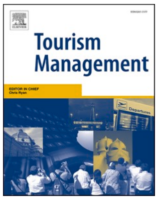
Tourism Management 87 (2021) 104392

Contents lists available at ScienceDirect

Tourism Management

journal homepage: www.elsevier.com/locate/tourman



Agglomerating or dispersing? Spatial effects of high-speed trains on regional tourism economies

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ARTICLE INFO

Keywords:
High-speed train
Agglomeration effect
Dispersion effect
New economic geography
Regional tourism economies

ABSTRACT

Following the paradigm of New Economic Geography, this study examines the impact of high-speed train (HST) services on the spatial structure of regional tourism economies in China. We collect panel data of 286 Chinese cities from 2007 to 2016 and adopt tourism-revenue location quotients to measure the relative agglomeration level of tourism economies for a city. According to the estimation results, tourism economies tend to agglomerate from the cities outside the HST network to those inside the network. Also, tourism economies start to disperse among cities within the network as more HST services become available. Furthermore, the results unveil the spatial heterogeneity of HST impacts. The moderating effects exerted by other transport modes are examined as well. Lastly, implications are provided for policy-makers and stakeholders on how to internalize the benefits from HST networks on tourism development.

1. Introduction

In a tourism system, transport plays a vital role in mobilizing tourists to access places at different scales. Transport infrastructure not only helps improve the accessibility of destinations but also improves tourist experiences through value-adding services (Pritchard & Havitz, 2006), which largely shape tourists' overall satisfaction with travel. Outstanding transport infrastructure, as a competitive advantage, strengthens destination competitiveness (Dwyer & Kim, 2003). Along with technological advancements in modern transportation, more innovative transport modes are available to support regional tourism growth. High-speed trains (HSTs) represent an example, offering a safe, convenient, and flexible transport mode to tourists, especially for those traveling to urban destinations (Yang, Li, & Li, 2019). Recent construction and expansion of HST networks in Europe (Pagliara, Mauriello, & Garofalo, 2017), Japan (Kurihara & Wu, 2016), and China (Yang et al., 2019) have successfully stimulated tourism growth.

The tourism literature recognizes the profound effects of transport infrastructure on promoting regional tourism (Khadaroo & Seetanah, 2007, 2008). Many empirical efforts confirmed the impacts of HSTs on local tourism demand and revenue (Pagliara et al., 2017; Yang et al., 2019). However, the analysis of the HST-tourism nexus inappropriately overlooks the spatial effects of HSTs. In the context of tourism economies, the spatial effects can be particularly noticeable due to tourism's reliance on people's mobility and sensitivity to transport improvement. The theory of New Economic Geography (NEG) in spatial economics and regional science offers a theoretical explanation on how transportation cost determines the location, geography pattern and spatial structure of economic activities (Krugman, 1991; Fujita & Thisse, 2002; Masson & Petiot, 2009; Lafourcade & Thisse, 2009). NEG provides essential theoretical underpinnings to understand the spatial effect of HSTs. Two major forces of spatial impacts (i.e., agglomeration and dispersion effects) may occur as a result of transport improvement (Krugman & Venables, 1995; Venables, 1996), which strengthens market accessibility and triggers a re-allocation of economic activities or resources. According to Krugman (1991), the agglomeration effect suggests a spatial concentration of tourism economies, while the dispersion effect indicates the opposite. Up to date, no solid empirical studies have examined how the accessibility of HSTs links to the agglomeration and dispersion of regional tourism economies.

To bridge this research gap, we conduct an econometric analysis with a sample of 286 Chinese cities, given that China has witnessed a substantial HST network expansion in the past decade. The development of an HST network is deemed as a critical national strategy to reduce the regional disparity in economic development and ensure the sustainable growth of the economy. Up to the end of 2017, the total length of HST

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https://doi.org/10.1016/j.tourman.2021.104392
Received 4 January 2021; Received in revised form 10 July 2021; Accepted 10 July 2021

lines in China reached 25,000 km, overtaking the entire high-speed railway lines operating in all other countries (Martha, Bullock, & Liu, 2019). The total number of HST passengers exceeded 2 billion in 2018, indicating a significant role that HST played in China's passenger transport system.

Specifically, we are interested in answering the following research questions in this study: (1) Does the availability of HST service lead to an agglomeration or dispersion of tourism economies? (2) Does the impact of HST service vary across regions with different features (the spatial heterogeneity of the HST impact)? (3) Is the impact of HST service moderated by the availability of other transportation modes? By doing so, we expect to make several contributions to the tourism literature. First and foremost, by using a location quotient coefficient as a dependent variable of econometric analysis, our study represents one of the pioneering empirical efforts to look into the effect of HSTs on the agglomeration/dispersion of regional tourism economies. The results provide more comprehensive insights into the spatial effect of HSTs and how they help shape the spatial pattern of tourism economies. Second, we examine the heterogeneity of HST impacts, demonstrating how the spatial effect of HSTs varies across different cities. Based on our empirical results, we are able to identify thresholds of HST accessibility when dispersion effects overweigh agglomeration effects. Compared with many studies that offer inconsistent, even contradictory, results (Li & Xu, 2017), the findings on the spatial heterogeneity of this study are more credible based on a large number of sample regions. Third, we scrutinize the interdependencies between HSTs and other transport modes, including conventional train service, road transport, and air transport, and how they moderate the role of HSTs in reshaping the spatial structure of regional tourism economies. The results provide vital policy implications on transport planning related to tourism growth.

2. Literature review

2.1. Transport and its spatial impacts on regional economies

Although it is well recognized that transportation plays a crucial role in determining the geographical distribution of economic activities, there is a long-term controversy on whether transport improvement leads to an agglomeration of economic activities in certain geographic areas or dispersion of activities along with a group of proximate regions. Some studies suggest that the agglomeration effect dominates, and transport network expansion and improvement drive economic activities to concentrate in particular regions (Blum, Haynes, & Karlsson, 1997). However, other studies propose the opposite (Chen & Haynes, 2017; Li, Linda, & Hu, 2016). The dispersion effect helps reshape regional economies through scattering economic activities over the corridor (including both the core region and the peripheries) of a transport system. The theoretical underpinnings and empirical examinations on these two effects are discussed in this sub-section.

2.1.1. Agglomeration effect

According to Marshall (1920), the improvement of transport service reduces travel times and travel costs, boosting four "accesses" for a business firm: access to specialized labor, specialized inputs, technology spillover (sharing of information and knowledge), and demand (Canina, Enz, & Harrison, 2005; Anjali, Collin, & Jonathan, 2017). Marshall's externalities have often been applied to explain the agglomeration of economic activities (Chung & Kalnins, 2001), which describes a phenomenon that firms concentrate or co-locate in a specific area to benefit from each other's presence. Graham and Melo (2011) argue that agglomeration economies rely on the flow of products, people, and information between regions. Logically, the improved transport connectivity among regions provides physical infrastructure that facilitates these flows, ultimately triggering agglomeration economies. Additionally, the improved transport infrastructure facilitates the agglomeration process by effectively linking input and output markets for more efficient economic transactions (Graham & Melo, 2011).

The strengthened transport infrastructure also heightens economic productivity within a cluster, which in turn generates an increasing return to scale of co-located producers within the cluster (Chatman & Noland, 2011). Without the increasing return to scale, according to Lafourcade and Thisse (2009), it would be more reasonable to subdivide a firm into very small units and then scatter the firm's production to different locations to serve geographically scattered consumers, maintaining lower shipping costs. Blum et al. (1997) claim that the enhanced productivity roots in the widening of labor markets and the expanding of product markets (or removing the market segregation), all of which can be considered as the expected outcomes of an integrated transport system.

Along with industrial specialization, different region specializes in or focuses on different industries based their comparative advantages, ultimately strengthening the productivity of specific industries. Industrial specialization closely relates to the geographical clustering of economic activities within a certain industry. Ahlfeldt and Fedderen (2018) suggest that a mutually reinforcing effect exists between spatial density and economic productivity, also termed "cumulative causation" by Sun, Yu, Peng, and Gao (2017). Over time, this effect shapes a persistent disparity of economies across regions. It is well observed that industrial specialization distinctly emerges in a region after the improvement of transport accessibility in this region (Cheng, Loo, & Vickerman, 2015; Li & Xu, 2017).

To date, many researchers have empirically investigated agglomeration effects from improved transport infrastructure. Puga (2008) witnesses an asymmetrical outcome for improved transport networks, and HST links benefit major cities at the expense of smaller ones, thus widening regional inequalities. In a study of metropolitan Seoul, South Korea, Song, Lee, and Anderson (2012) conclude that, in general, a developed transport network is positively associated with the agglomeration of industries (especially the service industry). Monzon, Ortega, and Lope (2013) claim that in Spain the agglomeration effects can be generated by the improved accessibility of HST services. Yu, Roo, and Servaas (2016) report that the expansion of a motorway network in China accelerates the geographic agglomeration of the economy at a national scale. Recently, Shao, Tian, and Yang (2017) employ a difference-in-differences model to demonstrate that high-speed rail (HSR) leads to a significant agglomeration effect on service industries in cities along the HSR lines in China's Yangtze River Delta region.

2.1.2. Dispersion effect

In contrast to the agglomeration effect, the dispersion effect of transport infrastructure on regional economies refers to an opposite scenario: the economic activities become evenly distributed over space after the improvement of transport infrastructure in certain areas. Fujita and Hu (2001) and Li et al. (2016) argue that as the transport network extends, production and business locations tend to decentralize and disperse over space. The equilibrium theory on regional economy (Perroux, 1955; Anjali et al., 2017; Friedmann, 1966) proposes that after certain areas experience economic growth, less developed areas start to catch up as capital, labor, and knowledge become mobile, or that less developed economies tend to grow faster in per capita terms than developed ones, ultimately leading to a convergence of regional economies (Fujita & Hu, 2001).

Agglomeration presents many challenges to producers. Dispersion or decentralization can be considered as an effective response to the negative externality produced by agglomeration and associated with a decrease or disappearance of agglomeration benefits. The geographical proximity between producers is generally synonymous with heightened spatial competition (Chung & Kalnins, 2001). Hotelling (1929) introduces an influential mathematic model to depict the spatial competition between two neighboring producers. Usually, spatial proximity stimulates competition on supplies such as labor and capital, and in specific scenarios, producers may choose to locate far from each other as a result. Additionally, it is challenging for a firm to keep its know-how and new technologies proprietary when co-locating with others (Canina et al., 2005). To pursue local monopoly profits, a rational firm may choose to separate from each other, and the enlarged transport network makes the geographical separation feasible (Bartolome, Enrique, Mercedes, & Patrocino, 2014). Therefore, the improved and enlarged transport network facilitates this process of dispersion.

Along with transport network improvement, the landscape of regional attractiveness to producers alters. Sasaki, Ohashi, and Ando (1997) argue that after a transport network connects less-developed regions with the developed ones, the attractiveness of the less-developed regions becomes prominent once these regions enjoy advantages such as cheap labor, rich production materials, and competitive land costs. The cost of land is central when a service facility such as an amusement park is under consideration (Li & Xu, 2017). These advantages on the supply side encourage the re-allocation of economic activities and resources between core cities and peripheral ones (Shao et al., 2017), leading to the spatial equity of economic activities with various sectors, including tourism one.

Many empirical studies confirm the dispersion effect of transport on regional economic development. Based on ex-post-facto simulation analyses, Sasaki et al. (1997) demonstrate that the introduction of HSTs in Japan (i.e., the Shinkansen network) contributed to the dispersion of economic activities and populations from developed to under-developed regions. Baum-Snow (2007) finds that a new highway passing through a city center led to an 18 percent decline in the population of that city in the U.S. The shortened commuting time to the city stimulates the housing demand towards suburban space, echoing dispersion effects. The development of railway infrastructure leads to a gradual economic convergence across regions in China (Chen & Haynes, 2017), meanwhile the operation of HSTs in China results in even geographical distribution of the tertiary industry (Li et al., 2016).

A few empirical studies recognize the agglomeration and dispersion effects are intertwined with each other in shaping regional economies after the opening of HST services. Li and Xu (2017) demonstrate that after HSR operations in Japan, economic activities tend to agglomerate from distant towards core areas, meanwhile, disperse from the core toward its periphery. Using manufacturing data along Beijing-Guangzhou high-speed rail in China as a case, Sun et al. (2017) propose that within a certain threshold of market potential, the HST service encourages an agglomeration effect; beyond the threshold, the HST service leads to a dispersion effect.

2.2. HST and regional tourism economies

Over the past decades, HSTs, regarded as a revolutionary technological advancement in transport, have become one of the major transport modes for passengers worldwide (Kim, Sultana, & Weber, 2018). Transport infrastructure is an integral part of regional tourism systems (Kaul, 1985; Leiper, 1990; Khadaroo & Seetanah, 2008) and contributes to the competitiveness of a destination (Reisinger, Michael, & Hayes, 2019).

A growing body of empirical studies investigates the association between HSTs and regional tourism demand. Most studies highlight a positive effect of HST operation on tourism demand. Using 47 Spanish provinces as the sample, Campa and Lopez-Lambas (2016) demonstrate that the availability of HSTs generated an increase in foreign tourist arrivals and tourism revenue. The accessibility of HST to a city in Italian is also positively related to the number and overnight stays of domestic visitors (Pagliara et al. (2017)). China built the most extensive national HST system in the world, and up to the end of 2015, the length of the network in China accounts for over two-thirds of the world total (Sun et al., 2017). Chen and Haynes (2012) were among the first empirical efforts to estimate the impact of HST services on the provincial tourism demand of China, and they conclude that the provinces linked by HST systems received about 20 percent more foreign arrivals and 25 percent higher tourism revenues than provinces without HSTs.

Only few studies specifically focus on the spatial outcome of HST services on regional tourism economies. According to the NEG theory, the spatial structure or geographical distribution of regional economies is determined by two opposing forces: agglomeration (or the centripetal force) and dispersion (or the centrifugal force). These two forces are largely determined by transport costs or time (Papageorgiou & Smith, 1983; Krugman, 1991; Lafourcade & Thisse, 2009; Zhang, Wan, & Yang, 2019). HST service significantly alters the transportation time and costs for tourists and reshapes spatial accessibilities among regions. As a result, the network of HSTs plays a crucial role in determining tourism economy's spatial structure. Moreover, compared to other industries, the tourism industry is more sensitive to the improved transport infrastructures. The main reason is that as a typical service industry, tourism desperately depends on the mobility of people (Shao et al., 2017). Without the influx of tourists from other regions, the tourism industry is unable to produce necessary products. Consequently, the spatial pattern of regional tourism economies is largely determined by transport access and response to transport improvement.

Masson and Petiot (2009) predict that the HSR line connecting Spain and France will result in an agglomeration of tourism activities around Barcelona (Spain) at the expense of tourism to Perpignan (France). In a qualitative study, Wang, Huang, Zou, and Yan (2012) add the time-space replacement concept into the traditional gravitational model and suggest that tourism activities will concentrate on regions along the HST lines, leaving other regions marginalized. The trend of agglomeration triggered by the massive HSR network will "shock" regional tourism economies of China, and consequently, the spatial structure of tourism markets will be greatly altered. Although Masson and Petiot (2009) and Wang et al. (2012) suggest that HST accessibility will reshape the spatial structure of regional tourism economies, no empirical studies present explicit and concrete evidence under a rigorous econometric framework.

Economic theories suggest both agglomeration and dispersion effects may be observed after the opening of HST services. According to Venables (1996), as the economic integration comes out on the condition of a significant reduction of transport cost, the agglomeration and dispersion of regional economies may be an equally possible result. A similar proposition was provided by Krugman and Venables (1995), Lafourcade and Thisse (2009), Combes (2011). In the context of regional tourism integrated by an extensive transportation network, several factors may contribute to agglomeration: (1) the positive spillover effect of regional tourism flows, mainly rooted in the productivity and market access spillover (Yang & Wong, 2012); (2) the uneven geographical distribution of human capital and investments in the tourism section; (3) the spatial concentration of tourist sources. For example, the major tourist sources of China are concentrated on regions in eastern China (Wang & Cao, 2019). Meanwhile, there are some factors leading to dispersion. First, tourism businesses would like to avoid spatial competition, as the NEG theory convincingly suggests. Second, tourists may undertake multi-destination travel in a large geographic area to enrich their travel experiences in the course of a single journey (Lue, Crompton, & Fesenmaier, 1993), so that the business opportunity will be evenly distributed among different regions. Third, tourism attractions such as natural parks, historical sites and cultural heritages may be spatially scattered (Zhou, Qu, & Li, 2016), the appeal of a marginalized destination will suddenly increase once this destination obtains accessibility through joining the HST service network (Zhou & Li, 2018a).

3. Research method

3.1. Econometric model

To examine the role of HSTs in shaping the spatial structure of regional tourism economies, we propose a baseline panel data model as follows:

$$\ln TRLQ_{it} = \alpha + \beta \mathbf{X}_{it} + \delta \mathbf{Z}_{it} + \mu_i + v_t + \varepsilon_{it} \tag{1}$$

where i indicates a sample city, and t denotes the year from 2007 to 2016. In the sample, we have a total of 286 Chinese cities, including four municipalities directly administered by the central government and prefecture-level cities. Additionally, $\mathbf{X}_{it}$ indicates the key variables of interest that reflect the HST accessibility of city i in year t. Further, as suggested by Abbott and Klaiber (2011), including a set of control variables can help to alleviate the potentially omitted variable bias. Accordingly, $\mathbf{Z}_{it}$, a set of control variables, is incorporated into the empirical model. Moreover, μ_i captures the city-specific factors of city i that can explain the dependent variable. We estimate the model using a fixed-effects model recommended by Wooldridge (2016) and Allison (2009). Further, v_t represents the year-specific effect that is constant across cities at a particular year. Lastly, ε_{it} represents a conventional error term.

3.2. Variable definition

The dependent variable, $\ln TRLQ_{it}$ represents the log of location quotient of tourism revenue of city i in year t. Like Yang (2012), we define the location quotient of tourism revenue ($TRLQ_{it}$) as follows:

$$TRLQ_{it} = \frac{TR_{it}/AREA_{it}}{\sum TR_{it}/\sum AREA_{it}} \tag{2}$$

where TR_{it} is the tourism revenue of city i in year t, including both domestic and inbound tourism revenue; $\sum TR_{it}$ denotes the sum of tourism revenue in the whole research area in year t; $AREA_{it}$ is the geographical area of city i in year t (in 1000 square kilometers); $\sum AREA_{it}$ is the area of the whole study area in year t.

As an index measuring the relative spatial density of economic activities, the location quotient has been extensively used to reflect industry agglomeration (Billings & Johnson, 2012; Guimarães, Figueiredo, & Woodward, 2009; Miller, Gibson, & Wright, 1991). When the tourism economy is evenly distributed among all space units, the TRLQ of city i should be 1. $TRLQ_{it} > 1$ suggests that city i has a higher-than-average spatial density level (or agglomeration level) of tourism economies in time t. The agglomeration effect is validated when the operation of HST leads to the increase of TRLQ for a city; meanwhile, the dispersion effect is supported if the operation of HSTs results in the diminishment of TRLQ.

Further, we conduct Local Moran's I (the Local Moran index) test on tourism revenue, which is a widely-used local spatial autocorrelation statistics (Anselin, 1995), and calculate the Local Moran's I statistic. The correlation analysis indicates a significant and positive correlation between Local Moran's I of tourism revenue and TRLQ. The overall correlation coefficient of two variables is 0.618, (see Table 1). Therefore, the results indicates that TRLQ can largely capture localized spatial dependence, a source of spatial agglomeration/dispersion.

Table 1
The Correlation coefficients between TRLQ and Local Moran's I of all sample cities.

Year	Obs.	Correlation coefficient
2007	286	0.675***
2008	286	0.663***
2009	286	0.674***
2010	286	0.688***
2011	286	0.651***
2012	286	0.642***
2013	286	0.566***
2014	286	0.506***
2015	286	0.465***
2016	286	0.430***
Overall	2860	0.618***

Notes: (1) *** indicate the level of significance at 1%.

We employ three major variables of interest to reflect HST availability for each sample city:

- lnhst_{it} indicates the log of the number of daily HSTs operating in city i in year t. This continuous variable indicates the intensity of HST service in cities, which allows observing whether the change of HST service intensity could impact the level of tourism-economy agglomeration for a sample city. Shao et al. (2017) demonstrate that the intensity of HST service has a significant effect on the agglomeration of service industries for a given city.
- D-hst_{it} is a dummy variable indicating whether an HST network serves a city i directly in year t. $\text{D-hst}_{it} = 1$ if at least one HST station is operating in the city i in year t; $\text{D-hst}_{it} = 0$, otherwise. Yan, Zhang, and Ye (2014) and Zhou and Li (2018a; b) adopt the same measure to reflect HST availability for a region in econometric analysis.
- lnW-hst_{it} is the log of the spatially weighted average number of high-speed trains of the neighboring city to city i, which captures the spatial spillover effect of HSTs demonstrated by Jiao, Wang, Zhang, Jin, and Liu (2020). To obtain this variable, we use a spatially-weighted matrix, W, to multiply the vector hst that denotes the number of HSTs for all sample cities. The element of matrix W, $w_{ij,}$ is set to be $1/d_{ij}^2$, where d_{ij} is the geographic distance (in km) between cities i and j. By doing this, we assume that the spillover of the HST effect decays over distance, as indicated by the first law of geography (Tobler, 1970).

We also add the following control variables to the proposed model, which help explain the relative concentration of tourism economies.

- $\mathrm{lntrain}_{it}$ is the log of the daily number of conventional trains operating in city i in year t. As a type of railway transport mode, the accessibility of conventional trains should be controlled when assessing the impact of HSTs (Zhou & Li, 2018b).
- lnroad_{it} denotes the log of highway mileages (in km) in city i in year t. Road transport enhances tourists' access to destinations (Anjali et al., 2017; Khadaroo & Seetanah, 2007, 2008), and therefore it contributes to the tourism economy concentration.
- D-air_{it} is a dummy variable indicating the air transport availability. Specifically, $\text{D-air}_{it} = 1$ if there was at least one airport located in city i in year t; $\text{D-air}_{it} = 0$, otherwise. Air transport is a key factor for tourism development since it provides accessibility to long-haul markets (Yang & Wong, 2012).
- lnta_{it} indicates the log number of high-profile tourism attractions in city i in year t. We consider national parks and AAAAA scenic spots as top-tier tourism attractions together. Since national parks are more popular than AAAAA scenic spots, we identify the number of tourism attractions as the weighted sum of national parks (weighted by 4) and AAAAA scenic spots (weighted by 1) (Yang & Fik, 2014).
- $\mathrm{lnhotel}_{it}$ denotes the log number of starred hotels in city i in year t, reflecting the capacity of tourism infrastructure that strengthens destination competitiveness (Patuelli, Mussoni & Candela, 2013; Yang & Wong, 2012).
- lngdp_{it} indicates the log of Gross Domestic Product (GDP) in city i in year t, which measures the scale of economic resources available for cities to boost the tourism economy (Marrocu & Paci, 2013; Zhang & Jensen, 2007).
- lnfdi_{it} denotes the log number of foreign direct investment in city i in year t, reflecting the city's attractiveness to inbound business tourists (Khan, Toh, & Chua, 2005; Kulendran & Wilson, 2000).

We also add the following variables as moderators into the model to elaboratively examine the spatial heterogeneity of the HST services effects.

- D-central$_{it}$ is a regional dummy, which is denoted as 1 if a given sample city is located in central China, and otherwise 0.
- D-west$_{it}$ is a regional dummy, which is marked as 1 if a particular sample city is located in western China, and otherwise 0.
- M-trlq$_{i,t-1}$ is denoted as 1 when TRLQ of city i is between 1.0 and 2.0 in year t-1 and otherwise 0, reflecting a medium-level tourism-economy agglomeration.
- L-trlq$_{i,t-1}$ is marked as 1 when TRLQ of city i in year t-1 is smaller than 1.0 and otherwise 0, measuring a low-level tourism-economy agglomeration.

3.3. Data source

We collected the data on HSTs and conventional train services from China's National Railway Timetables published by the Ministry of Railways of China. For tourism attractions, we gathered the data from the official website of China's National Tourism Administration and the Ministry of Housing and Urban-Rural Development. For the spatially-weighted matrix, we generated the weights from shape files of Chinese administrative maps via GeoDa software. Additionally, other data came from the China Economic and Industrial Database (CEIC).

3.4. Data description

According to Yang (2012), the trend of agglomeration of regional tourism economies can be reflected by the coefficient of variation (CV). Fig. 1 presents the CV score of the location quotient of tourism revenues from 2007 to 2016, indicating the overall trend of tourism agglomeration in China. This indicator has almost steadily decreased during the research period, suggesting that the spatial inequity of tourism economies has been shrinking over time.

Figs. 2–3 demonstrate the spatial distribution of TRLQ of our sample regions at the starting year and the ending year of the research time period, respectively. Fig. 2 shows that in 2007 most cities with a high TRLQ value are located in the coastal area in the eastern part of China. In 2016 more cities in central and western China have a larger-than-one TRLQ value (Fig. 3). Fig. 4 presents the growth rate of TRLQ for all sample regions during 2007–2016, which shows that the spatial concentration of tourism economies in central and western China experienced a distinct increasing trend, with a noticeable change of spatial distribution of regional tourism economies.

Table 2 provides descriptive statistics of continuous variables used in the proposed econometric model. The panel data set comprises 2860 observations from 286 cities from 2007 to 2016. The results of the Variance Inflation Factor (VIF), the most widely-used diagnostic for multicollinearity problems, are also reported. The VIF values are lower than 5, implying the absence of multicollinearity issues (Dormann et al., 2013).

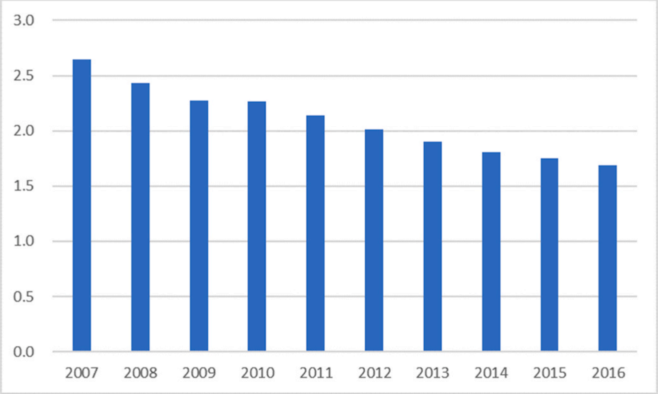

Fig. 1. The coefficients of variation of tourism-revenue location quotient.

Table 3 reports the descriptive statistical results for all dummy variables used in our model.

4. Estimation results and discussions

Table 4 shows the estimation results for models. In general, Hausman test results prefer fixed effects (FE) over random effects (RE) for estimating the models (Hausman, 1978). Therefore, only FE results are provided.

4.1. Basic results and discussions

Model 1 in Table 4 incorporates the lnhst, whose coefficient reflects the effects of the number of daily operation of HST service on the concentration level of tourism economy, and it is negative and statistically significant. The result indicates that a one percent increase in the number of HSTs is associated with a 0.0120 percent decline in the relative concentration level of tourism economies. The coefficients of other transport variables are all estimated to be positive and significant, suggesting their positive effects on the level of agglomeration. Specifically, a one percent increase in the number of conventional trains serving a city and the length of highways lead to a 0.0407 percent and 0.173 percent increase of TRLQ, respectively. Meanwhile, the availability of commercial airports leads to a higher relative concentration level of the tourism economy, as indicated by the significant and positive coefficient of D-air. According to these results, the service intensity of HST plays a different role from traditional transport modes because it lowers the tourism concentration level, highlighting a dispersion effect. For other control variables, the coefficient of lnta is insignificant. One possible explanation is that the national parks and AAAAA scenic spots only reflect a small part of tourism resources within a region. Additionally, most of these attractions rely heavily on ticket revenue to maintain their operations, which may limit their ability to promote other regional tourism and may fail to stimulate tourism economy concentrations. The coefficient of lnhotel is significantly positive, reporting that a one percent increase of the number of hotels results in a 0.238 percent increase in TRLQ. The coefficient of lngdp indicates that the GDP exerts the most substantial influence on tourism economy agglomeration among all variables. A one percent increase in GDP leads to a 0.365 percent increase in TRLQ. The coefficient of lnfdi shows that a one percent increase in FDI is associated with a 0.0133 percent increase in TRLQ.

We introduce D-hst into model 2 in Table 4. The coefficient of D-hst is 0.30 and statistically significant, highlighting that linking to an HST network directly leads to a 0.30 percent increase in the relative concentration level of tourism economies.

We add lnW-hst (a measure of HST service availability among neighboring regions) into model 3. The coefficient of lnW-hst is positive but not statistically significant, suggesting that the TRLQ level of a given city is not significantly impacted by the HST services of nearby cities.

Models 1 and 2 report an important result of this study: HST services can function as both agglomerating and dispersing forces in shaping the geographic pattern of tourism activities. Herein we provide a theoretical explanation for this result. On the one hand, tourism economies tend to agglomerate on the area covered by the HST service network (the HST zone) for several reasons. First of all, the HST zone has a predominant advantage over the non-HST zone in terms of accessibility or transportation connectivity (Wang et al., 2012). Additionally, the mobility of people differs from the movement of merchandise, and a comfortable travel experience, which can be offered by HST services, becomes particularly appealing to tourists who can afford it (Wang, Qian, Chen, Zhao, & Zhang, 2014; Yang et al., 2019). As a result, a clustering of tourism demand is observed in the HST zone (Wei, Jiao, Wang, & Xu, 2020), sacrificing the tourism demand to the non-HST zone as suggested by Wang et al. (2012).

On the other hand, within the HST zone, tourism economies start to

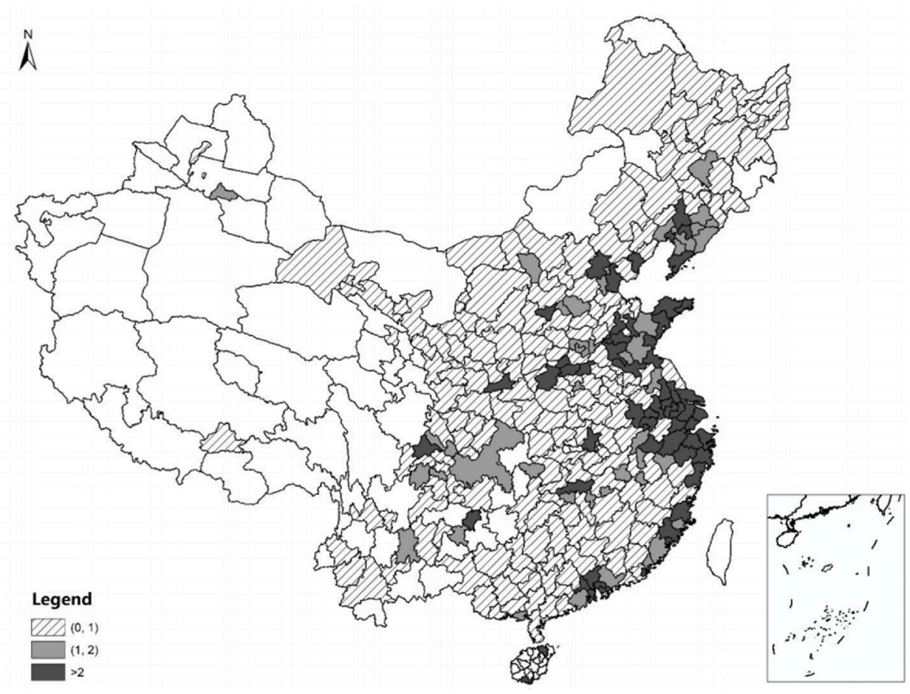

Fig. 2. The distribution of TRLQ of sample regions in 2007. Notes: (1) Blank regions indicate data unavailability; (2) All sample regions are divided into three groups according to their value of TRLQ.

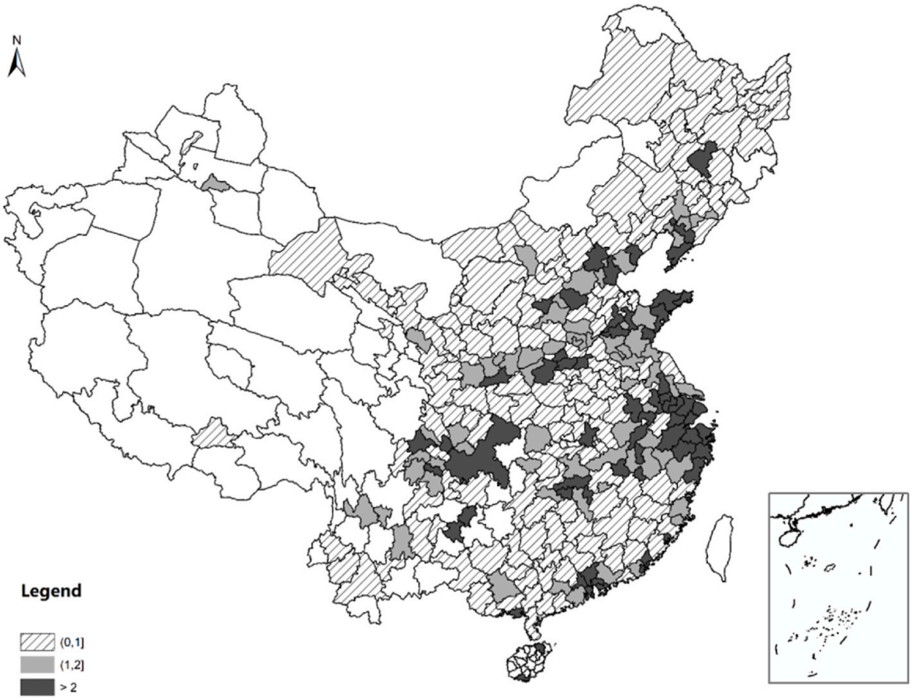

Fig. 3. The distribution of TRLQ of sample regions in 2016. Notes: (1) Blank regions indicate data unavailability; (2) All sample regions are divided into three groups according to their value of TRLQ.

disperse as more HST services become available. This could be partly explained by the multi-destination travel of tourists (Lue et al., 1993). As cities in the HST zone share an integrated HST transportation system, it is convenient for tourists to take multi-destination travels between cities in the HST zone, leading to the dispersion of tourism demand within the geographical scope of the HST zone. In particular, the attractiveness of the less-developed regions (in terms of tourism economy) may be prominent when these regions are initially connected by the HST service network. The dispersion of demand further leads to a dispersion of tourism economy as the supply chain of tourism industry is very flexible or elastic, and tourism businesses can relocate and re-organize the supply chains to cater for the dispersed demand (Murakami & Cervero, 2012).

According to the results of model 2, we may consider agglomeration

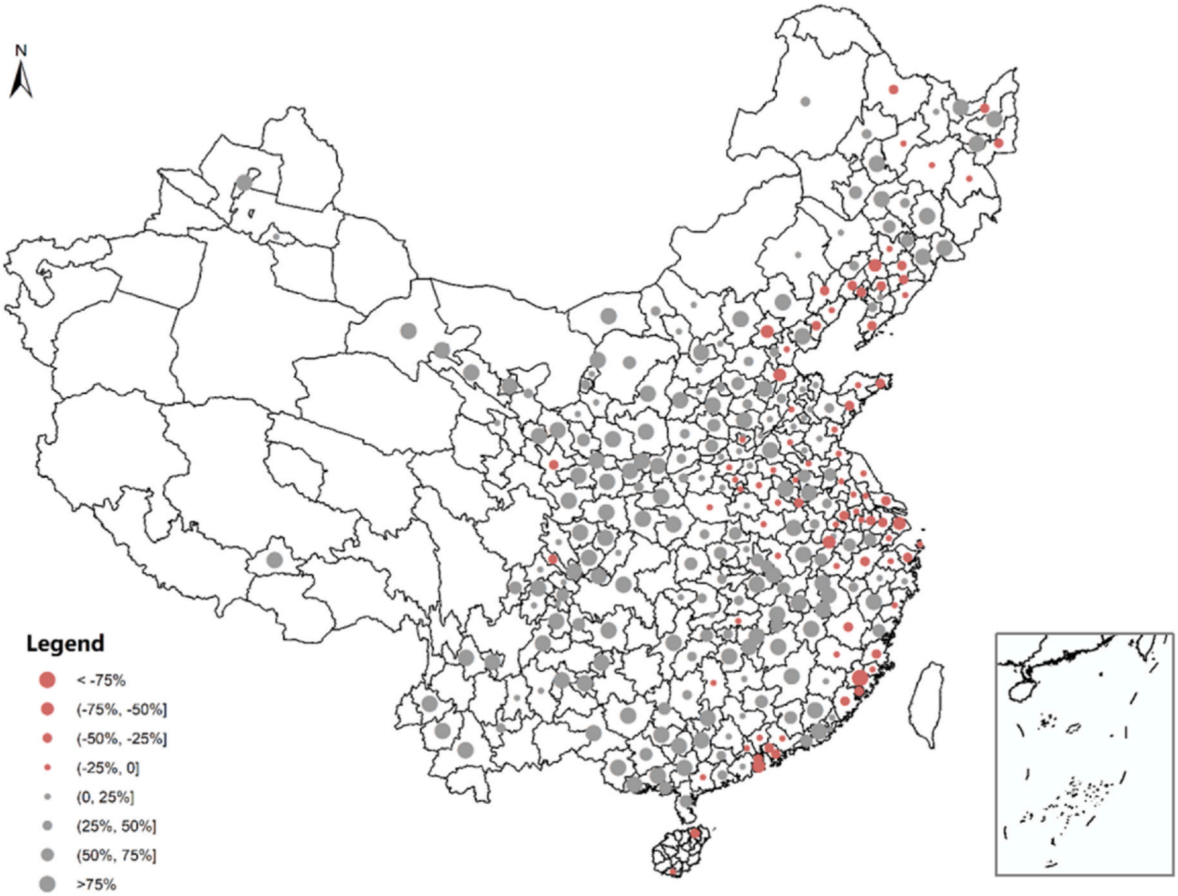

Fig. 4. The growth rate of TRLQ of sample regions during 2007–2016. Notes: (1) Blank regions indicate data unavailability; (2) The growth rate of city i is equal to (TRLQ$_{i,\ 2016}$ -TRLQ$_{i,\ 2007}$)/TRLQ$_{i,\ 2007}$.

Table 2
Descriptive statistics of continuous variables.

Variable	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	VIF
lnTRLQit	2860	−0.309	1.450	−0.156	3.341	
lnhst_{it}	2860	−0.123	2.987	0.760	1.792	1.73
lnW-hst_{it}	2860	2.707	1.464	−0.634	2.716	1.58
lntrain_{it}	2860	3.441	1.672	−2.085	7.711	1.28
lnroad_{it}	2860	9.188	0.696	−0.907	4.809	1.28
lnta_{it}	2860	−0.341	1.982	0.129	1.206	1.44
lnhotel_{it}	2860	3.381	0.861	0.007	3.768	2.15
lngdp_{it}	2860	4.699	0.969	0.342	3.164	3.98
lnfdi_{it}	2860	5.057	2.138	−1.106	6.254	2.22

Table 3
Descriptive statistics of dummy variables.

	Frequency	Percent	Cum. Percent
$\text{D-hst}_{it} = 0$	1819	63.61	63.61
$\text{D-hst}_{it} = 1$	1041	36.39	100.00
$\text{D-air}_{it} = 0$	1519	53.11	53.11
$\text{D-air}_{it} = 1$	1341	46.89	100.00
$\text{D-central}_{it} = 0$	2060	72.03	72.03
$\text{D-central}_{it} = 1$	800	27.97	100.00
$\text{D-west}_{it} = 0$	2010	70.28	70.28
$\text{D-west}_{it} = 1$	850	29.72	100.00
$\text{M-trlq}_{it} = 0$	2342	81.89	81.89
$\text{M-trlq}_{it} = 1$	518	18.11	100.00
$\text{L-trlq}_{it} = 0$	1167	40.80	40.80
$\text{L-trlq}_{it} = 1$	1693	59.20	100.00

effects and dispersion effects together, and calculate a threshold value $\text{hst}_{\text{threshold}}$ for the spatial effect of HST service intensity as follows. The net effects of HST, which is equal to 0.300 (the coefficient of D-hst) + (−0.0602) (the coefficient of lnhst)* lnhst, is presented in Fig. 5. Accordingly, we obtain the threshold value $\text{hst}_{\text{threshold}} = 146$, where the net effect of HST is equal to 0. Specifically, when the number of daily HST operations is smaller than the threshold, the agglomeration effect of HST dominates, and when the number is above 146, the dispersion effect prevails.

4.2. *Extended results: heterogeneity and moderators*

Spatial heterogeneity indicates the spatially varying impact for cities across different locations. In model 4, we capture the spatial heterogeneity of HST impacts by adding interaction terms between regional dummies and lnhst. We divide sample cities into three groups: eastern China (D-east, the benchmark group), central China (D-central) and western China (D-west). Note that the coefficients of D-central and D-west are unavailable as the F.E. estimation drops the coefficients of these two time-invariant variables automatically. The positive and significant coefficients of two interaction terms in model 4, D-central * lnhst and D-west* lnhst, clearly disclose the spatial heterogeneity. Specially, in western and central parts of China, the dispersion effects of HST service on tourism economies tend to be significantly weaker than those in eastern China. The reason may be that the less developed intra-regional transport infrastructure in western and central parts of China limits the mobility of multi-destination tourists within the HST zone, which diminishes the dispersion effect of HSTs. Similar to the way identifying the threshold for HST number in Fig. 5, we take the coefficients of lnhst, D-hst, D-central* lnhst, and D-west* lnhst together into consideration to

Table 4
Estimation results of major econometric models.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Lnhst	−0.0120***	−0.0602***	−0.0603***	−0.0649***	−0.0651***	−0.0643***	−0.0643***	−0.0474***
	(0.003)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Lntrain	0.0407***	0.0357***	0.0357***	0.0333***	0.0432***	0.0410***	0.0348***	0.0365***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Lnroad	0.173***	0.155***	0.155***	0.140***	0.115**	0.157***	0.166***	0.153***
	(0.043)	(0.043)	(0.043)	(0.043)	(0.045)	(0.043)	(0.043)	(0.043)
D-air	0.0593**	0.0493*	0.0494*	0.0645**	0.0552**	0.0465	0.0483*	0.0284
	(0.029)	(0.028)	(0.029)	(0.028)	(0.028)	(0.028)	(0.028)	(0.029)
Lnta	−0.0108	−0.00737	−0.00736	−0.00645	−0.00170	−0.00768	−0.00971	−0.00934
	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
Lnhotel	0.238***	0.229***	0.229***	0.219***	0.189***	0.227***	0.226***	0.224***
	(0.022)	(0.022)	(0.022)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
Lngdp	0.365***	0.346***	0.346***	0.257***	0.319***	0.348***	0.331***	0.353***
	(0.049)	(0.049)	(0.049)	(0.049)	(0.047)	(0.049)	(0.049)	(0.049)
Lnfdi	0.0133**	0.0133**	0.0133**	0.0117**	0.00591	0.0121**	0.0130**	0.0125**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
D-hst		0.300***	0.300***	0.197***	0.193***	0.325***	0.323***	0.281***
		(0.050)	(0.050)	(0.051)	(0.049)	(0.051)	(0.051)	(0.050)
lnW-hst			0.000655	0.00158	0.0538***	0.00378	0.00616	0.000742
			(0.013)	(0.013)	(0.018)	(0.013)	(0.013)	(0.013)
D-central* lnhst				0.0316***				
				(0.006)				
D-west* lnhst				0.0627***				
				(0.007)				
M-trlq*lnhst					0.0285***			
					(0.006)			
L-trlq*lnhst					0.0396***			
					(0.005)			
M-trlq					−0.324***			
					(0.032)			
L-trlq					−0.584***			
					(0.040)			
lntrain*lnhst						0.00516***		
						(0.001)		
lnroad*lnhst							0.0118***	
							(0.003)	
D-air*lnhst								−0.0211***
								(0.005)
Constant	−4.583***	−4.426***	−4.426***	−3.819***	−3.381***	−4.470***	−4.462***	−4.392***
	(0.449)	(0.447)	(0.447)	(0.445)	(0.475)	(0.446)	(0.446)	(0.445)
observations	2860	2860	2860	2860	2574	2860	2860	2860
R-square	0.243	0.254	0.254	0.279	0.303	0.258	0.257	0.259
adj. R-square	0.154	0.165	0.165	0.192	0.209	0.17	0.169	0.171
AIC	−341.7	−379.2	−377.2	−470.5	−1118.7	−392.4	−389.2	−396.3
BIC	−234.4	−266	−258	−339.4	−984.1	−267.3	−264.1	−271.2
Hausman test	327.0***	329.1***	326.6***	326.5***	337.3***	337.1***	331.0 ***	355.1***

Notes: (1) AIC: Akaike's information criterion; BIC: Bayesian information criterion. (2) *,**,*** indicate the level of significance at 10%, 5% and 1%, respectively. (3) Standard errors are presented in parentheses.

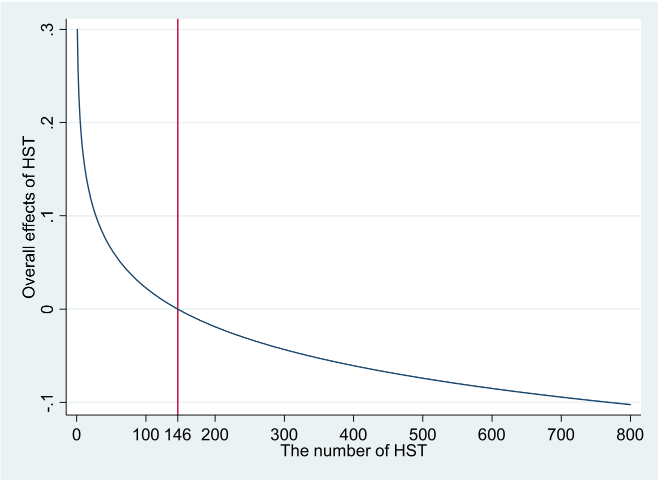

Fig. 5. The net effects of daily HST operation (All sample).

consider the net spatial effects of HST, and find the potential thresholds for different regions. The threshold values for the number of daily HST operation in eastern China and central China is 371 and 21 respectively, below which the agglomeration effect dominates and above which the dispersion effect prevails in these two regions. For cities in western China, the agglomeration effect dominates irrespective of daily HST operation number. For revealing the spatial heterogeneity further, in model 5, we test whether the dispersion effect of lnhst is contingent on the relative level of tourism-economy agglomeration of a city. We add two dummy variables, M-trlq and L-trlq$_i$, and two interaction terms into the model accordingly. The estimated coefficients of M-trlq*lnhst and L-trlq*lnhst are significantly positive, suggesting that, compared with cities with high-level tourism-economy agglomeration, the cities with a medium-level or low-level tourism-economy agglomeration would suffer fewer dispersion effects from an increase of the number of HSTs. Thus, the convergency of tourism economies can be expected when more regions are connected by the HST network. To further clarify the potential threshold value for the HST service intensity, we further divide the sample cities into 10 groups by their TRLQ level at the lagged time. Ten dummy variables are incorporated in interaction terms with lnhst

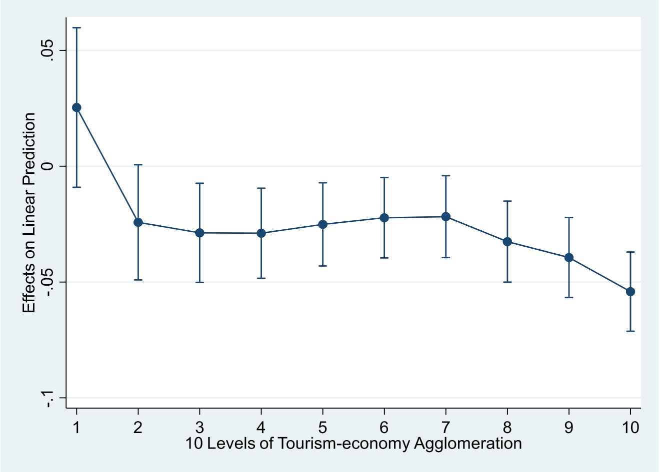

Fig. 6. Net Marginal Effects of lnhst by different levels of tourism-economy agglomeration. Notes: (1) The horizontal axis presents 10 city-groups with different levels of tourism-economy agglomeration. The location quotient of tourism revenue of the cities in the n-th group are between the n-1-th decile and the n-th decile. (2) The confidence interval is 95%.

into the model. The results are shown in Fig. 6, which indicates that the intensity of HST services has insignificant effects in the first and second groups (TRLQ levels below or equal to the second decile), while in the third to tenth groups (TRLQ levels over the second decile), the significant and negative effect indicates the dispersion effects.

To reveal the moderating effect exerted by other transportation modes, in models 6–8, we add three interaction terms, lntrain*lnhst, lnroad*lnhst, and D-air*lnhst, respectively. The coefficients of lntrain*lnhst and lnroad*lnhst are significantly positive, suggesting that conventional trains and road transport can reduce the dispersion effect of HST services. In other words, the dispersion effect of HST service is smaller in regions which have the better conventional train access or road infrastructure. One reason may be that as a key element of the internal transport within a given region, road transport can make the attractions within a region more accessible to HST passengers. These passengers would then concentrate their tourism activities within this region, resulting in a lower level of dispersion effect to other regions. Conventional trains are very slow and generally stop at many stations within a region. They can be viewed as an intraregional transportation infrastructure just as roads are from the tourist perspective, so that conventional trains exert the same moderating effects as road transport does. In contrast, as reflected in the negative and significant coefficient of D-air*lnhst, air transport can amplify the dispersion effects of HST services. This result can be explained by the fact that air transport facilitates long-haul travel, and HST services help quickly transfer these air passengers to other regions, so that air transportation strengthens the dispersion effect.

4.3. Robustness check

To carry out a robustness test, we use another proxy of high-speed train intensity lnhst_stop to replace the lnhst. A train may have multiple stops in a city (e.g., stops in the suburban and rural areas), and lnhst_stop measures the number of high-speed train stops in a sample city. We re-estimate all models and get the robust test results as Table 5 indicates. Overall, the results of the robust tests consistently support all the main conclusions of this study.

5. Conclusions and implications

This study represents a pioneering research effort to examine the relationship between HST service and the level of regional tourism-economy concentration, through which the spatial impact of HST accessibility is well revealed. With FE panel data models, this study concludes that both agglomeration and dispersion effects exist. Tourism economies tend to agglomerate in the HST zone, an area consisting of the cities connected and integrated by HST service network. Accessibility advantage of HST network and unique level of HST travel comfortability help explain the agglomeration effect, while multi-destination travel along the HST zone and easy (re)location of tourism supply chain largely explains the dispersion effect. For a particular city, its initial connection to the HST network leads to an agglomeration effect on its tourism economy. But as the HST numbers (the intensity of HST service) increase, a dispersion effect occurs, which ultimately leads to the convergence of tourism economies among cities within the HST service network. Taking two effects together, a threshold of daily HST operation of 146 is found for all sample cities (the daily HST operation is 146). Agglomeration dominates below this threshold and dispersion prevails above.

Additionally, this paper identifies the spatial heterogeneity of HST impacts. First, the dispersion effect is less dominant in cities in western and central China due to a less-developed local transport infrastructure to transfer multidestination HST passengers to other regions. Second, the marginal dispersion effect of HST service becomes stronger if a city is associated with a higher level of tourism economy agglomeration. Further, the interdependency of different transportation modes is apparent, where conventional train and road transport seem to inhibit the dispersion effect, while air transport tends to amplify the dispersion effect.

Our empirical results provide several managerial and policy implications. This study recognizes the HST accessibility as a key determinant of spatial pattern of tourism economies. For policy-makers, the dispersion effect of HST services on connected regions predicts a convergence or a balanced development of the regional tourism economy, a benefit policy-makers should leverage when planning to extend the network of HSTs. The dispersion effect brings a unique opportunity for a region when it becomes a new member of the HST network, especially if its tourism economy is not developed well. Therefore, these regions should consider more strategic plans to fully internalize the benefits of HST by developing and promoting tourism products to potential markets connected by HST services. Improving the quality and marketing of tourism products, as well as collaborating with neighboring regions to draw tourists via joint marketing campaigns and cross-destination route design, all help a region to seize the opportunity. Moreover, to facilitate the dispersion effect from the HST network, destinations in the HST zone should alleviate the “last mile” issue associated with the lack of road transport access to connect HST stations and attractions. For example, HST shuttle bus services can be provided to fully internalize the benefits of HST dispersion. At the national level, the central government and tourism administration can work with the rail services and transport planners to strategically adopt HST networks as a useful tool to promote local tourism in underdeveloped regions.

Asymmetric impacts of HST service on the HST zone covered by the network and the non-HST zone (the area bypassed by the network) suggest uneven tourism investment opportunities among regions. Since the regions without HST accessibility seem to be marginalized, it is wise for tourism firms to invest more in the HST zone. HSTs contribute to spatial equality or convergence after the dispersion effect of HST services. Therefore, investment opportunities exist in under-developed tourism destinations with ideal attractions along the HST zone. Even though the destination may locate at the peripheral region of the HST zone, their potential for HST accesses with land transport connections should be a positive factor to consider. Since there is significant spatial heterogeneity regarding the spatial impacts of HSTs as well as the moderating effects of other transport modes, stakeholders should make a specific analysis when they make investment decisions. Agglomeration towards the HST zone corresponds to the so-called siphon effect of the HST service (Zhang et al., 2019), which means the talent, investments

Table 5
Estimation results from robustness checks.

	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
lnhst_stop	−0.0113***	−0.0561***	−0.0560***	−0.0616***	−0.0600***	−0.0588***	−0.0604***	−0.0433***
	(0.003)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)
lntrain	0.0407***	0.0360***	0.0360***	0.0332***	0.0434***	0.0412***	0.0351***	0.0369***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
lnroad	0.173***	0.157***	0.157***	0.140***	0.117**	0.159***	0.168***	0.155***
	(0.043)	(0.043)	(0.043)	(0.043)	(0.045)	(0.043)	(0.043)	(0.043)
D-air	0.0593**	0.0497*	0.0495*	0.0646**	0.0548**	0.0470*	0.0484*	0.0297
	(0.029)	(0.028)	(0.029)	(0.028)	(0.028)	(0.028)	(0.028)	(0.029)
Lnta	−0.0108	−0.00775	−0.00778	−0.00668	−0.00227	−0.00819	−0.0102	−0.00992
	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
lnhotel	0.237***	0.228***	0.228***	0.217***	0.189***	0.225***	0.224***	0.223***
	(0.022)	(0.022)	(0.022)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
Lngdp	0.365***	0.346***	0.346***	0.255***	0.324***	0.348***	0.330***	0.353***
	(0.049)	(0.049)	(0.049)	(0.049)	(0.047)	(0.049)	(0.049)	(0.049)
Lnfdi	0.0132**	0.0131**	0.0131**	0.0116**	0.00582	0.0119**	0.0126**	0.0123**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
D-hst		0.294***	0.294***	0.196***	0.185***	0.314***	0.321***	0.271***
		(0.050)	(0.050)	(0.050)	(0.049)	(0.050)	(0.050)	(0.050)
lnW-hst			−0.00171	−0.000191	0.0487***	0.00110	0.00381	−0.00104
			(0.012)	(0.012)	(0.017)	(0.012)	(0.012)	(0.012)
D-central* lnhst				0.0303***				
				(0.005)				
D-west* lnhst				0.0601***				
				(0.006)				
M-trlq*lnhst					0.0277***			
					(0.005)			
L-trlq*lnhst					0.0377***			
					(0.005)			
M-trlq					−0.324***			
					(0.032)			
L-trlq					−0.584***			
					(0.040)			
lntrain*lnhst						0.00473***		
						(0.001)		
lnroad*lnhst							0.0121***	
							(0.003)	
D-air*lnhst								−0.0196***
								(0.005)
constant	−4.583***	−4.429***	−4.430***	−3.801***	−3.404***	−4.473***	−4.466***	−4.400***
	(0.449)	(0.447)	(0.447)	(0.445)	(0.474)	(0.446)	(0.446)	(0.445)
Observations.	2860	2860	2860	2860	2574	2860	2860	2860
R-square	0.243	0.253	0.253	0.280	0.303	0.258	0.258	0.259
adj. R-square	0.154	0.165	0.165	0.193	0.208	0.169	0.169	0.17
AIC	−341.6	−378.3	−376.3	−473.9	−1117.2	−390.8	−390.8	−394.7
BIC	−234.4	−265.1	−257.1	−342.9	−982.6	−265.7	−265.6	−269.6
Hausman test	326.4***	328.7***	326.4***	326.5***	336.9***	336.9***	330.7***	348.0***

Notes: (1) AIC: Akaike's information criterion; BIC: Bayesian information criterion. (2) *,**,*** indicate the level of significance at 10%, 5% and 1%, respectively. (3) Standard errors are presented in parentheses.

and spatial opportunities will be taken away through the HST corridor. In this case, regions in the non-HST zone should carefully cope with this challenge and customize marketing strategies, such as re-positioning their tourism products, highlighting unique tourism attractions, and partnering with neighboring areas that have HST accessibility.

Our results are not free from limitations. First, despite its popularity in regional sciences, the location quotient used to measure agglomeration cannot reflect the interregional industrial linkages among regions. Therefore, more sophisticated measurements and tools should be applied to future studies. Second, this paper has not used econometric techniques to address the potential endogeneity induced by a possible simultaneity between HSTs and tourism economy size. For example, areas with more developed tourism might be prioritized to offer HST services. Besides, the control variable, lngdp, may also suffer from endogeneity problems. Future studies can identify potential instrumental variables to tackle this issue. Lastly, our sample did not include the autonomous prefectures for Ethnic Minorities Autonomous Regions due to data unavailability. Therefore, we recommend future studies incorporate a more geographically comprehensive sample.

Impact statement

By looking into the spatial effect of high-speed trains (HSTs) on regional tourism economies, we are providing vital practical and policy implications on tourism planning, tourism marketing, and transport planning. Our results recognized the dispersion effect of HST services, which brings a unique opportunity for a region when it becomes a new member of HST network, especially if its tourism economy is not developed well. Therefore, these regions should consider more strategic plans to fully internalize the benefits of HST by developing and promoting tourism products to potential markets connected by HST services. At the national level, the central government and tourism administration can work with the rail services and transport planners to strategically adopt HST networks as a useful tool to promote local tourism in underdeveloped regions.

Author contribution

Bo Zhou: Conceptualization, Project administration, Resources, Writing – original draft, Zhihong Wen: Data curation, Formal analysis, Writing original draft, Yang Yang: Conceptualization, Methodology, Formal analysis, Writing–review and editing.

Acknowledgment

Professor Bo Zhou would like to acknowledge the financial support from the Natural Science Foundation of China (NSFC) under project number 71773101.

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