

COVID-19 and tourism industry: An investigation of spatial dependence in Europe

Putu Mahardika Adi Saputra

To cite this article: Putu Mahardika Adi Saputra (2023) COVID-19 and tourism industry: An investigation of spatial dependence in Europe, Cogent Social Sciences, 9:2, 2282413, DOI: [10.1080/23311886.2023.2282413](https://doi.org/10.1080/23311886.2023.2282413)

To link to this article: <https://doi.org/10.1080/23311886.2023.2282413>



© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.



Published online: 16 Nov 2023.



Submit your article to this journal [↗](#)



Article views: 1591



View related articles [↗](#)



View Crossmark data [↗](#)



Citing articles: 3 View citing articles [↗](#)



Received: 25 July 2023
Accepted: 08 November 2023

*Corresponding author: Putu Mahardika Adi Saputra, Department of Economics, Faculty of Economics and Business, Universitas Brawijaya, Jln. M.T. Hariyono 165, Malang, Indonesia
E-mail: putu@ub.ac.id

Reviewing editor:
Pier Luigi Sacco, Humanities, IULM University, Italy

Additional information is available at the end of the article

TOURISM AND HOSPITALITY | REVIEW ARTICLE

COVID-19 and tourism industry: An investigation of spatial dependence in Europe

Putu Mahardika Adi Saputra^{1*}

Abstract: The tourism industry suffered the worst impact due to the spread of the COVID-19 pandemic. In this case, the Europe is the region whose tourism industry has been hardest hit globally. This study aims to analyze the relationship between the COVID-19 pandemic and the tourism industry in the Europe involving 19 countries with a period of about 514 days (early March 2020 to late July 2021) using spatial econometric analysis techniques. The data used was obtained from the European Center for Diseases Prevention and Control (ECDC) and several data providers that can be accessed online. The Spatial Durbin Model (SDM) with fixed effects was selected as the best spatial panel model that shows the spatial dependence among European countries on the tourism industry in relation to the COVID-19 pandemic. There is significant evidence of indirect effects indicating spatial spillovers in almost all independent variables in the model.

Subjects: Economics of Tourism; International Economics; The Tourism Industry; Tourism

Keywords: COVID-19 pandemic; tourism; hotels; aviation; spatial econometrics

Subjects Classification: Development Economics; International Tourism; Tourism and Hospitality

1. Introduction

The concept of “Tourism-Led Growth” proposed by Balaguer and Cantavella-Jordá (2002) states that expanding international tourism activities may promote long-term economic growth. The tourism industry can generate considerable foreign exchange, stimulate investment, create jobs, and therefore increase income or GDP (Brida et al., 2014; Stabler et al., 2010). Various countries then consider the tourism industry as a pillar of economic development (Khan et al., 2020; Sharpley & Telfer, 2015). According to Polemis and Stengos (2020), the tourism industry, including the travel industry, is generally divided into four main types of sectors, namely hotel, aviation, cruises, and car rental. Globally, the tourism industry is one of the most important industrial sectors in the world economy, which can contribute up to 10% of the world’s GDP or around US\$

ABOUT THE AUTHOR

Putu Mahardika Adi Saputra is a Lecturer and Researcher at the Department of Economics, Faculty of Economics and Business, Universitas Brawijaya, Indonesia. He holds a Ph.D. in International Economics from the Faculty of Economics, University of Rome II, Italy. His primary research interests are in International Trade, Development Economics, and Applied Econometrics. He has collaborated actively with public institutions (central and local governments, including universities) and private institutions (SMEs) in research, teaching, and community service activities.

7.6 trillion, 7% in international trade, 30% in services, and provides around 300 million jobs across the globe (Chebly & Said, 2020; UNWTO, 2020).

However, the tourism industry is prone to shocks. It has been hit hard by various global crises in the past, for example, the political turmoil -the 9/11 Terrorist Attacks, the economic and financial crisis -the 2008 global financial crisis, and the health crisis -the 2003 SARS outbreak (Khalid et al., 2021). Abbas et al. (2021) and Ozili and Arun (2020) state that the tourism industry experienced the worst impact due to the spread of the latest health crisis, namely the COVID-19 pandemic, which was officially announced in mid-March 2020.

Considering the ongoing global health crisis, it is imperative to acknowledge and closely monitor the developments of the pandemic in European countries. The COVID-19 pandemic, with its multifaceted challenges and far-reaching consequences, has profoundly impacted nations across the European continent. As the situation continues to evolve, understanding the trends, responses, and effects of the pandemic in this region is of paramount importance. The developments in European countries, characterized by varying infection rates, vaccination efforts, and government responses, serve as a crucial backdrop against which numerous societal, economic, and healthcare considerations are assessed. In this context, examining the ever-changing landscape of the pandemic in Europe is essential for informed decision-making, public health planning, and the collective pursuit of solutions to mitigate the pandemic's impact on societies and economies.

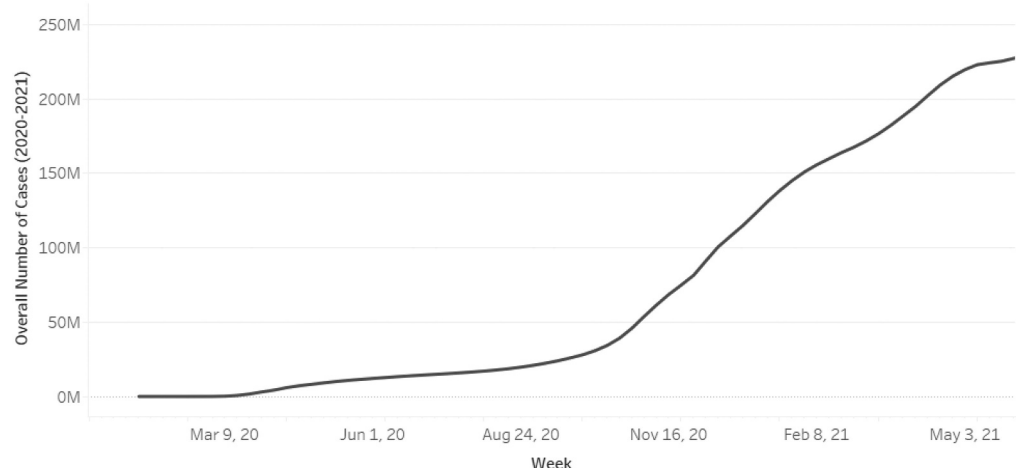
Figure 1 provides a visual narrative of the dynamics of COVID-19 pandemic cases in Europe over several weeks in 2020–2021. In early 2020, as the world was grappling with the emergence of the virus, Europe experienced a rapid surge in new cases, reaching a peak in May 2021 (with more than 100,000 new cases recorded each day).

The government's policy choices that focus on indicators in the health sector, such as social distancing and lockdowns have severe consequences for the decline in human mobility activities, which in turn triggers a drop in the performance of the global tourism industry (Anyfantaki et al., 2020; Casini & Roccetti, 2020; Stojkoski et al., 2020). In the first five-month period during January–May 2020, the rate of international tourist arrivals in Asia-Pacific declined by 60%. In Europe, it fell 58%. These two regions exceeded the average global decline (–56%). Meanwhile, America and Africa recorded a drop of 47% (UNWTO, 2021).

The hotel and aviation sectors are included in the global tourism industry and have an essential role in GDP, job creation, and social development in various countries (Ocheni et al., 2020; Tretheway & Markhvida, 2014). Both sectors become the most affected sectors due to the

Figure 1. The overall number of COVID-19 cases in Europe (January 2020 to May 2021).

Source: Our World in Data, 2021



pandemic, from either supply or demand (Christidis & Christodoulou, 2020; Maria Del Rio-Chanona et al., 2020). In times of a global health crisis, such as COVID-19, the tourism industry is collapsing worldwide due to the disruption of business-as-usual activities from the interruption of flows on both the demand and supply sides (Arbulú et al., 2021). Such decline is because the tourism industry, especially the hotel sector, is a labor-intensive industry that relies heavily on face-to-face interactions between employees and customers (King, 1995).

The tourism industry in Europe, which is the first destination in the world, contributed around US\$ 713 million in 2018 (more than half of the global tourism industry) and grew by 6% in 2018 (Weston et al., 2019). However, due to the COVID-19 pandemic, approximately US\$ 1 billion in revenue per month is estimated to be lost. According to Statista (2023), the percentage of international tourists visiting various regions in Europe has drastically decreased. The growth of international visitors from January 2020 until April 2021 is consistently falling (estimated using 2019 as a baseline). It is known that the total number of tourists visiting Europe on 4 January 2020, still grew 4%, but since the end of January 2020, the growth of foreign tourists began to decline very sharply. In April 2020, it touched -97%. In June 2020, the data trend began to show recovery and touched -65% in August 2020. However, with the second wave of COVID-19 and the re-imposition of the policy of tightening people's movements, international tourists' growth has, again, slumped.

During the pandemic, ICAO (2021) recorded that the outbreak of COVID-19 positive cases led to the decline of the number of flights in 27 European countries. However, the trend has shifted after the vaccination program since late December 2020, where the increase in inbound flight to Europe follows the number of positive cases. This phenomenon indicates an increase in tourist confidence to visit those regions, which indirectly supports tourism industry recovery. On the other hand, the permitting of flights has indirectly contributed to the increase in COVID-19 cases, as evidenced by the outbreak of new variants in European countries (Ourworldindata, 2023).

Previous studies explaining the link between the global tourism industry and the pandemic can generally be classified into two groups. The first group of studies focuses on investigating the impact of individual movement patterns or mobility, including activities in the tourism industry such as inflow-outflow of tourists and inbound-outbound flights, and other socioeconomic factors on the pandemic spread patterns or increase in numbers of confirmed cases (Mulder, 2020; Škare et al., 2021). In comparison, the second group of studies explores the effects of outbreaks spreading or increasing the number of COVID-19 cases on the pattern of movement or individual mobility represented by movements in economic activities. An example of such economic activity is the tourism and travel industry which includes the number of tourist visits, the number of flights, and hotel occupancy rates (Blake et al., 2003; Hoque et al., 2020; Sharma et al., 2021; Yang et al., 2020).

In this context, Adegboye et al. (2021) identified a significant association between the timing of disease introduction and the quantity of cases imported from Italy. These outcomes indicate that the introduction of the disease tends to transpire earlier when a higher number of cases are imported from Italy. Conversely, an escalation in the count of COVID-19 cases exhibits a positive correlation with an increased volume of daily travel originating from Italy. The spatial correlation observed between COVID-19 cases and travel patterns serves to underscore varying risk profiles across regions. Specifically, the Asia-Pacific region confronts an elevated risk of disease importation from China, whereas Europe, South America, and Africa demonstrate heightened susceptibility to diseases stemming from Italy. These findings underscore the imperative nature of devising region-specific strategies for managing the risk associated with disease importation, contingent upon the epicenter of origin.

Moreover, Khedhiri (2022) further elucidated that the spatial repercussions and alterations in travel policies constitute pivotal factors in explaining the mechanisms underpinning the spread of the coronavirus pandemic across North Africa. Consequently, this study postulates the hypothesis that a substantial spatial interdependence exists between the progression of COVID-19 within

a European nation and the performance metrics of the tourism industry, encompassing variables such as hotel revenue and aviation departures, within its adjacent nations. This proposition suggests that unfavorable COVID-19 conditions in one country may exert detrimental repercussions on the tourism sector of neighboring countries.

Although various studies explain the impact of the spread of COVID-19 on the global tourism industry, there are still limited studies that explore the relationship between the two from a spatial analysis perspective (some of them are Hafner, 2020; Jeon & Yang, 2021, Kervankiran & Bagmanci, 2021; Kriztin et al., 2020; Rogerson & Rogerson, 2020). For this reason, this research has the priority to contribute to explaining the impact of the escalation of the number of COVID-19 pandemic victims (both infected and dead) on the dynamics of the movement of the economic value of the tourism industry (using the proxy of the numbers of movements/mobility of individuals in tourism activities). In addition, it will also be estimated whether the influence of spatial dependence between regions has a significant role in exacerbating the condition of the global tourism industry during the COVID-19 pandemic. Thus, the main objective of this research is to identify the impact of the widespread COVID-19 pandemic on the development of the tourism industry through a spatial perspective in European countries. The selection of European countries considering that Europe is one of the epicenter areas of the COVID-19 pandemic and is also an area whose tourism industry has been worst affected globally.

2. Literature review

2.1. Health shocks and economics

Health is believed to play an important role in the history of economic development and has a great real influence on the process of economic development (Acemoglu et al., 2003). Studies on the relationship between health crises and the economy have been discussed by previous researchers using various concepts and methods, such as neoclassical economic growth models to empirical studies related to pandemics and the economy (Bontempi & Coccia, 2021; Wang et al., 2021). In the classical view, economic growth can be pursued through increasing the quantity and quality of labor, as well as increasing capital (Todaro & Smith, 2020). Therefore, when a worker's life expectancy has the potential to change along with a health shock, the condition of the number population, labor productivity level, and human capital per worker also has the potential to change (Acemoglu & Johnson, 2007). The theoretical framework of Bleakley (2010) states that health conditions have a direct effect on work productivity and the amount of time in work, as well as an indirect effect on changes in the level of investment in human capital.

WHO (2009) explained that there is a relationship between the pandemic and the economy, both from a macro and micro perspective, for the short and long term. The macroeconomic point of view emphasizes achieving equilibrium between the demand and supply of goods and services in economic activities carried out by economic actors (households, private sector, and government). The condition of macroeconomic equilibrium focuses on controlling injections and leakages in the economic system, where the aggregate income of an economy must be equal to its aggregate expenditure. The flow of income and expenditure between economic actors will be interconnected with each other. Therefore, when a health shock (pandemic) occurs, the impact of the shock will be able to bring about a change in the equilibrium in the economic system.

From a microeconomic point of view, there are differences in the behaviour and preferences of each economic actor in making their choices in overcoming problems. Households tend to optimize their goods or services consumption obtained from the market and non-market due to the limited income. If households are exposed to disease, they are forced to reduce the productivity as labour in producing output. As a result, household income decreases while expenses increase because they seek treatment to cure their illness. Moreover, the household also faces changes in their consumption behaviour due to time and risk preferences (WHO, 2009). The findings of Christelis et al. (2020) can provide empirical evidence of the pandemic impact framework at the household

level where there is a consumption response to the COVID-19 pandemic in six European countries. Households tend to worry about the uncertainty of the pandemic, which in turn strengthens the negative consumption response to income reduction.

At the same time, the case in every industry, such as in the tourism industry, the pandemic crisis shows a structural weakness for good protection in a world full of complexity and vulnerability affected by the turmoil caused by COVID-19 (Sigala, 2020). Every company experiences pressure to turn a profit during a health shock like the pandemic (COVID-19). This pressure can come from reduced operational activities due to changes in labor productivity (WHO, 2009). Companies are also experiencing changes in behavior and preferences in conducting financing activities because they have to make adjustments to the negative impact of the pandemic. Organizational design, as in the tourism industry must have elements that are flexible, creative and adaptive in order to achieve both: work efficiently and sustainably within the framework of the new normal, and reorient business models quickly and effectively to deal with systemic crises (Gretzel et al., 2020; Higgins-Desbiolles, 2020; Rodríguez-Antón & Alonso-Almeida, 2020; WHO, 2009).

The last economic actor is the government which is obliged to provide public goods and services to the community. The government also has two economic roles, namely as a consumer and producer, just like other economic actors. The pandemic causes an economic downturn, forcing decision makers to make policies that will be implemented to help the affected households and companies. In addition, the government will also experience a decrease in productivity as well as a decrease in tax-based revenues as a result of the pandemic (WHO, 2009). The economic collapse caused by the pandemic led policymakers to decide on policies (such as fiscal and monetary) that needed to be implemented to help affected households and firms (Gopinath, 2020).

2.2. Health shock and tourism industry: a spatial dependence perspective

The development of increasingly dynamic and globally connected tourism industry will be able to increase the mobility of goods and people within a country on the one hand, but on the other hand will also increase the level of vulnerability of the tourism industry to crises or shocks, such as health crises (Aliperti et al., 2019; Hall, 2010; Ma et al., 2020). Sectoral results show that the tourism sectors are far more severely affected by COVID-19. Under the no-border scenario, the tourism sectors of restaurant, accommodation, entertainment, trade, rail and air transport sectors are in a very difficult situation (Wang et al., 2022). The tourism industry is characterized by uncertainty due to its highly risk-prone nature. Over the years, there has been a marked decrease in demand as a result of crises such as the COVID-19 pandemic and the economic downturn that have impacted the global travel and tourism industry (Pappas et al., 2023). The high dependence of the global tourism industry on human mobility activities raises concerns over the risk of impact from a health crisis (Yang et al., 2020).

One of the most considered factors to have a significant role in expanding the impact of contagion and suppressing the economic side is the spatial dependence factor (Koopman, 2005). A spatial dependence refers to the degree of spatial autocorrelation between values measured independently in geographic space or simply called the “neighborhood effect” (Crawford, 2009). Studies related to spatial dependence have long been considered crucial in geostatistics and econometrics; therefore, the dimensions and models of the spread of pandemics are diverse, namely: (1) traditional epidemiological models; (2) spatial proximity model; (3) Explicit Spatial Epidemiological Models; and (4) the TPSN (Territory, Place, Scale, Network) Framework (Bian, 2004; Holmes, 1997; Jessop et al., 2008; Kuebart & Stabler, 2020; Lesage, 2008).

The TPSN framework is a suitable approach for empirical research related to social phenomena in a given space. This framework can explain how socio-spatial processes are structured through four dimensions: Territory, Place, Scale, and Network. Based on the development of Kuebart and Stabler (2020) this concept believes that a pandemic can have a contagious effect and even broader impact on all aspects of human life. The four spatial dimensions of the TPSN are

interconnected and can then be explained with the basic epidemiological concepts of disease transmission. First, Territory/T is an important matter that the public must understand concerning the pandemic outbreak. The territorial agency must recognize outbreaks to be correctly identified (Brenner, 2004; Wimmer & Glick-Schiller, 2002). Second, Place/P has characteristics that can determine the socio-demographic configuration of people living or domiciled in a place and how they interact. Massive or super-spreading events may occur under certain conditions, such as crowds or poor ventilation. Third, Scale/S can be seen as a process of pathogen spread or pathogen diffusion within and between social networks. Lastly, Network/N is a reinforcer of “infection pathways” and a prerequisite for infectious diseases to pass from one individual to another (Bian, 2004). Network refers to the spread of a pandemic through ties between individuals, so this dimension is also influenced by Place (P) and Scale (S). Meade and Emch (2010) state three processes of spatial diffusion or “scaling”, namely (i) infectious diseases can spread spatially (spread spatial contagious) through spaces and networks such as mobility, (ii) hierarchical diffusion that occurs along with existing patterns such as the centrality of the transport network, and (iii) relocation diffusion when the disease enters a new place and spreads from there.

2.3. COVID-19 and the travel industry: hotel and aviation indices

The global economy and industries have experienced unparalleled and substantial consequences due to the COVID-19 pandemic, which is instigated by the novel SARS-CoV-2 coronavirus. Among the severely affected sectors are the hospitality industry, as gauged by the Hotel Index, and the aviation industry, as measured by the Aviation Index. The Hotel Index, serving as a pivotal metric for assessing the health of the hospitality industry by quantifying daily hotel revenue per available room, faced an immediate and significant adverse impact upon the pandemic’s onset (Rodríguez-Antón & Alonso-Almeida, 2020). Multiple research studies have underscored a substantial reduction in hotel revenue after the propagation of COVID-19 (Anguera-Torrell et al., 2021; Danso et al., 2020). This decline can be ascribed to a multitude of factors, including travel constraints, lockdown measures, and a diminished willingness among consumers to patronize hotels. It is noteworthy that the repercussions of the pandemic on the Hotel Index exhibit heterogeneity across different regions, contingent on the outbreak’s gravity and the efficacy of mitigation strategies implemented in various countries (Abou Kamar, 2022). Several investigations have indicated that regions heavily reliant on international tourism, such as prominent European urban centers and sought-after tourist destinations, have experienced the most pronounced declines. Conversely, regions characterized by a robust domestic tourism sector have demonstrated greater resilience (Korinth, 2022).

The Aviation Index, which serves as a critical gauge for assessing daily international flight departures, represents a fundamental indicator of the global aviation industry’s overall health. The onset of the COVID-19 pandemic has led to an unprecedented disruption of air travel on a global scale. A consistent body of research underscores a substantial reduction in international air travel stemming from the pandemic’s multifaceted impacts. Airlines across the globe have grappled with a significant decrease in passenger volumes due to a confluence of factors, including travel restrictions, border closures, and diminished demand (Budd et al., 2020). Importantly, the repercussions extend beyond the airlines themselves, as studies have shed light on the broader economic consequences. These repercussions encompass substantial job losses, declines in airport revenues, and decreased demand for interconnected sectors such as tourism and hospitality (Nižetić, 2020).

3. Research methodology

3.1. Data

In this research, we employ the TPSN (Territory, Place, Scale, Network) approach to approximate the independent variables utilized in our model. TPSN serves as a crucial component of our research methodology. We have adopted this approach to delve deeper into the analysis of how these independent variables interact with specific territories, influence places, exhibit varying impacts across different scales, and how their interconnectedness through networks affects the

outcomes of our model. Through this approach, we gain a more profound understanding of the complex dynamics of these variables and create a more accurate and comprehensive model. This study adopts the Territory, Place, Scale, Network (TPSN) approach, which informs the selection of variables typically employed in research on the impacts of COVID-19. As a result, the variables chosen for this study are those commonly utilized in COVID-19 impact studies. This approach ensures that the study's variables align with established research practices, facilitating comparisons and insights within the broader context of COVID-19-related research.

This study employs 19 sample countries in the Europe, which were selected by considering the characteristics of international tourism (the leading destination for international tourists) and regional aspects adjusted to the availability of data for each sample country. The countries are divided into five regions: Western Europe (Belgium, Netherlands, Germany, and France), Southern Europe (Italy, Portugal, and Spain), Central Europe (Austria, Czech Republic, Hungary, and Poland), Eastern Europe (Romania, Estonia, Latvia and Lithuania), and Northern Europe (Denmark, Finland, Norway and Sweden).

The variables considered in the model are divided into 2 (two) clusters, namely the COVID-19 Cluster (as the independent variable) and the Tourism cluster (as the dependent variable). This study utilizes a data period from March 2020 to the end of July 2021 (around 514 days). The data used is daily data obtained from several sources available in each country through the official government website and several data providers that can be accessed online. Details regarding variable descriptions, variable definitions, and data sources are presented in Table 1.

3.2. Empirical model

This study utilizes spatial econometric analysis techniques to analyze the relationship between the COVID-19 pandemic and the Europe's tourism industry by considering the spatial dependencies between the analyzed countries. To explore the influence of the COVID-19 pandemic on the dynamics of the tourism industry, it will be analyzed using a spatial panel model analysis. The selection of the best spatial panel model will follow the path or stage of determination presented by Lesage and Pace (2009) using the Top-Down Approach method. The standard test for selecting the best form of panel data model (Fixed Effect -FE or Random Effect -RE) through the Hausman test mechanism is carried out on each considered spatial panel model, i.e., Linear, SDM-Spatial Durbin Model, SAR-Spatial Auto-Regressive Model, and SEM-Spatial Error Model.

The Spatial Durbin Model (SDM) is a statistical framework used in spatial econometrics to analyze data with spatial dependencies. It accounts for the influence of neighboring locations on a dependent variable of interest, such as the hotel or aviation sector's performance. SDM involves a spatial weight matrix (W) that quantifies these relationships, and it formulates regression models to estimate how direct factors (X) and indirect spatial effects (WX) impact the dependent variable. The model helps disentangle the unique contributions of variables within a specific location and their spatial interactions with nearby regions, providing insights into spatial dynamics and dependencies in the data (Kopczewska, 2020).

According to Lesage and Pace (2009), SAR models assume that the value of a variable at a particular location is influenced not only by its own characteristics but also by the characteristics of neighboring locations. In other words, it incorporates spatial lag, which is the weighted sum of the values of the variable in neighboring locations. SEM models assume that the spatial autocorrelation exists in the error term of a regression model. Unlike SAR models that incorporate spatial dependence directly into the explanatory variables, SEM models focus on modeling the spatial autocorrelation in the residuals.

As an effort to expand the possibility of the best type of panel data selected, this study also conducted model competition testing for the types of spatial models SARAR/SAC (Spatial Autoregressive Combined) and GSPRE (Generalized Spatial Random Effect Model) in accordance

Table 1. Variables Description, definition, and sources

Variables	Description	Definitions	Source
Dependent Variables			
<i>HotelIndex</i>	The daily hotel revenue in a given country	An index calculated based on daily data (revenue per available room) of a country's hotels. This index is expressed in units of index 1–100. Level 100 indicates recovery to the normal level.	www.COVID19tourism.com
<i>AviationIndex</i>	Number of daily departures from international flights in a given country	An index calculated based on daily departure data from a country's international airport. This index is expressed in units of index 1–100. Level 100 indicates recovery to the normal level.	www.COVID19tourism.com
Independent Variables			
<i>NewConfirmed</i>	New confirmed cases of COVID-19	The number of COVID-19 confirmed cases per day. A confirmed case is “a person with laboratory test results declared infected with COVID-19”, as described by the World Health Organization (WHO).	European Centre for Diseases Prevention and Control (ECDC)
<i>NewDeath</i>	New death of confirmed COVID-19 case	The number of new death from COVID-19 recorded, according to the standards in reporting deaths and the ‘cause of death’ classification of the WHO International Classification of Diseases guidelines.	European Centre for Diseases Prevention and Control (ECDC)
<i>Vaccine</i>	The total number of people who received full doses determined by the vaccination protocol per 100 people in the total population	The number of individuals who have received all doses that is determined by a country's vaccination system. It is calculated as the number of people who received the full dose of the vaccine divided by the population multiplied by 100.	www.ourworldindata.org
<i>Stringen</i>	Government Response Stringency Index	The Stringency Index is a composite of nine response metrics, namely school closures; closure of the workplace; cancellation of public events; restrictions on public gatherings; closure of public transportation; stay-at-home requirements; public information campaign; restriction of internal movement; and international travel control. A higher index value indicates a tighter response (where 100 = the strictest response).	www.ourworldindata.org

with the modified flow or stage of spatial model selection presented by Burrige et al. (2017). In this study, the top-down approach is utilized as a systematic method for selecting a suitable spatial econometrics model. Specifically, the Spatial Durbin Model (SDM) is chosen as the starting point in this approach. The top-down approach involves a structured process that begins with the selection of the SDM and then proceeds to examine and test various spatial effects within the chosen model (Lesage & Pace, 2009). Therefore, the constructed equation is as follows:

$$\begin{aligned}
 Y_{it} &= \rho WY + (\alpha_{1N} + \gamma_i) + \beta X_{it} + \theta WX_{jt} + \mu_{it}; \\
 \mu_{it} &= \lambda \sum_{j=1}^N W_{ij} \mu_{jt} + \varepsilon_{it}
 \end{aligned}
 \tag{1}$$

In the context of spatial regression modeling, several key components play crucial roles in understanding the relationships and dependencies among variables. The dependent variable, denoted as $Y_{it}(\text{Hotelindex and Aviationindex})$, represents the observed outcome for a specific entity i at time t . The spatial autocorrelation coefficient, ρ , signifies the strength of spatial dependence, highlighting the degree to which neighboring observations influence each other. The spatial weight matrix, W , is instrumental in defining these spatial relationships, elucidating how one observation's characteristics impact those of its neighboring entities.

The individual-specific (fixed) effects, denoted as α_i , are pivotal in capturing latent characteristics that are unique to each entity but remain constant over time, allowing us to control for these unobservable factors. N represents the vector of these individual-specific fixed effects. Coefficients, represented by β , encompass the explanatory variables X_{it} (*NewConfirmed*, *NewDeath*, *Vaccine*, and *Stringent*) that potentially affect the dependent variable $Y_{it}(\text{Hotelindex and Aviationindex})$. Furthermore, θ symbolizes the coefficient responsible for encapsulating spatial spillover effects by considering the spatial lag of the explanatory variables. The idiosyncratic error term, ε_{it} , factors in unexplained variations that are specific to each observation at time t . The coefficient λ , governing the spatial lag of the error term, reflects the extent to which errors are spatially correlated.

To incorporate the spatial context, $\sum_{j=1}^N$ signifies a summation across neighboring locations or observations surrounding entity i . This summation accounts for all neighboring locations' contributions to the spatial lag effect. Each μ_{jt} represents the value of the dependent variable in a neighboring location j at time t , contributing to the spatial lag effect. In addition to these components, γ_i represents the entity-specific fixed effects. These fixed effects capture individual-specific characteristics that persist over time, ensuring that the model controls for entity-specific factors while focusing on spatial relationships and interactions.

After incorporating the variables considered in the study, equation (1) will be modified into Equation 2. In Equation 2, there are two dependent variables, namely the hotel index and aviation index. Each dependent variable will be analyzed in a separate spatial panel model, although using the same independent variables.

$$\begin{aligned} \text{HotelIndex, AviationIndex}_{it} = & \rho W \text{HoteIndex, AviationIndex}_{jt} + (\alpha_{1N} + \gamma_i) + \beta_1 \text{NewCovid}_{it} \\ & + \beta_2 \text{NewDeath}_{it} + \beta_3 \text{Vaksin}_{it} + \beta_4 \text{Stringen}_{it} + \theta_1 W \text{NewCovid}_{jt} \\ & + \theta_2 W \text{NewDeath}_{jt} + \theta_3 W \text{Vaksin}_{jt} + \theta_4 W \text{Stringen}_{jt} + \text{gama}_i + \mu_{it}; \\ \mu_{it} = & \lambda \sum_{j=1}^N W_{ij} \mu_{jt} + \varepsilon_{it} \end{aligned} \quad (2)$$

The ideal way of interpreting the spatial panel model is to interpret the partial derivatives of direct and indirect effects (spillover effects). According to Lesage and Pace (2009) and Elhorst (2013), the method is a more valid way to test the spillover effect, where the total effect of a variable is decomposed into direct and indirect effects. The direct effect in this study will indicate that the dynamics of the hotel and aviation sector (dependent variable) in a country are influenced by variations in the country's independent variables (*NewConfirmed*, *NewDeath*, *Vaccine*, and *Stringen*). Meanwhile, the indirect effect implies that the dynamics in the hotel and aviation sector of a particular country are influenced by changes in the independent variables of its neighboring or surrounding countries (*NewConfirmed*, *NewDeath*, *Vaccines*, and *Stringen*). The direct, indirect, and total effects will have different characteristics of mathematical expressions for each spatial model used. In this context, a mathematical expression of the general basic form of the spatial panel model (SDM) will be presented, following the path of selecting the spatial model from Lesage and Pace (2009).

In spatial regression models, effects measure variable impacts, considering spatial dependencies among regions. Direct effects gauge changes within a region's variable on its dependent

variable. Indirect effects measure changes in one region's variable affecting neighboring regions. Total effects sum both direct and indirect impacts. These effects' significance depends on model specifics, spatial weight matrices, and data characteristics. Interpretation involves formula-based calculation and significance testing. Sources like Lesage and Pace (2009) and Elhorst (2010) guidance, addressing complexities like non-linearity and endogeneity. The equations of direct, indirect, and total effects for different spatial econometric models are as follows:

For the static spatial Durbin model, the direct effect of a change in the k^{th} explanatory variable on the dependent variable is:

$$\frac{\partial E(Y)}{\partial X_k} = (I - \rho W)^{-1} (b_k I + h_k W) \quad (3)$$

where Y is a vector of observations on the dependent variable, W is a spatial weights matrix, ρ is a spatial autoregressive coefficient, X_k is a vector of observations on the k^{th} explanatory variable, b_k is the regression coefficient of X_k , and h_k is the regression coefficient of its spatial lag WX_k . The indirect effect of a change in X_k on Y is:

$$\frac{\partial E(Y)}{\partial X_k} \cdot W \quad (4)$$

Furthermore, the total effect can be calculated by summing the direct and indirect effects, thereby providing researchers with a holistic understanding of the intricate dynamics at play in their spatial models. Based on equations (1) and Equation 2, it is possible to develop the form of Equation 8 for the Hotel Index variable, which can be written as follows (the Aviation Index variable will have the same form):

$$HotelIndex_{it} = (I_n - \rho W)^{-1} (\alpha_{iN} + X\beta + \theta WX + \mu_{it}) \quad (5)$$

where the expected value of Equation 3 will look like below:

$$\begin{aligned} E(HotelIndex|X) &= E[(I_n - \rho W)^{-1} (\alpha_{iN} + X\beta + \theta WX + \mu_{it})] \\ &= [(I_n - \rho W)^{-1} E(\alpha_{iN} + X\beta + \theta WX + \mu_{it})] \\ &= (I_n - \rho W)^{-1} (\alpha_{iN} + X\beta + \theta WX) \end{aligned} \quad (6)$$

Furthermore, to obtain direct and indirect effects from the model form in Equation 2, a partial derivative for Equation 2 is carried out on the k^{th} exogenous variable (in this case, k value is equal to 4):

$$\begin{aligned} \begin{bmatrix} \frac{\partial HotelIndex_1}{\partial X_{1K}} & \dots & \frac{\partial HotelIndex_1}{\partial X_{NK}} \\ \dots & \dots & \dots \\ \frac{\partial HotelIndex_N}{\partial X_{1K}} & \dots & \frac{\partial HotelIndex_N}{\partial X_{NK}} \end{bmatrix} &= (-\rho W)^{-1} \begin{bmatrix} \beta_k & \theta_k W_{12} & \dots & \theta_k W_{1N} \\ \theta_k W_{21} & \beta_k & \dots & \theta_k W_{2N} \\ \dots & \dots & \dots & \dots \\ \theta_k W_{N1} & \theta_k W_{N2} & \dots & \beta_k \end{bmatrix} \\ &= (-\rho W)^{-1} (\beta_k I + \theta_k W) \end{aligned} \quad (7)$$

Regarding Equation 8 Elhorst (2013) noted that the partial derivatives of $E(Y)$ with respect to the k^{th} explanatory variable have three important properties. First, if a particular explanatory variable in a particular unit changes, not only will the dependent variable in that unit itself change but also the dependent variables in other units. The first is called a direct effect and the second an indirect effect. Thus, it can be concluded from Equation 8 that both direct and indirect effects of a particular exogenous variable will depend on the estimated coefficient of the spatial lag variable of that variable (θ_k).

Considering the extended time series data, it's possible that temporal dependence could have a more significant influence than spatial dependence, raising questions about the use of a spatial Durbin model (SDM) that neglects temporal dependence. However, for the purposes of this study, we have chosen to focus exclusively on the spatial dimension. We used the SDM equation model in this case, with a focus on both regional and proximity spatial effects and ignoring time-specific effects in the panel model employed in the analysis.

4. Results

In this section, we present a comprehensive overview of the dataset's descriptive statistics. These statistics serve as the initial step in understanding the characteristics and distributions of the key variables under investigation. A detailed examination of these statistics provides valuable insights into the central tendencies, variations, and overall profile of the data. Such insights are essential for researchers and analysts seeking to gain a deeper understanding of the dataset and lay the groundwork for more advanced analyses and modeling techniques. The following statistics encompass key variables related to the hotel and aviation sectors, as well as COVID-19-related variables, contributing to a holistic understanding of the dataset's composition.

Table 2 offers valuable insights into the characteristics and distribution of the variables under investigation. Among the key observations, the Hotel Index ranges from a minimum value of 0.778 to a maximum of 96.960, with an average of approximately 22.793 and a standard deviation of 15.124. Similarly, the Aviation Index spans from 0.239 to 100.000, with a mean value of about 21.460 and a standard deviation of 16.729. The New Confirmed Cases variable displays a wide range of values, from 0 to 86,852, with an average of 3,292.06 and a substantial standard deviation of 6311.216. New Deaths range from 0 to 2,004, with a mean of 69.58 and a standard deviation of 145.982. The Vaccine variable ranges from 0 to 59.370, with a mean value of 5.362 and a standard deviation of 11.442. Lastly, the Stringent variable varies from 0.00 to 93.52, with an average of 59.0466 and a standard deviation of 15.66787. These statistics provide a foundational understanding of the dataset, facilitating further in-depth analysis and modeling in the research study.

Furthermore, this section will explain the results of two spatial econometric models, distinguished by the two dependent variables aforementioned. The two models are the spatial panel model using Hotel Index and Aviation Index as the dependent variable, respectively. Based on Yang et al. (2020), the two different dependent variables represent two main sectors in the tourism industry, which are the hotel sector (Hotel Index) and the aviation sector (Aviation Index).

Multicollinearity, a common issue in regression analysis, refers to the high correlation between two or more independent variables in a statistical model. It can have detrimental effects on the model's stability and the interpretability of the coefficients. In the context of spatial modeling, multicollinearity is of particular concern because it can lead to biased parameter estimates and reduced model reliability. Therefore, it is crucial to assess multicollinearity before proceeding with the spatial model.

Table 2. Descriptive statistic

	Minimum	Maximum	Mean	Std. Deviation	Variance
HotelIndex	0,778	96,960	22,793	15,124	228,750
AviationIndex	0,239	100,000	21,460	16,729	279,872
NewConfirmed	0,000	86852,000	3292,056	6311,216	39831444,244
NewDeath	0,000	2004,000	69,578	145,982	21310,638
Vaccine	0,000	59,370	5,362	11,442	130,917
Stringen	0,000	93,520	59,047	15,668	245,482

Several diagnostic tools and statistics can help identify multicollinearity. One commonly used metric is the Variance Inflation Factor (VIF), which measures the extent to which the variance of an estimated regression coefficient is increased due to multicollinearity. A high VIF value, typically above 10, indicates problematic multicollinearity. Table 3 presents Variance Inflation Factor (VIF) values to assess multicollinearity among predictor variables. VIF values are as follows: “NewConfirmed” (VIF = 1.679), “NewDeath” (VIF = 1.884), “Vaccine” (VIF = 1.045), and “Stringen” (VIF = 1.292). All VIFs are below 2, indicating minimal multicollinearity and enhancing the reliability of coefficient estimates in the regression model.

The execution of the spatial panel model begins with conducting Hausman Test to obtain the best panel model for every possible spatial panel model. The Hausman test is used to choose the best panel model between Random Effect Model (REM) and Fixed Effect Model (FEM) on three primary spatial models on this study (SDM-Spatial Durbin Model, SAR-Spatial Auto Regressive Model, and SEM-Spatial Error Model). As shown in Table 4, the Hausman Test Result for SDM, SAR, and SEM model consistently show that FEM is the best panel model, where the null hypothesis is rejected ($prob < \alpha$ 5%). The Hausman test also shows a consistent result on both dependent variables (Hotel Index and Aviation Index) in every possible spatial panel model. As a note, the $prob$ or p -value is the probability that a sample will have an effect that is at least as extreme as the effect observed in the sample if the null hypothesis is true. If the p -value is less than or equal to the alpha level, then the null hypothesis will be rejected (Sharma, 2019). Alpha, also known as the level of significance, is the probability of rejecting the null hypothesis when it is true (Anderson, 2016).

In the next stage, a test is carried out to determine the best spatial panel model (SDM, SAR or SEM) to investigate the impact of the COVID-19 pandemic on the tourism industry in the Europe by considering the existence of spatial dependence between regions. Table 5 presents the test results for selecting the best spatial panel model by considering three main models in spatial econometrics (SDM, SAR and SEM). SDM (Spatial Durbin Model) was chosen to be the best spatial panel model when the respective models were compared with its competitor models, namely SAR and SEM. The results obtained also look consistent, both when the dependent variable considered in

Table 3. Multicollinearity test

Variable	Collinearity Statistics	
	Tolerance	VIF
NewConfirmed	0,595	1,679
NewDeath	0,531	1,884
Vaccine	0,957	1,045
Stringen	0,774	1,292

Table 4. Estimation results: best panel model for each spatial model

Spatial Models	chi-square (Prob)	Best Panel Model
<i>Dep. Var: Hotel Index</i>		
SDM	229.28 (0.0000)	FE (Fixed Effect)
SAR	57.01 (0.0000)	FE (Fixed Effect)
SEM	11.46 (0.0429)	FE (Fixed Effect)
<i>Dep. Var: Aviation Index</i>		
SDM	84.39 (0.0000)	FE (Fixed Effect)
SAR	65.32 (0.0000)	FE (Fixed Effect)
SEM	24.00 (0.0000)	FE (Fixed Effect)

Source: Author estimation

Table 5. Estimation results: selection of the best spatial panel model

Spatial Panel Model Comparison	chi-square (Prob)	Best Spatial Panel Model
<i>Dep. Var: Hotel Index</i>		
SDM (FE) vs. SAR (FE)	690.92 (0.0000)	SDM (FE)
SDM (FE) vs. SEM (FE)	1255.25 (0.0000)	SDM (FE)
<i>Dep. Var: Aviation Index</i>		
SDM (FE) vs. SAR (FE)	2179.14 (0.0000)	SDM (FE)
SDM (FE) vs. SEM (FE)	2033.52 (0.0000)	SDM (FE)

Source: Author estimation

the model is the Hotel Index (a proxy for the hotel sector in the tourism industry) and the Aviation Index (a proxy for the aviation sector in the tourism industry).

As the chosen spatial panel model, Spatial Durbin Model with Fixed Effect (SDM-FE) shows evidence of spatial dependence between countries regarding the COVID-19 impact on the tourism industry in Europe. This dependence was indicated by the significant spatial effect (ρ) in Table 6. These findings indicate a spatial correlation in both the Hotel and Aviation Indices. When one region observes an increase in its Hotel Index, there is a tendency for neighboring regions to exhibit a corresponding increase, and conversely, a decrease in one region's Hotel Index is likely mirrored in its neighboring regions. Similarly, spatial correlations are evident in the Aviation Index, where changes in one region are positively associated with changes in nearby regions. Thus, an increase in the Aviation Index in one area often coincides with similar increases in neighboring regions, and conversely, a decrease tends to be mirrored in nearby regions as well. This outcome aligns with prior research by Su et al. (2022), which documented the transmission of COVID-19 from Wuhan to adjacent cities, leading to a positive spatial autocorrelation. Cities experiencing frequent virus recurrences witnessed a decline in civil aviation passenger throughput.

As the chosen spatial panel model, Spatial Durbin Model with Fixed Effect (SDM-FE) shows evidence of spatial dependence between countries regarding the COVID-19 impact on the tourism industry in Europe. This dependence was indicated by the significant spatial effect (ρ) in Table 6. These findings indicate a spatial correlation in both the Hotel and Aviation Indices. When one region observes an increase in its Hotel Index, there is a tendency for neighboring regions to exhibit a corresponding increase, and conversely, a decrease in one region's Hotel Index is likely mirrored in its neighboring regions. Similarly, spatial correlations are evident in the Aviation Index, where changes in one region are positively associated with changes in nearby regions. Thus, an increase in the Aviation Index in one area often coincides with similar increases in neighboring regions, and conversely, a decrease tends to be mirrored in nearby regions as well. This outcome aligns with prior research by Su et al. (2022), which documented the transmission of COVID-19 from Wuhan to adjacent cities, leading to a positive spatial autocorrelation. Cities experiencing frequent virus recurrences witnessed a decline in civil aviation passenger throughput.

On interpreting the best spatial panel model, Lesage and Pace (2009) stated that along with the spatial econometric model that considers the presence of spatial dependence, the magnitude of the coefficient and statistical significance of the independent variables on the form of SDM standard is no longer appropriate to measure the effect of an independent variable. The estimation results of the SDM standard cannot be interpreted directly as partial derivatives as in the form of ordinary linear regression models. The presence of a spatial dependence effect will have an impact on differences in responding to the resulting coefficients, where the influence of the independent variable on the dependent variable must first be decomposed into direct and indirect effects (Lesage, 2008). Thus, the correct interpretation of the parameter estimates in the SDM (Spatial

Durbin Model) needs to consider the direct, indirect and total effects associated with changes in the independent variables in the model (Ezcurra & Rios, 2015).

Concerning the coefficients of direct, indirect and total effects, Table 6 shows mixed results for each independent variable considered in the model. The results of the SDM-FE spatial panel model by using the Hotel Index (hotel sector index) as the dependent variable concluded that a negative direct effect appeared for the variable number of new confirmed cases (*NewConfirmed*) and new cases of death due to COVID-19 (*NewDeath*) recorded by a certain European country; although this effect was only shown to be significant in the variable of new cases of death due to COVID-19 (*NewDeath*). This means that the hotel sector index in the European country is negatively affected by the number of new confirmed cases and new cases of death due to COVID-19. However, the effect is only statistically significant for the new cases of death due to COVID-19 variable. This is likely because the number of new cases of death due to COVID-19 is a more severe indicator of the pandemic than the number of new confirmed cases. People are more likely to avoid traveling to a country with a high number of deaths due to COVID-19 (Uğur & Akbıyık, 2020). The indirect or spillover effect for the two variables in question shows that the increase in new confirmed cases

Table 6. Prediction result of SDM spatial panel model with Fixed effect

Independent Variable	Hotel Index		Aviation Index	
	Coef.	Prob.	Coef.	Prob.
<i>Main</i>				
NewConfirmed	-.0000479	0.032*	.0000484	0.001**
NewDeath	-.0078325	0.000**	-.0009245	0.115
Vaccine	-.1902975	0.000**	-.5745507	0.000**
Stringent	-.17131	0.000**	-.0893564	0.000**
<i>Weight (Wx)</i>				
NewConfirmed_wx	.00022	0.000**	.0000409	0.007**
NewDeath_wx	.0065084	0.000**	.0013472	0.033*
Vaccine_wx	.3813879	0.000**	.6609532	0.000**
Stringent_wx	-.2084731	0.000**	-.1257184	0.000**
<i>Direct Effect</i>				
NewConfirmed	-6.93e-06	0.763	.000097	0.000**
NewDeath	-.0071911	0.000**	-.0005345	0.509
Vaccine	-.1270241	0.000**	-.427088	0.000**
Stringent	-.2265092	0.000**	-.209338	0.000**
<i>Indirect Effect</i>				
NewConfirmed	.0002922	0.000**	.0002514	0.000**
NewDeath	.0050209	0.000**	.0022008	0.293
Vaccine	.4428512	0.000**	.7631962	0.000**
Stringent	-.4013333	0.000**	-.6273176	0.000**
<i>Total Effect</i>				
NewConfirmed	.0002853	0.000**	.0003484	0.000**
NewDeath	-.0021702	0.240	.0016663	0.544
Vaccine	.3158271	0.000**	.3361083	0.000**
Stringent	-.6278425	0.000**	-.8366556	0.000**
<i>Spatial</i>				
rho	.3940264	0.000**	.7423935	0.000**

Note: ** Significant at 1% level; * Significant at 5% level

Source: Author estimation

(*NewConfirmed*) and new deaths due to COVID-19 (*NewDeath*) recorded by a certain European country turned out to have a significant impact in increasing the recovery of the hotel sector of their neighbouring countries as in the normal period. The increase in COVID-19 cases in the European country led to a decrease in the number of tourists from other countries. This led to an increase in the number of tourists from neighboring countries, as they were more likely to travel to a nearby country that was less affected by the pandemic (Chen et al., 2022).

Furthermore, the number of individuals vaccinated with a full dose (*Vaccine*) was found to have a negative effect on the recovery of the hotel sector in the country in question during the COVID-19 pandemic. This result indicates that an increase in the population vaccinated with a full dose (*Vaccine*) in European countries will significantly impact the decline in the performance of the hotel sector in that country during the COVID-19 pandemic. On the other hand, for the indirect effect, the variable total number of individuals vaccinated with the full dose appears to have a real spatial effect on the recovery of the Europe's hotel sector. The increasing number of individuals vaccinated with full doses in a European country will positively trigger an increase in the hotel index of its neighbouring countries. Considering the general effect of the Stringency Index (*Stringent*) by the European countries governments, including the implementation of tightening rules in conducting social distancing or interactions, on the dynamics of the recovery of the hotel sector in the Europe, it can be concluded that the tightening of government regulations related to the COVID-19 pandemic would have a negative effect on accelerating the recovery of the hotel sector in the Europe.

In addition, based on the results of the SDM-FE spatial panel model using the Aviation Index (aviation sector index) found differences in characteristics with the response given by the hotel sector in the face of the COVID-19 pandemic. The aviation sector is classified as one of the most critical sectors in the international tourism industry beside the hotel sector (Yang et al., 2020). In this case, the dynamics of the aviation sector (*Aviation Index*) is positioned as the dependent variable representing the direct movement of individuals in the international tourism industry through air transportation (airlines). Technically, fluctuations in the aviation sector are measured by the movement of air flight departure data in a particular country (air flight departure).

Table 6 shows the presence of a positive and significant direct and indirect effect for the variable of new confirmed cases of COVID-19 (*NewConfirmed*) on the movement of the number of air flight departures in the country, which appear to be positive and significant. Furthermore, the direct and indirect effects of the variable new death cases due to COVID-19 (*NewDeath*) did not significantly impact the aviation sector's recovery. At the same time, the direct and indirect effects of the total number of people who received full doses determined by the vaccination protocol per 100 people in the total population (*Vaccine*) and the Stringency Index (*Stringen*) were seen to be significant in influencing the dynamics of aviation sector during COVID-19 period.

In line with the estimation results in the hotel sector, an increase in the fully vaccinated people (*Vaccine*) in the Europe countries will have a significant impact on the decline in the performance of the aviation sector in the concerned country during the COVID-19 pandemic. As for the indirect effect, the total number of fully vaccinated individuals was proven to have a real spatial effect on the recovery of the aviation sector in the Europe. Specifically, the positive indirect effect of the variable the total number of individuals vaccinated with the full dose (.7631962) was greater than the negative direct effect (-.427088), so that the impact on the total effect was recorded as having a positive magnitude (.3361083). The direct and indirect effects of the Stringency Index (*Stringent*) on the dynamics of activity in the aviation sector were found to be significantly negative (as previously found in the hotel sector). Negative indirect effects were recorded to dominate the total negative effect of the variable firmness of a country's government response to the condition of the aviation sector in the tourism industry.

5. Discussion

This study found that the spatial effect (ρ) was positive and significant for the two dependent variables (hotel index and aviation index). This indicates that along with the recovery of the hotel and aviation sector as a result of the COVID-19 pandemic in a certain European country, it will have a positive impact on the recovery process of the two sectors for its neighboring countries. On the contrary, if there is a decline in the hotel and aviation sector in a particular European country, it will negatively impact the same sector in its neighbouring country. In addition to gaining a profound comprehension of the individual trajectories and transformations observed in the Hotel Index and the Aviation Index, an examination of their mutual interplay emerges as a particularly intriguing facet within the purview of this study. Within the discourse section, we meticulously scrutinize the reciprocal dynamics and reciprocal influence exhibited by these two variables within the context of the prevailing pandemic. Notably, it is discerned that “the Hotel Index and Aviation Index evince a closely intertwined relationship.” This entwinement ostensibly signifies a robust nexus between the domain of hospitality and the aviation sector, vis-à-vis the multifaceted challenges imposed by the pandemic (Gunay & Kurtulmuş, 2021). It is elucidated that the curtailment of aviation undertakings, encompassing flight cancellations and border closures, wields a direct repercussion on the presence of tourists within hotels. In situations where airlines truncate their routes and suspend flight operations, there ensues a reduction in the influx of tourists at various destinations, consequently engendering a decline in both booking activities and the revenue garnered by hotels. In summation, the intricate interplay between the Hotel Index and Aviation Index emerges as a pivotal focal point, affording valuable insights into the pandemic’s ramifications on the tourism sector. This underscores the imperative for enhanced coordination between these hitherto discrete sectors, as they confront the dynamic contours of the challenges at hand.

There is a fact that the increase in the number of new deaths due to the COVID-19 pandemic in a European country has a significant direct effect on the deterioration of the hotel sector in the concerned European country. This finding proves that there is a symmetrical mechanism in the hotel sector where the mobility of individuals (including tourists) with the aim of staying and utilizing hotel facilities in a country will decrease along with the increasing threat from the COVID-19 pandemic in the area (Aharon et al., 2021).

This phenomenon can be attributed to the decision-making process of individuals intending to embark on tourism-related travels, wherein they tend to take into account the broader regional context. When prospective travelers assess the COVID-19 control measures and vaccination rates across countries within a region, it significantly influences their travel choices (Chen et al., 2022). In instances where a specific country demonstrates effective pandemic containment measures and boasts a robust vaccination rate, it becomes a more favorable destination for potential tourists. Conversely, if another country exhibits inadequate pandemic control efforts and possesses a lower vaccination rate, it diminishes its attractiveness as a travel destination for these individuals.

Furthermore, the high additional confirmed cases of COVID-19 and new deaths due to COVID-19 in a European country will prove to be followed by an increase in hotel index scores in other neighbouring European countries. The indirect effect that was found to be significant strengthens the empirical relevance of spatial spillover in this context. The COVID-19 outbreak in a particular European country has triggered an increase in the demand for hotel services in neighbouring countries. This trend is possible because of an effect that this study calls the “*pandemic avoidance effect*”. The pandemic avoidance effect can be defined as the movement of individuals to avoid a pandemic outbreak (including COVID-19) that is widespread in the country of origin of the individuals. Individuals from certain countries with high levels of spread or victims of the pandemic will choose to make efforts to move to the neighbouring countries that are relatively safe to isolate themselves away from the area of origin that is being affected. With the support of advanced transportation infrastructure (land, sea and air) throughout Europe, the pandemic avoidance effect

has the opportunity to be the reason why the spatial dependence of the variables of confirmed cases and new deaths is positive and significant in this case.

The concept of the pandemic avoidance effect pertains to the deliberate relocation of individuals in response to a widespread pandemic outbreak, such as the COVID-19 pandemic, within their country of origin. In circumstances where specific countries experience a high prevalence of the pandemic or have a substantial number of pandemic-related casualties, individuals often opt to proactively relocate to neighboring countries that offer a relatively safer environment. This relocation serves as a means for these individuals to isolate themselves from the affected area of their origin.

A possible cause of the negative effect of the vaccine on the recovery of the hotel sector in the country in question during the COVID-19 pandemic is because the vaccine is thought to trigger an increase in individual confidence in meeting the requirements travel outside their home country safely. With the increasing tourist confidence, the demand for hotel sector services in the tourist country of origin is decreasing in the era of the COVID-19 pandemic. These individuals have more diverse preference patterns in visiting or staying outside their domicile area (abroad) than just staying and taking advantage of hotel services provided within their own country (Asian Development Bank, 2021).

This change in behavior reflects the evolving landscape of the tourism and hotel sectors. It suggests that the recovery of the hotel industry in a given country, while positively influenced by vaccination efforts, may also be tempered by the changing preferences of travelers (Kovačić et al., 2023). The changing preferences of travelers are now central to the recovery equation. Travelers, armed with the protection afforded by vaccination, are exhibiting a willingness to explore a broader spectrum of travel experiences. Rather than confining themselves to familiar locales within their own country, they are embarking on journeys that encompass international destinations. This shift reflects a desire for novelty and diversity in travel experiences (Orden Mejía et al., 2022).

As the world navigates the ongoing challenges posed by the COVID-19 pandemic, understanding these shifts in traveler behavior becomes essential for adapting strategies and ensuring the long-term resilience of the hotel sector. Thus, the interplay between vaccination, traveler confidence, and shifting preferences contributes to the complex dynamics impacting the recovery of the hotel sector during the COVID-19 pandemic. This phenomenon accentuates the significance of industry resilience and adaptability in response to the evolving terrain of the tourism and hospitality sectors during an epoch characterized by health-related apprehensions and vaccination initiatives.

The tightening of government stringency or Stringency Index (*Stringent*) by European governments, including the enforcement of tightening rules in social or distance interactions, was found to harm the dynamics of the recovery of the hotel sector in the Europe. This is in line with the opinion of Chen et al. (2020) which states that with the tightening of government policies aimed at limiting the movement and crowds of individuals in the pandemic era, the hotel sector will directly receive the impact of pressure to bring in guests, and collect revenue from the services it offers. In another possibility, Maliszewska et al. (2020) state that restrictions imposed by the government will tend to cause domestic individuals or households to consume fewer goods and services that involve intense individual interaction or mobility activities, such as hospitality flights, restaurants, and recreational services. The diversion of individual consumption will tend to shift to the demand to fulfil basic needs and medicines. For both direct and indirect effects, the government stringency index to managing the COVID-19 outbreak from a country was found to have a significant negative effect on the recovery of the hotel sector in the country and neighbouring countries. It is concluded that the tightening of social restrictions imposed by the government of a certain European country can lead to a worsening of the recovery process for the hotel sector in the country and neighboring countries. Indirect effects are seen to account for more than half of the total effects caused by

fluctuations in the government's response firmness index to manage the COVID-19, thus confirming the spatial spillover phenomenon in this case.

Both the direct and indirect consequences of the Stringency Index employed by governments in their management of the COVID-19 outbreak have been determined to exert a significantly adverse impact on the recovery prospects of the hotel sector within the affected country and neighboring nations. Consequently, it can be inferred that the augmentation of social restrictions by a specific European nation's government has the potential to exacerbate the convalescence process of the hotel sector within both the country itself and its proximate neighbors (Gani, 2022; Janzen & Radulescu, 2022). Of noteworthy significance is the observation that the indirect effects stemming from fluctuations in the government's stringency index, as a means of COVID-19 management, account for a substantial proportion of the overall effects, underscoring the presence of the spatial spillover phenomenon in this context.

The direct effect of the confirmed case variable (*NewConfirmed*) is found to be positive and significant. It can be interpreted that an increase in confirmed cases of COVID-19 in a European country will increase the aviation index in that country. In addition, with the positive indirect effect coefficient, it is suspected that the increasing number of new confirmed cases in a country in Europe will also impact the higher movement of the number of flight departures in neighbouring countries. This fact indicates an increase in air flight departure activities throughout the Europe due to the effects of the widespread COVID-19 pandemic outbreak in the region. However, these findings should be viewed with caution, given that the effect of increasing new confirmed cases of COVID-19 on the recovery of the aviation sector was not as expected (i.e. negative). Some of the arguments that can be the cause include the study of Haanappel (2020), which finds that most aviation sector data depend on the dynamics of the number of flights only and tends to ignore data on the actual number of passengers from each airline. Therefore, the data set is often unable to accommodate assumptions about the alignment between the number of flight activities and the number of individuals flown (a representation of the level of mobility and individual interaction). There have been reports of several airlines flying empty planes to keep them from losing their slots at airports that have limited slots during the COVID-19 pandemic. In addition, according to Strauss et al. (2020), there is also the potential for neglecting the fact that several airlines use the cabin area for cargo (goods) transportation. These findings further blur assumptions about the alignment between the number of flight activities and individual passengers flown. Sun et al. (2021) warn that an analysis of the impact of the COVID-19 pandemic on the aviation sector as a system will be challenging if the study only relies on activity data on the number of flights that have limitations in their interpretation. Meanwhile, the tightened response from the government related to the COVID-19 pandemic has proven not only to worsen the recovery process in the hotel sector, but also in the aviation sector, both in the country concerned and in neighboring countries.

Furthermore, it is noteworthy that government responses to the COVID-19 pandemic, characterized by heightened stringency measures, have proven to not only hinder the recovery process within the hotel sector but also exert adverse effects on the aviation sector, both within the country of focus and its neighboring counterparts (Abate et al., 2020; Gani, 2022). This further underscores the interconnectedness and interdependence of various sectors in the face of pandemic-induced disruptions, emphasizing the importance of considering holistic and coordinated approaches in managing the impacts of such crises.

6. Conclusion

This study investigates the impact of the COVID-19 pandemic on the tourism industry (represented by the hotel sector and aviation sector) in the Europe by considering the existence of spatial dependence among regions. The results show that the effect of spatial dependence in the Europe in cases of the impact of the COVID-19 pandemic on the tourism industry is proven to be present along with the significant spatial effect (ρ). The spatial effect (ρ) was found to be positive,

which indicates that along with the recovery (or deterioration) of the hotel and aviation sector as a result of the COVID-19 pandemic in a certain European country, it will also bring a positive (negative) impact on the recovery process of the hotel and aviation sector for its neighbouring countries.

The direct negative effect of the COVID-19 pandemic on the tourism industry in the Europe was found to be significant for the hotel sector. It indicates that the hotel sector of a country has experienced a hard hit as a result of the increasing number of new deaths due to COVID-19 in the country. The Indirect effects indicating the presence of spatial spillover were found to be significant in almost all independent variables in the model, namely confirmed cases (*NewConfirmed*), the new cases of death due to COVID-19 (*NewDeath*), the total number of people who are fully vaccinated determined by the vaccination protocol per 100 people in the total population (*Vaccine*), and the Stringency Index (*Stringent*) for cases in the hotel sector. Except for the *NewDeath* variable, all independent variables were also found to have a significant indirect effect for cases in the aviation sector.

This study found several result characteristics related to the different use of proxies to represent the dynamics of the tourism industry during the COVID-19 pandemic (i.e. the hotel sector and the aviation sector) in the selected spatial panel model (SDM-FE), including: (i) The direct effect of the number of new confirmed cases of COVID-19 only seems to affect the dynamics that occur in the aviation sector, while the indirect effect of the variable number of new confirmed cases of COVID-19 appears to be present for both sectors, namely the hotel sector and the aviation sector; (ii) The direct and indirect effects of the new death cases due to COVID-19 only proved significant for the hotel sector; (iii) The direct effect of the total number of fully vaccinated individuals on the dynamics that occur in the hotel or aviation sector looks equally negative and significant, while the indirect effect of these variables is found to both show a significant positive effect in the hotel and aviation sectors; (iv) The direct and indirect effects of the government's response in managing the COVID-19 pandemic on the dynamics in the hotel and aviation sector were found to be consistently negative and significant.

Some suggestions that can be put forward regarding this study are: (i) In future studies, it is necessary to consider the use of more comprehensive data to represent the actual dynamics that occur in the aviation sector. Aviation sector data should display not only the number or volume of flights departing from a country, but also describe the number of individuals or passengers departing from each country; (ii) It is highly recommended to develop a spatial panel simultaneous-equation model related to further investigation of the relationship between the COVID-19 pandemic and the tourism industry.

Funding

The work was supported by the Universitas Brawijaya [No. DIPA-023.17.2.677512/2021].

Author details

Putu Mahardika Adi Saputra¹

E-mail: putu@ub.ac.id

ORCID ID: <http://orcid.org/0000-0002-6228-8500>

¹ Department of Economics, Faculty of Economics and Business, Universitas Brawijaya, Malang, Indonesia.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Citation information

Cite this article as: COVID-19 and tourism industry: An investigation of spatial dependence in Europe, Putu Mahardika Adi Saputra, *Cogent Social Sciences* (2023), 9: 2282413.

References

- Abate, M., Christidis, P., & Purwanto, A. J. (2020). Government support to airlines in the aftermath of the COVID-19 pandemic. *Journal of Air Transport Management*, 89, 101931. <https://doi.org/10.1016/j.jairtraman.2020.101931>
- Abbas, J., Mubeen, R., Terhemba, P., & Raza, S. (2021). Current research in behavioral sciences exploring the impact of COVID-19 on tourism: Transformational potential and implications for a sustainable recovery of the travel and leisure industry. *Current Research in Behavioral Sciences*, 2, 100033. <https://doi.org/10.1016/j.crbeha.2021.100033>
- Abou Kamar, M. (2022). The impact of COVID-19 disruptions on hotel supply chain resilience and robustness: The role of risk alleviation practices. *Journal of Association of Arab Universities for Tourism and Hospitality*, 22(1), 132–152. <https://doi.org/10.21608/jaauth.2022.111284.1279>
- Acemoglu, D., & Johnson, S. (2007). Disease and development: The effect of life expectancy on economic

- growth. *The Journal of Political Economy*, 115(6), 925–985. <https://doi.org/10.1086/529000>
- Acemoglu, D., Johnson, S., & Robinson, J. (2003). Disease and development in historical perspective. *Journal of the European Economic Association*, 1(2–3), 397–405. <https://doi.org/10.1162/154247603322391035>
- Adegboye, O. A., Adekunle, A. I., Pak, A., Gayawan, E., Leung, D. H., Rojas, D. P., Elfaki, F., McBryde, E. S. & Eisen, D. P. (2021). Change in outbreak epicentre and its impact on the importation risks of COVID-19 progression: A modelling study. *Travel Medicine and Infectious Disease*, 40, 101988. <https://doi.org/10.1016/j.tmaid.2021.101988>
- Aharon, D. Y., Jacobi, A., Cohen, E., Tzur, J., & Qadan, M. (2021). COVID-19, government measures and hospital-ity industry performance. *PLoS ONE*, 16(8), e0255819. <https://doi.org/10.1371/journal.pone.0255819>
- Aliperti, G., Sandholz, S., Hagenlocher, M., Rizzi, F., Frey, M., & Garschagen, M. (2019). Tourism, crisis, disaster: An interdisciplinary approach. *Annals of Tourism Research*, 79, 102808. <https://doi.org/10.1016/j.annals.2019.102808>
- Anderson, D. R. (2016) *Statistics for Business & Economics*. Cengage Learning. <https://books.google.co.id/books?id=6r0aCgAAQBAJ>
- Anguera-Torrell, O., Aznar-Alarcón, J. P. & Vives-Perez, J. (2021). COVID-19: Hotel industry response to the pandemic evolution and to the public sector economic measures. *Tourism Recreation Research*, 46(2), 148–157. <https://doi.org/10.1080/02508281.2020.1826225>
- Anyfantaki, S., Hiona, B., Dimitra, D., Heather, G., Dimitris, P., Filippou, P., Anastasia, T., & Melina, V. (2020). COVID-19 and other pandemics: A literature review for economists. *Bank of Greece Economic Bulletin*, (51), 2654–1904.
- Arbulú, I., Razumova, M., Rey-Maqueira, J., Sastre, F., & Carlo, M. (2021). Measuring risks and vulnerability of tourism to the COVID-19 crisis in the context of extreme uncertainty: The case of the Balearic Islands. *Tourism Management Perspectives*, 39, 100857. <https://doi.org/10.1016/j.tmp.2021.100857>
- Asian Development Bank. (2021). Can vaccination help restart tourism? *ADB Briefs*, 186(12). <https://doi.org/10.22617/BRF210321-2>
- Balaguer, J., & Cantavella-Jordá, M. (2002). Tourism as a long-run economic growth factor: The Spanish case. *Applied Economics*, 34(7), 877–884. <https://doi.org/10.1080/00036840110058923>
- Bian, L. (2004). A conceptual framework for an individual-based spatially explicit epidemiological model. *Environment and Planning B: Planning and Design*, 31(3), 381–395. <https://doi.org/10.1068/b2833>
- Blake, A. M., Thea, S., & Guntur, S. (2003). Quantifying the impact of foot and mouth disease on tourism and the UK economy. *Tourism Economics*, 9(4), 449–465. <https://doi.org/10.5367/000000003322663221>
- Bleakley, H. (2010). Health, human capital, and development. *Annual Review of Economics*, 2(1), 283–310. <https://doi.org/10.1146/annurev.econom.ics.102308.124436>
- Bontempi, E., & Coccia, M. (2021). International trade as critical parameter of COVID-19 spread that outclasses demographic, economic, environmental, and pollution factors. *Environmental Research*, 201, 111514. <https://doi.org/10.1016/j.envres.2021.111514>
- Brenner, N. (2004). *New state spaces: Urban governance and the rescaling of statehood*. Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199270057.001.0001>
- Brida, J. G., Cortes-Jimenez, I., & Pulina, M. (2014). Has the tourism-led growth hypothesis been validated? a literature review. *Current Issues in Tourism*, 19(5), 394–430. <https://doi.org/10.1080/13683500.2013.868414>
- Budd, L., Ison, S. & Adrienne, N. (2020). European airline response to the COVID-19 pandemic – contraction, consolidation and future considerations for airline business and management. *Research in Transportation Business & Management*, 37, 100578. <https://doi.org/10.1016/j.rtbm.2020.100578>
- Burridge, A., Gill, N., Kocher, A., & Martin, L. (2017). Polymorphic borders. *Territory, Politics, Governance*, 5 (3), 239–251. <https://doi.org/10.1080/21622671.2017.1297253>
- Casini, L., & Roccetti, M. (2020). A cross-regional analysis of the COVID-19 spread during the 2020 Italian vacation period: Results from three computational models are compared. *Sensors*, 20(24), 7319. <https://doi.org/10.3390/s20247319>
- Chebly, A., & Said, F. B. (2020). The impact of COVID-19 on tourist consumption behavior: A perspective article. *Journal of Tourism Management Research*, 7(2), 196–207. <https://doi.org/10.18488/journal.31.2020.72.196.207>
- Chen, M.-H., Demir, E., Garcia-Gomez, C. D., & Zaremba, A. (2020). The impact of policy responses to COVID-19 on U.S. travel and leisure companies. *Annals of Tourism Research Empirical Insights*, 1(1), 100003–100008. <https://doi.org/10.1016/j.annale.2020.100003>
- Chen, T., Fu, X., Hensher, D. A., Li, Z.-C., & Sze, N. N. (2022). Air travel choice, online meeting and passenger heterogeneity – an international study on travellers' preference during a pandemic. *Transportation Research Part A: Policy and Practice*, 165, 439–453. <https://doi.org/10.1016/j.tra.2022.09.020>
- Christelis, D., Georgarakos, D., Jappelli, T., & Kenny, G. (2020). The COVID-19 crisis and consumption: Survey evidence from six EU countries. *SSRN Electronic Journal*, 2507. <https://doi.org/10.2139/ssrn.3751097>
- Christidis, P., & Christodoulou, A. (2020). The predictive capacity of air travel patterns during the global spread of the COVID-19 pandemic: Risk, uncertainty and randomness. *International Journal of Environmental Research and Public Health*, 17(10), 3356. <https://doi.org/10.3390/ijerph17103356>
- Crawford, T. W. (2009). Scale analytical. *International Encyclopedia of Human Geography*, 29–36. <https://doi.org/10.1016/B978-008044910-4.00399-0>
- Danso, B. A. Osei-Tutu, N. A. Maamle Whyte, T. N. & Ocquaye, E. N. (2020). Ghana Hotel Industry (three-five star rated) and covid-19: Present scenario and the way forward. *EASMB*, 3(9), 279–292. <https://doi.org/10.36349/easmb.2020.v03i09.001>
- Elhorst, J. P. (2010). Applied spatial econometrics: Raising the bar. *Spatial Economic Analysis*, 5(1), 9–28. <https://doi.org/10.1080/17421770903541772>
- Elhorst, J. P. (2013) *Spatial econometrics: From cross-sectional data to spatial panels*. Springer Berlin Heidelberg (SpringerBriefs in Regional Science). <https://books.google.co.id/books?id=mu25BAAQBAJ>
- Ezcurra, R., & Rios, V. (2015). Volatility and regional growth in Europe: Does space matter? spatial economic analysis. *Taylor & Francis Journals*, 10(3), 344–368. <https://doi.org/10.1080/17421772.2015.1062123>
- Gani, A. (2022). Using a consumer choice model to explain the effect of the newly developed oxford COVID-19 government stringency measure on hotel occupancy rates. *Quality & Quantity*, 56(6), 4313–4333. <https://doi.org/10.1007/s11135-022-01323-x>

- Gopinath, G. (2020). Mitigating the COVID economic crisis: Act fast and do whatever it takes. In R. Balwin & B. W. diMauro (Eds.), *Mitigating the COVID economic crisis: Act Fast and do whatever it takes*. CEPR Press. <https://voxeu.org/content/mitigating-covid-economic-crisis-act-fast-and-do-whatever-it-takes>
- Gretzel, U., Fuchs, M., Baggio, R., Hoepken, W., Law, R., Neidhardt, J., Pesonen, J., Zanker, M., & Xiang, Z. (2020). E-Tourism beyond COVID-19: A call for transformative research. *Journal of Information Technology & Tourism*, 22(2), 187–203. <https://doi.org/10.1007/s40558-020-00181-3>
- Gunay, S., & Kurtulmuş, B. E. (2021). COVID-19 social distancing and the US service sector: What do we learn? *Research in International Business and Finance*, 56, 101361. <https://doi.org/10.1016/j.ribaf.2020.101361>
- Haanappel, P. (2020). Slots: Use it or lose it. *Air and Space Law*, 45(Special issue), 83–93. <https://doi.org/10.54648/aila2020050>
- Hafner, C. M. (2020). The spread of the COVID-19 pandemic in time and space. *International Journal of Environmental Research and Public Health*, 17(11), 3827. <https://doi.org/10.3390/ijerph17113827>
- Hall, C. M. (2010). Crisis events in tourism: Subjects of crisis in tourism. *Current Issues in Tourism*, 13(5), 401–417. <https://doi.org/10.1080/13683500.2010.491900>
- Higgins-Desbiolles, F. (2020). Socialising tourism for social and ecological justice after COVID-19. *Tourism Geographies*, 22(3), 610–623. <https://doi.org/10.1080/14616688.2020.1757748>
- Holmes, E. E. (1997). Basic epidemiological concepts in a spatial context. In D. Tilman & P. Kareiva (Eds.), *Spatial ecology* (pp. 111–136). Princeton University Press.
- Hoque, A., Shikha, F. A., Hasanat, M. W., Arif, I., & Hamid, A. B. A. (2020). The effect of coronavirus (COVID-19) in the tourism industry in China. *Asian Journal of Multidisciplinary Studies*, 3(1), 52–58.
- Janzen, B., & Radulescu, D. (2022). Effects of COVID-19 related government response stringency and support policies: Evidence from European firms. *Economic Analysis and Policy*, 76, 129–145. <https://doi.org/10.1016/j.eap.2022.07.013>
- Jeon, C.-Y., & Yang, H.-W. (2021). The structural changes of a local tourism network: Comparison of before and after COVID-19. *Current Issues in Tourism*, 24(23), 3324–3338. <https://doi.org/10.1080/13683500.2021.1874890>
- Jessop, B., Brenner, N., & Jones, M. (2008). Theorizing sociospatial relations. *Environment and Planning D: Society and Space*, 26(3), 389–401. <https://doi.org/10.1068/d9107>
- Kervankiran, İ., & Bağmancı, M. F. (2021). COVID-19 Sürecinde Türkiye Turizminin Mekansal Görünümü: Hangi İl Nasıl Etkilendi? Spatial View of Tourism in Turkey in COVID-19 Process: Which Provinces Were Affected and How?. *Coğrafi Bilimler Dergisi*, 19(1), 263–287. <https://doi.org/10.33688/aucbd.897621>
- Khalid, U., Okafor, L. E., & Burzynska, K. (2021). Does the size of the tourism sector influence the economic policy response to the COVID-19 pandemic? *Current Issues in Tourism*, 24(19), 2801–2820. <https://doi.org/10.1080/13683500.2021.1874311>
- Khan, A., Bibi, S., Lorenzo, A., Lyu, J., & Babar, Z. U. (2020). Tourism and development in developing economies: A policy implication perspective. *Sustainability*, 12(4), 1618. <https://doi.org/10.3390/su12041618>
- Khedhiri, S. (2022). A spatiotemporal analysis of the COVID-19 Pandemic in North Africa. *GeoHealth*, 6(7). <https://doi.org/10.1029/2022GH000630>
- King, C. A. (1995). Viewpoint: What is “training”? *International Journal Hospitality Management*, 14(3), 219–234. [https://doi.org/10.1016/0278-4319\(95\)00045-3](https://doi.org/10.1016/0278-4319(95)00045-3)
- Koopman, J. S. (2005). Infection transmission, science and models. *Japanese Journal of Infectious Diseases*, 58(6), 3–8.
- Kopczewska, K. (2020) *Applied spatial statistics and econometrics: Data analysis in R*. Taylor & Francis. Routledge Advanced Texts in Economics and Finance. https://books.google.co.id/books?id=hDv_DwAAQBAJ
- Korin, B. (2022). Impact of the COVID-19 Pandemic on International Tourism Income in Tourism Receiving Countries. *Sustainability*, 14(19), 12550. <https://doi.org/10.3390/su141912550>
- Kovačić, S., Cimbaljević, M., Tretyakova, T. N., Syromiatnikova, Y. A., García Henche, B., Petrović, M. D., Blešić, I., Pivac, T., Demirović Bajrami, D., & Gajić, T. (2023). How has COVID-19 changed the way we travel? Exploring tourist personality, reactions to the perceived risk and change in travel behavior. *Sustainability*, 15(3), 1951. <https://doi.org/10.3390/su15031951>
- Krisztin, T., Piribauer, P., & Wögerer, M. (2020). The spatial econometrics of the coronavirus pandemic. *Lett Spat Resour Sci*, 13(3), 209–218. <https://doi.org/10.1007/s12076-020-00254-1>
- Kuebart, A., & Stabler, M. (2020). Infectious diseases as socio-spatial processes: The COVID-19 outbreak in Germany. *Journal of Economic and Human Geography*, 111(3), 482–496. <https://doi.org/10.1111/tesg.12429>
- Lesage, J. P. (2008). An introduction to spatial econometrics. *Revue D'Économie Industrielle*, 123(3). <https://doi.org/10.4000/rei.3887>
- Lesage, J. P., & Pace, R. K. (2009). *Introduction to spatial econometrics*. Chemical Rubber Company Press.
- Ma, H., Chiu, Y., Tian, X., Zhang, J., & Guo, Q. (2020). Safety or travel: Which is more important? The impact of disaster events on tourism. *Sustainability*, 12(7), 3038. <https://doi.org/10.3390/su12073038>
- Maliszewska, M., Mattoo, A., & Van Der Mensbrugghe, D. (2020). The potential impact of COVID-19 on GDP and trade: A preliminary assessment. *World Bank Policy Research Working Paper*, 9211.
- Maria Del Rio-Chanona, R., Mealy, P., Pichler, A., Lafond, F., & Doynne Farmer, J. (2020). Supply and demand shocks in the COVID-19 pandemic: An industry and occupation perspective. *Oxford Review of Economic Policy*, 36(Supplement_1), S94–S137. <https://doi.org/10.1093/oxrep/graa033>
- Meade, M., & Emch, M. (2010). *Medical geography*. The Guilford Press.
- Mulder, N. (2020). The impact of the COVID-19 pandemic on the tourism sector in Latin America and the Caribbean, and options for a sustainable and resilient recovery. *ECLAC-International Trade Series*, 157. <https://hdl.handle.net/11362/46502>
- Nižetić, S. (2020). Impact of coronavirus (COVID -19) pandemic on air transport mobility, energy, and environment: A case study. *International Journal of Energy Research*, 44(13), 10953–10961. <https://doi.org/10.1002/er.5706>
- Ocheni, S. I., Ogaboh Agba, A. M., Agba, M. S., & Eteng, F. O. (2020). COVID-19 and the tourism industry: Critical overview, lessons and policy options. *Academic Journal of Interdisciplinary Studies*, 9(6), 114–129. <https://doi.org/10.36941/AJIS-2020-0116>
- Orden Mejía, M., Carvache-Franco, M., Huertas, A., Carvache-Franco, W., Landeta-Bejarano, N., &

- Carvache-Franco, O. (2022). Post-COVID-19 tourists' preferences, attitudes and travel expectations: A study in Guayaquil, Ecuador. *International Journal of Environmental Research and Public Health*, 19(8), 4822. <https://doi.org/10.3390/ijerph19084822>
- Ourworldindata. (2023). COVID-19: Stringency Index. <https://ourworldindata.org/covid-stringency-index>
- Ozili, P., & Arun, T. (2020). Spillover of COVID-19: Impact on the global economy. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3562570>
- Pappas, N., Michopoulou, E., & Farmaki, A. (2023). Tourism innovation and resilience during uncertainty. *Tourism Planning & Development*, 20(2), 135–137. <https://doi.org/10.1080/21568316.2023.2176647>
- Polemis, M. L., & Stengosc, T. (2020). Threshold effects during the COVID-19 pandemic: Evidence from international tourist destinations. *Current Issues in Tourism*, 25(3), 387–393. <https://doi.org/10.1080/13683500.2021.1960286>
- Rodríguez-Antón, J. M., & Alonso-Almeida, M. D. M. (2020). COVID-19 impacts and recovery strategies: The case of the hospitality industry in Spain. *Sustainability*, 12(20), 1–17. <https://doi.org/10.3390/su12208599>
- Rogerson, C. M., & Rogerson, J. M. (2020). COVID-19 and tourism spaces of vulnerability in South Africa. *African Journal of Hospitality, Tourism & Leisure*, 9(4), 328–401. <https://doi.org/10.46222/ajhtl.19770720-26>
- Sharma, J. K. (2019). *Business statistics* (5th ed.). Vikas Publishing.
- Sharma, A., Shin, H., Santa-Maria, M. J., & Nicolau, J. L. (2021). Hotels' COVID-19 innovation and performance. *Annals of Tourism Research*, 88, 88. <https://doi.org/10.1016/j.annals.2021.103180>
- Sharpley, R., & Telfer, D. J. (2015). *Tourism and development in the developing world*. Routledge.
- Sigala, M. (2020). Tourism and COVID-19: Impacts and implications for advancing and resetting industry and research. *Journal of Business Research*, 117, 312–321. <https://doi.org/10.1016/j.jbusres.2020.06.015>
- Škare, M., Soriano, D. R., & Porada-Rochoń, M. (2021). Impact of COVID-19 on the travel and tourism industry. *Technological Forecasting & Social Change*, 163, 163. <https://doi.org/10.1016/j.techfore.2020.120469>
- Stabler, M. J., Papatheodorou, A., & Sinclair, M. T. (2010). *The economics of tourism*. Routledge. <https://doi.org/10.1080/1755182x.2010.516898>
- Statista. (2023). Coronavirus cases in Europe 2023 [webpage]. <https://www.statista.com/statistics/1102896/coronavirus-cases-development-europe/>
- Stojkoski, V., Utkovski, Z., Jolakoski, P., Tevdovski, D., & Kocarev, L. (2020). The socio-economic determinants of the coronavirus disease (COVID-19) pandemic. *medRxiv*. <https://doi.org/10.1038/s41598-022-10894-6>
- Strauss, A. T., Cartier, D., Gunning, B. A., Boyarsky, B. J., Snyder, J., Segev, D. L., Roush, M., & Massie, A. B. (2020). Impact of the COVID-19 pandemic on commercial airlines in the United States and implications for the kidney transplant community. *American Journal of Transplantation: Official Journal of the American Society of Transplantation and the American Society of Transplant Surgeons*, 20(11), 3123–3130. <https://doi.org/10.1111/ajt.16284>
- Su, M. (2022). Effects of COVID-19 on China's civil aviation passenger transport market. *Research in Transportation Economics*, 96, 101217. <https://doi.org/10.1016/j.retrec.2022.101217>
- Sun, X., Wandelt, S., & Zhang, A. (2021). On the degree of synchronization between air transport connectivity and COVID-19 cases at worldwide level. *Transport Policy*, 105, 115–123. <https://doi.org/10.1016/j.tranpol.2021.03.005>
- Todaro, M. P., & Smith, S. C. (2020). *Development economics*. Pearson Education Limited.
- Tretheway, M. W., & Markhvida, K. (2014). The aviation value chain: Economic returns and policy issues. *Journal of Air Transport Management*, 41, 3–16. <https://doi.org/10.1016/j.jairtraman.2014.06.011>
- Uğur, N. G., & Akbiyik, A. (2020). Impacts of COVID-19 on global tourism industry: A cross-regional comparison. *Tourism Management Perspectives*, 36, 100744. <https://doi.org/10.1016/j.tmp.2020.100744>
- UNWTO. (2020). *World Tourism Barometer*. <https://www.unwto.org/international-tourism-and-COVID-19>
- UNWTO. (2021). *International tourism highlights 2020 edition*. <https://doi.org/10.18111/9789284422456>
- Wang, C., Meng, X., Siriwardana, M., & Pham, T. (2022). The impact of COVID-19 on the Chinese tourism industry. *Tourism Economics*, 28(1), 131–152. <https://doi.org/10.1177/13548166211041209>
- Wang, L., Zhang, M., & Verousis, T. (2021). The road to economic recovery: Pandemics and innovation. *International Review of Financial Analysis*, 75, 101729. <https://doi.org/10.1016/j.irfa.2021.101729>
- Weston, R., Guia, J., Mihalić, T., Prats, L., Blasco, D., Ferrer-Roca, N., Lawler, M., & Jarratt, D. (2019). *European tourism: Recent developments and future challenges*. European Parliament, Policy Department for Structural and Cohesion Policies.
- WHO. (2009). *WHO guide to identifying the economic consequences of disease and injury*. World Health Organization. https://www.who.int/choice/publications/d_economic_impact_guide.pdf
- Wimmer, A., & Glick-Schiller, N. (2002). Methodological nationalism and beyond: Nation-state building, migration and the social sciences. *Global Networks*, 2(4), 301–334. <https://doi.org/10.1111/1471-0374.00043>
- Yang, Y., Altschuler, B., Liang, Z., & Li, X. (2020). Monitoring the global COVID-19 impact on tourism: The COVID-19 tourism index. *Annals of Tourism Research*, 90, 103120. <https://doi.org/10.1016/j.annals.2020.103120>