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Article

The Empirical Test on the Impact of Climate Volatility on Tourism Demand: A Case of Japanese tourist visiting Korea

YunSeop Hwang [1], HyungSik Kim[2], Cheon Yu [3,*]

[1] Department of International Business and Trade, College of Politics and Economics KyungHee University, Seoul, Republic of Korea; rusiahys@khu.ac.kr
[2] Economic Research Institute, The Bank of Korea, Seoul, Republic of Korea; hariskim@bok.or.kr
[3] The International Trade Research Center at KyungHee University, Seoul, Republic of Korea; cheon.yu@khu.ac.kr
* Correspondence: cheon.yu@khu.ac.kr; Tel.: +82-10-9992-1961

Abstract: As climate is not only a valuable tourism resource but also a factor influencing travel experience, estimating climate change can provide implications to sustainable development of the tourism industry. This study develops Climate Volatility Index (CVI) using GARCH model and estimates the relationship between CVI and Japanese tourism demand for Korea using a tourism demand model, based on data from January 2000 to December 2013. Time lag is applied based on a decision making process regarding travel destinations. The result shows that an increase in volatility of climate change leads to a decrease in tourism demand.

Keywords: tourism demand, climate change, climate volatility, GARCH model

1. Introduction

Adapting and responding to climate change is very important in achieving sustainability of the tourism industry [1], because climate factors are tourism resources and determinants of tourism satisfaction level, both of which subsequently affect tourism demand. Therefore many studies have focused on verifying the relationship between climate change and tourism demand. Some studies utilize individual climate factors, such as the average or the extreme of precipitation and temperature, to explain how these individual climate factors affect tourism demand [2, 3]. Other studies explain the impact of climate change on tourism demand by using an index comprised of multiple indicators [4-6].

However, climate change can be estimated more efficiently when considering not only changing weather events but also the degree of the change caused by volatility clustering, which refers to how much climate change of the past affects that of the present [7]. It implies that we should analyze how climate volatility affects tourism demand, in order to better explain the impact of climate change, not how climate indicators or the changes of the average or the extreme of indexes affect tourism demand. Some studies attempted to estimate tourism demand based on climate volatility, but systematic approach to volatility has not been sufficiently made so far.

This study seeks to estimate climate volatility using Generalized Autoregressive Conditional Heteroscedasticity (hereafter, GARCH) model and verify the relationship between climate volatility and tourism demand. GARCH model is useful in estimating the existence of time-dependent variance in climatic time series [7-8]. This study develops and applies two separate climate volatility index, main GARCH Climate Volatility Index (hereafter, called mGCVI) based on precipitation, temperature, and snowfall, and GARCH Climate Volatility Index (hereafter, called GCVI) based on precipitation, temperature, snowfall, sunshine, wind speed, insolation, and humidity. This is because tourism demand can be affected not only by climate indicators primarily used in preceding studies such as precipitation, temperature, and snowfall but also by other climate indicators. Using mGCVI

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and GCVI separately would help more closely look into the relationship between climate volatility and tourism demand.

The analysis of this study is based on Japanese tourists to Korea. Korea and Japan are closely located, being suitable for studying the link between climate change and tourism demand. In 2005, 2.4 million Japanese tourists visited Korea, accounting for 40.52% of the total foreign tourists to Korea. Since then, Japanese tourists have accounted for 34.43% on average out of Korea's total foreign tourists [33]. In addition, during the same time period, 16.36% of Japanese people who went overseas headed for Korea, and the figure rose to 19.35% in 2011 [34]. Studying how climate volatility affects the tourism behaviors of Japanese tourists to Korea, therefore, would provide practical and policy implications for sustainable development of the Korean tourism industry.

The content of this study is as follows. Section two presents theoretical backgrounds and previous studies on the relationship between climate change and tourism demand including concepts regarding climate volatility. Section three develops and presents CVI and sets an analysis model. Section four presents the results of the analysis on the relationship between CVI and tourism demand based on data from January 2000 to December 2013. Section five summarizes the results and its implications and suggests its limitations and directions for future studies.

2. Theoretical background and Literature Review

2.1. Climate change and tourism demand

Climate change is a very important factor that influences tourism demand [1]. The environmental changes caused by climate change have effects on not only tourists' choice on where to visit but also word-of-mouth and their intention to revisit the destination, by forming their experience through tourism activities [9]. Previous studies on climate change and tourism demand are categorized into those using individual climate indicators and those using an index created based on multiple climate indicators. Studies that use individual climate indicators verify the impacts of climate change centering on temperature and precipitation. Specifically, Maddison [2] conducts a study on British tourists using temperature and precipitation as climate indicators and finds that both temperature and precipitation have influences on tourism demand. In Maddison's study, temperature shows a reversed-U shape, and the most preferred temperature is 30.7℃, although the number of visits slightly declines at that point. Lise & Tol [3] carry out a study of tourists from OECD member countries and estimate the relationship between climate change and tourism demand by using temperature and precipitation as climate variables. The results show that temperature and precipitation both affect tourism demand. The study also estimates that temperature shows a reversed-U shape, and the most preferred temperature is 21℃ on average. According to a study of Chinese tourists to Korea conducted by Hwang et al. [10], a moderate increase in the average temperature positively affects tourism demand, and tourism demand is more influenced by precipitation than by temperature when it comes to extreme weather events. In a study that used temperature as a climate indicator, Koenig & Abegg [11] argue that a 2℃ increase of temperature lowers the proportion of ski resorts in Switzerland down to 65%. These studies based on individual climate indicators are useful in estimating the direct influences of climate indicators but are limited in estimating the overall impacts of climate change because tourists' choice on travel destinations is reflected by their response to more various climate factors.

Research on Tourism Climate Index (hereafter, TCI) is one of the most representative studies that make climate indicators into an index and verify its relationship with tourism demand. TCI, an index based on the climate environments of tourist destinations, standardizes and combines five climate indicators such as daytime comfort index, day comfort index, precipitation, the duration of sunshine, and wind speed [12]. TCI ranges from -20 to 100, and tourist destinations with a higher TCI are better for tourist activities. The estimation of the changes of TCI is useful in figuring out how tourism demand in a specific region will change. By comparing Canada's past TCI and future TCI based on climate scenarios, Scott & McBoyle [6] estimate that tourism demand will increase in

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Western Canada and decrease in Eastern Canada. Through a TCI simulation, Amelung et al. [4] estimate and suggest the changing patterns of tourism demand depending on climate change. Moore [5] looks into the Caribbean regions and estimates that changing TCI has an influence on the attractiveness of tourism destinations, consequently affecting tourism demand. TCI, however, also has limitations in that each tourist has different views of optimal climate conditions, and that no direct relationship is proven between climate change and tourism demand [5, 13].

2.2. The relationship between climate volatility and tourism demand

Before discussing the relationship between climate volatility and tourism demand, the concepts of climate, climate change, and climate volatility should be clarified first. Climate refers to the average weather condition during a certain period of time regularly repeating in a certain region with a specific distribution. Climate change refers to changes in this weather event distribution, which is a set of physical phenomena taking place in the atmosphere of a certain area. Climate volatility refers to how much these changes of weather events change. Volatility is actually a concept that originated from econophysics, and the higher the volatility, the more the price changes [14-15]. When applying this concept of volatility to climate, we can figure out that climate indicators show heteroscedasticity based on time series [7, 16]. It means that when volatility is not considered in estimating climate change, the statistical characteristics of climate indicators cannot be fully reflected. Therefore, in order to estimate climate change more efficiently, studies should consider volatility clustering that refers to a phenomenon where climate volatility of the past affects that of the present [17].

Climate volatility affects tourism demand in two ways. First, tourism demand is affected through tourists' expectations on travel destinations. Tourists choose travel destinations based on their expectations toward the region. These expectations are determined by tourists' perception of the region, and one of the variables that affect their perception is the region's climate [18-19]. By changing tourists' expectations, climate change can influence their choice of travel destinations, thereby affecting tourism demand. In this process, an increase in climate volatility makes it difficult for tourists to make predictions about their possible travel destinations. To avoid heightened uncertainties, they end up choosing alternative destinations with lower levels of climate volatility and uncertainties [20]. This is how an increase in climate volatility negatively affects tourism demand. Second, tourism demand is affected through tourist experience. Tourists' experience is determined by their activities in travel destinations, and climate plays an important role in outdoor activities. In a study of tourists to Scotland conducted by Smith [21], 20% of the visitors cite climate as the cause of their dissatisfactory travel experience. An increase in climate volatility implies tourists' higher possibility of encountering unexpected climate events during their travel. These unexpected climate events directly affect tourists' experiences and satisfaction, and subsequently their reviews and willingness to revisit the region, thereby affecting tourism demand.

Another factor that should be considered when estimating the relationship between climate volatility and tourism demand is time-lag. The choice of tourist destinations is the result of individuals' free decision-making process. To choose where to visit, tourists collect various kinds of information and make plans based on the information they gathered [22]. Potential tourists choose a certain region when the gathered information says the region's climate is suitable for travel. On the other hand, when the information says climate is not desirable for travel due to weather events owing to climate change, they choose other regions or adjust the timing of their travel to avoid such weather events [3]. Thus, tourism demand of the present is formed based on the information that was gathered a certain amount of time ago. According to a study conducted by Money & Crotts [23], Japanese tourists decide whether to travel 66 days prior to their departure date, while German tourists do so 131 days ago. Also, Japanese tourists book flights 35 days prior to their departure, while German tourists do so 89 days ago. What this implies is that climate volatility has an impact on tourism demand with a certain amount of time gap.

Although some studies attempted to verify the impact of the volatility of climate indicators on tourism demand, the volatility side still requires a more systematic approach. Agnew & Palutikof [24] confirms the impact that how much temperature, precipitation, and sunshine deviate from the

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average has on tourism demand in the Britain. The results show that an increase in precipitation negatively affects tourism demand, and that tourism demand is most sensitive to the volatility of climate indicators in March and April. Cin & Hwang [25] also carry out a study of Japanese tourists to Korea to find out the relationship between climate volatility and tourism demand. Their model using daily average temperature and daily highest temperature show that an increase in temperature boosts tourism demand among Japanese tourists to Korea, while volatility does not have the same effect.

This study seeks to use GARCH model to develop a climate volatility index that considers the changes of climate indicators depending on time. GARCH model enables us to identify the second moments of variability of climate indicators and provides us with time-continuous series of GARCH variance that can be used to estimate the effect of climate volatility on the economic variables such as output or business activities. It is also advantageous as it can reflect extreme weather events.

2.3. Control Variables

In order to estimate the impact of climate volatility on tourism demand, this study sets income and travel cost as control variables based on previous studies. An increase in tourists' income implies an increase in their purchasing power, which positively affects tourism demand. Most studies on tourism demand show that income is the most influential variable affecting tourism demand [26, 27]. GDP, national income, disposable income, index of industrial production are mainly used in measuring tourists' income. This study uses Japan's index of industrial production as a proxy variable for monthly analysis. Index of industrial production, an index that refers to the level of industrial production activities during a certain period of time, moves in line with the overall economic trend, so it well reflects changes in income. Another control variable is travel cost. An increase in travel cost reduces tourism demand, and a decrease in travel cost increases tourism demand. Travel cost is comprised of transportation costs and other expenses in tourist destinations, but the recent trend excludes transportation cost in tourism demand studies due to multicollinearity with income and problems with measurement methods [28-29]. So this study excludes transportation costs and reflects other expenses in tourist destinations, applying the ratio of Korea's Consumer Price Index to that of Japan and adjusting exchange rates in the measurement. A low travel cost in Korea implies that Japan's Consumer Price Index is relatively higher than that of Korea after adjusting exchange rates.

3. Research Model

3.1. The development of Climate Volatility Index

Based on preceding research, seven climate indicators expected to affect the tourism industry are chosen for the estimation of CVI. The indicators are precipitation, temperature, wind speed, sunshine, snowfall, insolation, and humidity. Precipitation, temperature, and snowfall are core climate variables, and insolation, wind speed, sunshine, and humidity are the variables that are mainly included in studies on tourists' perception of climate. This study employs an index called mGCVI that consists of three core climate indicators and another one called GCVI consisting of all the seven indicators. This will help figure out which volatility index is more suitable for explaining the changes of tourism demand. The operational definitions of each variable are as follows. The data used in this study is daily data observed for 24 hours (every one hour) at 79 observation points nationwide, obtained from national climate data center operated by Korea Meteorological Administration. The period of analysis is 168 months from January 2000 to December 2013.

We estimate a climate volatility index using an econometric method. We calculate the increase or decrease of each of the seven climate indicators compared to the same month in the previous year for the period from 2000 to 2013. And then we obtain GARCH Variance by applying the GARCH model, provided that we use estimated volatility from January 2000 to December 2013 by removing

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discrepancies and outliers of data. The GARCH (q,p) model applied for the estimation is as follows. The first formula is an average equation which has a constant term (c) and a standard error (ε_t). The second formula is a conditional variance equation, which is defined as ARCH (ε_{t-p}^2) with a constant term (ω) and p lag of standard error and GARCH (σ_{t-q}^2) which is a conditional variance of predicted error that has q lag. The value that refers to climate volatility is GARCH Variance (σ_t^2) that is estimated from this formula.

$$Y_t = c + \varepsilon_t$$
$$\sigma_t^2 = \omega + \sum^q \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \qquad (1)$$

The volatility estimation results under the GARCH model are shown in Table 2, which shows that all of the seven indicators have statistically significant volatility.

Table 1. Results of GARCH analysis

Indicator	Precipitation	Temperature	Wind speed	Insolation	Snowfall	Sunshine	Humidity
ARCH(-1)^2	0.4120** (0.0777)	-0.0103 (0.0170)	0.0946 (0.1176)	0.2769** (0.1052)	0.5292** (0.0754)	0.1379* (0.0703)	0.0446 (0.0501)
ARCH(-1)^2 *(ARCH(-1)<0)							-0.0585* (0.0250)
ARCH(-2)^2			-0.1513 (0.1126)		-0.4563** (0.0656)	-0.1104 (0.0717)	-0.0232 (0.0499)
GARCH(-1)	0.2068** (0.0517)	0.8280** (0.3206)	0.7821** (0.2059)	0.5283† (0.2713)	0.8237** (0.0367)	0.9607** (0.0314)	0.9724** (0.0248)
Adjusted R^2	0.0021	0.0020	0.0020	0.0006	0.0021	0.0017	0.0016
Durbin-Watson	1.8974	1.4789	2.0908	1.4687	1.78736	1.5988	1.6720

( ) refers to standard deviation, †= 90% of statistical significance, *= 95% of statistical significance, **= 99% of statistical significance.

In order to estimate climate volatility index under the GARCH model, each of GARCH variance of the seven indicators is standardized to have values ranging from 0 to 1, and then we obtain composite volatility indexes under the GARCH model through linear combination. In this study, two types of CVIs are employed for estimation. GCVI is a linear combination of the seven climate indicators, and mGCVI is a combination of precipitation, temperature, and snowfall. <Figure 1> is a graph showing the trend of GCVI and mGCVI during analysis period. To verify normality of the time series, the ADF (Augmented Dickey-Fuller) unit root test was performed. The results found that neither of GCVI (t=-7.2462***) or mGCVI (t=-7.5469***) has a unit root.

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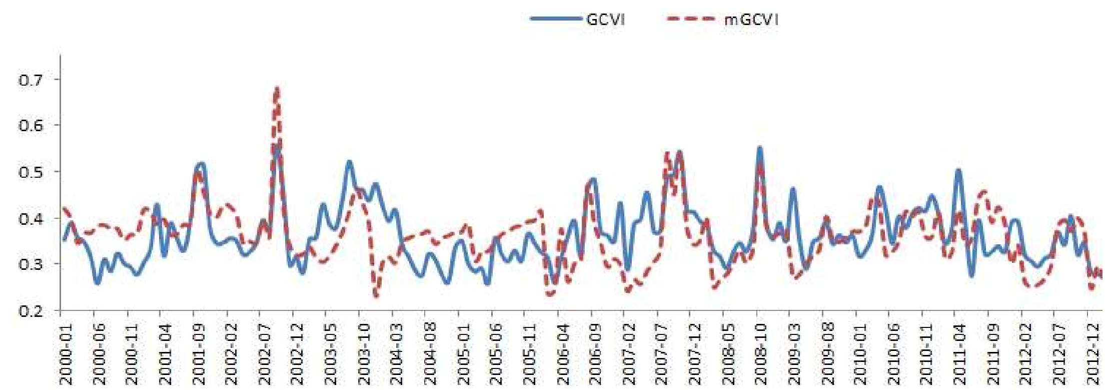

Figure 1. The trend of Climate Volatility Index. Source: Author's own elaboration.

3.2 Tourism Demand Model

In order to verify the relationship between climate volatility and tourism demand, this study sets a study model as shown in (2) using a Tourism demand model. $\ln(Y)_t$ refers to a log transformation of the number of Japanese tourists visiting Korea at time t. $Income_t$ refers to the income of Japanese tourists at time t. $ReCost_t$ refers to the relative travel cost at time t. CVI_t refers to Korea's Climate Volatility Index at time t.

$$\ln(Y)_t = \alpha + \delta_1 CVI_t + \beta_1 Income_t + \beta_2 ReCost_t + \varepsilon_t \quad (2)$$

Tourism demand is expected to be autoregressive, and the past values of income, relative travel cost, and climate volatility, which are explanatory variables, are expected to affect tourism demand in the present. So we modify equation (2) by applying Autoregressive and Distributed Lags (ARDL) model as shown in equation (3). ARDL model is a dynamic model that considers time lags distribution by reflecting not only time lags of dependent variables but also multiple time lags of explanatory variables into regression equations [30]. So the autocorrelation of error term of time series data is alleviated, and a more efficient estimation becomes possible. Adding a time lag variable to the model can provide better explanations thanks to the added information. But at the same time, it could increase the distribution of the estimated value. Therefore, we apply AIC (Akaike Information Criterion) and determine the time lag model by considering the advantages and disadvantages of adding time lag variables.

$$\ln(Y)_t = \alpha + \gamma_1 \ln(Y)_{t-1} \cdots \gamma_p \ln(Y)_{t-p} + \beta_1 Income_t + \beta_2 Income_{t-1} + \beta_l Income_{t-l} + \delta_1 ReCost_t + \delta_2 ReCost_{t-1} + \delta_m ReCost_{t-m} + \theta_1 CVI_t + \theta_2 CVI_{t-1} + \theta_n CVI_{t-n} + \varepsilon_t \quad (3)$$

3.3 Data

The data used in this study are as follows. Daily climate observation data from January 2000 to December 2013 offered by the National Meteorological Office are transitioned into monthly average and used to calculate CVI using GARCH model. Tourism demand is measured based on the number of Japanese nationals who visited Korea from January 2000 to December 2013 derived from monthly statistical data of Korea Tourism Organization. Income was based on the index of industrial production in 2010 offered by Japan's Ministry of Economy, Trade and Industry. The Consumer Price Index of Korea and Japan that are used to calculate relative travel cost are based on the data of 2010

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provided by the national statistical office of each country. Exchange rates are based on KRW/JPY rates from the Ministry of Strategy and Finance.

Table 2. Operational Definition of variables

Variables	Operational Definition	Data Source
ln(Y)	Number of Japanese tourists at t	Korea Tourism organization
Income	Industrial Production Index at t	Japan's Ministry of Economy, Trade and Industry & Korea's Ministry of Strategy and Finance
ReCost	Relative Travel Cost, {(KRW/JYP)* Consumer Price Index of Japan)}/CPI of Korea at t	
mGCVI	CVI based on precipitation, temperature, and snowfall at t	
GCVI	CVI based on precipitation, temperature, wind speed, insolation, snowfall, sunshine, and humidity at t	

4. Results

4.1 Descriptive statistics

The analysis results of descriptive statistics are as follows. The monthly average of the number of Japanese tourists to Korea from January 2000 to December 2013 is 216,909.9 with the lowest of 83,228 and the highest of 360,719. The standard deviation is 48,586.21. The average income is 102.1268 with the lowest of 89.9 and the highest of 118.4. The standard deviation is 5.2936. The average relative travel cost is 1231.05 with the lowest of 840.66 and the highest of 1654.65. The standard deviation is 193.07. The average of mGCVI and GCVI are 0.3805 and 0.3125 with the lowest of 0.1820 and 0.2076 and the highest of 0.6329 and 0.5053, respectively. The fluctuation of mGCVI is greater than that of GCVI.

Table 3. Summary of descriptive statistics (n=168)

Variable	Mean	Std.	Min.	Max.
No.of Tourist visiting Korea	216,909.9	48,586.21	83,228	360,719
Income	102.1268	5.2936	89.9	118.4
Relative Travel Cost	1231.05	193.07	840.66	1654.65
mGCVI	0.3085	0.0632	0.1820	0.6329
GCVI	0.3125	0.0633	0.2076	0.5053

4.2 Analysis results

Prior to analyzing the relationship between climate volatility and tourism demand, a test is conducted to determine time lag, considering the autocorrelation of dependent variables and independent variables. First, we apply time lags for tourism demand ranging from t-1 to t-3. The comparison results show that including up to t-3 can minimize AIC. To determine the time lag of independent variables, we apply time lag models starting from t-1 to income and relative travel cost. The results show that the goodness of the model is high when t is included for $Income_t$ and $ReCost_{t-1}$. Estimation in the same method shows that including t-2 for mGCVI and t-3 for GCVI minimizes AIC.

Table 4. AIC Results

Variable	Time lags	Variable	Time lags
ln(Y)	3	mGCVI	2
Income	0	GCVI	3
ReCost	1		

Based on these test results, we set our analysis model as follows. Equation (4) intends to estimate the impacts of mGCVI, and equation (5) intends to estimate those of GCVI.

$$\ln(Y)_t = \alpha + \gamma_1 \ln(Y)_{t-1} \cdots \gamma_3 \ln(Y)_{t-3} + \beta_1 Income_t + \delta_1 ReCost_t + \delta_2 ReCost_{t-1} + \theta_1 mGCVI_t + \theta_2 mGCVI_{t-1} + \theta_3 mGCVI_{t-2} + \varepsilon_t \quad (4)$$

$$\ln(Y)_t = \alpha + \gamma_1 \ln(Y)_{t-1} \cdots \gamma_3 \ln(Y)_{t-3} + \beta_1 Income_t + \delta_1 ReCost_t + \delta_2 ReCost_{t-1} + \theta_1 GCVI_t + \theta_2 GCVI_{t-1} \cdots \theta_4 GCVI_{t-3} + \varepsilon_t \quad (5)$$

Before analyzing the relationship between mGCVI and tourism demand, we conduct a multicollinearity diagnosis on equation (4). The VIF of t and t-1 of travel cost is over 10, which means there is multicollinearity. So we conduct a regression analysis excluding $ReCost_{t-1}$. We also conduct an autocorrelation test of error term using Breusch-Godfrey and find the first-order autocorrelation in error term. As a result, we modify equation (4) into equation (6) to estimate the relationship between mGCVI and tourism demand, excluding $\ln Y_{t-2}$ and $\ln Y_{t-3}$.

$$\ln(Y)_t = \alpha + \gamma_1 \ln(Y)_{t-1} + \beta_1 Income_t + \delta_1 ReCost_t + \theta_1 mGCVI_t \cdots + \theta_3 mGCVI_{t-2} + \varepsilon_t \quad (6)$$

The explained variance of equation (6) applied with mGCVI is 65.53%, and Durbin-Watson value is 1.91, which implies that there is no autocorrelation. Looking at the analysis results more specifically, tourism demand shows no significant relationship with $mGCVI_t$ and $mGCVI_{t-1}$, but shows a negative relationship at $mGCVI_{t-2}$. It means that the volatility of core climate indicators two months ago decreases tourism demand in the present. This result is in conformity with the study results of Money & Crotts (2003) that say Japanese tourists generally make travel decisions two months prior to their departure. Meanwhile, $\ln Y_t$ shows a positive relationship with $\ln(Y)_{t-1}$ and $Income_t$ and $ReCost_t$ display a positive relationship with $\ln(Y)_t$. This means that an increase in Japanese tourists' income leads to an increase in tourism demand to Korea, and a decrease in relative travel cost in Korea also has the same effect, which conforms to the results of previous studies (Dritsakis, 2004; Daniel & Ramos, 2002).

Prior to analyzing the relationship between GCVI and tourism demand, we conduct a multicollinearity diagnosis on equation (5). The analysis results show that VIF of $ReCost_t$ and $ReCost_{t-1}$ is over 10, so we exclude $ReCost_{t-1}$ from our analysis. We also test an autocorrelation of error term using Breusch-Godfrey. Excluding t-2 and t-3 of ln(Y) and $GCVI_{t-3}$ where we find the first-order autocorrelation in error term, we modify equation (5) to equation (7) in order to estimate the relationship between GCVI and tourism demand.

$$\ln(Y)_t = \alpha + \gamma_1 \ln(Y)_{t-1} + \beta_1 Income_t + \delta_1 ReCost_t + \theta_1 GCVI_t \cdots + \theta_3 GCVI_{t-2} + \varepsilon_t \quad (7)$$

The explained variance of equation (7) applied with GCVI is 64.58%, and Durbin-Watson value is 1.83, which implies that there is no autocorrelation. A closer look into the analysis results shows that there is no significant relationship between GCVI and tourism demand. $\ln(Y)_t$ shows a positive relationship with $\ln Y_{t-1}$, and $Income_t$ and $ReCost_t$ show a positive relationship with $\ln(Y)_t$. These

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results imply that an increase in Japanese tourists' income leads to an increase in tourism demand to Korea, and a decrease in relative travel cost of Korea also has the same effect, which conforms to the results of previous literatures [31-32].

While mGCVI and tourism demand show a significant relationship, we find no such relationship between GCVI and tourism demand. We estimate that this is attributable to how people actually feel about climate indicators and also to the fact that Japanese tourists mostly visit large cities. While temperature and rainfall have direct impacts on tourists' activities, humidity, insolation, sunshine, and wind speed have less direct impacts on tourism compared to those of temperature and rainfall. Another explanation might be that weather forecasts mainly focus on temperature and rainfall [22]. Insolation, wind speed, sunshine, and humidity are not included in general weather information, so they rarely affect tourists' decision making.

Table 5. The Effects of CVI on Tourism Demand

mGCVI		GCVI	
Variables	Coef.	Variables	Coef.
$\ln(Y)_{t-1}$	0.7809*** (0.0475)	$\ln(Y)_{t-1}$	0.7648*** (0.0483)
$Income_t$	0.9030*** (0.2379)	$Income_t$	0.8189*** (0.2377)
$ReCost_t$	0.2331*** (0.0766)	$ReCost_t$	0.2275*** (0.0748)
$mGCVI_t$	0.1844 (0.1920)	$GCVI_t$	0.0881 (0.1974)
$mGCVI_{t-1}$	0.2558 (0.2119)	$GCVI_{t-1}$	-0.0903 (0.2206)
$mGCVI_{t-2}$	-0.4244** (0.1953)	$GCVI_{t-2}$	-0.1936 (0.1981)
Adj R^2	0.6553	Adj R^2	0.6458
Obs	166	Obs	166
Durbin-Watson	1.91	Durbin-Watson	1.83
Mean VIF	1.37	Mean VIF	1.37

5. Summary and Implications

This study conducts an empirical analysis using monthly data from January 2000 to December 2013 in order to verify the impacts of climate volatility on tourism demand. Based on the distribution that was estimated using GARCH model, we develop GCVI that consists of precipitation, temperature, wind speed, insolation, snow fall, sunshine, and humidity and mGCVI that consists of precipitation, temperature, and snow fall in order to find out their impacts on tourism demand as well as the impacts of income and relative travel cost on tourism demand. To reflect time lag of dependent variables and independent variables into the model, we use Autoregressive and Distributed Lags, and based on AIC, set an analysis model that includes t-3 for tourism demand, t for income, t-1 for relative travel cost, t-2 for mGCVI, and t-3 for GCVI. We conduct the empirical analysis, excluding variables that exhibit multicollinearity and autocorrelation in error term. Our results show that $\ln(Y)_{t-1}$, $Income_t$, $ReCost_t$ all have a positive relationship with $\ln(Y)_t$. An increase in the income of Japanese tourists leads to an increase in tourism demand to Korea. Also, a decrease in

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travel cost in Korea leads to an increase in tourism demand to Korea. We also find that an increase in tourism demand of the preceding period positively affects that of the current period. However, the two types of climate volatility indexes show different results. While mGCVI shows a negative relationship with tourism demand at t-2, GCVI shows no significant relationship with tourism demand.

The implications of this study are as follows. First, tourism services should be able to reflect climate volatility. An increase in climate volatility leads to a decrease in tourism demand. Specifically, greater climate volatility undermines the attractiveness of tourist destinations and the satisfaction of tourism experiences, thereby negatively affecting tourism demand [9]. Therefore, providers in the tourism industry should consider not only the average and extreme climate events but also the volatility of climate events when discussing how to respond to climate change. For example, tourism service providers could reduce the influence of climate on tourism attractiveness by expanding indoor tourist activities. Also, they could develop tourism services which can address unexpected inconveniences caused by climate volatility and provide them to major tourist attractions and facilities. Adding a climate-related item to the International Visitor Survey annually conducted by Korea Tourism Organization could help tourism service providers closely monitor changes in the perception and attitudes of foreign tourists. By reflecting the results into their services, providers will be able to efficiently respond to changes in tourism demand owing to climate volatility. Second, this study offers a new climate index regarding tourism. While TCI [12] is useful in the evaluation of the climate environment of tourist destinations, it is limited in providing explanations for changes in tourism demand caused by climate change [5, 13]. Individual climate indicators also have limitations as they cannot reflect the reality where tourists' perception of climate is influenced by various factors. CVI suggested in this study consists of various climate indicators and show climate volatility in the form of an index. If used together with TCI and individual climate indicators when estimating the relationship between climate change and tourism demand, CVI could provide a more comprehensive understanding of the relationship by addressing the limitations of existing studies. Lastly, this study applies the concept of volatility to climate change. Studies on volatility enable a more efficient estimation by separately looking at intrinsic changes and changes caused by trends. Although climate indicators show heteroskedasticity with time, they have been discussed in a limited manner in the existing studies. This study applies volatility to climate change by making how much time series variables deviate from the changes of trends into an index using GARCH model and separately proving intrinsic climate change and climate change caused by trends. By using GARCH model, this study reflects non-linear characteristics of climate indicators caused by time series [8].

The limitations of this study are as follows. This study uses climate variables that are expected to affect tourists' decision such as wind speed, insolation, sunshine, and humidity, but fails to consider the direct tourist's perception about climate volatility. Climate is an important factor in deciding tourist destinations, but some destinations are chosen despite their bad weather according to previous studies [19]. Therefore, considering the perception of tourists, the relationship between climate variability and tourism demand can be estimated more efficiently. This study is also limited in reflecting various control variables that affect tourism demand. In particular, regions that can replace tourist destinations should be considered because when an attractive tourist destination emerges, tourism demand for neighboring regions is undermined [29]. Therefore, future studies should examine the relationship between climate volatility and tourism demand with consideration of tourists' perspective and competing tourist destinations.

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