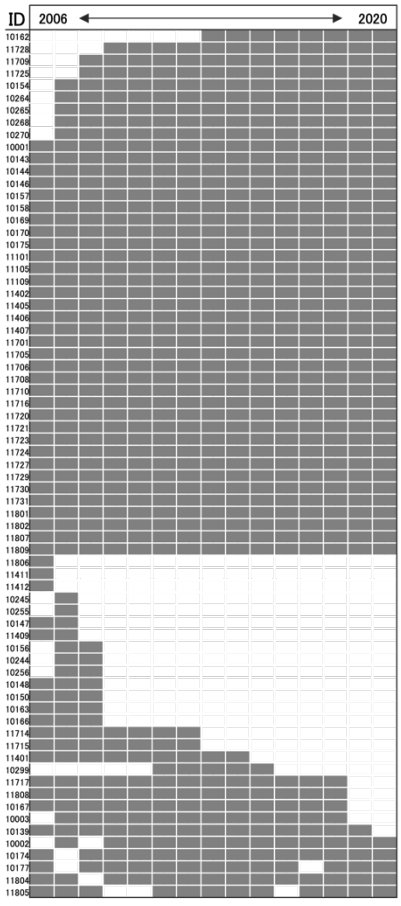
In this work, we carried out data collection from four aspects:

1) The first is the basic attribute data of ski resorts, including the number of openings of 71 ski resorts in the Hokkaido region in each ski season from 2006 to 2020, geographic location, elevation, number of lifts, the maximum slope of the piste, and other basic attributes provided by Railway Information System, meanwhile, the change in the business statuses in the past 15 years is examined. **(Fig. 1)**
2) Secondly, the transportation accessibility of the ski resorts is investigated.
3) In addition, as an indicator to measure social trends, we introduced the skiing population of the year according to *leisure white paper* provided by *Japan Productivity Center* and the total population of Hokkaido ropeway transportation in every year provided by the *Hokkaido Ropeway Ski Lift Association* as a reference.

a. 71 ski resorts in the Hokkaido region



b. Transition of business status in 15 years



c. Three types of business mode

Figure 1. Research Objects in this study

4) Finally, the most challenging data collection work falls on meteorological data collection for the past 15 years. Eight variables under the bias-corrected climate scenarios over Japan based on CDFDM method using CMIP6, provided by National Institute for Environmental Studies, Japan are collected in this work:

Daily mean Temperature (°C), Daily maximum temperature (°C), Daily minimum temperature (°C), Daily precipitation(mm/day), Global solar radiation (MJ/m^2/day), Wind speed(m/s), Surface relative humidity (%), and Downward longwave radiation (MJ/m^2/day).

3. Methodology and Results

The panel data set in this research is balance panel data which means comprises all observations for each individual measured at the same time points. It includes data collected on 71 individuals, business statuses, attribute data, meteorological data, social trend index, etc. over the same time period, which is every ten-day period from 2006 to 2020 ski season. The sample size is 71 individuals $*$ 3 ten-day periods $*$ 7 months $*$ 15 years = 22365. In this model, the business status of every ten-day period was taken as the dependent variable (dummy), and comprehensive meteorological and socioeconomic data were treated as independent variables. The general equation for a logit model under panel data can be given as:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \cdots + \beta_{nX} nit + \mu_i + v_t + u_{it} \quad (1)$$

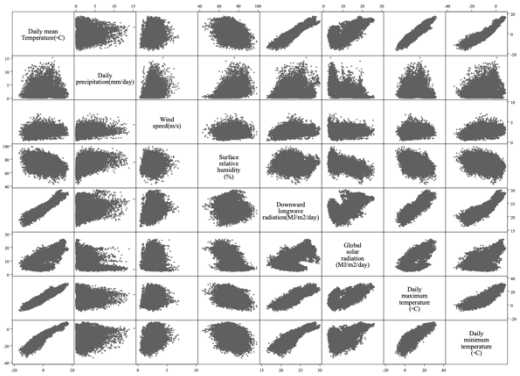
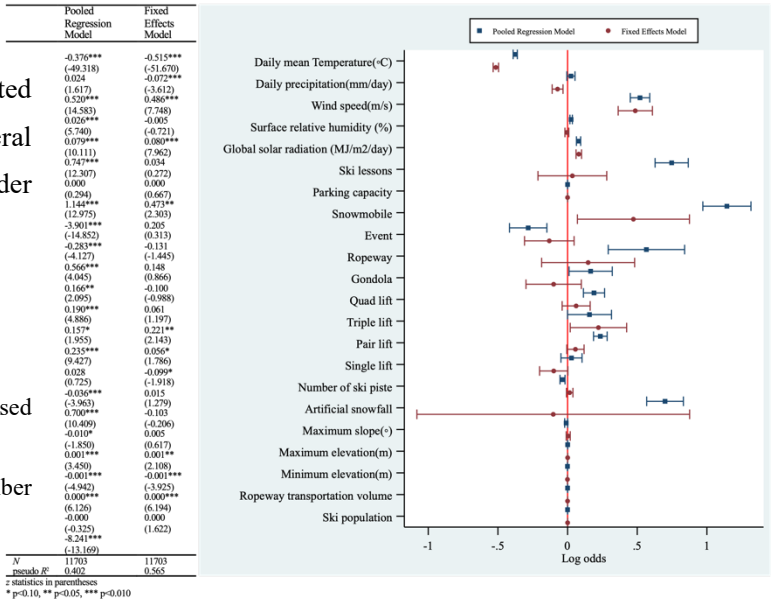


Figure 2. Correlation of climate factors

Before constructing the model, we first verified the correlation between each independent variable. **Fig.2** shows the correlation between the eight climatic factors described in the previous section. Among them, the daily mean temperature is positively correlated with the daily maximum temperature, daily minimum temperature, and downward longwave radiation. Thus, in the following model building, the daily mean temperature, daily precipitation, global solar radiation, wind speed, and surface relative humidity, these five items will be imported into the model as independent variables of climate factors. The results of the **Pooled Regression Model** and **Single-factor Fixed Effect Model** are shown in **Fig.3**. It indicated a one-degree increase in daily mean temperature will reduce the probability of a ski resort opening by 40.35 %, and a one-unit increase in daily precipitation will reduce the probability of a ski resort opening by 6.95 %.

4. Summary and Future Work

In this study, the model and analysis were conducted under the MRI-ESM2-0, one of the five general circulation models (GCMs). The comparative study under different climate models is also worth looking forward to.



	Pooled Regression Model	Fixed Effects Model
	-0.376***	-0.515***
	(-49.318)	(-51.670)
	0.024	-0.072***
	(1.617)	(-3.612)
	0.520***	0.486***
	(14.583)	(7.748)
	0.026***	-0.005
	(5.740)	(-0.721)
	0.079***	0.080***
	(10.111)	(7.962)
	0.747***	0.034
	(12.307)	(0.272)
	0.000	0.000
	(0.294)	(0.667)
	1.144***	0.473**
	(12.975)	(2.303)
	-3.901***	0.205
	(-14.852)	(0.313)
	-0.283***	-0.131
	(-4.127)	(-1.445)
	0.566***	0.148
	(4.045)	(0.866)
	0.166**	-0.100
	(2.095)	(-0.988)
	0.190***	0.061
	(4.886)	(1.197)
	0.157*	0.221**
	(1.955)	(2.143)
	0.235***	0.056*
	(9.427)	(1.786)
	0.028	-0.099*
	(0.725)	(-1.918)
	-0.036***	0.015
	(-3.963)	(1.279)
	0.700***	-0.103
	(10.409)	(-0.206)
	-0.010*	0.005
	(-1.850)	(0.617)
	0.001***	0.001**
	(3.450)	(2.108)
	-0.001***	-0.001***
	(-4.942)	(-3.925)
	0.000***	0.000***
	(6.126)	(6.194)
	-0.000	0.000
	(-0.325)	(1.622)
	-8.241***	
	(-13.169)	
N	11703	11703
pseudo R^2	0.402	0.565

z statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.010

Figure 3. Coefplot of Pooled Regression Model and Fixed Effects

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