

Spatial spillover of transport improvement on tourism growth

Fengjun Tian

Jiangxi University of Finance and Economics, China

Yang Yang 

Temple University, USA

Lan Jiang

Florida Gulf Coast University, USA

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Abstract

Transport infrastructure plays an important role in moving tourists to and between destinations. In this study, we investigate the spatial spillover effects of transport improvements on regional tourism growth. Using panel data from 337 Chinese prefecture-level regions from 2007 to 2016, we estimate a spatial Durbin model to understand whether enhancements in road, air, railway, and high-speed rail transport stimulated tourism growth in nearby regions. Our empirical models confirm transport spillover. High-speed rail services generated spillover to nearby regions' domestic and inbound tourism growth. For domestic tourism, road transport and air transport yielded significant spillover, while only air transport generated significant spillover in tourism revenue from inbound tourism. Findings also highlight the limited geographic scope of high-speed rail spillover and the broader scope of air transport spillover. Lastly, relevant implications are discussed.

Keywords

high-speed rail, regional tourism growth, spatial Durbin model, spatial spillover, transport infrastructure

Introduction

Transport plays a vital role in tourism development by providing visitors a safe, comfortable, and efficient means of traveling between locations. Therefore, tourism growth requires improved

Corresponding author:

Yang Yang, Department of Tourism and Hospitality Management, Temple University, 1801 N Broad St, Philadelphia, PA 19122, USA.

Email: yangy@temple.edu

transport infrastructure to attract more tourists and maintain a certain mobility standard (Khadaroo and Seetanah, 2007). Transport infrastructure is particularly vital to peripheral destinations with poor access to major source markets (Yang and Wong, 2012). Enhanced transport infrastructure is thus expected to strengthen market accessibility and reduce travel costs, making destinations more likely to be considered when tourists ponder where to visit.

Many studies have confirmed the effects of different forms of transport, such as air, road, rail, and water transport, on tourism growth (Khadaroo and Seetanah, 2007, Yang and Wong, 2012). However, findings differ by transport mode. For example, Duval and Schiff (2011) found that the availability of non-stop flights did not stimulate tourism demand, while Bazin et al. (2006) argued that opening high-speed rail services adds little value to leisure travel. Moreover, no studies have investigated the spillover effects of transport infrastructure on tourism growth, namely whether regional transport improvement might facilitate or hinder tourism growth in neighboring regions. Spillover effects are frequently discussed in the economics literature, referring to the positive and negative consequences of seemingly unrelated economic activities upon other sectors (Garmaise and Natividad, 2016). Although regional economic studies have demonstrated transport spillover in terms of economic growth (Álvarez et al., 2016; Pereira and Andraz, 2004), none have examined such spillover vis-à-vis tourism growth.

To bridge this research gap, the present study looks into the spillover effects of transport on regional tourism growth. In particular, we examine four modes of transport: road, air, traditional railway, and high-speed railway (HSR) transport. The panel data spatial Durbin model, a popular approach in spatial econometrics, can capture cross-regional spillover effects by incorporating the spatial lags of dependent and independent variables. By doing so, we expect to make at least three major contributions to the literature. First, our research represents one of the first efforts to scrutinize the spillover effects of transport in the tourism literature. Findings with a large sample of cities will thus enrich knowledge of tourism transport to clarify the effects of transport infrastructure from a spatial perspective. Second, by comparing the impacts of different types of transport accessibility/infrastructure, we can draw a more vivid picture of the effectiveness of diverse modes of transport on regional tourism growth. Last but not least, we adopt different spatial weighting matrices of the spillover threshold to better determine the geographic scope of transport-related spillover; therefore, the results are able to shed light on the geographic distribution of these spillovers.

Literature review

Transport infrastructure and economic growth

Economic theories provide several explanations for the impact of transport infrastructure improvement on economic growth. Endogenous growth theory indicates that transport infrastructure (as a part of public infrastructure) can lead to technical change and therefore serve as a source of economic growth (Melo et al., 2013). The New Economic Geography regards such infrastructure as a critical determinant of transport cost, which dictates location patterns under imperfect competition (Fujita et al., 1999). Yet it remains unclear whether transport infrastructure can foster economic growth, especially in countries with well-developed economies (Banister and Berechman, 2001). Although it is widely acknowledged that transport infrastructure investment reduces travel time and facilitates information exchange, scholars continue to debate whether it can bring substantial economic benefits. Banister and Berechman (2001) developed an approach

integrating economic, political, institutional, and investment conditions to understand how contextual information can elucidate the effects of transport improvements. They found that infrastructure investment in countries with well-developed economies will not promote economic growth due to existing infrastructure networks. Additionally, they argued that transport infrastructure investment can only play a supporting role in developed economies given other underlying conditions.

Many empirical studies have emphasized the vital role of transport in stimulating economic growth. Lakshmanan and Anderson (2002) noted that waterway and railroad infrastructure provides substantial economic benefits based on cost–benefit analysis. Cantos et al. (2005) confirmed the economic growth driven by transport infrastructure investment, and Banister and Thurstain-Goodwin (2011) reached similar conclusions via a three-level analysis incorporating macroeconomics, mesoeconomics, and microeconomics. Recent studies have returned mixed results: while some have corroborated the significant impact of transport infrastructure investment on economic growth (Laird and Venables, 2017), others have indicated the absence of such impacts (Rokicki and Sępnia, 2018). In a meta-analysis, Elburz et al. (2017) summarized that US studies tend to identify a more negative impact of transport infrastructure on economic growth but a more positive impact in the long run. In light of such controversy, the next section details the effects of different forms of transport infrastructure on tourism development.

Transport and tourism

As a way of transporting tourists to their destination, transport infrastructure is essential to tourism development. In general, infrastructure investment promotes gross domestic product (GDP) growth, which serves as a prerequisite for tourism development (Banister and Berechman, 2001; Lohmann and Duval, 2015). Such investment also lowers tourists' transportation costs (Khadaroo and Seetanah, 2007; Chung and Whang, 2011) and promotes tourism growth through a well-connected network (Ahrholdt et al., 2017; Prideaux, 2000). The following subsections discuss the impacts of different modes of transport on tourism, such as air, rail (including HSR), and road transport.

Air transport. Air transport has been recognized as the most efficient form of transport in stimulating economic growth due to its speed (Bieger and Wittmer, 2006), reliability (Mukkala and Tervo, 2013), high security and safety (Yang et al., 2019a), and service quality (Spasojevic et al., 2018). In particular, air travel significantly reduces long-haul tourists' travel time. It also plays a crucial role in bringing tourists to destinations with poor accessibility via alternative modes of transport, such as islands and mountainous regions (Yang et al., 2019a). For some countries, international tourist arrivals account for a large proportion of destinations' air transport (Bieger and Wittmer, 2006). Advances in aviation technology and the adoption of new business models (e.g. low-cost air carriers) continue to reduce the costs associated with air transport to spur international travel (Duval, 2013). Shorter travel times via air transport also enable tourists to visit tourism destinations for longer, thus contributing to local economies through a multiplier effect (Yang et al., 2018).

Empirical findings related to whether improved air transport infrastructure fosters tourism growth appear inconsistent. Many studies have noted a significant effect; for example, Khadaroo and Seetanah (2007) found that air transport contributed positively to island tourism when they investigated the impact of such transport on inbound tourist flows to island destinations. Tveteras and Roll (2014) pointed out that the growth of non-stop flights could raise the number of tourists

visiting Peru. Likewise, Yang et al. (2019a) found that air transport connectivity had a significant impact on tourist flows between Chinese cities. However, other studies have documented an insignificant effect of air transport: based on the results from Duval and Schiff (2011), no significant relationship apparently exists between the availability of non-stop flights and tourist arrivals in New Zealand. The importance of air transport to tourism development cannot be understated, especially as air travel costs continue to fall. Bieger and Wittmer (2006) developed a model analyzing the impact of air transport on tourism growth and derived useful conclusions for policymakers in airline destinations; they suggested that airlines and tourism destinations establish a win-win relationship because they rely heavily on each other. This win-win relationship still applies today and should be seriously considered by policymakers.

Rail transport. Rail transport presents an appealing travel option owing to its affordability and convenience (Yan et al., 2014). Due to the price sensitivity of most travelers, rail transport can be preferable to air transport for mid- and long-haul trips. People also favor rail transport for convenience, as many train stations are in city centers and urban areas (Fu et al., 2012). Many tourists use rail transport as an alternative to driving to avoid traffic congestion and parking problems in urban destinations (Bazin et al., 2006). Over the past decade, HSR systems have become popular worldwide as a revolutionized travel method (Albalade and Fageda, 2016). Urban tourism, which usually includes short stays, has grown substantially in France due to the convenience of HSR (Delaplace et al., 2014). With its improved accessibility and mobility, HSR serves as an efficient means of tourist supply renewal by drawing tourists from metropolitan areas (Delaplace et al., 2014; Feliu, 2012). This travel mode also alters travelers' perceptions of destination accessibility and attractiveness (Pagliara et al., 2015).

Various studies have evaluated the impact of rail transport on tourism development, especially in terms of the tourism benefits associated with railway enhancement (Bazin et al., 2006; Edwards, 2012; Murakami and Cervero, 2012; Yin et al., 2019). Some scholars have contended that HSR may only add slight value to developed destinations. Bazin et al. (2006) stated that new rail transport services could not pique tourists' curiosity and had a limited impact on leisure tourism. Some researchers believe that the benefits of HSR differ across destinations (Yang et al., 2019a). For example, studies on the effects of HSR on cities in the United States (Yu and Fan, 2018), Spain (Pagliara et al., 2015), and France (Delaplace et al., 2014) showed that only a few cities (especially those close to a metropolitan city) witnessed tourist increases after HSR launches. However, empirical studies in Asian countries came to different conclusions, such as by identifying the significant impacts of HSR development in Japan (Okabe, 1979) and China (Chen and Haynes, 2015).

Over the last decade, China has witnessed rapid HSR development because of the government's prioritized infrastructure budget. Many empirical efforts have aimed to investigate the HSR-tourism relationship. Su and Wall (2009) found that rail transport significantly boosted tourism in Tibet, and such transport was a major factor when travelers chose to visit. Yan et al. (2014) unveiled significant impacts of the Wu-Guang HSR on local tourism. Chen and Haynes (2015) discovered that the HSR network was responsible for up to one-third of China's tourism increase. Most recently, Yin et al. (2019) examined the effects of HSR transport on tourism-based spatial interactions between two major cities in China. Their findings supported Pagliara et al.'s (2015) argument that HSR has only a limited effect on international tourists. However, they also found that HSR promotes new tourism infrastructure investment (i.e. hotels), consistent with findings from Hannam et al. (2014).

In summary, rail transport, especially HSR services, can improve accessibility (Ravazzoli et al., 2017; Wang et al., 2018), trigger tourism spatial agglomeration (Masson and Petiot, 2009), and revitalize urban tourism as well as how people travel (Albalade and Fageda, 2016). However, the effect of HSR in tourism depends on destination geography (e.g. Europe vs. Asia), urbanization levels, and tourist types (i.e. domestic vs. international).

Road transport. Road transport consists of auto transport modes such as cars, buses, and coaches. Buses and coaches are generally operated by public transportation networks or tourism agencies, while cars include privately owned vehicles and rental cars that travelers use for short durations (Prideaux, 2018). Public road transport has drawn less attention in academia (Peeters and Schouten, 2006, Prideaux et al., 2001) than private road transport, which is more prevalent in developed countries due to expanding private vehicle ownership. The International Organization of Motor Vehicle Manufacturers reported that global sales of private cars peaked at 71 million in 2017 and declined slightly to 64 million in 2019. Notable advantages of road transport include convenience, flexibility, affordability, ease of tourism destination access, fewer luggage restrictions, and greater agency over one's travel experience (Kanwal et al., 2020, Virkar and Mallya, 2018).

Road transport infrastructure is essential to economic and tourism development in developed and developing countries (Oladipo, 2018). Essentially, road transport represents the main avenue through which different parts of the world are linked, including urban and rural areas. For example, 77% of tourists in Zimbabwe used road transport to travel within the country, whereas only 18% of visitors traveled by air (Nyaruwata and Runyowa, 2017). Similar patterns have manifested in Croatia, in that foreign tourists generally enter the country via road transport (91%) rather than air transport (8%); even fewer tourists arrive via rail or other transport modes (Kovačić and Milošević, 2016). These patterns are also reflective of those in China, namely that air transport's impact on tourism demand is not as strong as that of road transport (Yang and Wong, 2012).

Superior road transportation systems act as a catalyst for tourism growth. The positive impact of road transport on tourism development has been confirmed in many studies (Kanwal et al., 2020). Road transport provides greater accessibility to tourism destinations (Masson and Petiot, 2009), encourages business activity in local areas (Khadaroo and Seetanah, 2007), and lures tourists and promotes new tourism destinations (Currie and Falconer, 2014; Virkar and Mallya, 2018). However, road transport can also create problems due to more frequent vehicle use, including air and noise pollution (Litman, 2009), increased road accidents (Rosselló et al., 2017), and environmental damage (Palmer et al., 2008).

Transport spillover

In tourism contexts, spillover effects refer to the indirect effects of an area's tourism industry on tourism flows to nearby locations (Yang and Wong, 2012). Drakos and Kutan (2003)'s study showed significant spillover effects of terrorism on tourism market shares in three Mediterranean countries. Gooroochurn and Hanley (2005) investigated the spillover effects for the Republic of Ireland and Northern Ireland, and significant spatial spillover effects were found. Yang and Wong (2012) confirmed the spillover effects in both inbound and domestic tourism flows to Chinese cities. A region or destination may benefit from the transportation infrastructure and tourism development of its neighbors (Yu et al., 2013). For example, a long-haul international tourist to New Jersey may fly into a major airport in New York and then travel to New Jersey by train or car.

As a result, the tourism industry in New Jersey benefits from the transport infrastructure in New York. Researchers around the world have explored the spillover effects of transport infrastructure on economic growth (Berechman et al., 2006). In the United States, Boarnet (1998) found that transport infrastructure investment in one region can draw production away from other regions, described as negative spillover. Pereira and Andr  z (2004) further suggested that only 20% of aggregate effects of highway investment in the United States are captured by direct effects on each state; the remaining 80% is tied to spillover effects in other states.   lvarez-Ayuso and Delgado-Rodr  guez (2012) examined spillover effects derived from road transport and uncovered significant positive effects on the private economic sector.   lvarez et al. (2016) found the spillover effects of transport infrastructure to be positive for more developed regions but negative for less developed regions.

Yang and Wong (2012) developed a five-factor framework covering productivity spillover (i.e. labor movement, demonstration effect, and competition effect), market access spillover, joint promotion, negative events, and multi-destination tourist travel. Productivity spillover refers to the productivity gains of a destination from neighboring destinations (Yang and Wong, 2012). To be specific, improved transport enables those well-developed tourism destinations to play the leading role for other tourism destinations through marketing effects (Dehghan Shabani and Safaie, 2018), strengthening the overall tourism competitiveness of a region. Furthermore, transport infrastructure improvement significantly strengthens a destination's market accessibility (Rokicki and St  pniak, 2018). As a result, it generates a market access spillover to nearby destinations because they are likely to share similar tourist attractions and serve similar markets (Yang and Wong, 2012). Lastly, with the transport improvement in a destination, more opportunities exist on joint promotion or marketing collaboration between the destination and neighboring destinations, ultimately yielding some spillovers from these efforts (Gooroochurn and Hanley, 2005).

Transport improvement particularly facilitated multi-destination travel. According to the literature, many tourists visit more than one destination during a single trip to maximize utility contingent upon cost and time constraints (Hwang and Fesenmaier, 2003). Improved transport infrastructure encouraged tourist movement across destinations and greatly promoted tourism demand spillover (Yang et al., 2017). Based on this framework, transport spillover can be explained in part by tourists' multi-destination travel: improved transport infrastructure heightens tourism demand, and because of multi-destination travel to nearby regions, the tourism industry in these regions can benefit from other regions' transport improvements. The transport spillover effects can also be generated from single-destination travelers by combining different transport modes in their transfer. For example, tourists may take air flights or HSR trains to a regional hub city and then transfer to road transport to the final destination. As a result, transport spillovers are generated from the hub city to the destination. In summary, the preceding literature review has outlined transport and economic growth; the impacts of different transport modes on tourism, including air, rail/HSR, and road transport; and the spillover effects of transport along with reasons behind such spillover based on a tourism spatial spillover framework (Yang and Wong, 2012).

Research methods

Research area

For this study, we referred to a sample of 337 prefecture-level regions in mainland China. The four municipalities of Beijing, Shanghai, Tianjin, and Chongqing were treated as prefecture-level

regions. We were particularly interested in each region's transport enhancements. Alongside China's economic boom over the last decade, the quantity and quality of the country's transport system have improved dramatically. For example, a growing number of commercial airports have been built in underdeveloped regions thanks to government-initiated deregulation efforts, and the nationwide HSR network has expanded substantially to HSR corridors with a plan for four north–south and four east–west lines (Yang et al., 2019b).

Econometric model

We adopted a panel data spatial Durbin model to capture the spillover effects of transport improvement on regional tourism growth. The model is specified as

$$y_{it} = \delta \mathbf{W}y_{it} + \mathbf{X}_{it}\beta + \mathbf{W}\mathbf{X}_{it}\gamma + \mu_i + \varepsilon_{it} \quad (1)$$

where i represents the prefecture-level region ($i = 1, \dots, n$) and t indicates the year between 2007 and 2016. In this model, y_{it} indicates the dependent variable related to tourism growth and $\mathbf{X}_{it}$ denotes independent variables. A spatial weighting matrix $\mathbf{W}$ demonstrates the spatial connection between regions, wherein μ_i is the region-specific effect representing the time-constant unobservable terms of region i and ε_{it} is the normal error term with a variance of σ^2 . In addition to traditional independent variables, $\mathbf{X}_{it}$, the right-hand side of the equation includes the spatial lag of y_{it} ($\mathbf{W}y_{it}$) and the spatial lag of the independent variables ($\mathbf{W}\mathbf{X}_{it}$). As suggested by LeSage and Fischer (2008), the spatial Durbin model represents a generalized specification in spatial econometrics, which nests most other spatial econometric models. Depending on whether μ_i is correlated with ε_{it} , we can specify a fixed-effects (FE) or random-effects (RE) model (Greene, 2007). FE models do not require the independence between the two terms and are therefore more common. We estimate this model using a quasi-maximum likelihood estimation after an orthogonal transformation (Lee and Yu, 2010). The estimated coefficients and variance–covariance matrix were obtained by maximizing the following log-likelihood function

$$\ln L(\theta) = -\frac{n(T-1)}{2} \ln(2\pi\sigma^2) + (T-1)[\ln|\mathbf{I}_n - \delta\mathbf{W}|] - \frac{1}{2\sigma^2} \sum_{t=1}^{T-1} \tilde{\mathbf{v}}'_{nt}(\theta) \tilde{\mathbf{v}}_{nt}(\theta) \quad (2)$$

where $\theta = (\delta, \beta', \gamma', \sigma^2)'$, and $\tilde{\mathbf{v}}_{nt}$ indicates the innovation term after an orthogonal transformation to remove the FE (Lee and Yu, 2010).

We specified four dependent variables, $\ln arrival_dom_{it}$ (log of domestic tourist arrivals, in 1000), $\ln revenue_dom_{it}$ (log of domestic tourism revenue, in million CNY), $\ln arrival_inb_{it}$ (log of inbound tourist arrivals, in 1000), and $\ln revenue_inb_{it}$ (log of inbound tourism revenue, in million USD). Domestic tourists are defined as those who reside in mainland China, while inbound tourists refer to those from foreign countries, Hong Kong, Macau, and Taiwan. For independent variables $\mathbf{X}_{it}$, we specified the following

- $\ln road_den_{it}$ is the log of road density of roads in the region (in km/km²). This variable captures the influence of land transport infrastructure on tourism development (Chhetri et al., 2017).
- $\ln flight_{it}$ is the log of one plus flight number at commercial airports in the region. This variable captures the capacity of air transport infrastructure (Tveteras and Roll, 2014).

- $\ln train_{it}$ is the log of one plus traditional train number at stations in the region. This variable captures the capacity of traditional rail transport infrastructure (Yang et al., 2019a).
- $\ln HSR_{it}$ is the log of one plus HSR train number at stations in the region. This variable captures the capacity of HSR transport infrastructure (Li et al., 2019).
- $\ln hotel_{it}$ is the log number of star-rated hotels. This variable captures the capacity of tourism facilities (Yang and Wong, 2012).
- $\ln NP_{it}$ is the log of one plus the number of national parks in the region. National parks represent one of the most popular government-designated tourist attractions; this variable captures the extent of a region's tourism appeal (Yang and Fik, 2014).
- $\ln GDP_per_{it}$ is the log of GDP per capita of the region (in CNY). This variable measures the region's income level; a more affluent region is expected to have more robust infrastructure to support tourism growth (Zhou et al., 2017).

We collected data on tourist arrivals, tourism revenue, GDP, hotel number, road length, and administrative area from the China Statistical Yearbook for Regional Economy. Data pertaining to the number of air flights in each commercial airport were gathered from the annual airport statistical report of the Civil Aviation Administration of China. Regarding train schedules, we calculated the number of traditional and HSR trains each year based on official timetables from the China Railway Corporation. Data on the number of national parks in each city were obtained from the website of the Ministry of Housing and Urban-Rural Development of China (<http://www.mohurd.gov.cn>).

In this study, $\mathbf{W}$ represents a 337×337 spatial weighting matrix that formalizes the spatial structure of each region. We used an inverse distance matrix with a threshold value. The matrix element $w_{ij} = 1/distance_{ij}$ if $distance_{ij} < D$ and $w_{ij} = 0$ otherwise, where $distance_{ij}$ indicates the geographic distance (in km) between regions i and j . Under this specification, spillover effects decay with distance and only exist between regions within a distance of D . The weighting matrix was row-standardized in our estimation. We set $D = 200$ km in this study; as such, we assumed that the spillover effect exists within a geographic scope of 200 km from the region. We then ran a sensitivity check to determine whether our results would change when adopting weighting matrices with different D values.

Data description

Across 337 regions of mainland China in 2016, eastern cities were especially popular among tourists, while Chongqing and Chengdu received substantial traffic in the west. In terms of inbound tourist arrivals, coastal areas in the east, such as Guangdong and Fujian provinces, received a large number of inbound tourists. Table 1 presents the descriptive statistics of variables in the model. The variance inflation factors of all variables were far below the cutoff value of 10, indicating an absence of multicollinearity in our sample (Dormann et al., 2013).

Empirical results

Table 2 lists estimation results from the panel data spatial Durbin models. Four models were estimated for four dependent variables. The Hausman test results for all four models supported the use of an FE rather than RE model. As the interpretation of coefficients is challenging, we further decomposed the total spatial effects of independent variables into direct and indirect

Table 1. Descriptive statistics of model variables.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	VIF
$\ln arrival_dom$	3370	8.872	1.784	0.787	13.911	
$\ln revenue_dom$	3370	9.616	1.710	3.655	16.607	
$\ln arrival_inb$	3370	3.450	2.575	-4.605	9.408	
$\ln revenue_inb$	3370	3.536	2.708	-2.996	11.976	
$\ln road_den$	3370	-0.399	0.922	-3.952	2.092	1.45
$\ln flight$	3370	4.430	4.691	0.000	13.517	1.54
$\ln train$	3370	3.725	1.723	0.000	6.851	1.26
$\ln HSR$	3370	1.171	1.944	0.000	6.550	1.48
$\ln hotel$	3370	3.309	0.900	0.000	6.729	1.94
$\ln NP$	3370	0.378	0.458	0.000	2.079	1.24
$\ln GDP_per$	3370	10.289	0.693	8.133	12.281	1.41

VIF: variance inflation factor.

Table 2. Estimation results from panel data spatial Durbin models.

Variables	Model 1 $\ln arrival_dom$	Model 2 $\ln rev_dom$	Model 3 $\ln arrival_inb$	Model 4 $\ln rev_inb$
$\ln road_den$	0.203*** (0.041)	0.467*** (0.053)	-0.107 (0.099)	-0.0341 (0.100)
$\ln flight$	0.0226*** (0.004)	0.0229*** (0.005)	0.0177** (0.009)	-0.00272 (0.009)
$\ln train$	0.0614*** (0.014)	0.0728*** (0.018)	-0.0492 (0.034)	-0.0138 (0.035)
$\ln HSR$	0.00249 (0.005)	-0.00563 (0.007)	-0.0155 (0.013)	0.00999 (0.013)
$\ln hotel$	0.0649*** (0.022)	0.0730*** (0.029)	0.156*** (0.054)	0.198*** (0.054)
$\ln NP$	0.141** (0.061)	0.161** (0.079)	0.566*** (0.147)	0.570*** (0.149)
$\ln GDP_per$	0.836*** (0.040)	0.789*** (0.052)	0.216** (0.096)	0.584*** (0.097)
$W \times \ln road_den$	-0.0366 (0.061)	-0.0741 (0.079)	-0.00416 (0.145)	0.236 (0.147)
$W \times \ln flight$	0.0216*** (0.008)	0.00475 (0.010)	-0.00590 (0.018)	0.0489*** (0.018)
$W \times \ln train$	-0.0685*** (0.023)	-0.0172 (0.030)	0.273*** (0.055)	0.233*** (0.056)
$W \times \ln HSR$	0.0529*** (0.009)	0.0512*** (0.011)	0.0654*** (0.020)	0.0455** (0.021)
$W \times \ln hotel$	-0.0576 (0.036)	-0.0113 (0.046)	0.253*** (0.086)	0.267*** (0.087)
$W \times \ln NP$	0.263** (0.120)	-0.522*** (0.155)	0.377 (0.289)	0.268 (0.293)
$W \times \ln GDP_per$	0.0727 (0.051)	-0.0305 (0.064)	0.261** (0.111)	-0.00772 (0.113)
δ	0.230*** (0.022)	0.470*** (0.019)	0.240*** (0.024)	0.211*** (0.024)
N	3370	3370	3370	3370
pseudo R-sq	0.540	0.0002	0.215	0.019
AIC	714.5	2378.7	6022.2	6108.3
BIC	812.5	2476.7	6120.1	6206.2
Log-likelihood	-341.3	-1173.3	-2995.1	-3038.1
Hausman test	138.95***	986.19***	214.03***	229.82***

Note: δ indicates the coefficient of the spatial lag of dependent variable.

***Significance at the 0.01 level.

**Significance at the 0.05 level.

*Significance at the 0.10 level.

Table 3. Decomposition of spatial effects.

Variables	Model 1	Model 2	Model 3	Model 4
Direct effect				
<i>ln road_den</i>	0.203***	0.485***	−0.108	−0.024
<i>ln flight</i>	0.024***	0.025***	0.018**	−0.001
<i>ln train</i>	0.059***	0.075***	−0.036	−0.003
<i>ln HSR</i>	0.005	0.000	−0.012	0.012
<i>ln hotel</i>	0.063***	0.076**	0.171***	0.211***
<i>ln NP</i>	0.156**	0.106	0.593***	0.587***
<i>ln GDP_per</i>	0.849***	0.831***	0.232**	0.590***
Indirect effect				
<i>ln road_den</i>	0.012	0.242**	−0.036	0.265
<i>ln flight</i>	0.032***	0.026	−0.002	0.056***
<i>ln train</i>	−0.064**	0.028	0.312***	0.266***
<i>ln HSR</i>	0.063***	0.081***	0.074***	0.055**
<i>ln hotel</i>	−0.050	0.038	0.346***	0.356***
<i>ln NP</i>	0.349**	−0.742***	0.612*	0.447
<i>ln GDP_per</i>	0.312***	0.567***	0.373***	0.133
Total effect				
<i>ln road_den</i>	0.215***	0.728***	−0.144	0.241
<i>ln flight</i>	0.056***	0.051***	0.016	0.055**
<i>ln train</i>	−0.005	0.103*	0.276***	0.262***
<i>ln HSR</i>	0.068***	0.081***	0.061***	0.067***
<i>ln hotel</i>	0.012	0.114	0.517***	0.567***
<i>ln NP</i>	0.505***	−0.636**	1.206***	1.035***
<i>ln GDP_per</i>	1.161***	1.398***	0.606***	0.723***

***Significance at the 0.01 level.

**Significance at the 0.05 level.

*Significance at the 0.10 level.

effects in the long-run steady-state equilibrium based on the model estimation results (LeSage and Pace, 2009). While direct effects can capture impacts in the local region, indirect effects reflect cumulative spillover effects throughout other regions. These results are presented in Table 3. In general, findings echo the coefficient estimates in Table 2 in terms of coefficient signs and significance.

In model 1 of domestic tourist arrivals, the direct effects of three out of four transport variables were statistically significant and positive: *ln road_den* for road transport, *ln flight* for air transport, and *ln train* for traditional rail transport. Judging by magnitude, road transport had the largest local impact on tourism growth during the sample period. For the spillover effects measured by indirect effects in model 1, we found *ln flight* and *ln HSR* to be statistically significant and positive, indicating positive spillover of air transport and HSR. This result suggests that improving a region's air and HSR transport can stimulate tourist arrivals to nearby regions. More specifically, a 10% increase in commercial flight numbers and HSR train numbers in a city leads to a 0.32% and 0.63% increase in domestic tourist arrivals to the neighboring destination cities. The negative and significant indirect effect of *ln train* reflected the negative spillover of traditional rail services. Regarding other variables, the direct effects of *ln hotel*, *ln NP*, and *ln GDP_per* were estimated to

be significant and positive. The indirect effect of $\ln NP$ was also estimated to be significant and positive, highlighting the spatial agglomeration effects of national parks in attracting domestic tourists. Model 2 of domestic tourism revenue returned similar estimation results in terms of coefficient signs and significance. The result suggests that a 10% increase in HSR train numbers in a city leads to a 0.81% increase in domestic tourist revenue of neighboring destination cities. However, select differences include the insignificant indirect effects of air transport ($\ln flight$) and traditional train services ($\ln train$) along with the negative and significant indirect effect of national parks ($\ln NP$). Upon comparing the magnitude of spatial effects between models 1 and 2, we noticed that the effect of road density ($\ln road_den$) doubled in the revenue model from the arrival model; road transport thus played a significant role in internalizing the economic benefits associated with a region's domestic tourism activities.

In model 3 of inbound tourist arrivals, only the direct effect of $\ln flight$ was estimated to be statistically significant among the four transport-related variables. This result underscores the importance of air transport in attracting inbound tourists. Regarding spillovers, significant and positive indirect effects of $\ln train$ and $\ln HSR$ confirmed the positive spillover effects of both types of rail service on inbound tourist arrivals. A 10% increase in traditional train numbers and HSR train numbers in a city leads to a 3.12% and 0.74% increase in inbound tourist arrivals to nearby cities. Model 4 of inbound tourism revenue provided similar results. However, different from model 3, the direct effect of $\ln flight$ was insignificant. These findings imply that although air transport improvement could stimulate inbound tourist arrivals to the city, it hardly boosted revenue from these visitors. Moreover, the indirect effect of $\ln flight$ was significant and positive in model 4. A 10% increase in commercial flight number in a city leads to a 0.56% increase in inbound tourism revenue of nearby cities. Also, compared to the domestic tourism revenue model (model 2), more transport spillover channels were identified in the inbound tourism revenue model (model 4). Transport spillover was thus more powerful with respect to inbound tourism development. For other non-transport variables, the direct effects of $\ln hotel$, $\ln NP$, and $\ln GDP_per$ were estimated to be significant and positive in models 3 and 4. The direct effects of $\ln hotel$ and $\ln NP$ were larger in inbound tourism models compared to their domestic tourism counterparts, indicating that tourism facilities and national parks were more useful in boosting inbound tourism demand for a given Chinese region. Also, in models 3 and 4, the indirect effect of $\ln hotel$ was estimated to be positive and significant, confirming that better tourism facilities yielded positive spillover to the inbound tourism growth of nearby regions.

The magnitudes of transport spillovers heavily depend on the geographic scope of spillovers. Table 4 displays estimation results of spatial effects with different spatial weighting matrices. We set different spillover threshold values from 200 km to 800 km. Due to space limitations, we only present the estimated indirect effects of variables here. Our results are generally robust to selected spatial weighting matrices. We also derived the geographic scope of different types of transport spillover. For instance, the indirect effects of $\ln HSR$ changed moderately across distance thresholds, indicating that the spillover of HSR transport on regional tourism had a limited geographic scope. By contrast, the indirect effects of $\ln flight$ increased noticeably over distance, suggesting that the spillover of air transport on tourism encompassed a broader geographic scope.

Discussion and conclusion

Based on panel data from 337 Chinese prefecture-level regions, we used a spatial Durbin model to understand the effects of transport on regional tourist arrivals and revenue. Results confirmed

Table 4. Decomposition of spatial effects with alternative spatial weighting matrices.

	200 km	300 km	400 km	500 km	600 km	700 km	800 km
<i>ln arrival_dom</i>							
$W \times \ln road_den$	0.012	0.031	−0.068	0.157	0.067	0.027	−0.039
$W \times \ln flight$	0.032***	0.053***	0.092***	0.105***	0.161***	0.170***	0.185***
$W \times \ln train$	−0.064**	−0.104**	−0.143***	−0.185***	−0.191**	−0.228***	−0.236***
$W \times \ln HSR$	0.063***	0.069***	0.071***	0.075***	0.070***	0.069***	0.066***
<i>ln rev_dom</i>							
$W \times \ln road_den$	0.242**	0.432**	−0.113	0.320	0.246	0.323	−0.291
$W \times \ln flight$	0.026	0.061**	0.116***	0.171***	0.268***	0.299***	0.319***
$W \times \ln train$	0.028	0.130	0.078	0.065	0.012	−0.157	−0.096
$W \times \ln HSR$	0.081***	0.111***	0.106***	0.142***	0.131***	0.140**	0.134**
<i>ln arrival_inb</i>							
$W \times \ln road_den$	−0.036	−0.294	−0.207	−0.101	−0.063	0.116	0.105
$W \times \ln flight$	−0.002	0.038	0.017	0.066	0.118*	0.101	0.041
$W \times \ln train$	0.312***	0.371***	0.711***	0.764***	1.029***	1.133***	1.208***
$W \times \ln HSR$	0.074***	0.094***	0.114***	0.124**	0.112**	0.123**	0.133**
<i>ln rev_inb</i>							
$W \times \ln road_den$	0.265	−0.097	0.163	0.361	0.475	0.564	0.349
$W \times \ln flight$	0.056***	0.145***	0.148***	0.182***	0.226***	0.240***	0.230***
$W \times \ln train$	0.266***	0.304***	0.603***	0.640***	0.842***	0.901***	0.981***
$W \times \ln HSR$	0.055**	0.059**	0.095***	0.109***	0.108**	0.112**	0.120**

Note: Only results of transport-related variables are presented.

***Significance at the 0.01 level.

**Significance at the 0.05 level.

*Significance at the 0.10 level.

cross-regional transport spillover. More specifically, HSR service was found to generate spillover to nearby regions' domestic and inbound tourism growth (in terms of arrival numbers and revenue). Our findings contribute to recent discussions on the impact of HSR on tourism from a spillover perspective. Nearby destinations can effectively develop their tourism industry through neighbors' HSR services, and the scope of the HSR service area extends beyond a given region's administrative boundary. Our results also highlighted several differences between domestic and inbound tourism models. For domestic tourism, road transport and air transport yielded significant spillover, while air transport alone generated significant spillover to revenue for inbound tourism. One possible reason for considerable road transport spillover is that a region can serve as a domestic tourist origin area for nearby regions, and improved road transport can bring more residents as domestic tourists to neighboring destinations in other regions.

Our comparison of the tourist arrival model and tourism revenue model revealed intriguing patterns. For domestic tourism, road transport had a larger impact on revenue than arrival numbers. One possible reason is that road transport can help mobilize tourists within a region, resulting in more lavish tourist spending. For inbound tourism, air transport had a direct effect on arrival numbers and an indirect effect (via spillover) on revenue. This result is attributable to the fact that airports are usually in major transport hubs that boost inbound tourist arrival numbers; regions with abundant attractions for inbound tourists must leverage flight spillover from these hubs to develop inbound tourism.

Results related to the spatial weighting matrices with different spillover thresholds provide promising results regarding the scope of such transport spillover. The limited geographic scope of HSR spillover can be explained by HSR passengers' travel behavior, as these visitors typically come from short-haul markets; their limited scope of multi-destination travel thus leads to a narrow scope of spillover effects (Yang et al., 2013). Likewise, this argument can be levied to explain the broad scope of air transport spillover: air passengers generally travel long distances and prefer to visit more attractions within a broader geographic area (Yang et al., 2013), thus yielding broader spillover.

Our empirical results provide several practical implications. First, the existence of cross-regional transport spillover calls for regional collaboration on transport investment. When proposing transportation policies and plans, national and provincial governments should consider cross-regional transport spillover when conducting a cost–benefit analysis. Second, destinations can strategically leverage and internalize positive spillover from transport improvements in nearby regions. For example, destinations can carry out aggressive tourism marketing campaigns targeting passengers in transport hubs and along highway/railway networks. Destinations can also provide express buses to retrieve tourists from airports and train stations in nearby regions.

In terms of study limitations, we did not specify different spatial weighting matrices to capture the spillover of different transport modes. Additionally, we did not consider substitutional or competition effects between transport modes (Yang et al., 2019a). Moreover, the transport's spillover effects on tourism occur through the combination of different transport modes, and we did not incorporate this combination effect in econometric modeling. Furthermore, some variables, such as hotel infrastructure, may suffer from endogeneity issues, which contaminate the consistency of our estimates. Lastly, we did not assess heterogeneity across Chinese regions in terms of geography or socioeconomics when investigating transport spillover (Zhou et al., 2017). We, therefore, call for future studies extending our research method and better specify the combination of transport modes in spillovers to incorporate these concerns.

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ORCID iD

Yang Yang  <https://orcid.org/0000-0001-9436-964X>

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Author biographies

Fengjun Tian, PhD, is a professor in the School of Tourism and Urban Management, Jiangxi University of Finance and Economics, Nanchang City, China. His research interests include tourist behavior analysis and tourism planning.

Yang Yang, PhD, is an associate professor in the Department of Tourism and Hospitality Management, Temple University. His research interests include tourism analytics and tourism economics.

Lan Jiang, PhD, is an associate professor in the Lutgert College of Business, Florida Gulf Coast University. His research interests include hospitality finance and revenue management.