

Constructing tourism market vulnerability indicator in Thailand

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Abstract

This paper attempts to develop a tourism market vulnerability indicator for Thailand as a real-time monitoring instrument in mitigating vulnerability in Thailand's tourism. The indicator is constructed by extracting a common vulnerability component using a dynamic approximate factor model with a blend of six variables of macroeconomics and tourism. This paper focused on the four dimensions of tourism market vulnerability that include physical, socio-cultural, economic, and institutional factors. Through the wavelet analysis, the empirical results shown in the wavelet coherence maps suggested that the constructed indicator leads tourist arrivals in Thailand and thus, can serve as an early signal monitoring instrument. Oil price shocks have also been studied since tourism is an energy-intensive sector. Analysis results from the wavelet coherence revealed a significant leading role of crude oil price in the Thailand tourism market. The results further validated the tourismled growth hypothesis and the economic-driven tourism growth hypothesis in Thailand. The empirical evidence shows that while higher visitor exports (LVE) positively correlate with international tourist arrivals (LTA), indicating a flourishing tourism sector, currency appreciation (LREER) negatively impacts arrivals due to increased travel costs. Additionally, inflation (LCPI) also exhibits a negative relationship with LTA, suggesting that rising prices deter tourists. The sufficient evidence on the causal relationship between the examined series provide tourism practitioners and policymakers more information to formulate hedging strategies against tourism market vulnerabilities and future oil price movements for the policy planning of economic development in Thailand.

Keywords Indicator · Tourism vulnerability · Monitoring tool · Thailand · Development

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1 Introduction

Vulnerability refers to the degree to which a system is susceptible to, or unable to cope with external forces (IPCC, 2001). The Oxford English Dictionary defines vulnerability as the quality or state of being exposed to the possibility of being attacked or harmed, either physically or emotionally (English Oxford Living Dictionaries, 2018). To understand the theory of vulnerability requires an understanding on the vulnerability concept in the realm of economics, set forth by the United Nations Development Program (UNDP). In this context, the notion of economic vulnerability refers to its capacity to withstand unexpected catastrophe (Guillaumont, 2009), and this has made "market vulnerability" an important decisive indicator in measuring the sustainable development of an economy. The Covid-19 pandemic has caused a stagnation phase in the world tourism cycle, affirming the common fact that tourism market is vulnerable to risks. Alvarez et al. (2022) emphasized that tourism is the most vulnerable sector to Covid-19 pandemic, especially in a tourism-dependent economy. This suggests that tourism vulnerability reflects a country's overall economic resilience in response to external forces.

The COVID-19 pandemic significantly impacted tourist arrivals and dealt a severe blow to the tourism sectors across the Asia-Pacific region. Southeast Asia has emerged as a lucrative tourist destination, contributing significantly to the region's Gross Domestic Product (GDP). According to the World Travel and Tourism Council (WTTC), Southeast Asia's Travel & Tourism industry is projected to experience substantial growth in 2024, increasing by 20.6% to USD 404.68 billion. This expansion would represent 9.7% of the region's GDP, surpassing its pre-pandemic peak in 2019. Employment in the sector is also set to grow significantly, reaching over 42 million jobs, which represents a 5.6% increase year-on-year and surpasses employment levels recorded in 2019. It is notable that Southeast Asian countries rely on tourism to stimulate their emerging economies. Thailand, as the leading tourism destination in the region, has witnessed 28 million of tourist arrivals in 2023. In Thailand, tourism accounted for 11.5% of the GDP, showing its central role in economic resilience and growth. Similarly, the tourism industry has fueled GDP and revenue growth in Malaysia (10.5% of GDP), the Philippines (7.1% of GDP), Vietnam (7.0% of GDP), and Indonesia (5.1% of GDP), highlighting its economic significance across these Southeast Asian nations (World Travel & Tourism Council, 2024). As the leading tourism destination in the Southeast Asia region, Thailand's vulnerability to various factors requires careful examination.

Unlike some of its rapidly growing neighbors, Thailand has a more mature and diversified economy. This maturity often results in slower (2.06%) but more stable growth. Key sectors such as manufacturing, agriculture, and services play pivotal roles in Thailand's economy. While these sectors have shown resilience, their growth rates have plateaued compared to emerging economies. Tourism is a cornerstone of Thailand's economy, accounting for a significant portion of its GDP and providing employment to millions. The COVID-19 pandemic underscored the sector's vulnerability to external shocks, prompting the need for strategic interventions to bolster its resilience. To enhance Thailand's economic resilience and growth prospects, it is imperative to tackle vulnerabilities in the tourism sector. In 2023, Malaysia was the leading source market for foreign tourists to Thailand, with 4.4 million arrivals. Following Malaysia, China contributed 2.7 million arrivals, Singapore 1.9 million, and India 1.6 million. Thailand does not overreliance on any single source market. However, intraregional travel is notably common, with seven of the top ten source markets situated in the Asia Pacific region. Any economic or political issues in the Asia Pacific region can lead to a significant drop in visitor exports. To identify promising growth markets for Thailand as a destination, it is crucial to understand the relative size of Asia Pacific countries and pinpoint high-potential markets beyond this region.

In Thailand, the tourism market vulnerability and resilience are under the jurisdiction of the Tourism Authority of Thailand (TAT) and managed through some public–private partnerships in destination management and marketing (Beirman, 2018). Over the past two decades, Thailand has conquered the probable detrimental risks and crisis as well as the reputational challenges for its tourism industry to flourish. TAT plays a role in engaging the strategic planning for risk and crisis management. Apart from government's initiatives, the collaboration with private stakeholders and the Pacific Asia Travel Association (PATA) also has a role during the recovery phases. The collaboration with key stakeholders, PATA and ASEAN tourism has paved the way towards a globally renowned tourism industry that became significant to the Thailand's economy.

Thailand's economy is the second largest among the Association of Southeast Asian Nations (ASEAN) and is remarkably dependent on tourism. Like other countries, Thailand's economy has been tremendously affected by the outbreak of Covid-19. The country's GDP fell by 6.1 percent in 2020, causing many tourism-related workers to lose their jobs (International Monetary Fund, 2022). The pandemic frozen tourism flows and caused remarkable contraction in economic activities. Recently, the government of Thailand officially announced that Thailand's economy has entered its recovery phase, driven by the substantially rebounded tourism sector after the lifted cross-border movement restrictions and quarantine requirements. Nonetheless, Thailand's tourism sector has shown a significant recovery from the COVID-19 pandemic, which drastically impacted international arrivals and the economy. In 2022, Thailand welcomed approximately 11.15 million international tourists, a considerable increase from just 430,000 in 2021, although this figure remains far below the pre-pandemic peak of 39.8 million tourists in 2019. Despite experiencing a decline in 2022, Thailand is quickly bouncing back. In 2023, Thailand experienced a significant surge in tourist arrivals, totaling approximately 28.09 million or 153.94% when compared to 2022. The tourism sector is expected to make a significant recovery in 2024, with projections estimating that approximately 36.1 million visitors will arrive in the country (Tourism.co.th., 2024). According to the World Travel and Tourism Council (2022), the travel and tourism industry in Thailand has contributed approximately 6.8 million jobs or 17.5% of total employment and about a fifth of the national GDP. Moreover, Tourism receipts from international visitors in Thailand have steadily increased, reaching over 139 billion Thai baht in December 2023. However, as the country has been heavily reliant on Chinese tourists that accounted for a quarter of the total tourist arrivals prior to the pandemic, the Chinese government's "zero-Covid" policy is still limiting outbound tourism and limiting Thailand's recovery.

Traditionally, the dimensions of risk and vulnerability in the theoretical concept of Tourism Destination Competitiveness (TDC) and its empirical applications use different indicators to rank tourism destinations (Duro et al., 2022). A destination with competitive advantageous position should contribute to the economic returns. However, statistics compiled in the UNWTO World Tourism Barometer (UNWTO, 2022) has shown that these highly competitive countries, as defined by the traditional classification of indicators, suffered from declined international tourism flows in 2020. The concept of risk and vulnerability remains unclear and neglected despite the increasing amount of TDC empirical applications in the literature (Enright & Newton, 2004; Shariffuddin et al., 2022). As far as the literature is concerned, four general types of events have been considered as vulnerable in tourism. Past studies evaluated the tourism market vulnerable to natural disasters and

environmental shocks (Becken & Santana-Gallego, 2020; Dogru et al., 2019); vulnerability of tourism destinations to armed conflicts and incidents of political conflicts (Liu & Pratt, 2017; Mansfeld, 1999); crisis impacts and economic shocks (Perles et al., 2016; Williams & Balaz, 2016); and the contingency of epidemic episodes that include the Covid-19 pandemic (Duro et al., 2021; Gossling et al., 2020).

Given the importance of Thailand's tourism-dependent economy, this paper attempts to address the vulnerability of tourism to the structure of the destination source markets. Different from the preceding studies that prioritized uncontrollable phenomenon, this paper delivers the *ex-ante* vulnerability associated with the destination demand's structure in which the managers, tourism practitioners or government policymakers can have some *ex-ante* control. This study aims to assess the vulnerability of Thailand's tourism sector by developing a composite indicator, the Tourism Market Vulnerability Indicator (TMVI) to evaluate factors such as financial, political, social, and macroeconomic risks. The TMVI will provide tourism managers, practitioners, and policymakers with an actionable tool to better understand and manage the sector's vulnerabilities in Thailand's tourism-dependent economy. The hypothesis is that the TMVI can effectively support tourism management by simplifying complex variables into a cohesive, cost-effective measure that optimizes information utility.

2 Literature review

Tourism market vulnerability is broadly referred to as indication of the extent to which the tourism system is affected by the adverse impacts of shocks disturbance or stressor in short-term and long-term, respectively (Cinner et al., 2018). Across various time scale, the possible disruptions may cause negative consequences to individuals, societies, infrastructures, and even the tourism structure. Vulnerability typically refers to a state or condition of being susceptible to harm or negative impacts. It's often associated with a higher probability of experiencing unforeseen events or hazards that can significantly affect a particular sector or activity. This includes the potential occurrence of adverse natural phenomena, such as storms, earthquakes, or floods. In simpler terms, vulnerability involves being at risk due to the increased likelihood of encountering hazards or adverse events, which could have significant consequences for the affected entity or system.

Alvarez et al. (2022) accentuated the needs for tourism vulnerability to be accounted in a composite index that embraces numerous context-dependent indicators to capture the fluctuations in tourism cycle and in response to specific risk or crisis. A composite index considers multiple dimensions or components of vulnerability, providing a more comprehensive and holistic assessment compared to single indicators (Roy et al., 2023b). By integrating various factors, such as socio-economic, physical, and institutional dimensions, a composite index captures the complexity of vulnerability more accurately. A rich body of literature on tourism vulnerability and resilience, as well as the indicator approach, has been drawn upon to strengthen the paper's credibility and depth. Key references include studies done by Basak et al. (2021) on driving factors of tourism demand and development, Alvarez et al. (2022) on destination resilience and risk management, Roy et al. (2022) on index construction using three interconnected dimensions including eco-environment and socio-economy, and Roy et al. (2023a) on sustainable development parameters.

In fact, all types of crisis such as economic crisis, environmental crisis, societal or political crisis, health-related crisis, and technological crisis can cause sharp contractions in tourism flows. The repetitive occurrence of similar crises can significantly damage the destination's image and reputation apart from creating physical impact. An intricate network of tourism market vulnerability constitutes of numerous dimensions likewise that include the social structure, economy and governance. The complexity of tourism market vulnerabilities has been expressed as high demographic density, disorganized planning of territorial, lower intimacy relationship among travelers and local environment as well as disaster risks. The cyclical and resilience nature of tourism market from various types of crisis strongly indicates the necessity to better comprehend the possible role of influential dimensions of vulnerability in the tourism-context.

Moreover, the link between vulnerability and the sustainable development of a nation, particularly within the context of the tourism sector, is paramount. Vulnerability within the tourism sector can arise from a multitude of factors, such as natural disasters, socio-economic disparities (Roy et al., 2023a, 2023b, 2023c), political instability, and public health crises. These vulnerabilities can significantly impact the sustainability of tourism development by disrupting visitor flows and undermining local livelihoods. Thus, efforts to enhance the resilience of the tourism sector and mitigate vulnerabilities are essential for achieving sustainable development goals. This involves adopting strategies that promote social inclusivity, economic diversification, and community empowerment. By addressing vulnerabilities and building resilience, nations can ensure the long-term viability of their tourism industry while fostering inclusive and sustainable growth for all stakeholders involved. In this paper, the key focus is on four dimensions (as shown in Fig. 1) of tourism market vulnerability comprising of physical, socio-cultural, economic, and institutional (UNDRR, 2020; Alvarez et al., 2022).

2.1 Dimensions of tourism market vulnerability

Physical vulnerability typically refers to the likelihood of assets (Adger et al., 2005), infrastructure, and coastal areas (Daire et al., 2012) being susceptible to harm or damage. This vulnerability encompasses various factors such as the condition of assets, the resilience of infrastructure, and the susceptibility to flooding in coastal regions. Transportation infrastructure is one of the important resources in tourism destination,



Fig. 1 Dimensions of the TMVI. Source: own elaboration

whereby its vulnerable characteristics can simply intensify the possible long-term stoppage for travelers to travel to a destination. Its contribution to the competitiveness of tourism destination can also enhance the interconnectivity of tourism assets in the country (Yang et al., 2019). Similar to the studies conducted by Novacká (2014), Non-thapot and Srichaiyo (2017), and Sofronov (2017), visitor exports has been identified as the first step in the process of economic impacts evaluation to measure the development of transportation infrastructure. Visitor exports (VE) is a tourism income variable that measures the foreign spending of tourists and business travelers, including the spending on transportation. Spending of foreign tourists from the source market of Thailand has been proven to be bi-directional with the GDP (Nonthapot & Srichaiyo, 2017).

Socio-cultural vulnerability refers to the differential susceptibility of individuals or groups based on social, economic, geographical and political factors (Alvarez et al., 2022). Socio-cultural vulnerability is locally rooted in the social capital conflicts among tourism stakeholders. Consumer price index (CPI), as a capital flow, is representative of consumption expenditure (Leng et al., 2021) and often used to measure the living costs and living standards of the local people. CPI is also proven to own a leading characteristic in determining the tourism demand of Thailand (Soh et al., 2021a, 2021b). Furthermore, Majumder et al. (2023) conducted a study on urban social vulnerability and associated risk assessment in India. Using a multiscale GIS-based model, they incorporated wages, literacy rates, workforce population, and educational qualifications to construct the urban social vulnerability index. Findings revealed that fostering economic growth in susceptible areas, bolstering small and medium-sized enterprises, and generating employment opportunities can assist vulnerable communities in broadening their income streams and ensuring stability. Improving education and skill development is critical.

On the other hand, institutional vulnerability has a strong domination on alertness, feedback, and remedial measures during crises (Alvarez et al., 2022). Institutional vulnerability is a function of factors including income disparity, political stability, the absence of violence, and ethnic fragmentation (Kraay et al., 2010). Political stability index (PSI) can act as one of the early signals for the organization and policymakers in crisis planning and preparedness. Effective leadership at the local level actively assists an efficient policy and planning framework for welcoming tourists (Ruhanen, 2013). Institutional vulnerability is linked to the economic vulnerability when a country becomes over-reliant on tourism and lacks a thorough understanding of the tourism market status, its potential and limitation.

Economic vulnerability refers to the threat of crises recognized from a source of macroscale economic risk to tourism destinations (Alvarez et al., 2022; Hoti et al., 2005). In practice, the dependency between tourism destinations and the arrival of tourists are due to the differential dependence of other economy sectors on daily cash flows as well. Tourism market vulnerability is also subjected to market volatility. This includes the volatility of the financial market and the economic vulnerability of the source market. The real effective exchange rate (REER), the Thailand's SET index (SET) and the China leading indicator (LCI) have been proxied as the variables in measuring economic vulnerability. However, over-dependence on tourism as an economic driver may put the nation at risk of economic collapse, especially during the period of a pandemic like Covid-19. The tourism market vulnerability highlights the importance of an economy to prepare for possible crises and identify the leading indicators for crisis preparedness and policy planning.

2.2 Oil prices, tourism development and economic growth

Given the energy-intensive nature of tourism market (Barsky & Kilian, 2004; Chatziantoniou et al., 2013), sudden change in oil prices requires a thorough investigation into the possible connection among tourism market development, economic growth, and fluctuations of oil price. Barsky and Kilian (2004) and Soh et al. (2019) emphasized that the effect of sudden fluctuation in oil prices exerted on transportation, production costs, economic uncertainty and disposable income may have a detrimental effect on economic and tourism activities. Tourism-dependent countries such as Thailand need to acknowledge the role of oil prices in causing global economic turbulence and trigger political events that further affect commodity markets and oil prices. Furthermore, the UNWTO has also expressed concerns on the possible negative impact of oil price hikes to the tourism market segments such as airlines and cruise lines.

From the macroeconomic perspective, oil price hikes may lead to a rise in inflation and create unfavorable consequences on the nation's prosperity. In the view of microeconomics, the sudden change of oil price may lead to a contraction in disposable income. As tourism is categorized as luxury good, the impact of oil price changes in tourism market is instantaneous (Chatziantoniou et al., 2013). Figure 2 demonstrates the comparative analysis of cyclical patterns between crude oil price and Thailand's international tourist arrivals. Changes in crude oil prices directly influence transportation costs, including airfares and fuel expenses for airlines and other modes of transportation. Within the span of 2003–2008, the price of crude oil surged from \$30 per barrel to \$60 by August 2005. Subsequently, in July 2008, it reached a peak of \$147.30 per barrel, as reported by the World Heritage Organization. When oil prices rise, transportation costs tend to increase, potentially leading to higher travel expenses for tourists. Conversely, decreases in oil prices



Fig. 2 Comparative analysis of cyclical patterns between crude oil price fluctuations and Thailand's international tourist arrivals. *Note:* The blue line on the graph represents Thailand's international tourist arrivals (TA), reflecting the tourism cycle. Conversely, the orange line represents the fluctuation of crude oil prices (BRENT), encapsulating the peaks and troughs of the cycle changes

within the span from 2015 to 2019 may result in lower transportation costs, making travel more affordable and potentially stimulating demand for tourism. Since tourism is an oil-intensive sector, an attentive policy planning against the sudden fluctuation of oil price is necessary to avoid the diminished benefits on tourism market, and thereafter minimize the vulnerability of the tourism market.

Building on the seminal theoretical work of Hazari and Sgro (1995), previous literature has broadly discussed the connection between tourism market and economic development in a country. The four general hypotheses of the said relationship include (i) the tourismled growth hypothesis (TLGH) (see, Shahzad et al., 2017; Lee, 2021); (ii) the economicdriven tourism growth (EDTG) hypothesis (see, Hakan et al., 2015); (iii) the bidirectional causality between tourism and economic growth hypothesis (see, Fauzel & Tandrayen-Ragoobur, 2021; Pulido-Fernández & Cárdenas-García, 2021; Gounder, 2022); and lastly, (iv) the absence of significant causality between tourism and economic growth hypothesis (see, Katircioglu, 2009). Pertaining to the overriding assumption that underpinned the TLGH, increase in tourism income is said to create multiplier effects on the economy, which include an increase in employment in tourism sector, positive progress in tourismrelated businesses and higher tourism receipts for the national balance of payments. On the other hand, the argument of EDTG hypothesis is that the initiatives of policy that advocate overall economic growth should embrace precedence measures to boost tourism growth as well. In brief, this paper intends to investigate the causal relationship among oil prices, tourism development and economic growth after the construction of TMVI following the vulnerability dimensions.

3 Methodology

For tourism market vulnerability, the UNWTO (2011) has acknowledged five types of crises impacting the tourism sector's activity, typically through economic crises, environmental crises, societal/political crises, health-related crises and technological crises. With crises occurrence coming from multiple dimensions, construction of one single indicator can serve as a proxy for tourism market vulnerability. To construct the tourism market vulnerability indicator, this paper employed the dynamic approximate factor model with the combination of expectations maximization algorithm following the application of van Roye (2014) and Kuek et al. (2021). The United Nations Statistical Commission, collaborating with Sachs et al. (2020), has outlined five essential criteria for selecting indicators for empirical analysis, emphasizing relevance, statistical adequacy, timeliness, data quality, and consistent coverage to inform policymaking effectively. As illustrated in Table 1, the indicators are selected based on their leading characteristics and the selection criteria determined by the United Nations Statistical Commission in determining the vulnerability of Thailand's tourism market. The constructed indicator is further analysed by utilising wavelet algorithm against key economic variables comprised of international tourist arrivals (TA) in Thailand, gross domestic product (GDP) as proxy to the economic growth and crude oil price (BRENT).

3.1 Dynamic approximate factor model

The dynamic approximate model estimation in this paper followed the application of van Roye (2014) whereby the model has been built in a state space form. Equation 1 depicts

Table 1 Selected indicators			
Domain	Indicators	Relevance and Justification	Source
Physical Vulnerability	Visitor Exports (VE)	Visitor exports is an important indicator to gauge the development of transportation infrastructure (Nonthapot & Srichaiyo, 2017; Novacká, 2014; Sofronov, 2017). It is a tourism income variable that quantifies the foreign spending of tourists and business travelers, including expenditures on transportation	World Travel and Tourism Coun- cil (WTTC)
Socio-cultural Vulnerability	Consumer Price Index (CPI)	CPI, a key indicator of consumption expenditure (Leng et al., 2021), is often used to measure the living costs and living standards of local populations. Changes in the CPI can significantly impact tourism in Thailand, as fluctuations in living costs influence both the affordability for tourists and the overall attractiveness of Thailand as a travel destination	Bureau of Trade and Economic Indices
Economic Vulnerability	Real Effective Exchange Rate Index (REER)	Fluctuations in the REER can reflect broader economic condi- tions. A stable REER can signal a stable economic environ- ment, which is attractive to tourists. Conversely, significant volatility can deter tourists due to perceived economic instability (Alvarez et al., 2022; Dincer et al., 2015; Pavlic et al., 2015)	Bank of Thailand
	Stock Exchange of Thailand – SET Index (SET)	SET index is a composite index that brings together the prices of all stocks trading on the Stock Exchange of Thailand, reflects the overall performance of Thai companies (Alvarez et al., 2022; Hoti et al., 2005). The SET index impacts Thailand's tourism sector through various channels, includ- ing economic confidence, investment in tourism infrastruc- ture, consumer spending, currency value, and the overall perception of economic stability (Puarattanaarunkorn & Kiatmanaroch, 2022; Soh et al., 2021b)	Bank of Thailand
	Leading Indicator: China (LCI)	China Composite Leading Indicator (LCI) is designed to provide early signals of turning points in business cycles showing fluctuation of the economic activity (Alvarez et al., 2022; Hoti et al., 2005)	CEIC Data

omain Indicators		Relevance and Justification	Source
stitutional Vulnerability Political Stability	/ and Absence of Violence / Terrorism (PSI)	Political Stability Index (PSI) can serve as an early indicator for organizations and policymakers in crisis planning and preparedness (Kraay et al., 2010). Effective local leadership plays a crucial role in establishing an efficient policy and planning framework for attracting tourists (Jong et al., 2022 Ruhanen, 2013)	World Bank

the modelling equation that links the observed data to the state vector of the latent factor, x_t . Similar to van Roye's (2014) work, the single factor modelling has been used for the assessment since additional factor will not meaningfully provide changes in the empirical findings.

$$x_t = \Delta f_t + e_t$$
, where $e_t \sim iidN(0, c)$ (1)

where x_t denotes a stationary and standardized endogenous variable of macroeconomic and tourism data in vector form, f_t denotes a single common latent factor and Δ denotes the factor loadings of each variable in the vector form of $n \times 1$. The factor loadings are defined by the degree to which each time series is affected by the common factor. The TMVI is specified as $TMVI_t = \Delta f_t$. The symbolization of e_t represents the idiosyncratic components in the form of $n \times 1$ vector, where low correlation in terms of series and cross-section at all leads and lags are permissible to prevent over-restriction. The subsequent transition equation indicates the dynamics of the latent factor f_t ,

$$f_t = af_{t-1} + \in_t \text{ where } \in_t \sim iid N(0, d)$$
(2)

where a denotes a matrix of the autoregressive coefficients, measuring the latent factor f_t development in an autoregressive model over time.

Following the application by van Roye (2014), the dynamic approximate model estimation in this paper utilised the model that combined the maximum-likelihood approach and the expectation maximization algorithm originally proposed by Dempster et al. (1977). The dynamic model employed has the advantages for an effective management of ragged edges, mixed-frequency data and a random configuration of missing data. The primary objective of this paper is to identify the key drivers of vulnerability in Thailand's tourism market, specifically focusing on the variables with leading characteristics. The dynamic approximate factor model excels at extracting latent factors that represent underlying drivers, enabling a clearer understanding of what most significantly influences the market. Additionally, the dynamic nature of the model supports robust forecasting and scenario analysis by understanding the factors that have historically influenced Thailand's tourism. The indicator constructed by means of dynamic approximate factor model (DAFM) spanned from 2000M01 through 2022M06. Only the data availability of PSI is limited to the year 2020 while the rest of the data are available up to year 2022. Most of the data were obtained in the monthly basis except the GDP, PSI and VE. Application of the Chow-Lin (1971) methodology is utilised for interpolation to allow consistency of the variables to be presented in monthly series. All the financial, political and macroeconomic data are obtained from the CEIC Database while the crude oil prices is obtained from the Energy Information Administration (EIA) Database and the tourism-specific data is obtained from the World Travel and Tourism Council (WTTC) Database.

3.2 Wavelet coherence

Spanning over the years from 2000M01 to 2022M06, a wavelet coherence analysis has been employed to further investigate the lead-lag relationship and time effect between the TMVI and Thailand tourism market, followed by a study of TMVI versus GDP to further verify the validity of the tourism-led growth hypothesis in Thailand. Apart from that, this study also examined the possible effects of oil price shocks on tourism arrivals in Thailand through the analysis of BRENT versus TMVI extended from the work done by Chatziantoniou et al. (2013) in examining the causal relationship among oil price shocks, tourism variables and economic indicators. The evidence of possible causal effects is vital for tourism practitioners and policymakers to decide the need to create hedging strategies against future oil price movements for future tourism economic development planning.

Following the pseudocode written by Percival and Walden (2000), this study implemented the packages of "biwavelet" and "waveslim" through R programming languages to conduct the wavelet coherence analysis. Wavelet coherency deals with the evolution of two different time series over time and frequency domain, suggesting high-movement regions in time–frequency space. Within the bivariate framework, the wavelet coherence between two selected time series is expressed as $W_{xy}(\tau, u) = W_x(\tau, u)W_y^*(\tau, u)$. The resultant illustrations of coherence maps via a contour plot can adequately ease the interpretation within the examined time series. The vertical scale presented in months denotes the frequency of 4–64 months while the horizontal scale denotes the timeline of this study. The power of the coherence coefficient is portrayed at the right-side of colour bar from dark blue to dark red. Darker red zones signify stronger evidence of co-movements between two examined time series. The black contour in boldface defines the zones, which are significant at the 5% level by the set boundaries, whereas the whitish area is recognized as the zone of influence that is statistically insignificant.

Following the previous studies done by Jiang et al. (2017), Kumar et al. (2019) and Soh et al. (2021a), the arrow sign in the wavelet coherence plots indicate the lead-lag phase relation within the examined time series. In the case when the two examined time series move together, a difference in zero phase is indicated. Rightward arrows denote an in-phase positive correlation while leftward arrows indicate an anti-phase negative correlation between the examined time series. When the arrows are portrayed as upwards (\uparrow), upwards-right (\nearrow) and downwards-left (\checkmark), the first time series is leading the second time series. On the contrary, when the arrows are pointing downwards (\downarrow), downwards-right (\searrow) and upwards-left (\nwarrow), the second time series is leading the first time series.

3.3 Impulse response functions

Impulse response functions (IRFs) trace the dynamic impact of a "shock" or change to an input within a system. It is widely used across various fields; they are especially useful in economics and finance for several reasons. First, the IRFs align with the application of theoretical economic and financial models. It is useful to analyze how outcomes alter in response to exogenous changes in the economic model. Second, the IRFs also assist in predicting the implications of policy changes within a macroeconomic framework. In this study, it is assumed that the impulse response functions (IRFs) exhibit no contemporaneous effects and the selected variables are not explained by the current period values. Following the previous studies done by Wiah (2017) and Huang et al. (2019), the impulse response functions (IRFs) are employed as a robustness check in this study to validate the findings. By analyzing IRFs, the dynamic response of the variables to shocks over time can be observed, thereby offering empirical evidence to support the stability and reliability of the results. This approach helps ensure that the observed relationships and effects are consistent and not merely artifacts of the model specifications or data peculiarities. In essence, IRFs provide a comprehensive view of the temporal effects, reinforcing the credibility of the empirical analysis.

4 Results and discussion

The indicator construction through DAFM in this paper is based on a blend of macroeconomic and tourism-related variables. The indicator is compiled from six variables, comprising of consumer price index (CPI), real effective exchange rate (REER), Thailand's SET index (SET), China leading indicator (LCI), political stability index (PSI) and visitor exports (VE). The development of the TMVI is demonstrated in Fig. 3. Several major episodes of vulnerability in the Thai tourism market history has been identified when evaluating the trend.

From the beginning of the period under study, the first substantial rise of tourism market vulnerability occurred before the dot-com bubble burst in 2000. The ensuing rise in vulnerability was due to the severe acute respiratory syndrome (SARS) outbreak in 2003, followed by the occurrence of the Indian Ocean Tsunami that severely impacted Thailand towards the end of 2004, particularly at popular destinations like Phuket and Phang Nga in southern Thailand. A period of relatively low vulnerability was disrupted with the Thai military coup in 2006 and the tourism market further worsened with the global financial crisis in 2008, triggered by the collapse of Lehman Brothers. A quick recovery in tourism market vulnerability from the global financial crisis has been fuelled by a swift rebound in tourist arrivals in 2010 following the improved economic condition globally. The quick recovery in the tourism sector is again disrupted due to the occurrence of massive flooding in central Thailand in 2011. The unstable political circumstance in Thailand since 2006 led to another military coup in 2014 and the tourism market was further impacted adversely by the bombing of Erawan Shrine and the global economic meltdown in 2015, instigated by the low commodity demand in China. With high-dependency of the Thai tourism market on Chinese tourists, the weak global economic recovery led to a soft tourism market that was again hit by the COVID-19 pandemic towards the end of 2019.



Fig. 3 Tourism market vulnerability indicator in Thailand. *Note*: The dotted points indicate episodes of tourism market vulnerability based on reports of various issues on Thailand by UNWTO

This section discusses the TMVI analysis findings, which entails the identification of the lead-lag relationship of the TMVI versus international tourist arrivals (TA), followed by TMVI versus Thailand's economic growth (GDP) and TMVI versus oil prices (BRENT) as suggested by Chatziantoniou et al. (2013). The color bar indications in the wavelet coherence plot (shown in Fig. 4) depict the strength and phase of the relationship between the two selected time series. Warm colors (red, orange, and yellow) indicate high coherence, meaning the two variables have a strong relationship at that specific time and frequency. Conversely, cool colors (blue and green) indicate low coherence, suggesting a weaker relationship or no significant relationship between the variables. These colors help identify periods when the variables move together or are out of phase, which is essential for understanding the dynamic interactions between variables. This insight is crucial for interpreting economic phenomena and assessing tourism vulnerability in Thailand. Thereby, the temporal and frequency-dependent relationships between variables can be identified.

The results revealed that the constructed TMVI has a significant in-phase positive relationship with TA since the arrows are pointing rightwards. Meanwhile, the TMVI is statistically proven to lead TA as the arrows are pointing downwards-right in the wavelet coherence maps. This has validated the leading role of TMVI to provide an early signal on the fluctuation of the Thailand's tourism cycle. Considering that the tourism market's vulnerability can effectively minimize the crisis impacts and contribute during the recovery period, more travelers should be welcomed to Thailand.

With reference to the TLGH and EDTG hypotheses in Thailand, an interesting finding has emerged, aligning with the work of Fauzel and Tandrayen-Ragoobur (2021), Pulido-Fernández and Cárdenas-García (2021), and Gounder (2022), which confirms a bidirectional causality between tourism and economic growth. Fauzel and Tandrayen-Ragoobur (2021) find that tourism boosts GDP and employment in small island economies but can strain resources, stressing the need for policies that support sustainable growth. Pulido-Fernández and Cárdenas-García (2021) highlight the crucial role of resident support for sustainable tourism in tourism-dependent areas, emphasizing the balance between economic and social benefits. Gounder (2022) examines how tourism can strengthen economic resilience in developing nations but notes vulnerabilities to external shocks, suggesting diversification in tourism sectors. This finding is further supported by studies such as Balaguer and Cantavella-Jordá (2002) and Shaheen et al. (2019), which emphasize the importance of regional economic structures in facilitating this relationship. The interdependence of tourism and economic growth suggests that fluctuations in one sector can significantly influence the other, highlighting the need for integrated policy approaches. For instance, governmental investment in tourism infrastructure can stimulate economic activity, while economic growth can enhance tourism development through increased disposable income and consumer spending. Furthermore, the dynamics of the tourism sector, including the impact of global events and trends, are crucial in understanding this relationship, as evidenced by the findings of Tung (2021), which discuss how external shocks can disrupt tourism flows and, consequently, economic stability.

Meanwhile, this paper found that GDP leads TMVI in the medium term, which corresponded well to the economic-driven tourism growth (EDTG) hypothesis. TMVI also lead GDP in the long term and this validated the tourism-led growth hypothesis (TLGH) in Thai tourism. Moreover, the wavelet coherence analysis shows a stronger relationship on the vertical scale of 16–32, highlighted by warm colors of red and orange, indicating a robust long term relationship between GDP and the Thailand's tourism market. Conversely, the relationship between GDP and the constructed TMVI is weaker in the shortterm period, as indicated by the cooler colors of yellow and blue during the period of 4–16



Wavelet Coherence: TA vs TMVI

Wavelet Coherence: GDP vs TMVI



Wavelet Coherence: BRENT vs TMVI



Fig. 4 Wavelet coherence maps

on the coherence maps. This suggests that, in the short term, the impact of GDP on tourism market vulnerabilities is less pronounced. This may be because short-term economic changes do not immediately translate into changes in tourism patterns or because other factors overshadow GDP's influence in the short term. Overall, the confirmation of bidirectional causality underscores the necessity for comprehensive strategies that consider both tourism and economic policies to foster sustainable growth in Thailand.

The wavelet coherence analysis reveals a high coherence between crude oil prices and the TMVI in the short term and medium term, as indicated by the predominantly red colors on the map. In contrast, the long term period shows cooler colors, such as yellow, signifying a weaker relationship between the TMVI and crude oil prices over the long term. Tourism relies heavily on oil for transportation, including air travel, cruises, and ground transportation. Consequently, changes in oil prices can directly affect travel costs and, subsequently, tourist behavior and spending patterns. As an oil-intensive industry, the findings from the wavelet analysis show that crude oil prices (BRENT) play a leading role in influencing the TMVI, as indicated by the upward-right pointing arrows (\nearrow). This implies that changes in oil prices can significantly impact the vulnerabilities of the tourism market in Thailand. The TMVI reflects the sensitivity of the tourism market to various risk factors, and a strong dependence on oil prices indicates that the market is vulnerable to external shocks in the energy sector. Understanding this relationship can help policymakers and industry stakeholders develop strategies to mitigate risks, such as diversifying energy sources, improving energy efficiency, or hedging against oil price volatility. Tourism businesses can use these insights for better risk management and contingency planning. For instance, they might invest in fuel-efficient technologies or seek alternative energy sources. By leveraging this knowledge, stakeholders can enhance the resilience of the tourism market against fluctuations in oil prices.

In addition to examining the role of the Tourism Market Vulnerability Indicator (TMVI) in Thailand's tourism market and economy, an impulse response functions (IRFs) analysis is conducted to further validate the relationships between the selected variables (as shown in Fig. 5). This analysis aims to delve into the dynamic effects of structural shocks, particularly focusing on how chosen variables including visitor exports (LVE), the Stock Exchange of Thailand (LSET), the Real Effective Exchange Rate (LREER), the Political Stability Index (LPSI), the Leading China Indicator (LLCI), and the Consumer Price Index (LCPI) influence International Tourist Arrivals (LTA). By relating to Thailand's vulnerability in the tourism market, this analysis seeks to further explore how external and internal factors impact tourist inflows and the overall economy.

First, the relationship between LTA and LVE typically shows that higher visitor exports positively influence Thailand's international tourist arrivals. A rise in LVE indicates a flourishing tourism sector in Thailand, which can attract more tourists through positive word of mouth. Policymakers should prioritize strategies aimed at enhancing visitor spending by improving tourist facilities. This could initiate a beneficial cycle where increased visitor expenditure attracts more tourists, thereby further boosting Thailand's economy.

Next, the initial positive shock from LSET led to a 0.1 standard deviation increase in LTA during periods 2–9, with the impact returning to zero by period 10, followed by a longer period of negative impact from periods 10–30. The Stock Exchange Index (SET) of Thailand has experienced a significant decline, dropping by 15% compared to global indices. Various domestic factors, including political uncertainties, have contributed to this decline, resulting in diminished confidence, and reduced foreign investments in Thailand's market. This could gradually affect international tourist arrivals to Thailand as investors seek more favorable market conditions elsewhere. Clarity on tax collection



Response to Cholesky One S.D. (d.f. adjusted) Innovations 95% CI using analytic asymptotic S.E.s

Fig. 5 Impulse response functions. *Note*: LTA denotes the logarithm of international tourist arrivals in Thailand, LVE denotes the logarithms of visitor exports, LSET denotes the logarithm of Stock Exchange of Thailand, LPSI denotes the logarithm of political stability index, LLCI denotes the logarithm of leading China indicator, and LCPI denotes the logarithm of consumer price index

policies could indirectly enhance domestic flexibility, allowing funds to reinvest in the Thailand stock market, thereby stimulating the economy.

Furthermore, tourism authorities and businesses can use SET Index trends to plan strategically. For instance, anticipating economic downturns can lead to proactive measures to mitigate impacts on tourism. In times of economic uncertainty indicated by a falling SET Index, the tourism sector can implement crisis management strategies, such as promoting domestic tourism or diversifying source markets. Diversification of the tourism source market through the development of tailored travel packages that cater to the preferences of tourists from Eastern Europe, or the Middle East is essential. For instance, forming strategic partnerships with local travel agencies and airlines in these regions can be highly beneficial. By using the SET Index as an economic barometer, stakeholders can make informed decisions regarding investment, marketing, and strategic planning to enhance resilience and sustain growth in the tourism industry. Similarly, during the initial periods 2–6, a positive shock from LREER to LTA is observed. However, from periods 6–30, a negative relationship emerges before converging back to zero. This finding suggests that an increase in LREER, indicating appreciation of the local currency, results in a decrease in tourist arrivals. Understanding this relationship assists policymakers in devising marketing strategies to mitigate the adverse effects of currency fluctuations. For example, promotional efforts could be intensified to maintain tourist flows, while businesses in the tourism sector can adjust pricing and service offerings in response to currency fluctuations to sustain tourism demand. The real effective exchange rate (REER) affects how Thailand is positioned relative to other popular destinations in Southeast Asia, such as Vietnam, Indonesia, and Malaysia. If Thailand's REER appreciates more than its neighbors, it could lose market share to these countries. Thus, the REER is included as a crucial indicator that affects Thailand's tourism sector by influencing the cost attractiveness of the destination. Policymakers, tourism operators, and stakeholders need to monitor REER trends and adjust their strategies accordingly to maintain Thailand's appeal as a top travel destination.

Moreover, the impact of a shock in LPSI is minimal during the initial periods 2–4, fading to zero swiftly, but it exhibits a negative relationship with LTA from periods 16–30. Considering Thailand's popularity as a destination for both new and returning tourists, political stability emerges as a crucial factor for sustaining tourism revenue. Although adverse publicity regarding political instability in Thailand's tourism market may be temporary, it can substantially influence tourist perceptions and travel choices, resulting in short-term declines in tourist arrivals and revenue. A short period of negative impact from LLCI to LTA is noted at the initial period. There is a notable spike around periods 2–24, followed by convergence back to zero after period 24. A positive shift in a leading economic indicator for China typically indicates economic expansion and heightened consumer confidence, fostering increased outbound travel from China to Thailand.

Furthermore, the graph illustrates that LTA responds to shocks in LCPI across the periods. There exists a negative relationship between LTA and LCPI, aligning with economic theory, where a positive shock to LCPI would negatively impact LTA. This is because higher inflation makes traveling to destinations more expensive for tourists, reducing the attractiveness and affordability of traveling to Thailand. To counteract the negative effects of inflation, policymakers can offer subsidies on key tourism-related expenses such as transportation and accommodation. Additionally, businesses can promote luxury experiences like spa retreats featuring traditional Thai massages, yoga sessions, and meditation classes, which justify higher prices while providing a comprehensive health experience. Furthermore, businesses can offer value-added goods and services such as scuba diving and snorkeling packages, adventure sports, and photography tours to enrich the overall tourist experience. In brief, the interconnectedness of the selected variables plays a significant role in shaping Thailand's tourism market and economy.

5 Conclusion

This study constructs the Tourism Market Vulnerability Indicator (TMVI) as a vital tool for monitoring and mitigating vulnerabilities within Thailand's tourism sector. Utilizing a dynamic approximate factor model based on six key macroeconomic and tourism-related variables from 2000 to 2022, the TMVI provides real-time insights that accommodate missing data configurations. Key findings highlight that the real effective exchange rate (REER) significantly impacts Thailand's tourism competitiveness relative to Southeast

Asian neighbors. Policymakers and stakeholders must closely monitor REER trends and develop targeted strategies, such as budget-friendly travel packages and marketing campaigns, to maintain Thailand's attractiveness as a travel destination. The analysis also emphasizes the importance of diversifying source markets to reduce over-reliance on a few regions, particularly given the dominance of Asia–Pacific countries among the top ten source markets. By strategically targeting emerging markets, such as those in Eastern Europe and the Middle East, Thailand can bolster its tourism resilience.

Additionally, the study identifies the Stock Exchange of Thailand (SET) Index as a valuable economic indicator, enabling tourism authorities to implement proactive measures during economic downturns. This proactive approach can include promoting domestic tourism and forming partnerships with local agencies in high-potential markets. Recognizing the importance of Thailand's political stability index in promoting the country as a safe and attractive destination, policymakers should implement a comprehensive approach that prioritizes investment in stability, fosters international cooperation, enhances crisis management capabilities, promotes stability messaging, engages stakeholders, ensures transparency, and integrates stability considerations into long-term planning. By effectively managing political stability, Thailand can maintain its position as a premier tourism destination and support sustainable economic growth and development. Additionally, regular training programs for tourism industry workers on business development, language skills, crisis management, and emergency response can be conducted to establish clear and effective communication channels between tourists and local businesses.

The study has successfully validated its hypothesis, showing that the TMVI can effectively aid tourism management by integrating complex variables into a unified, cost-efficient metric that maximizes information utility. However, the study acknowledges limitations, particularly regarding the assumptions of linear relationships and potential causality issues in the wavelet analysis. Future research should focus on expanding the range of variables analyzed, incorporating direct indicators of transportation and infrastructure, and refining methodologies to enhance the robustness of monitoring tools. In conclusion, the TMVI can play a crucial role in fostering sustainable tourism development in Thailand. The similar approach of this study can be further explored and expanded to other industries such as manufacturing or agriculture, which Thailand's economy also relies on. By addressing the highlighted vulnerabilities and leveraging the insights provided by the TMVI, policymakers and stakeholders can make informed decisions to strengthen the resilience of Thailand's tourism industry.

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Data availability The datasets generated and analyzed during this study are available in the online database, and the data sources are stated in this published article. All secondary sources and supporting data were publicly available at the time of submission.

Declarations

Conflict of interest We have no conflicts of interest to disclose. This work was supported by Tunku Abdul Rahman University of Management and Technology (TAR UMT) and Universiti Malaysia Sarawak (UNI-MAS).

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