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Article

Weather conditions and tourism demand: A tested by threshold regression in 5 major tourism destinations in Thailand

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Abstract: The objective of this study is to explore the relationship between changing weather conditions and tourism demand in Thailand across five selected provinces: Chonburi (Pattaya), Surat Thani, Phuket, Chiang Mai, and Bangkok. The annual data used in this study from 2012 to 2022. The estimation method is threshold regression (TR). The results indicate that weather conditions proxied by the Temperature Humidity Index (THI) significantly affect tourism demand in these five provinces. Specifically, changes in weather conditions, such as an increase in temperature, generally result in a decrease in tourism demand. However, the impact of weather conditions varies according to each province's unique characteristics or highlights. For example, tourism demand in Bangkok is not significantly affected by weather conditions. In contrast, provinces that rely heavily on maritime tourism, such as Chonburi (Pattaya), Phuket, and Surat Thani, are notably affected by weather conditions. When the THI in each province rises beyond a certain threshold, the demand for tourism in these provinces by foreign tourists decreases significantly. Furthermore, economic factors, particularly tourists' income, significantly impact tourism demand. An increase in the income of foreign tourists is associated with a decrease in tourism in Pattaya. This trend possibly occurs because higher-income tourists tend to upgrade their travel destinations from Pattaya to more upscale locations such as Phuket or Surat Thani. For Thai tourists, an increase in income leads to a decrease in domestic tourism, as higher incomes enable more frequent international travel, thereby reducing tourism in the five provinces. Additionally, the study found that the availability and convenience of accommodation and food services are critical factors influencing tourism demand in all the provinces studied.

Keywords: tourism demand; temperature humidity index; threshold regression; Thai tourism

1. Introduction

Travel and tourism is one of the fastest-growing industries and a vital source of employment globally. The World Travel and Tourism Council (WTTC) projected that the sector's contribution to GDP will reach 9.2% of global GDP by the end of 2023, a 23.3% increase from 2022. WTTC also forecast that the travel and tourism sector will create 24 million new jobs, bringing the total to 320 million by the end of 2023. Moreover, in many developing countries, the proportion of tourism is of great significance for economic growth. It is estimated that domestic tourism plays a crucial role in sustainable development goals (Hall et al., 2015; World Bank, 2017). This is because the tourism sector contributes to employment, poverty reduction, and promotes sustainable development (Scheyvens and Hughes, 2018; UNWTO, 2017; World Bank, 2017). Thailand, now, being an emerging tourism destination leading the Travel and Tourism sector is significantly contributes to economic growth. The total

contribution of travel and tourism to Thailand's GDP was 1,740.6 billion baht in 2022 (10.1% of GDP). It is forecasted to rise by 37.4% in 2023, reaching 2,391.0 billion baht (62.8 billion USD) and accounting for 13.3% of GDP (WTTC, 2023). In terms of employment, the sector provided 6,993,462 jobs in 2022 (17.9% of total employment) and is expected to create approximately 7.29 million jobs, accounting for 18.6% of total employment in 2023 (WTTC, 2023).

Another important issue currently being addressed is climate change. Climate change generally refers to the increase in surface temperatures observed since the mid-20th century, primarily caused by human activities (IPCC, 2013). The IPCC (2023) report states that the average temperature of the Earth's surface is now approximately 1.1 ℃ warmer than it was in the late 1800s. The global surface temperature was 1.09 [0.95 to 1.20] ℃ higher in 2011–2020 than in 1850–1900. Thailand, according to a joint report from the World Bank Group (WBG) and Asian Development Bank (ADB) published in 2021, is identified as highly susceptible to climate variability and change. This vulnerability is attributed to the escalating occurrence of natural hazards such as heavy rainfall, floods, and droughts, alongside the adverse impacts of rising sea levels along the country's coasts. Over the period spanning 1991 to 2020, Thailand experienced a mean annual temperature of 26.3 ℃. The temperature exhibited a seasonal variation of 5.7 ℃, with lows recorded at 23.2 ℃ and highs reaching 28.9 ℃. Weather conditions particularly in rising temperatures, precipitation and changing rainfall patterns is also affecting both the world and Thailand's natural attractions. For example, coral bleaching, caused by warmer ocean temperatures, has damaged the country's famed coral reefs, as in the Andaman Sea. As a result, snorkelers and scuba divers are welcomed with bleached, lifeless coral instead of the vibrant underwater ecosystems they once enjoyed. This decline in marine biodiversity not only diminishes the tourist experience but also presents a significant threat to the economic sustainability of local communities reliant on marine tourism. Furthermore, tourists may be deterred by the prospect of sweltering heat or unexpected rain showers, leading to fluctuations in visitor numbers and revenues for businesses reliant on tourism.

The impacts of climate change on tourism is overall a well-interpreted topic in the current scientific literature (Becken, 2013; Becken and Hay, 2012; Scott et al., 2016). Tourism sector is highly vulnerable to natural resource dependency, especially concerning climate change, as emphasized by the IPCC in 2007. Furthermore, temperature shifts not only affect destination selection but also alter the timing of travel, emphasizing the role of seasonality in tourism decision-making processes. NA Ngxongo (2021) found that climate change is a key influence on tourists' decision-making, behavior and spending habits at tourist destination.

The tourism sector faces a series of socio-economic consequences, including a decline in the number of tourists and shortened stays, leading to reduced expenditure. This, in turn, results in an income reduction in the travel and tourism sector and diminishes opportunities to create employment. Additionally, there's a direct impact on locally produced goods and services, such as foods, handicrafts, and cultural performances, with decreased demand leading to income reduction. The repercussions extend to urban accommodation facilities and associated activities, experiencing knock-on effects as occupancy rates decline. Thus, climate change presents substantial challenges to the tourism industry because there is a direct relationship between rising

temperatures and a decline in the attractiveness of tourist destinations. (Agnew and Palutikof, 2006; Frimpong et al., 2020; Jørgensen and Solvoll, 1996; Tucker and Gilliland, 2007).

Becken et al. (2019) used the Climate Change Risk Assessment (CCRA) to identify existing and future climate change risks for the Thai tourism sector, highlighting impacts such as sea level rise, increased average temperatures, extreme weather events, and ocean acidification. They identified five key risks, including reduced visitor comfort and destination competitiveness due to hotter temperatures. De Freitas (2003) emphasized the importance of weather conditions in attracting tourists, suggesting an optimal range, while severe weather can deter tourism. However, defining thresholds for unfavorable conditions, particularly excessive heat, remains debated (Rutty and Scott, 2010). They noted differing perceptions among beach tourists and city sightseers on what constitutes 'too hot' with thresholds at 36 ℃ for beach tourists and 30 ℃ for city sightseers. These perceptions are significantly influenced by tourists' expectations of temperature comfort. This variability in temperature thresholds poses challenges for tourists' decision-making in tourism management.

One of the challenges hindering the understanding of tourism development resulting from climate change's implications on the competitiveness and sustainability of Thailand's tourism sector is the lack of assessment or consideration of the range of possible impacts arising from weather conditions change, which might influence tourists' travel decisions. Thailand, with tourism contributing approximately 11% to its GDP, is significantly affected by an increasing in temperatures across various regions. Over the past few years, Thailand's temperatures have been on average increasing. Therefore, analyzing tourists' demand for Thailand in light of the increasing temperatures and precipitation due to weather conditions change is crucial to understanding whether tourists choose Thailand as their destination. This constitutes the study's goal. If rising temperatures indeed influence destination choices, determining the temperature threshold used in tourists' decision-making to select Thailand as their travel destination becomes essential. This threshold could significantly impact tourism decisions, either in favor of choosing or switching away from Thailand as a destination. While there is a large volume of academic literature, particularly in terms of weather conditions impacts on tourism, for Thailand, we still have not found a study that tries to find the effect of weather conditions change once a certain temperature threshold is reached. Variations in weather conditions below or above this threshold may result in divergent impacts, thereby giving rise to a non-linear relationship between weather conditions change and its effect on the demand for Thai tourism. Consequently, identifying the temperature threshold in tourists' decision-making regarding Thailand as their destination could serve as a valuable tool for informing strategic tourism development in the future. Therefore, the aim of this paper is to investigate the interaction between changing weather conditions and tourism demand. This will be done by utilizing the Temperature-Humidity Index (THI) and employing threshold regression analysis to identify the threshold temperature that affects tourism demand.

The rest of the paper is organized as follows: Section 2 provides a literature review on the impact of changing weather conditions on tourism demand and weather

condition indices. Section 3 describes the data used, the model and estimation method employed, and the study's hypothesis. Section 4 presents the results. Section 5 discusses the findings. Sections 6 and 7 offer the conclusion and policy recommendations. Finally, Section 8 provides limitations and suggests areas for further study.

2. Literature review

Tourism demand modeling plays a crucial role in understanding the factors influencing tourist arrivals and predicting future trends in tourist behavior. Understanding the factors that determine the demand for tourism is crucial for all stakeholders in the tourism industry. Therefore, there are numerous empirical studies have examined the relationship between tourism demand and various explanatory variables such as tourists' income, exchange rate, and transportation cost (Puah et al., 2022, Ulucak et al., 2020, Soh et al., 2022). Crouch (1994), Lim (1997), Morley (2000), Song and Li (2008) have comprehensively and extensively complied the factors that affect tourism demand. The key determinants of tourism demand can be summarized into two categories, economic and non-economic factors. Economic factors usually represent as tourist's income, exchange rate, price levels, transportation cost, and political and economic stability. Non-economic factors are population growth, education, cultural, climate and seasonality, government policies, and health and safety. Moreover, in present day, weather conditions are a crucial factor influencing the demand for tourism.

Specific to the weather conditions, there are numerous empirical studies have examined the relationship between tourism demand and weather conditions with significant contributions from researchers such as such as Mieczkowski (1985), Scott and McBoyle (2001), Hamilton et al. (2005), Gossling and Hall (2006), Amelung et al. (2007), Becken (2010), Perch-Nielsen et al. (2010), Rutty and Scott (2010), Kajan and Saarinen (2013), Moore et al. (2013), Falk (2014), Hein et al. (2019), Setanah and Fanzel (2019). These studies consistently indicate that weather conditions significantly influence tourists' decisions regarding their travel destinations and timing. Key weather factors affecting tourism include temperature, relative humidity, wind speed, and rainfall. Tourists generally prefer destinations with mild to warm temperatures, as higher temperatures tend to reduce the number of visitors. Similarly, high humidity and heavy rainfall deter tourists, especially those interested in outdoor activities. Additionally, many studies have demonstrated the effects of changing climatic conditions, particularly rising temperatures and precipitation, on tourism demand (Gómez Martín, 2005; Scott et al., 2004). Additionally, studies by Hein et al. (2009), Maddison (2001), Perry (2006), and Amelung et al. (2007) highlights the increased risks associated with rising temperatures, such as heatwaves, which particularly affect tourism in the Mediterranean region.

Studies have explored the interrelationships between climate change and tourism, including reviews of its influence on international tourism (Scott et al., 2012) and tourism in specific geographic regions, such as Austria (Gühnemann et al., 2021), Indonesia (Satyawan et al., 2021), the Nordic countries (Hall and Saarinen, 2021), and small island developing states (SIDS) (Pedapalli et al., 2022).

Furthermore, many studies have responded to the impact of climate change on tourism demand by developing a multitude of indices aimed at quantifying the influence of temperature on tourist preferences, such as Mieczkowski's (1985) developed Tourism Climate Index (TCI) and Holiday Climate Index (HCI), which have gained significant popularity. The TCI combines seven weather parameters, including maximum and average daily temperatures, minimum and average humidity, precipitation, sunshine hours, and average wind speed, into a single index. Nieuwolt (1977) developed the Temperature Humidity Index (THI) using the air temperature (in Celsius) and the relative humidity (in %). Improved indices, such as the climate index for tourism (CIT) by De Freitas (2003), and Scott et al. (2008), have been developed to better assess the impact of climate on tourism. Additionally, there is the Multi-Dimensional Climate Change Vulnerability Index, which measures susceptibility to both temporary climatic changes and spatial variations, influencing travel patterns and tourism activities (Agnew and Palutikof, 2006; Jørgensen and Solvoll, 1996; Tucker and Gilliland, 2007).

Despite numerous studies exploring the relationship between weather conditions and tourism, a significant research gap remains. No study has investigated whether specific weather conditions, such as temperature or precipitation, have a threshold effect on tourism demand. This gap highlights the need for focused research to determine if there are critical points at which weather variations significantly influence tourist behavior and destination choice. Understanding these thresholds could provide valuable insights for tourism management and planning in the face of changing climatic conditions.

3. Data and methodology

3.1. Data

The data utilized in our analysis are sourced from the Bank of Thailand (BOT) and the CEIC database, covering the period from 2012 to 2022. We selected five provinces in Thailand: Bangkok, Chiang Mai, Phuket, Surat Thani, and the notable tourist destination of Pattaya in Chonburi. The demand for tourism is represented by total tourist's arrivals in each province. Using macroeconomic variables as control variables for the model, we considered including the following variables in the model: Thai per capita income (PerCapTHAI), provincial consumer price index in each province, (CPI_i), per capita of top five tourist countries in each province ($PerCapMAJOR_i$), and real gross provincial product in accommodation and food services ($GPPACF_i$), The weather conditions which is the focus point in the study, we employ the Tourism Humidity Index in each province (THI_i), which encapsulates temperature and precipitation data.

Note here that the five major tourist nations differ in their composition as follows: In the five major provinces are China, Russia, Japan, Germany, and the United Kingdom. In Bangkok, the major tourists come from China, Japan, India, the USA, and the United Kingdom. In Chiang Mai, they come from China, Japan, France, the United Kingdom, and the USA. In Chonburi (Pattaya), the tourists are from China, Russia, India, Korea, and the Middle East. In Phuket, the primary tourists are from China, Russia, Australia, Germany, and the United Kingdom. In Surat Thani, they

come from Germany, the United Kingdom, China, Australia, and France.

3.2. Methodology

This paper applied the threshold regression models to examine the relationship between the weather conditions and tourism demand by hypothesized that the response of tourism demand may vary across different state of weather conditions. These different states of weather conditions are characterized by threshold points, beyond which the relationship between the tourism demand and weather conditions undergoes a significant change.

Threshold regression models can be expressed as piecewise linear or nonlinear functions, with separate regression equations estimated for each regime. Moreover, this approach informs more effective destination management strategies.

According to the referencing work on tourism demand in Crouch (1994), Lim (1997), and Song and Li (2008), the tourism demand functions which include weather conditions, can be expressed as follows:

$$TF_{it} = f(PerCapMAJOR_{it}, CPI_{it,}GPPACF_{it}, COVID_t, THI_{it} \quad (1)$$

$$TT_{it} = f(PerCapTHAI_t, CPI_{it,}GPPACF_{it}, COVID_t, THI_{it} \quad (2)$$

The definition of all variables is presented in **Table 1**.

Table 1. Variables and definition.

Variable	Definition	Unit
Tourist	Total number of tourist	million persons
TF	Number of foreign tourists	million persons
TT	Number of Thai tourists	million persons
PerCapTHAI	Real per capita of Thai tourists	Baht
PerCapMAJOR	Real per capital of major foreign tourists	Baht
CPI	Consumper price index	2022 = 100
GPPACF	Real gross provincial product in accommodation and food services	Baht
COVID	dummy variable for COVID19 pandemic equals to 0 in period before pandemic (2012–2019) equals 1 during the period when COVID19 pandemic began spreading and the period thereafter (2020–2022)	
THI	Temperature humidity index	
T	Average temperature	degree celsius
RH	Relative humidity	percent
i	Major destination in Thailand i = 1 for Bangkok, i = 2 is Chiang Mai, i = 3 is Pattaya, i = 4 is Phuket and i = 5 is Surat Thani	

There is a substantial amount of empirical research attempting to create indices that represent weather conditions. One of the indices related to weather conditions is Temperature Humidity Index (THI). THI combines air temperature and relative humidity into a single value to represent perceived temperature or thermal comfort.

THI used as a representative of weather condition on humans and animals. THI helps in understanding how temperature and humidity interact to impact thermal comfort, productivity and health. THI influences tourist's comfort, health and overall experience at a destination. High THI values indicate uncomfortable and potentially hazardous conditions for tourists, leading to a decline in tourism demand. Tourist generally prefer destinations with moderate THI levels that provide a comfortable climate. Therefore, the destinations recorded high THI tend to push away tourists. In contrast, destination with consistently favorable THI values tend to attract more visitors. The high value of THI can limit the feasibility of outdoor activities, pose health risks, and finally reducing the attractiveness of a destination.

There are several methods for calculating the THI. One common formal by Neiuwolt (1977) is:

$$THI = 0.8T + (RH/500) \tag{3}$$

where T is the average temperature (degrees Celsius), and RH is relative humidity (percent).

In this article, the tourism demand function will be presented using the threshold regression (TR) model. TR is a simple form of nonlinear regression model that allows the magnitude of the relationship to change when the value of the specified variable exceeds an unknown threshold. According to Hansen (1999, 2011) and Koop and Potter. (2003), there are various types of TR specifications, sample splitting, multiple equilibria, threshold auto regressive (TAR), and Self-exciting threshold autoregressive (SETAR). Consider a linear regression model with two groups of independent variables ($x^{/}$ and $z^{/}$). Variable $x^{/}$ is the variables whose parameter values do not change across the regimes, and variable $z^{/}$ is the variables with the parameters that are regime-specific. The equation can write as follows:

$$y_t = x_t^{/}\beta + \boldsymbol{z}_t^{/}\delta + e_t \tag{4}$$

where δ and β are parameters and e is disturbance term.

Assume that q_t is an observable threshold variable with m potential thresholds $(\gamma_1, \gamma_2, \ldots \gamma_m)$ which can produce $m + 1$ regimes and strictly increasing of threshold value $(\gamma_1 < \gamma_2 < \gamma_3 < \cdots \gamma_m)$. For the jth regime $\gamma_j \leq q_t < \gamma_{j+1}$

The $m + 1$ regimes can be presented as

$$\begin{gathered} y_t = x_t^{/}\beta + \sum_{j=0}^{m} 1_j(q_t, \gamma) + \boldsymbol{z}_t^{/}\delta + \varepsilon_t \\ 1_j(q_t, \gamma) = 1(\gamma_j \leq q_t \leq \gamma_{j+1} \end{gathered} \tag{5}$$

where q_t is threshold value.

In this paper, the threshold regression models (TR) can used to examine the relationship between the weather conditions and tourism demand by hypothesized that the response of tourism demand may vary across different state of weather conditions, presented as THI. These different states of THI are characterized by threshold points (THItr), beyond which the relationship between the tourism demand and THI undergoes a significant change. Based on this concept, the tourism demand function

with threshold regression with m threshold (or m + 1 regimes) presented as following:

$$TF_{it} = THI_{it}\beta + z_t^{/}\delta_j + e_t$$
$$TT_{it} = THI_{it}\beta + z_t^{/}\delta_j + e_t \quad (6)$$

The nonlinear least squares (NLS) employed for estimating the parameters in (5). In the absence of a threshold, using NLS is equivalent to using least squares estimators. The F statistic is used for a comparison with the fully restricted and no threshold or constant only model. For the threshold specification, to test whether q_t has a threshold or not, the multiple threshold test will be setup following Bai (1997) and Bai and Perron (1998, 2003a). The sequential F statistic is used to determine the number of thresholds in the model.

4. Results

The estimated demand for tourism in five major destinations in Thailand, Bangkok, Chiang Mai, Pattaya, Phuket and Surat Thani, is shown in **Table 2**. It is worth recapping the notation used in the results as follows: PerCapTHAI represents the real per capita expenditure of Thai tourists (measured in Baht), and PerCapMAJOR_i denotes the real per capita expenditure of major foreign tourists in destination i (measured in Baht). GPPACFi, CPIi, and THIi are the real gross provincial product in accommodation and food services, consumer price index, and temperature and humidity index in province i, respectively. Here, i corresponds to the specific province discussed in each subsection. For example, in subsection 4.2, i refers to Bangkok. However, for the analysis of demand across all destinations (subsection 4.1), the values of GPPACF, CPI, and THI represent by the average values across all provinces. The details of the results are as follows:

Table 2. Estimation of demand for tourism in 5 major destinations in Thailand.

	5 Major Provinces			**Bangkok**		
	Total	**Foreign**	**Thai**	**Total**	**Foreign**	**Thai**
	Tourist	**TF**	**TT**	**T_BK**	**TF_BK**	**TT_BK**
constant	25,025,116.2	9,151,969.2	−19,377,409	9,746,490.7	−125,260.7	−15,058,047
t stat.	2.49	2.18	−2.34	3.70	−2.14	−2.26
PerCapTHAI	−914.33		−353.01	−322.16		−205.48
t stat.	−15.68		−3.87	−3.74		−2.06
PerCapMAJOR	16.60					
t stat.	4.33					
CPIi			444,282.48			243,197.08
t stat.			2.98			2.62
GPPACFi	329.69	88.49	104.88	238.53	69.69	102.79
t stat.	27.15	6.44	9.63	7.69	5.44	3.50
COVIDi		−6,166,229.84		−2,069,475.09	−3,017,004.42	−1,205,785.6
t stat.		−6.95		−3.23	−7.03	−2.06
THIi	−659,175.79	−370,680.17	−376,057.32			
t stat.	−1.77	−1.86	−1.76			

Table 2. (*Continued*).

	5 Major Provinces			**Bangkok**		
	Total	**Foreign**	**Thai**	**Total**	**Foreign**	**Thai**
	Tourist	**TF**	**TT**	**T_BK**	**TF_BK**	**TT_BK**
Threshold_THIi						
coeff.						
t stat.						
Threshold_THIi						
coeff.						
t stat.						
Bai-Perron Test						
F Statistic						
Thershold 0 vs 1	1.65	4.39	5.79	-	-	-
Thershold 1 vs 2	-	-	-	-	-	-
R-Squared	0.9364	0.8597	0.7579	0.8558	0.8258	0.6637
F Statistic	143.56	81.68	30.53	79.13	97.19	19.24
	Chiangmai			Pattaya		
	Total	Foreign	Thai	Total	Foreign	Thai
	T_CM	TF_CM	TT_CM	T_PT	TF_PT	TT_PT
constant	2,924,959.3	1,076,764.6	2,781,127.7	6,067,649.3	−503,971	−442,489
t stat.	2.32	6.15	1.89	2.67	−2.29	−1.89
PerCapTHAI	−69.05		−17.07			
t stat.	−10.71		−2.55			
PerCapMAJOR					−4.31	
t stat.					−2.44	
CPIi	67,000.34		39,345.05			
t stat.	4.51		2.61			
GPPACFi	179.82	34.31	84.82	183.00	106.77	82.59
t stat.	20.85	5.80	8.99	14.91	6.69	5.67
COVIDi		−436,364.82			−603,865.03	761,510.61
t stat.		−7.24			−2.24	3.13
THIi		−36,119.90				
t stat.		−3.59				
Threshold_THIi	<22.18		<22.19	<23.68	<22.76	
coeff.	−267,729.48		−242,040.35	−253,998.84	−115,438.72	
t stat.	−9.99		−6.73	−2.65	−2.10	
Threshold_THIi	≥22.18		≥22.19	≥23.68	≥22.76	
coeff.	−287,748.54		−262,281.39	−279,599.53	−136,559.27	
t stat.	−10.17		−6.87	−2.71	−2.30	
Bai-Perron Test						
F Statistic						

Table 2. (*Continued*).

	5 Major Provinces			**Bangkok**		
	Total	**Foreign**	**Thai**	**Total**	**Foreign**	**Thai**
	Tourist	**TF**	**TT**	**T_BK**	**TF_BK**	**TT_BK**
Thershold 0 vs 1	40.17*	2.74	41.28*	9.01*	12.17*	-
Thershold 1 vs 2	5.93	-	-	9.80	4.12	-
R-Squared	0.8767	0.8683	0.7403	0.8629	0.9127	0.5495
F Statistic	54.01	87.91	21.66	83.95	79.48	25.01
	Phuket			Suratthani		
	Total	Foreign	Thai	Total	Foreign	Thai
	T_PK	TF_PK	TT_PK	T_SR	TF_SR	TT_SR
constant	3,116,840.7	826,9682.0	4,102,855	274,679.5	2,875,833.5	−3,069,507
t stat.	2.63	1.72	2.71	2.28	4.64	−3.59
PerCapTHAI	−204.92		−33.45	−17.16		−15.36
t stat.	−8.51		−2.88	−2.16		−2.78
PerCapMAJOR				−0.95		
t stat.				−3.07		
CPIi				69,595.14		40,059.73
t stat.				4.91		3.77
GPPACFi	2782.27	776.99	522.58	49.84	89.77	55.07
t stat.	9.56	5.80	4.83	4.66	7.14	7.69
COVIDi		−1,417,847.49	−157,197.25	−439,429.76	−322,241.35	
t stat.		−7.57	−1.25	−3.19	−4.12	
THIi	−44,645.13		−148,709.25			
t stat.	−2.20		−2.13			
Threshold_THIi		<22.53		<21.79	<21.79	
coeff.		−363,755.24		−189,884.59	−120,915.23	
t stat.		−1.74		−5.09	−4.26	
Threshold_THIi		≥22.53		≥21.79	≥21.79	
coeff.		−400,617.56		−204,105.76	−130,979.05	
t stat.		−1.84		−5.22	−4.35	
Bai-Perron Test						
F Statistic						
Thershold 0 vs. 1	6.98	12.13*	4.29	36.04*	19.93*	-
Thershold 1 vs. 2	-	-	-	1.72	2.54	-
R-Squared	0.6659	0.7343	0.5680	0.9407	0.9002	0.7388
F Statistic	26.58	26.94	12.82	81.57	87.95	37.72

Note: * significant at the 0.05 level.
Bai-Perron (2003) critical values for Threshold Test; 0 vs. 1 = 8.58, 1 vs. 2 = 10.13.

4.1. The 5 major destinations in Thailand

For the behavior of tourists (both foreign and Thai tourists), the estimated demand function indicates that the per capita income of foreign tourists (PerCapMAJOR: the

five countries with the highest number of inbound Thailand tourists including China, Russia, Japan, Germany, and the United Kingdom) is positively related to the demand for tourism in five major destinations in Thailand. Specifically, an increase in foreign income by 1 Baht results in an increase of 16.60 tourists to the five provinces of Thailand. According to this finding it indicates that foreign tourists perceive Tourism in five major destinations a normal good, though with a relatively modest impact. Regarding the PerCapTHAI, it is interesting to note that as income increases, the demand for tourism in five major destinations decreases. Thai tourists reduce their demand for domestic destinations when income increases. This finding may be attributed to the fact that many Thai tourists have already visited these destinations and seek new experiences by traveling to other destinations both in domestic and international destination.

For the macroeconomic conditions, the demand for tourism is also positively influenced by the basic amenities in accommodation and food services measured as GPPACF. The results of the study also found that the average CPI in the 5 destinations has a positive effect on the tourism demand. This may be because most Thai tourists prefer to travel according to special festivals that are unique to a particular time period that can draw more tourists despite higher prices. For example, a Full Moon Party in Surat Thani or Songkran in Chiang Mai lead to increased travel demand even if prices for accommodation and other services go up.

For weather conditions that affect tourism, the THI is used a representative measure of weather conditions in five major tourism destinations in Thailand. An increase in THI indicates higher temperatures and/or higher humidity, which can have a negative impact on tourism demand because tourists may feel uncomfortable during their travels, such as in high temperatures, it can hinder outdoor activities. The results indicate a negative relationship between THI and tourism demand in Thailand. As the temperature increases, the demand for tourism decreases for all tourists. No threshold effect was found, demonstrating a linear relationship between temperature and tourism demand. Specifically, an increase in the THI by 1 unit (equivalent to a temperature rise of 1.25 degrees Celsius) leads to a decrease in tourism demand in the five provinces of Thailand by 659,175.75 tourists.

For foreign tourists, there are several factors affect demand for tourism among foreign tourists in the five destinations, including the GPPACF, COVID-19 epidemic, and weather condition, as measured by THI. The THI has a negative impact on the number of foreign tourists, with no threshold effect identified. Specifically, an increase in the THI by 1 unit, or approximately a 1 degree Celsius rise, leads to a decrease of 370,680.17 foreign tourists in major destinations.

For Thai tourists, the study confirms that an increase in per capita income leads to a decrease in tourism demand, with 353.01 fewer Thai tourists visiting the five destinations for each income increase. However, the expansion of GPPACF, and an increase in the average CPI in these provinces all contribute to an increased demand from Thai tourists. The THI index also negatively affects the number of Thai tourists, with no threshold effect. Specifically, an increase in the THI by 1 unit (approximately a 1 degree Celsius rise) results in a decrease of 376,057 Thai tourists in the five main tourist provinces.

4.2. Bangkok

In Bangkok, tourism demand is negatively affected by the PerCapTHAI and the spread of COVID-19. However, the GPPACFi positively impacts tourism demand in Bangkok. Notably, CPIi and THIi do not influence tourism demand in the capital city.

For foreign tourists, tourism demand in Bangkok is influenced by the COVID-19 epidemic and GPPACFi, but with differing effects. The GPPACFi positively affects tourism demand, while the COVID-19 epidemic negatively impacts it.

For Thai tourists, the per capita income of Thai tourists (PerCapTHAI) negatively impacts tourism demand in Bangkok, meaning that as their income increases, Bangkok becomes less attractive compared to foreign destinations. However, the CPIi and GPPACFi positively affect the number of Thai tourists. Conversely, the COVID-19 outbreak negatively affects the number of Thai tourists in Bangkok. Additionally, the THIi has no effect on tourism demand in Bangkok, the weather conditions do not affect the number of Thai and foreign tourists.

4.3. Chiang Mai

For all types of tourists in Chiang Mai, we find that the per capita income of Thai tourists (PerCapTHAI) has a negative relationship with tourism demand. Conversely, GPPACFi, and CPIi, have a positive relationship with tourism demand. Regarding the THIi, it influences tourism demand in Chiang Mai with a threshold effect. The estimation confirms that the threshold of THIi is 22.18 which equals to 27.71 degrees Celsius given average humidity in Chiang Mai. Specifically, when the THIi is lower than 22.18 (or the temperature is below 27.71 degrees Celsius), an increase in the THIi results in a decrease of 267,729.48 tourists. When the THIi is 22.17 or higher (or the temperature is 27.71 degrees Celsius or higher), an increase in the THIi results in a decrease of 287,748.54 total tourists.

The results for the foreign tourists, we found that GPPACFi and the COVID-19 outbreak have an effect on the number of foreign tourists. As for the THI index, it will have a constant negative effect on tourism demand in Chiang Mai. An increase in the THI index of 1 unit (or 1.25 degrees Celsius given average humidity in Chiang Mai) will result in a decrease in the number of foreign tourists by 36,119.90.

For the demand of Thai tourists, it was found that income (PerCapTHAI) has a negative relationship on tourism demand in Chiang Mai. The GPPACFi, and CPIi have a positive relationship with the number of Thai tourists in Chiang Mai. The THIi has a non-linear effect or a threshold effect to the number of Thai tourists. The THIi threshold value for Chiang Mai is 22.19 or 27.74 degrees Celsius, given the average humidity in Chiang Mai. Specifically, if the index is lower than 22.19 (or if the temperature is lower than 27.74 degrees Celsius), an increase in the index causes the Thai tourists demand for tourism in Chiang Mai to decrease by 242,040.35 tourists. However, if the THIi increases to 22.19 or higher (or if the temperature is 27.74 degrees Celsius or higher), the increase in the index causes the Thai tourists demand for tourism in Chiang Mai to decrease by 262,281.39. This is because Thai tourists often visit Chiang Mai to experience cool weather, especially during the winter period. Therefore, increases in temperatures significantly influence their decision to travel to Chiang Mai. If the temperature rises above a certain threshold, it will significantly

impact Thai tourists' decisions to visit Chiang Mai.

4.4. Chonburi (Pattaya)

For total tourists in Pattaya, we found that only the GPPACFi and the THIi affect tourism demand in this destination. GPPACFi positively influences demand, while THIi has a negative relationship with demand, with a threshold response at 23.68. The findings indicate that if the THIi is below 23.68 (or if the average temperature is lower than 29.59 degrees Celsius), an increase in the index will lead to a decrease of 253,998.84 tourists in Pattaya. When the THIi is equal to or higher than 23.68 (or if the average temperature is higher than 29.59 degrees Celsius), an increase in the index will result in a decrease of 279,599.53 tourists in Pattaya.

The demand for tourism among foreign tourists in Pattaya is adversely affected by PerCapMAJORi, indicating that as the income of foreign tourists increases, their interest in visiting Pattaya decreases. Additionally, the spread of COVID-19 shows a negative correlation with demand. However, demand is positively influenced by the GPPACFi. THIi has a threshold effect on the tourism demand of foreign tourists, with the threshold value being 22.76 (or the temperature being 28.45 degrees Celsius). An increase in THIi of 1 unit results in a decrease in the demand for tourism in Pattaya from foreign tourists by 115,438.72 tourists. If the index value is equal to or higher than 22.76 (or if the average temperature is higher than or equal to 28.45 degrees Celsius), an increase in the index will reduce tourism demand in Pattaya by 136,559.27 tourists.

For Thai tourists, tourism demand is influenced solely by GPPACFi and COVID-19. GPPACFi has a positive effect on demand, indicating that an increase in these amenities boosts tourist interest. Surprisingly, the spread of COVID-19 also shows a positive relationship with demand, suggesting a complex interplay between pandemic conditions and tourist behavior among Thai travelers. However, PerCapTHAI and THIi do not seem to influence tourism demand among Thai tourists.

4.5. Phuket

For tourism demand in Phuket, in case of total tourists, it was found that PerCapTHAI and the THIi have opposite relationship with the total number of tourists in Phuket. As for the THIi, it is a constant negative relationship, that is, an increase in the THIi of 1 unit (or an increase in temperature of 1.25 degrees Celsius) will result in a decrease in total tourists in Phuket by 44,645.13 tourists

The findings for both foreign tourists and Thai tourists indicate a similar pattern of the impact of GPPACFi and COVID-19 on tourism demand. The number of foreign tourists or Thai tourists have a positive relationship with GPPACFi, suggesting that improvements in these sectors boost tourism interest. Conversely, both groups exhibit a negative relationship with the COVID-19 outbreak. PerCapMAJORi doesn't influence tourism demand. For foreign tourists, there is a reversed relationship between THIi and tourism demand in Phuket, with a threshold value of 22.53 (equivalent to 28.16 degrees Celsius). When the index increases by 1 but remains below 22.53 (or when the temperature is lower than 28.16 degrees Celsius), the demand for tourism in Phuket decreases by 363,755.24 tourists. However, if the index

value equals or exceeds 22.53 (or the temperature is 28.16 degrees Celsius or higher), each increase in the index leads to a decrease in tourism demand in Phuket by 400,617.56 tourists.

The relationship between income and the THIi differs between foreign and Thai tourists in Phuket. PerCapTHAI has an inverse effect, suggesting that demand for tourism in Phuket decreases as income rises among Thai tourists. Moreover, an increase in the THIi affects tourism demand differently for each group. For Thai tourists, the effect remains constant, with a 1-unit increase in THIi resulting in a decrease of 148,709.25 tourists.

4.6. Surat Thani

In Surat Thani, tourism demand among total tourists is influenced by all factors in the study except for the THIi. However, there are variations in the nature of the relationships with PerCapTHAI and PerCapMAJORi, with the COVID-19 epidemic showing a negative relationship with demand. Conversely, tourism demand is positively influenced by the GPPACFi, as well as CPIi. Regarding the THIi, it influences tourism demand in Surat Thani with a threshold effect. The threshold of THIi is 21.79 which equals to 27.24 degrees Celsius given average humidity in Surat Thani. Specifically, when the THIi is lower than 21.79 (or the temperature is below 27.24 degrees Celsius), an increase in the THIi results in a decrease of 189,884.59 tourists. When the THIi is 21.79 or higher (or the temperature is 27.24 degrees Celsius or higher), an increase in the THIi results in a decrease of 204,105.76 total tourists.

For foreign tourists, GPPACFi reveal the positive relationship with demand, however, demand receives results in the opposite direction from the spread of COVID-19. There is a relationship between demand and THI in the opposite direction with a threshold value of 21.79 (or 27.24 degrees Celsius), meaning that when the index increases by 1 but is less than 21.79 (or the temperature is lower than 27.24 degrees Celsius), it causes tourism demand in Surat Thani decreased by 120,915.23 people, while if the index value is equal to or higher than 21.79 (or the temperature is higher than or equal to 27.24 degrees Celsius), when the index increases further, it will cause the demand for tourism in Surat Thani to decrease by 130,979.05 tourists.

For Thai tourists, the demand for tourism in Surat Thani exhibits a negative correlation with the per capita income of Thai tourists. Conversely, it is positively associated with GPPACFi. Additionally, the demand for tourism in Surat Thani by Thai tourists is positively related to the CPIi. However, the THIi does not affect demand in Surat Thani for Thai tourists.

5. Finding and discussion of results

Results from the estimation of demand for Thai tourism both Thai and foreign tourists in five major tourism destinations. Not only the macroeconomic condition the affect tourism demand but also place importance on the role of weather conditions. The Temperature Humidity Index (THI) presented as a representative measure of weather conditions in five major tourism destinations in Thailand. An increase in THI indicates the deteriorating weather conditions caused by higher temperatures and/or higher humidity, which can have a negative impact on tourism demand because

tourists may feel uncomfortable during their travels, such as in high temperatures, it can hinder outdoor activities. (Moore et al.; 2013, Hein et al.; 2019).

For the empirical results, the weather conditions have a statistically significant negative impact on demand of Thai tourism in major destinations. The increasing of average temperature and/or average humidity can lead to decreased demand for tourism without threshold effect. The weather condition influences demand for tourism in Phuket, Pattaya, Surat Thani, and Chiang Mai. Only the tourism demand in Bangkok, the capital city of Thailand, is unaffected by weather conditions. Because Bangkok naturally attracts tourists who seek to experience the nation's cultural heritage, advanced facilities, efficient transportation, and diverse civilizations. Serving as a gateway to various provinces in the country, Bangkok holds a unique appeal. Additionally, Suvarnabhumi Airport, a primary entry point for foreign tourists, is located in Bangkok, making the city an essential destination even the weather conditions are poor.

Tourism demand in Chiang Mai, Pattaya, Phuket, and Surat Thani is negatively impacted by weather conditions, with varying patterns depending on the destination and the nationality of the tourists. Chiang Mai, located in northern Thailand, offers a tourism experience that emphasizes culture, traditions (such as the Yi Peng and Songkran festivals), foods, and the renowned warm hospitality of Thai culture. These attractions make Chiang Mai more adaptable for foreign tourists in their travel planning. Consequently, for foreign tourists, the weather conditions affect tourism demand in Chiang Mai without the nonlinear threshold effects observed in the other provinces. However, the weather conditions in Chiang Mai influence the tourism demand of Thai tourists with a threshold effect. Thai tourists, who are familiar with the region's culture, traditions, and weather, primarily plan their trips for convenience and often visit during the cooler winter months. Consequently, when temperatures exceed the threshold, the desire to travel to Chiang Mai significantly decreases. Thai tourists may prefer to travel abroad to experience more comfortable temperatures and different cultural traditions.

In Phuket, Pattaya, and Surat Thani, recognized as sea, sand, and sun destinations, the impact of weather conditions on tourism demand differs between foreign and Thai tourists. Thai tourists respond negatively to weather conditions in Phuket, while Thai tourists in Pattaya and Surat Thani do not respond to weather conditions. Weather conditions affect tourism demand in Phuket because the high cost of living and high tourism costs mean that the expense of vacationing there can be comparable to traveling abroad. Poor weather conditions can reduce the comfort and enjoyment of activities in Phuket, making international travel more appealing. With the availability of various airlines, advanced information technology systems for booking accommodations, planning trips, and translating languages, Thai tourists find it more convenient to explore foreign countries where they can experience different cultures and new experiences. For foreign tourists, weather conditions affect tourism demand in Phuket, Pattaya, and Surat Thani with a threshold level. Specifically, when the temperature exceeds a certain threshold, the decline in tourism demand becomes more pronounced. Phuket has the highest threshold value, whereas Surat Thani has the lowest. This phenomenon can be attributed to the fact that Phuket, Pattaya, and Surat Thani are key destinations for foreign tourists, necessitating advanced travel planning.

Comfort, which is closely linked to temperature, is a critical factor in this planning process. As poor weather condition such as temperatures rise, the desire for tourism generally decreases, consistent with the hypothesis. However, once weather conditions significant deteriorate surpass the threshold, the impact on tourism demand intensifies. This is particularly pertinent for destination like Phuket, Pattaya, and Surat Thani, which heavily rely on sea tourism and outdoor activities such as beach visits, coral viewing, and sailing. The poor weather conditions, as excessive temperatures, can compromise the comfort and safety of these activities, posing risks such as dehydration, heat exhaustion, or heat stroke. These risks are especially severe for vulnerable groups, including the elderly, children, and individuals with health issues like heart or respiratory conditions, leading to a marked decrease in tourism demand from these populations.

Economic variable issues

In addition to the effects of weather conditions on tourism demand, this paper also identifies several macroeconomic variables that affect tourism demand across five major destinations. First, the expansion of the accommodation and food services sector is a significant variable that drives increased tourism demand in all destinations and across all nationalities of tourists. This indicates that tourists place high importance on the comfort and convenience of accommodation and food services to enhance their travel experiences. Second, the study reveals distinct impacts of income on tourism demand between foreign and Thai tourists. For foreign tourists, per capita income generally does not affect tourism demand in major provinces, except for Pattaya, where it shows a slight negative effect. This suggests that as foreign tourists' income increases, their demand for Pattaya decreases. This can be attributed to Pattaya's appeal, which includes entertainment options such as water sports, nightlife, and cultural shows, catering more to mass tourism rather than high-end experiences. Consequently, higher-income foreign tourists may prefer upscale destinations like Phuket or Surat Thani. For Thai tourists, per capita income negatively affects tourism demand in every province except Pattaya, where it has no significant impact. This indicates that as Thai tourists' income increases, they tend to favor international travel over domestic destinations. The diverse and often affordable options for international travel appeal to higher-income Thai tourists. In summary, while tourism demand in Pattaya remains relatively stable regardless of income levels, other provinces experience a decline in tourism demand as the income of Thai tourists increases.

6. Conclusions

The study on tourism demand in Thailand's five major destinations, focusing on weather conditions and area-specific macroeconomic factors, we shade the highlight on three points. First, weather conditions significantly influence tourism demand, with adverse weather conditions leading to a decline in tourism, as supported by previous studies such as those by Yu et al. (2009), and NA Ngxongo (2021). However the effects vary across different destinations. Bangkok, the capital city, remains largely unaffected by weather conditions. For the sea, sand, and sun destinations, Pattaya, Phuket, and Surat Thani exhibit a strong dependence on temperature. Here,

temperature fluctuations play a significant role in shaping tourism demand, with higher temperatures potentially deterring visitors from engaging in outdoor activities. Conversely, Chiang Mai, known for its cultural and culinary attractions, demonstrates a distinct pattern. Temperature exerts a constant effect on tourism demand in this region, reflecting the prioritization of cultural experiences over outdoor pursuits. These results emphasize the intricate interplay between temperature and tourism demand, shedding light on the multifaceted factors that shape traveler preferences across various destinations in Thailand. The study also found that worsening climatic conditions beyond a certain threshold result in a significant decline in the number of tourists. While this does not occur in every destination, for international tourists engaged in sea, sand, and sun tourism destinations, the threshold is applicable across all destinations.

Second, the study highlights key differences in how income influences tourism demand for foreign and Thai tourists. For foreign tourists, higher income tends to reduce demand for Pattaya, as they prefer more upscale destinations like Phuket or Surat Thani, given Pattaya's focus on mass tourism. Conversely, for Thai tourists, increased income leads to a preference for international travel over domestic destinations, except for Pattaya, where income levels have no significant impact on tourism demand. This trend underscores the diverse preferences and travel behaviors shaped by income among different tourist groups.

Third, the important role of convenience, a variety of accommodation options, and culinary offerings in shaping travel preferences and attracting tourists is emphasized. Empirical evidence highlights the substantial positive impact of these factors on overall tourism demand, influencing both Thai and foreign tourists across provinces. Then, the expansion and quality of accommodation and food services are key determinants in attracting tourists, emphasizing the importance of these amenities for a positive travel experience.

7. Policy recommendation

Based on the findings of the study, there are some policy recommendations to promote sustainable tourism are

(1) Implement ongoing monitoring of weather conditions and adapt tourism strategies accordingly to mitigate the impacts of weather conditions on tourism demand, for example minimize the environmental impact associated with battery regulation, electric vehicle (EV) conversion. The engagement of key stakeholders including government, local communities, tourism operators and environmental organizations is required ensuring the long-term sustainability of tourism industry.

(2) Diversifying tourism destination offerings by develop alternative attractions and activities that are less dependent on weather conditions to maintain tourist interest year-round. The key success to diversifying destinations are the variety of cultures such as festivals, events and heritage site, then the destinations can attract tourists regardless of weather conditions. Additionally, to make Thailand a more attractive tourist destination, inbound policies for specific countries may be revised to be visa-free.

(3) Strengthening the accommodation and food services sector such as improve

the quality and availability of accommodation and food services to meet the expectations of tourists such as training programs to improve service quality, provide financial support, tax policy, and incentives to invest in advance technologies or eco-friendly products, encourage entrepreneurs to highlight local cuisine to enriches the tourist experience, and enhance the public-private partnership to co-develop high quality tourism amenities and services to align with the market demands and sustainability goals.

(4) For policy implications in Asian countries with tourism patterns and climate conditions similar to Thailand, this study's findings could be used as a guideline to consider the impact of weather condition on tourism demand. In particular, in countries with tourism similar to Thailand, such as Indonesia and Malaysia.

8. Limitation and further study

The limitation of this study is the relatively small dataset available for each province, which restricts us to identifying only one threshold value. With a larger dataset, we could determine multiple threshold values, allowing for a more comprehensive assessment of the impact of climate conditions on tourism.

For further study, we suggest using alternative indices to measure weather conditions such as Climate Index for Tourism (CIT), Modified Climate Index for Tourism (MCIT), or Holiday Climate Index and explore their relationship with tourism demand. This approach will enable researchers to compare and confirm the previously observed non-linear relationship between weather conditions and tourism demand.

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