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The Impact Of Particulate Matter 2.5 On Tourist Arrival In Chiang Mai

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ABSTRACT
Particulate matter 2.5 is air pollution that affects human health and negatively affects the economy. This study investigates the impacts of particulate matter 2.5 on the number of international tourists arriving in Chiang Mai. We employ the test kink effect and panel kink regression to examine the nonlinear relationship between variables. The data set used in our study is quarterly data from January 2012 to December 2018. The empirical results show that an increase in particulate matter 2.5 leads to a decrease in foreign tourists.

Keyword: PM 2.5; Air pollution; Panel kink regression; Tourism

1. INTRODUCTION
Tourism is one of the essential sectors driving Thailand's economy. It increases local consciousness of the financial value of natural and cultural resources and strengthens cultural and historical tradition, which leads to preserving and protecting local heritage by creating more job opportunities for local people (Romao, 2018). In 2018, Tourism accounted for 12.3 percent of Thai GDP, compared to 5.3 percent in 2009. Moreover, the overall contribution of Thailand's travel and tourism to Thailand's GDP is expected to increase by 5.6 percent annually to 28.2 percent of GDP in 2028 (Bangkok Bank, 2019).

In 2018 the number of international tourists to Thailand increased to 38.12 million people or reached 7.1 percent. Thailand received about 2.01 trillion Thai baht in revenue from international tourists (Bangkok Bank, 2019). From January to August 2019, International tourists' arrivals to Thailand increased to 2.61 million from 2018, and the revenue has expanded to 3.04 trillion Thai baht from international tourists. The top five tourist arrivals from 2009 to 2018 are Chinese, Malaysian, Japanese, Korean, and Laos. The top four provinces that have the most visits are Bangkok, Chonburi, Phuket, and Chiang Mai (Ministry of Tourism and Sports, 2021: Online).

However, Chiang Mai has become a rapidly growing city in the Thai tourism industry. The city serves as a regional economic and cultural hub in the north part of Thailand and ranks as the fourth largest city in terms of population. It is also a well-known historical city with a rich cultural heritage and environmental amenities. Tourism has replaced commercial trade as Chiang Mai's number one source of external income since the mid-1960s. In the last ten years, Chiang Mai's economy has grown continuously, largely driven by the commercial sector and the tourism industry. In the past three years, Chiang Mai had an average number of tourists of 10.3 million, representing an average income of 99 billion baht, or about 3.91 percent of the country's total tourism revenue. In addition, Chiang Mai has always been ranked among the top places to visit and relax

(Ministry of Tourism and Sports, 2021: Online).

From the report of the Tourism Authority of Thailand (TAT), Chiang Mai Office shown in table 1, during the first seven months (From January to July 2019), Chiang Mai province had more than 5,755,677 tourists but lost about 1.8 percent of the same period in 2018. In March 2019, the number of tourists in Chiang Mai decreased by 12.21 percent and continued to decline in April at 6.46 percent. This may happen due to particulate matter 2.5 problems. After the period has passed, the number of tourists has increased an average is 1-2 percent per month, but still cannot cover the loss.

Table1: Tourism Arrivals in Chiang Mai January to July 2019

Month	Number of tourists in Chiang Mai (person)	Growth rate (%)	Tourism revenue (Thai Baht)	Growth rate (%)
January	1,106,000	1.11	11,850	6.29
February	973,600	1.80	10,380	5.30
March	834,700	-12.21	8,850	-9.45
April	753,100	-6.46	7,460	-4.64
May	714,900	1.92	7,130	3.69
June	690,000	2.00	7,000	5.17
July	683,500	0.32	7,590	1.79

Source: Tourism Authority of Thailand (TAT), Chiang Mai Office, 2020

The increases in international tourist arrivals are estimated based on the assumption of a long-run relationship between tourist arrivals and other variables (Song et al., 2012). Environmental quality is one of the variables that can consider relevant determinants in selecting tourist destinations (Deng et al., 2017). Air pollution may be considered in potential travel plans, and a level of particulate matter 2.5 can indicate environmental quality during the travel season (Zhang et al., 2015). In the short run, air pollution may affect travel decisions, while in the long run, it might affect the destination image (Tang et al., 2019).

Particulate matter 2.5 means the mass per cubic meter of air of particles with a size (diameter) generally less than 2.5 micrometers (μm). It is caused by natural and human-made occurring such as open burning, which can estimate at about 209,937 tons per year. Emission of particulate matter 2.5 includes toxic haze in the upper north of Thailand and the Mekong region, which happen due to the burning of monoculture crops by large agro-industrial companies, especially the food production. In addition, the toxic haze also comes from the neighboring country, resulting from two decades of swamp destruction and forest ecosystems. Moreover, the sector that will create more particulate matter 2.5 is transportation, electricity generation, manufacturing industries, and household (Namcome and Tansuchat, 2021).

Particulate matter 2.5 (PM2.5) can directly affect people's health. The most significant impact of particulate air pollution on public health is from long-term exposure to particulate matter 2.5, which increases the age-specific mortality risk, particularly from cardiovascular causes. Children, the elderly, and those with predisposed respiratory and cardiovascular diseases are more susceptible to air pollution's health impacts. Besides the health cost, air pollution can also cost people many expenses, for example, medical expenses, the cost of buying a mask, and an air purifier.

As mentioned earlier, air pollution can cause not only the local people's health problems but also negatively affect tourism in the area, which can hinder the economy. Therefore, this paper aims to analyze the effect of PM 2.5 on international tourist arrival in Chiang Mai. The scope of international tourist arrivals in this study includes China, America, Japan, France, the United Kingdom, Australia, Germany, Malaysia, Korea, and Singapore, which are the major tourist arrivals to Thailand. Furthermore, this paper will apply panel kink regression to explore the nonlinear effects of air pollution, as suggested by Maneejuk et al. (2022) and Maneejuk et al. (2020). The findings of this study will benefit policymakers in developing tourism policies that are appropriate for the situation and policy to help local companies cope with the situation. So that in the future, Chiang Mai and Thailand will become more sustainable tourist destinations.

The rest of the paper is organized as follows. First, section 2 provides the literature review. Next, section 3 describes the data and variables, followed by section 4, which provides the research methodology. Then section 5 discusses the empirical results. Lastly, section 6 provides a conclusion.

2. LITERATURE REVIEW

For the past decade, several aspects of tourism have been explored. Among them, tourism demand is one of the prevalent issues. Many studies usually adopted the number of tourist arrivals to measure demand for tourism. Chaiboonsri et al. (2010) investigated relationships between international tourist arrivals in Thailand and economic variables such as GDP, the price of goods and services, transportation costs, and the exchange rate. They found that the GDP growth of Thailand's major tourist source markets positively impacts international visitor arrivals to Thailand, while transportation costs and the exchange rate negatively impact international visitor arrivals to Thailand. Similarly, a study by Nonthapot and Lean (2015) found that source countries' income level or GDP is essential for international tourism demand. Puah (2018) studied Chinese tourism demand determinants in Malaysia and found that real income positively affects Chinese tourism demand while travel cost and exchange rate harm Chinese tourists' decision to travel to Malaysia.

Besides the tourism demand, several studies also examined the impact of air pollution on tourism demand. For example, Zhang et al. (2015) found that haze pollution has a considerable potential impact on travel. Haze pollution could be considered in tourists' decision-making processes, causing a portion of potential tourists to cancel tourism plans. According to Chen et al. (2017), the effects of carbon dioxide emissions on demand for tourism at a famous scenic spot in Taiwan, Sun Moon Lake. The results reveal that during the peaks of bad air quality, the monthly number of tourists traveling at Sun Moon Lake would fall by 25,725 people. Similarly, Deng et al. (2017) studied the impacts of air pollution on China's international tourist visiting using panel data on 31 Chinese provinces from 2001-2013. They found that air pollution has a negatively direct effect on international tourists visiting China. In addition, Tang et al. (2019) studied the impact of air pollution on tourism in Beijing, China, and found similar results that air pollution had adverse effects on tourist arrivals in the long run.

Apart from the tourism demand, the study model is another issue that needs consideration. As we presume that the impacts of air pollution might be nonlinear due to the cycle of PM2.5. For example, PM2.5 in Chiang Mai has seasonal peak periods and is usually high from February to April every year. Therefore, the nonlinear model is considered in this study. Among the existing nonlinear models, this study focuses on the Kink regression, which is well known for examining a discontinuous slope of the relationship between variables and has been applied in many fields. For instance, Maneejuk et al. (2020) used kink regression to explore the nonlinear impacts of economic development on Sulfur dioxide emission and found the nonlinear relationship between these variables. In addition, this model is also applied in other macroeconomic fields, such as Tibprasorn et al. (2017) studied the structure of foreign direct investment flows into the European region by applying the panel regression kink model based on the generalized maximum entropy estimator. Likewise, Srichaikul et al. (2019) used the panel regression kink design based on the GME estimator to investigate the impacts of macroeconomic variables, namely foreign direct investment, population, and real effective exchange rate, on the economic growth of China, Japan, and South Korea, and found discontinuity in the process of changes.

3. DATA AND VARIABLE DESCRIPTION

We collected the data on the number of international tourism arrivals (ITA) from the top ten international tourist arrivals to Chiang Mai, namely China, America, Japan, France, the United Kingdom, Australia, Germany, Malaysia, Korea, and Singapore. The data are collected from the office of tourism and sports of Chiang Mai from January 2012 to December 2018. Then, the explanatory variables used in this study are gross domestic product (GDP), transportation cost (TC), relative prices (RP), the real effective exchange rate (REER), and level of particulate matter 2.5 (PM 2.5). The variable details are provided in Table 2.

Table 2 Variable Description

Variable	**Label**	**Description**	**Source**
International tourism arrivals	ITA_{it}	Number of tourist arrivals to Chiang Mai from country i at time t. (Unit: person)	The Office of Tourism and Sports Chiang Mai
Gross domestic product	GDP_{it}	Gross domestic product of country i at time t, a proxy for tourist income. (Unit: US dollar)	World Bank
Transportation cost	TC_{it}	Transportation cost from the origin country i to Thailand at time t measured by distance multiplied by the average quarterly price of barrel of oil (AAPO). (Unit: US dollar) $TC = Distance_i * AAPO$	The Ministry of Tourism and Sports Thailand
Relative prices	RP_{it}	The relative price is measured by consumer price indices (CPI) for Thailand and origin country i, the exchange rate between Thai baht and US dollar and the currency of origin country i and the US dollar. (Unit: Thai baht) $RP_{it} = \frac{CPI_{THt} / EX_{THt}}{CPI_{it} / EX_{it}}$	World Bank.
Real effective exchange rate	$REER_{it}$	The real effective exchange rate of country i at time t is calculated by $REER_{it} = \frac{NER_{it} * p^{th}}{p^{f}}$	Bank of Thailand
Particulate matters 2.5	$PM2.5_t$	Level of particulate matter 2.5 in Chiang Mai at time t (unit: micrometer)	The Pollution Control Department

Table 3 presents the descriptive statistics of the data. The mean values are positive for all variables, the skewness of data growth is not equal to zero, and it indicates almost positive skewness. All feedback data also showed excessive kurtosis, meaning that the data growth rate has the typical characteristics of leptokurtosis and fat-tail. In addition, the Jarque-Bera statistics are significant, with strong evidence to support the alternative hypothesis based on the minimum Bayes factor (MBF).

Table 3 Descriptive statistics.

	ITA	GDP	TC	RP	REER	PM2.5
Mean	10.444	14.895	9.203	-2.071	4.648	3.293
Median	10.391	14.881	9.337	-3.251	4.664	3.278
Maximum	12.724	16.894	10.716	3.642	5.059	4.242
Minimum	9.368	12.976	7.069	-4.007	4.223	2.454
Std. Dev.	0.607	1.148	0.864	2.387	0.158	0.502
Skewness	1.345	0.195	-0.440	1.388	-0.033	0.126
Kurtosis	5.728	2.128	2.318	3.529	3.928	1.955
Jarque-Bera	171.319*	10.643*	14.477*	93.223*	10.103*	13.477*
Observations	280	280	280	280	280	280

Note: "*" indicates the strong evidence support the alternative hypothesis by MBF.

4. RESEARCH METHODOLOGY

To explore the impacts of air pollution (measured by PM2.5) on the tourist arrivals to Chiang Mai, we construct the specified model as follows. However, it is noted that this study will not include seasonality in the tourism demand equation because this study will test the kink effect and apply panel kink regression to investigate the nonlinear impacts of PM 2.5 on the tourist arrival. The model can be specified as follows.

$$\ln ITA_{it} = \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln TC_{it} + \alpha_3 \ln RP_{it} + \alpha_4 \ln REER_{it} + \alpha_5 \ln PM2.5_t + \varepsilon_{it} \quad (1)$$

From Eq.(1), $\ln ITA_{it}$ is the natural logarithm of the number of tourists to Chiang Mai from country i in time period t. $\ln GDP_{it}$ is natural logarithm of gross domestic product of the source country i. $\ln TC_{it}$ is natural logarithm of transportation cost from country of origin i to Thailand. $\ln RP_{it}$ is natural logarithm of relative price variable of country i in time period t. $\ln REER_{it}$ is natural logarithm of real effective exchange rate and $\ln PM2.5_t$ is natural logarithm of particulate matters 2.5 in Chiang Mai in time period t. Lastly, ε_{it} is the error term.

4.1 Panel Unit Root Test

Since the panel data is also characterized as time series, we first perform the unit root test to confirm that all variables used are stationary to avoid spurious relationships. Therefore, we apply the unit root test of Levin, Lin, and Chu (2002), which can be written as follows.

$$\Delta y_{it} = \mu_i + \rho y_{it-1} + \sum_{j=1}^{k} \alpha_j \Delta y_{it-j} + \delta_i t + \theta_t + \varepsilon_{it}, \quad (2)$$

where μ_i is a unit-specific fixed effect and θ_t is a unit-specific time effect. The rejection of the null hypothesis ($\rho = 0$) suggests that the data is stationary.

4.2 Testing for the Kink Effect

As the nonlinear relationship between the number of international tourism arrivals and PM2.5 and other explanatory variables are considered in this study, the kink effect is employed to examine which independent variable has a nonlinear impact on tourism arrivals. Hence, we define a test of no kink effect against the presence of kink effect for each pair of dependent variables and the covariate k. That is, the null and alternative hypotheses for each covariate k are

$$H_0 : \beta_k^- = \beta_k^+$$
$$H_a : \beta_k^- \neq \beta_k^+ . \quad (3)$$

To test this hypothesis, Hansen (2017) recommended using the F-test:

$$F_k^* = \frac{\left(SSE_0^k - SSE_1^k\left(\widehat{\gamma}\right)\right)}{SSE_1^k\left(\widehat{\gamma}\right)/\left(T-1\right)}, \quad (4)$$

where

$$SSE_0^k = \sum_{t=1}^{T}\left(Y_t - \hat{\beta}_k x_{k,t}\right)^2 , \quad (5)$$

$$SSE_1^k = \sum_{t=1}^{T}\left(Y_t - \widehat{\beta}_k^-\left(x_{k,t} - \widehat{\gamma}_k\right)_- - \widehat{\beta}_k^+\left(x_{k,t} - \widehat{\gamma}_k\right)_+\right) . \quad (6)$$

Hansen (2017) mentioned that this F-test might not have a standard distribution. Thus, the bootstrap method is suggested to generate asymptotically first-order corrected p-values. Zhang and Cheng (2019) mentioned that the p-value yielded from the bootstrap could be used to validate the existence of a nonlinear relationship. Therefore, in this study, we follow the traditional criteria; the null hypothesis of the kink effect is rejected if the p-value is less than the desired critical value, e.g., 0.10, 0.05, and 0.01.

4.3 Panel Kink Regression Model

In order to investigate the impact of particulate matter 2.5 on international tourist arrival in Chiang Mai, we apply the panel kink regression model with unknown threshold. The model was extended to a nonlinear structure by incorporating the kink parameter in the panel regression, which can be written as follows.

$$Y_{it} = \beta_1^-\left(X'_{1,it} - \gamma_1\right)_- + \beta_1^+\left(X'_{1,it} - \gamma_1\right)_+ +,\ldots,+\beta_k^-\left(X'_{k,it} - \gamma_k\right)_- + \beta \quad (7)$$

where Y_{it} is NT × 1 vector of dependent variable, $X_{k,it}$ is NT × K matrix of explanatory variables. γ is a kink or a threshold parameter. β^- and β^+ are slope associated with different regimes. θ denotes G × 1 vector of coefficient of other independent variables D_{it}, which are linearly related to Y_{it}. The assumption about the error term ε_{it} is that it usually has no correlation with X_{it}. The individual-specific effect error component u_i are also assumed to vary across individuals but is constant over time (Zhang et al.,2017; Tibprasorn et al., 2017; Maneejuk and Yamaka, 2021).

5. EMPIRICAL RESULTS

5.1 Results of Panel Unit Root Tests

In this section, we examine whether the variables are stationary using the panel unit root test of Levin, Lin, and Chu (2002). As shown in Table 4, the results reveal that the panel unit root test with none-individual intercept and trend strongly rejects the null hypotheses for all variables, indicating that the variables are stationary. Then, we can use this data set to analyze the nonlinear impact of pollution and other factors on tourist arrival using the panel kink model. The results will be presented in the next section.

Table 4: Results for panel unit root tests at level.

	Individual Intercept	**Individual intercept and trend**	**None**
ln(ITA)	-3.515***	-4.245***	-19.422***
ln(GDP)	-1.456***	-6.248***	-2.465***
ln(TC)	-11.353***	-9.787***	-12.456***
ln(RP)	-9.564***	4.745	-14.456***
ln(REER)	-7.450***	-4.452***	-8.452***

ln(PM2.5)	54.428	59.678	25.785***

Note: *** statistically significant at 0.01 level.

5.2 Results of the Kink Effect Test

This section presents the kink test results. The kink parameter indicates the nonlinear relationship between the dependent and independent variables. In this part, we employ the kink test of Hansen (2017) to determine whether the kink effect exists between each pair of the independent variable, including PM2.5 and tourist arrivals (ITA). The F-statistic is utilized to test for the kink effect's existence. Table 5 shows the results of the tests of each pair of ITA and independent variables. It is found that transportation cost (TC) and PM2.5 have nonlinear effects on the international visitor arrivals to Chiang Mai due to the existence of the significant kink point.

Table 5: Panel kink effect test.

	ln(GDP)	**ln(TC)**	**ln(RP)**	**ln(REER)**	**ln(PM2.5)**
ln(ITA)	0.000	0.025**	0.003	0.003	0.015***
	(0.752)	(0.014)	(0.188)	(0.160)	(0.000)

Note: Values inside the parentheses are p-values.

***, ** are statistically significant at the 0.01 and 0.05 levels, respectively.

5.3 Results of the Panel Kink Regression

Following the panel kink test, the variables TC and PM2.5 are found to have nonlinear impacts on tourist arrival. Therefore, as shown in Table 6, the coefficient of these two variables is split into two different values across different regimes. However, before we discuss the results, we aim to assess the robustness of the panel kink regression model. Therefore, we consider three estimation methods: random-effect, fixed-effect, and pooled OLS estimations. Then, the performance of the models will be explored through the AIC shown at the bottom of the table. As presented in the table, the panel kink regression with fixed effect is a relatively high-quality model for this dataset due to the lowest AIC value.

Table 6: Empirical results obtained from the panel kink regressions.

Variable	Random Effect	Fixed Effect	Pooled OLS
(Intercept)	-0.331	0	4.454
	0.042	0	0.000
$\ln PM2.5 \leq 3.606$	0.134*	0.072	0.096*
	0.031	0.066	0.000
$\ln PM2.5 > 3.606$	-0.545***	-0.471***	-0.388***
	0.073	0.060	0.000
$\ln TC \leq 9.227$	0.242	0.075	0.118*
	0.238	0.082	0.000
$\ln TC > 9.227$	-0.048	-0.271***	-0.324***
	0.335	0.064	0.000
lnGDP	-0.845	3.671***	0.449***
	0.852	0.293	0.000
lnRP	1.345	-1.423	-0.051***
	3.546	0.323	0.000
lnRP	-0.662	-0.436	-0.179
	0.787	0.289	0.000
AIC	-63.484	-78.239	-72.513

Note: Values inside the parentheses are p-values.

***, **, and * are statistically significant at the 0.01, 0.05, and 0.1 level, respectively.

According to the results of the panel kink regression model with a fixed effect, the effect between the predictive variables and the number of tourist arrival in Chiang Mai appears to be a nonlinear relationship. However, the study's findings are quite surprising. This is because almost none of the analyzed variables substantially impacted the number of tourists. While particulate matter 2.5 has a highly significant nonlinear effect on tourist arrival in Chiang Mai. Particulate matter 2.5 negatively affects the number of tourists arriving in Chiang Mai when the kink value of lnPM 2.5 is more than 3.606 equal to 36.835 micrometers. Note that 36.835 micrometers are the quarterly average value of PM2.5 in Chiang Mai. This result implies that an increase in particulate matter 2.5 will result in a decrease in the number of tourists in Chiang Mai. That is because tourists want to avoid pollution that affects their health. This finding is consistent an air quality index (AQI) by US standard, which become lightly polluted state (some pollutants may slightly affect very few hypersensitive individuals.), and it also relates with Zhang et al. (2015), Deng et al. (2017), and Tang et al. (2019), which conclude that air pollution has had a negative effect on tourist arrivals. However, travelers do not care about particulate matter 2.5 when it is lower than 3.606. Obviously, the number of travelers still increases even though the PM 2.5 rising (It has a positive correlation coefficient).

Similarly, the transportation cost (TC) has a significant nonlinear impact on tourist arrival in Chiang Mai when its value exceeds 9.227 or equal to 10,169.192 Thai baht (the quarterly average value). This finding indicated that a rise in transportation costs, excluding taxes and fees, will reduce the number of tourists in Chiang Mai. Therefore, the PM2.5 and the transport cost have a significant negative effect on the number of tourists in Chiang Mai when their value have been increasing more than kink point.

Table 7: Estimated kink point values and the corresponding optimal.

	ITA -PM2.5	**ITA -TC**

Kink Point (κ)	3.606	9.227
Optimal Point	36.835 (micrometers)	10,169.192 (Thai baht)

Note: Particulate matters 2.5 (micrometer) and transport cost (THB) was obtained by converting the kink point value into the exponential form.

The estimated kink point values of optimal particulate matter 2.5 (micrometers) and transport cost (Thai baht) for the international tourism arrivals to Chiang Mai, Thailand are presented in Table 7. The particulate matter 2.5 (micrometers) at the kink point that should be maintained or increased for a total number of tourists can be obtained by exponentially transforming the corresponding kink point value. Then, international tourism will get a different effect when the level of particulate matter 2.5 is equal to or more than 36.835 micrometers. Similarly, transport cost (Thai baht) at the kink point should be maintained or decreased for travelers when transport cost reaches 10,169.192 Thai baht which exclude the tax and fee.

6. CONCLUSION

The objective of this paper is to examine the impacts of particulate matter 2.5 on the number of international tourists arriving in Chiang Mai. We employ the test kink effect and panel kink regression to investigate the relationship between variables. Our empirical results present that, from the kink effect test, particulate matter 2.5 and transport cost have nonlinear effects on the international visitor arrivals to Chiang Mai when their have upper or lower the kink point. Moreover, from the panel kink estimation, we find that an increase in particulate matter 2.5 leads and transport cost to a decrease in the number of tourists.

Our study provides useful information to policymakers in developing tourism policies that are appropriate for the situation and policy to help local companies cope with the situation such as can decrease forest fire from agriculturist by set strong legal punishment for those who violate the law and increases carbon tax to decrease air pollution for better environment.

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