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Does high-speed rail mitigate peak vacation car traffic to tourist city? Evidence from China

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ABSTRACT

Tourist travel contributes greatly to transport problems in attractive tourist cities. To take full advantage of high-speed rail (HSR) for alleviating massive car traffic during the peak vacation period, this paper analyses the travel modes of domestic visitors to Shaoxing before and after the operation of HSR. Scenario-based comparison and a random-coefficients structure Mixed Logit (MXL) model with error components were adopted to analyze the travel mode change and the factors explaining tourists' travel mode choices. Our findings show that the HSR modal share increased substantially at the expense of express buses, more than cars. Also, HSR was found to be less competitive than cars on toll-free days for medium short travel distances. The MXL model results indicate that HSR was more likely to be used over automobiles by young people, females, and one-destination travellers, for longer travel distances, and with high service frequency to Shaoxing. Besides, online booking services were highly associated with HSR use. Driving was favoured over HSR by higher income level groups, when travelling with family or friends, on toll-free national holidays. Current government policy to waive road tolls during the peak holiday period further induced car traffic to tourist cities. When individual taste was considered, tourists showed a similar preference in their valuation of the travel time variable, while were heterogenous in their preference for low per-distance cost. Our findings suggest that the adjustment of the road-toll policy, pre-booking design for targeted tourists, and measures to reduce the total travel time of HSR should be considered to promote HSR as well as impede the use of cars during peak periods. This study offers empirical evidence of achieving effective travel demand management and reducing car dependence through HSR and complementary measures.

1. Introduction

Many attractive tourist cities are facing increasing pressures from growing vacation travel demand. Examples can be found in Japan (Kyoto) and in Europe (Rome, Amsterdam and Barcelona) (Cuccia and Rizzo, 2011; Milano et al., 2018). Historical cities, especially those in which the main tourist attractions are located, are typically over-crowded during peak vacation periods. Small and medium-sized historical cities with rich tourist resources are particularly vulnerable to increasing car traffic, given limited road space and the weak local management capacity. Beyond aggravated traffic congestion, the negative outcomes include increased accidents, severe air pollution, and a deteriorated tourism environment. Accordingly, the concern about traffic congestion for vacation travel has drawn attention from both academia and government. In particular, severe congestion on highways during the national holiday seasons has been a frequent headline (Charlotte, 2017; Allen, 2023).

The popularity of automobile travel, known as 'self-drive tourism' is a major contributing factor to excessive traffic congestion in tourist cities (Fu and Gu, 2017). In China, since 2012, the State Council has waived highway tolls for passenger vehicles with fewer than eight seats during four statutory holidays—the Spring Festival, Tomb-sweeping

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Day, Labor Day and National Day. Self-drive vacation has been encouraged by the toll-free government policy and fueled by the country's rapid motorization.

Massive investment in road construction and upgrading has been proposed as a solution to peak demand, but has proven to be a futile exercise (Cervero, 2003). At the same time, the extensive high-speed rail (HSR) network provides an alternative mode of transportation for tourists. By the end of 2021, China have built a total of 40,000 km of HSR lines to connect cities across the country, including smaller cities with tourist attractions. High demand for tourist travel has been observed along HSR corridors connecting cities with tourism resources (Campa et al., 2016; Gao et al., 2019).

Generated travel demand by HSR can be induced or diverted (Cascetta and Coppola, 2014a; Givoni and Dobruszkes, 2013). For the induced demand, HSR is expected to enlarge the tourist market geographically for more travellers (Cartenì et al., 2017; Wang et al., 2012). For the diverted demand, as a fast, comfortable, safe and reliable rail system, HSR can shift a significant portion of the existing air, conventional rail, and road transport passengers (Givoni and Dobruszkes, 2013; Li et al., 2020). Although the potential of HSR to reduce automobile use during peak vacation periods by HSR has been mentioned in previous research (Gonzáles-Savignat, 2004; Moyano et al., 2016; Sperry et al., 2017), relatively less attention has been paid to examining the conversion of HSR passengers from car drivers.

Furthermore, the impact of HSR on vacation travel mode choice has not received sufficient attention, especially in tourist cities where HSR service is provided. Although vacation travel is spatiotemporally dispersed and difficult to manage by public transport, a study by Le-Klähn et al.(2015) reveals that tourists will use public transport for extended travel beyond a city if it is sufficiently provided. Also, in Spain, tourist cities with HSR connections to the major metropolitan area were a positive demand factor for passenger volume (Guirao and Campa, 2015). Despite the positive trend observed, there has been little research on the impact of HSR on tourists' travel mode choices. Understanding the factors that influence the use of HSR after its introduction can help cities accommodate the increasing influx of tourists without massive road expansion.

Another technological development that may influence tourists' travel mode choices is the Internet Reservation System (IRS), which now includes vacation packages, transportation tickets, hotel accommodations, events and attractions (Han et al., 2020). The online travel market is burgeoning. Most studies on the IRS have only focused on the traveller's choice of destination, departure time, train type and seat class (Han et al., 2020; Hetrakul and Cirillo, 2014; Y. Sun et al., 2018). Pre-booking, however, can also reduce unplanned and dispersed travel by car travellers. In addition, transportation is a part of the tourist experience. Convenient online booking services can positively affect passenger satisfaction (Guan et al., 2020) and improve the attractiveness of rail travel. Therefore, we can expect online booking services to attract tourist travel by HSR.

Empirical studies of travel mode change and factors affecting HSR are necessary for travel demand management aimed at increasing the use of HSR while reducing automobile dependency. The objective of this paper is twofold: First, we analyze the vacation travel modes before and after the introduction of HSR in a medium-sized city Shaoxing, a popular tourist destination in China for historical and cultural heritage. We examine how first-time and returning tourists choose HSR to visit Shaoxing after its introduction. Additionally, the differences in tourists' travel mode choices for different distance intervals and toll-free/non-toll-free holidays are examined. Second, we seek to identify the key factors that either support or impede the choice of HSR as the tourist travel mode. A mixed logit model with random parameters and error components was adopted to capture the tourists' heterogeneous tastes depending on the level-of-service attributes and for possible correlations between different choice alternatives.

The remainder of the paper is organized as follows. Section 2 reviews the existing literature on travel mode change and the influencing factors of HSR and other competing travel modes. Then we describe our survey and methodology in Section 3. Next, in Section 4, tourist travel mode choices are compared based on three scenarios. Section 5 compares model results to identify the key factors that influence the choice of using HSR, express bus, or automobile. Finally, in Section 6, conclusions are drawn, and policy recommendations are discussed.

2. Literature review

2.1. HSR and travel mode change

The introduction of the new HSR service has engendered modal share change in intercity travel. HSR typically becomes a substitute mode in the 400–600 km range for medium-to long-distance travel (Vickerman, 2021). In a review paper by Givoni and Dobruszkes (2013), they found that when only considering the competition between HSR and air trave, HSR market share peaks at 3.5 h of travel time. However, when considering HSR against all modes, including road and conventional rail transport, HSR market share generally increased with travel time. HSR's market share exceeded 30% as travel time increased to 1 h. Competition and coordination between HSR and airplane, HSR and conventional rail have been thoroughly assessed (Albalate and Fageda, 2016; Li et al., 2020; Ren et al., 2020; Zhang et al., 2019). In contrast, the impacts of HSR on medium-short transportation modes, such as cars and express buses, are still underdeveloped.

Some research has confirmed that HSR could also affect medium-short trips, competing with normal rail, express buses, and private cars. Based on a Revealed Preference (RP) survey in Italy, Cascetta et al. (2011) found that the HSR demand in the Rome-Naples corridor (222 km) was partially subtracted from former car drivers, with 7.8% of weekday and 13.3% of weekend former car drivers switching to HSR passengers. They also mentioned that more passengers switched from intercity or Eurostar trains to HSR. Using RP/SP survey data in Spain, Cascetta and Coppola (2014b) reported that HSR passengers mainly switched from highway transport for travel distances between 100 and 250 km. In China, Wang et al. (2014) compared the intercity mode split for different distance intervals. They found that for distances between 100 and 150 km, express buses dominated (50%), while for distances between 250 and 300 km, HSR became the dominant mode with a 58% share. However, there is still a lack of understanding of tourist travel mode change. One of the attempts was made by Sun and Lin (2018). They compared the travel mode choice of domestic travellers in Taiwan based on the revealed mode choice and the hypothesized scenario without HSR. The author concluded that HSR was a substitute tourist travel mode for conventional trains (41%), shuttle buses (21%), and private cars (18%). Tourists in Taiwan reported an average travel distance of 205 km by HSR. Therefore, most of the substitution was from conventional rail and road transportation. The ex-post evidence based on our tourist travel survey at the tourist destination could provide complementary knowledge in this area.

Also, facing severe traffic congestion during peak periods, the modal choice under different distance categories, on toll-free and non-toll-free holidays, particularly for medium and short distances, has not been fully explored in previous research. Studying HSR's impact on medium-short distance is important due to more than 80 percent of intercity travel trips are within 300 km (Wang et al., 2022). Also, from a tourism market perspective, the distance decay of tourism travel demand implies that most tourists may come from shorter travel distances (Wang et al., 2012). Furthermore, HSR is expected to increase integration in a region where the travel distance between city pairs is not too long (Cascetta and Coppola, 2014b; Sun and Lin, 2018). Therefore, our paper discusses the modal split within different distance ranges and between toll-free and non-toll-free days to examine the mode share change of tourists over medium-short distances.

2.2. Factors influencing HSR and other competitive modes

Different competing modes, such as air, conventional rail, express bus, and car, were considered to analyze the factors influencing intercity travel mode choice. Using data collected at airport, express bus, and railway stations in the tourist city of Xi'an, X. Li et al. (2020) applied a Bayesian multinomial logistic regression to model the multimodal choice of visitors. Airplanes, HSR, normal trains and express buses were included in their model. Socio-economic factors, traveller's ticketing method, and subjective perceptions of service quality were examined in their study. Their findings indicated that online ticketing passengers, perceived comfort, safety and punctuality were positively associated with the choice of HSR over express buses.

Another recent study by Ren et al. (2020) conducted a station survey for rail passengers and built separate discrete choice models before and after the introduction of HSR to examine the factors that influence the modal choice between HSR and normal rail. They concluded that compared to normal rail, high fares, travel habits, and long-distance amenities discourage passengers from choosing HSR compared to normal rail. At the same time, a direct HSR connection to travellers' destinations showed a positive effect. However, the station-based survey method could not cover travellers using car transport. Since self-driving tourism has been widely adopted by domestic tourists (Cartenì et al., 2017; Pagliara et al., 2015), the car mode should be considered.

The choice between car and other rail alternatives was modelled by Cascetta et al. (2011) using multinominal logit and nested logit models. High professionals (managers or freelancers) were found to favour HSR, while older travellers or those travelling with two or more people were more likely to choose car. In addition, short access/egress times, short in-vehicle times, and small differences between desired and actual HSR travel times by HSR were more attractive to rail passengers. Since the aforementioned models were built for all travel purposes, travel attributes related to tourists were not tested.

2.3. Car and HSR in tourist travel mode choices

Several studies have demonstrated the incentives to drive during vacation periods, such as the desire for free and independent travel experiences (Shih, 2006). Travel companies, carrying heavy luggage, and other perceptual measures, such as perceived ease of use or safety, have also been mentioned in previous studies (Givoni and Dobruszkes, 2013; Strömblad et al., 2022).

Gonzáles-Savignat (2004) presented a discrete choice model to estimate the potential of the future Spanish high-speed train to substitute for road travel in the Madrid-Barcelona corridor. For leisure travel purposes, the percentage of car users diverting to HSR depended on travel time, fare price, and service frequency. In Italy, Mancuso (2014) showed that a reduction in the fare price of high-speed rail reduced the demand for car for leisure travel on the Milan-Rome route. Wang et al. (2014) employed a nested logit model of travellers' travel mode choice for leisure travel in a new HSR corridor in China. They found that travel distance over 280 km is negatively associated with the choice of car over HSR. Besides, travellers tend to choose a travel mode with lower travel time and cost. Moyano et al. (2016) noted the advantage of HSR for weekend tourism when considering the number of travellers and the availability of flexible ticket fares. In Spain, the fare reductions and tourist packages introduced by RENFE (a Spanish rail operator) had made HSR an attractive travel mode for weekend trips to substitute the car. Finally, considering road tolls, Lin et al. (2018) found that higher road tolls positively affect the choice of express bus and HSR over car. However, with limited knowledge of how tourists' socio-economic characteristics and travel attributes (travel itinerary, length of stay) affect the mode choice of in-flow visitors, it is difficult to effectively stimulate mode change from car to HSR for peak vacation travel. A recent paper by Strömblad et al. (2022) also mentions that detailed travel information typically lacked in individual-based surveys, such as travelling with young children, elderly family members, the need to carry luggage, or adapt to weather conditions may also influence leisure travel mode choices.

Generally, previous articles have identified three groups of factors that may influence the competition between HSR and other travel modes. First, socio-economic factors such as age, gender, education, employment, occupation, car ownership and income have been examined (Cascetta et al., 2011; Kamga, 2015; Li et al., 2015, 2020; Lin et al., 2018; Pagliara et al., 2015; Ren et al., 2020). They have been found to have statistical significance in choosing HSR for travel in some cases. Second, in terms of travel characteristics, most tourists choose HSR for a short-stay vacation (Chan and Yuan, 2017; Clewlow et al., 2014). Small travel group size tends to favour HSR (Le-Klähn et al., 2015; Moyano et al., 2016; Wu et al., 2012). Third, different level-of-service variables have been considered, including service frequency, travel time, travel cost or fare price, and travel distance (Cascetta et al., 2011; Pagliara et al., 2015; Ren et al., 2020; Román et al., 2010), as well as other perceptual measurements (comfort, punctuality, on-board services) (Cascetta and Coppola, 2012; Li et al., 2020). Recently Internet reservation system is also included in tourism travel demand management packages. The previous study found that car trips significantly reduce the proportion of trips planned and purchased online (Garín-Muñoz and Pérez-Amaral, 2011), while public transport and pre-trip information use are positively related (Farag and Lyons, 2012). However, there is a lack of understanding of how online travel booking services affect HSR use, which hinders the role of mobility services in promoting HSR use. In addition, only one or two groups of the above factors, if not all, have been tested simultaneously in previous studies.

Given the limitations of previous studies, our paper focuses on the extent of travel mode split changes, with particular attention to cars and express buses made by vacation travellers before and after the introduction of HSR for medium-short trips. We systematically considered the factors influencing the choice of HSR or express bus over car, including tourists' socio-economic characteristics, travel attributes, pre-booking, and level-of-service factors. Our study also adopted a mixed logit model with random parameters and error components, which distinguishes our study from previous works that typically used nested logit or multinominal logit models. Individual heterogeneity has increasingly been noticed in recent articles. The model specification could allow us to test individual heterogeneity toward certain factors and possibly allow certain nest structures. We thoroughly discussed the methodology in Section 3. Furthermore, with a focus on tourist travel, this study contributes empirical evidence to formulate effective sustainable vacation travel policies and promote HSR as an attractive tourist travel option in China and other countries.

3. Data and methodology

3.1. The case

As mentioned in the previous section, it is difficult to capture visitors travelling by car in the station-based survey. Therefore, we conducted a face-to-face survey in Shaoxing, Zhejiang Province. Three reasons were considered when choosing this case.

First, Shaoxing is one of the popular tourist cities. The historic urban areas of Shaoxing city, located along the Grand Canal, were listed as a World Heritage Site in 2014. In addition, the story of the great writer Lu Xun's former residence in Shaoxing has been included in the textbooks for junior high school students. The rich historical and cultural heritage and tourist attractions are located in the old city area.

Second, it is a medium-sized tourist city with HSR service available. In 2015, 99% of the visitors to Shaoxing were from the domestic market, and the proportion remained stable before the pandemic. According to the Zhejiang Tourism Yearbook (Zhejiang Tourism Bureau, 2016), 50.1% and 73% of tourists travelled from the Zhejiang province and the Yangtze River Delta region (YRD) to Shaoxing, respectively. The HSR service in Shaoxing began operation in 2013, connecting Shaoxing with the surrounding populous cities of Shanghai, Hangzhou, Nanjing and Ningbo. The Shaoxing North Railway Station was newly built for the HSR and is located approximately 12 km north of the old city center (shown in Fig. 1).

Thirdly, self-driving tourism at peak times has created serious traffic and environmental problems. The Yuecheng district, where the historic urban areas are located, attracts more than 20 million domestic visitors annually. As driving has become an increasingly popular mode of transportation during national holidays, the large volume of holiday car traffic puts significant pressure on the transport system and the historic urban fabric.

3.2. Tourist travel data collection

Tourist travel data were collected through visitor intercept surveys conducted during the mational Labor Day holiday (May 1–3, which are toll-free days) and September 11–13 (one weekday and two weekend days, which are all non-toll-free days) in 2015. People were surveyed by trained interviewers at four major tourist sites in Shaoxing: The Lu Xun Memorial Hall, Cangqiao Street, the Wang Xizhi Memorial Hall, and the Keyan Scenic Resort. Respondents were randomly selected from within the crowds at each site, but only those who reported visiting from cities other than Shaoxing and being on vacation (hereafter called tourists) were retained to complete the face-to-face questionnaire survey. In total, 959 respondents completed the survey. After removing those under the age of 16, a total of 951 samples remained for further analysis.

According to the Yearbook of Zhejiang Tourism, the number of domestic visitors to Shaoxing in 2015 was 72.03 million (Zhejiang Tourism Bureau, 2016). The main sampling strategy for the survey was random sampling, and the main metric used to validate the collected sample is the geographical distribution of the tourists' departure area. Other metrics discussed in previous research to validate the responses of the intercity travel survey, such as population, income level and dwelling type, were for intercity trips with regional departure, not a destination city (Wong, 2013).

In Fig. 2, we compared the top 10 tourist departure areas from our observations with the panel data from the Yearbook of Zhejiang Tourism. In general, the responses from the survey were satisfactory given the time and resources to approach tourists from different departure areas. In our sample, 51.8% of the Shaoxing tourists came from the Zhejiang Province, and 72.3% came from the top four departure areas (known as the Yangtze River Delta region). These proportions were similar to the statistics in the Yearbook of Zhejiang Tourism, with 50.1% and 73.0% of tourists coming from Zhejiang Province and the Yangtze River Delta region, respectively. Tourists from Shanghai were slightly overrepresented in our sample, while tourists from Jiangsu Province were slightly underrepresented. Since 2015, there have been almost no significant changes to the highway system and the HSR network.

The survey was designed to collect data on three categories of factors: (1) the socio-demographic characteristics of individual tourists, including age, gender, income, and occupation; (2) individuals' travel information, such as where they came from, whether or not it was their first visit to Shaoxing, their primary travel mode to Shaoxing, the factor they value most in making their mode choice, the planned length of stay, and their travel companion(s); and (3) the methods used to book tourist products, specifically whether pre-booking (of hotel accommodation, attractions, transportation tickets, travel packages, etc.) was used, and if so, whether it was done through the Internet, through a travel agency, by telephone or other methods. Besides that, the level-of-service attributes, including travel distance, travel time, and travel costs, were calculated based on the respondents' reported departure city to the centroid point of the Shaoxing old city area.

3.3. Conceptual framework

The conceptual framework is presented in Fig. 3. Scenario-based comparison was used to examine tourist travel mode choice under different scenarios: the travel mode change before and after the introduction of HSR, the primary travel mode within different distance categories and the modal split difference between toll-free and non-toll-free days. The variables of distance intervals and whether tourists travel on toll-free days or not are further estimated in our model. Due to the lack of individual-level panel data to analyze the travel mode change before and after the operation of HSR, retrospective questions were included in

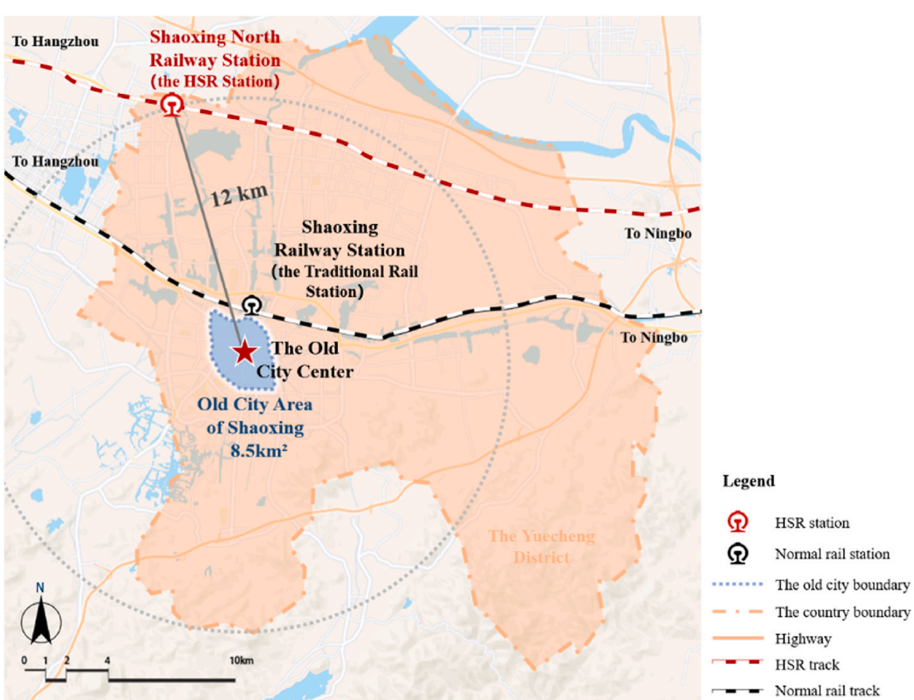

Fig. 1. Location of the new HSR station in Shaoxing.

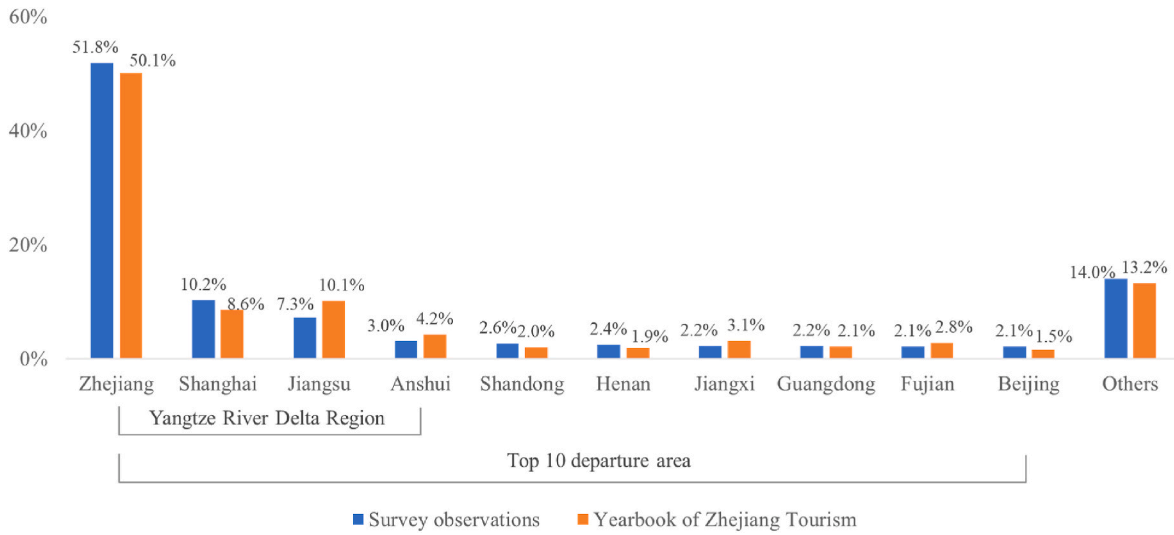

Fig. 2. Distribution of departure area for Shaoxing tourists for observations and the Yearbook of Zhejiang Tourism (panel data).

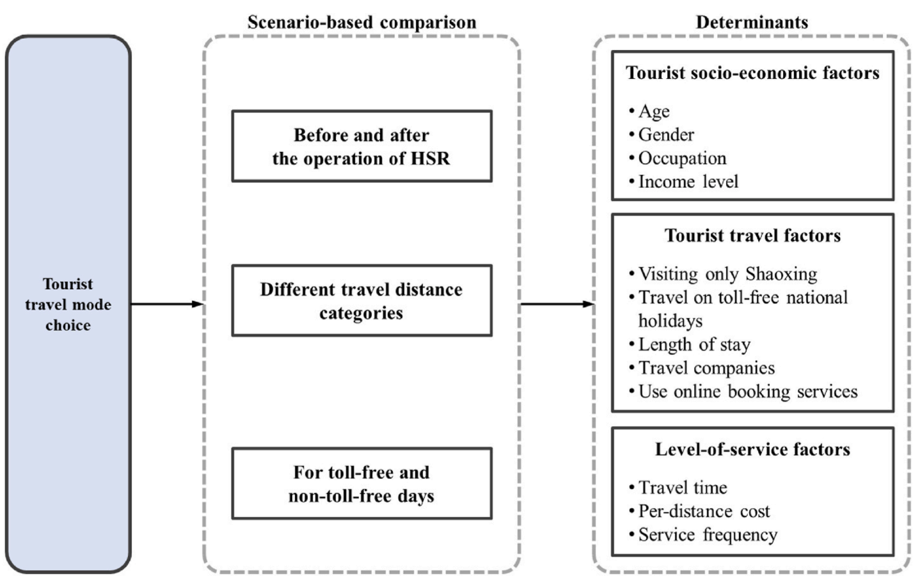

Fig. 3. Conceptual framework.

the tourist travel questionnaire. Travel mode and modal splits change was analyzed by comparing respondents who were first-time and returning tourists in Shaoxing. In addition, the study of modal split changes of HSR against other competing modes was divided by distance categories. Comparisons of modal split changes can provide insightful results on the competitiveness of HSR for tourist travel within different distance categories.

Socio-economic, tourist travel and level-of-service factors are examined in tourist mode choice behaviour. The variables listed in our framework were selected based on the literature review and our own judgement. The mixed logit (MXL) model was used to quantify the impact of selected factors on tourists' mode choice. Although multinomial logit (MNL) and nested logit (NL) models have been widely applied to analyze the multi-travel mode choice of intercity travellers (Bhat, 1998; Ren et al., 2020; Román et al., 2010; Thrane, 2015; Y. Wang et al., 2014), the independence from irrelevant alternatives (IIA) assumption persists, and the taste variation across individuals issue exists. Compared to MNL and NL, MXL could capture observed and unobserved heterogeneity by allowing random coefficients and error components. Random parameters are used to capture specific individual tastes by re-parameterizing the mean and/or variance of each random parameter's distribution. Also, to account for possible correlation between different choice alternatives, a normal error component could be added to constrain the variances under the same nests (Greene and Hensher, 2007; Hensher et al., 2008; Hensher and Greene, 2003; Train, 2009; Walker, 2002). We assume that differences in travellers' preferences depend in part on level-of-service variables and certain 'nest' structure between different alternatives exists. Hence, a random-coefficient structure mixed logit (MXL) model with error components was adopted to analyze the factors explaining tourists' travel mode choices to Shaoxing.

4. Scenario-based comparison

4.1. Modal change after the introduction of HSR

The extent of HSR in mitigating car traffic is reflected by modal splits change after introducing HSR. Survey responses showed that a higher proportion of first-time visitors than returning visitors travelled to Shaoxing by HSR (shown in Fig. 4). The higher share of HSR passengers

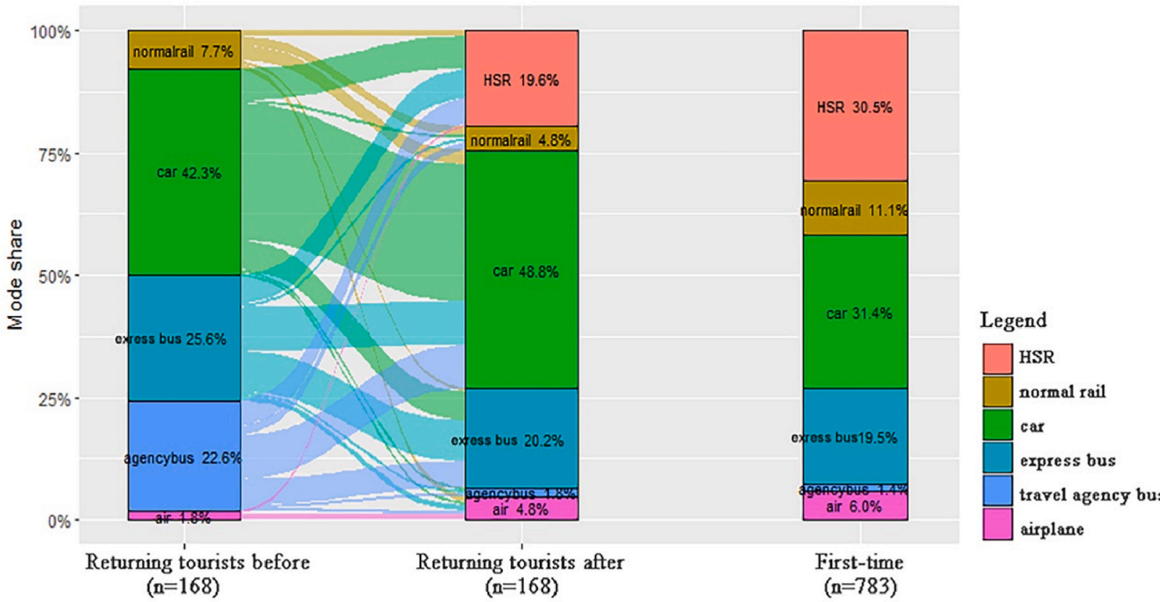

Fig. 4. Modal selection before and after the introduction of HSR (n = 168) and first-time travellers (n = 783) after the introduction of the HSR.

among first-time visitors may result from the induced effect of HSR on attracting new visitors.

A substantial change in the share of HSR and bus was observed among the 168 returning tourists. Among them, only 19.6% who came to Shaoxing both before and after the introduction of HSR, changed to HSR after its introduction (Fig. 3). The new HSR riders among the returning visitors were almost equally distributed among previous car users (33.3%), express bus users (27.3%) and agency bus users (30.3%). Car users increased from 42.3% to 48.8%, while the use of express buses slightly declined. New drivers for returning visitors were mainly former agency bus and express bus passengers. The increase in the mode split of driving for returning visitors was inferred to result from the increase in self-drive tourism and rapid motorization during these years. The most dramatic change was among travel agency bus users, who dropped from 22.6% to 1.8% of travellers. Tours organized by travel agencies and companies are common in China, and express buses and travel agency buses have traditionally been the basic travel services for intercity vacation travel. The development of information and communication technologies (ICT) and increasing consumer demand for individually planned trips have undermined the traditional intermediary role of travel agencies (Castillo-Manzano and López-Valpuesta, 2010). With the decline of the travel agency market, these bus services appear to have lost their competitive edge to both car and HSR. Only a small proportion of normal rail passengers converted to HSR after its introduction. The emergence of self-drive tourism may have already substituted normal rail before the introduction of HSR. Therefore, the substitution effect on normal rail is not as obvious as in previous studies (Cascettaa and Coppola, 2014b; Cascetta et al., 2011; Sun and Lin, 2018).

Our sample also showed that, for the remaining 783 respondents (the first-time visitors who reported travelling to Shaoxing only after the introduction of the HSR), 30.5% chose HSR as their primary mode. Self-drivers still accounted for the highest share after the introduction of the HSR (31.4%), while express bus and travel agency bus riders made up 20.9% of first-time tourists. The share of normal rail and airplane was slightly higher for first-time tourists than for the returning ones. Reasons for this may be linked to the revival of rail travel and the decrease in airfares.

4.2. Differences in mode split by distance travelled

Previous studies found that the introduction of HSR increased the catchment area of tourist markets (Cartenì et al., 2017). Our findings show consistent results, with 77.3% of the 168 returning respondents travelled shorter than 300 km. In comparison, of the 783 first-time visitors, 63.5% travelled within 300 km distances. Moreover, with longer travel distances on average, the first-time visitors to Shaoxing showed a higher share of HSR passengers.

We further explored differences in mode choice by travel distance (Fig. 5). Before HSR, of those who travelled less than 300 km, 45% were by car, 31% chose express buses, and 18% were travel agency bus riders. Since the introduction of HSR, automobile use still dominates for travel distances shorter than 300 km, with 55% of returning visitors and 38% of first-time visitors using this mode, compared to 15% of returning visitors and 31% of first-time visitors using HSR. This indicates that tourists are unlikely to switch to HSR within shorter distances. However, in the range between 300-600 km and 600–900 km, the percentage of HSR users for first-time visitors surpasses that of the other modes. These results suggest that HSR is more competitive with driving for trip distances longer than 300 km. Our result is similar to the Japan case, where the car market share is dominant in travel distances less than 300 km, while rail becomes dominant between 300 and 900 km (see **Appendix A**). Another possible reason that car mode is dominant in shorter distances might be that tourists are not willing to drive long distances (Wang et al., 2014), and car travel time could be lower within short distances. Further, in this sample, HSR competes with air travel for distances up to 900 km.

4.3. Differences in mode split on toll-free days and non-toll-free days

In Fig. 6, we compare tourists' travel mode choices between toll-free and non-toll-free days stratified by travel distances. For tourists who travelled less than 300 km on non-toll-free days, 32% were drivers, and 38% were HSR passengers. In contrast, on toll-free days within the same distance range, 49% of travellers chose to drive, while only 20% chose HSR. We conjecture that the free tolls may induce car travel demand within short distances, and the reduced cost of cars may make HSR less competitive during the toll-free period. However, for tourists who travelled more than 300 km, HSR was preferred on both toll-free and non-toll-free days and was more likely to be chosen during the toll-free period. Probably due to its competitiveness in terms of travel time and cost over medium-long distances. We also observed a higher proportion of travellers selecting normal rail on toll-free days, which may result

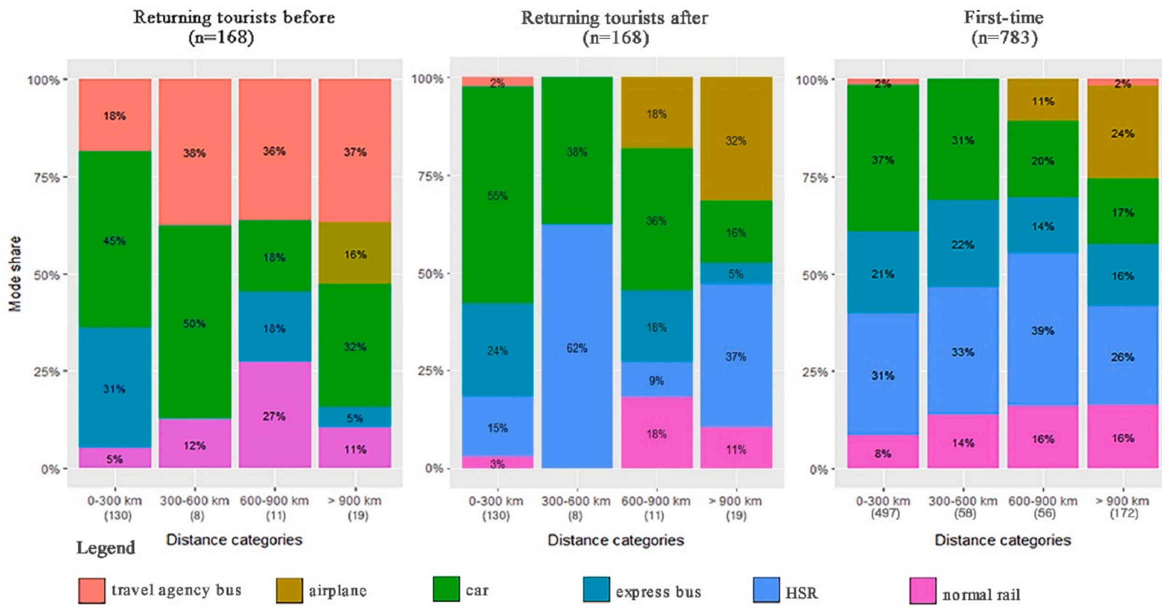

Fig. 5. Tourist primary travel mode by travel distance categories
Note: A small number of returning tourists in our sample travelled more than 300 km. We propose that appropriate caution be used when comparing the mode share changes for trips longer than 300 km.

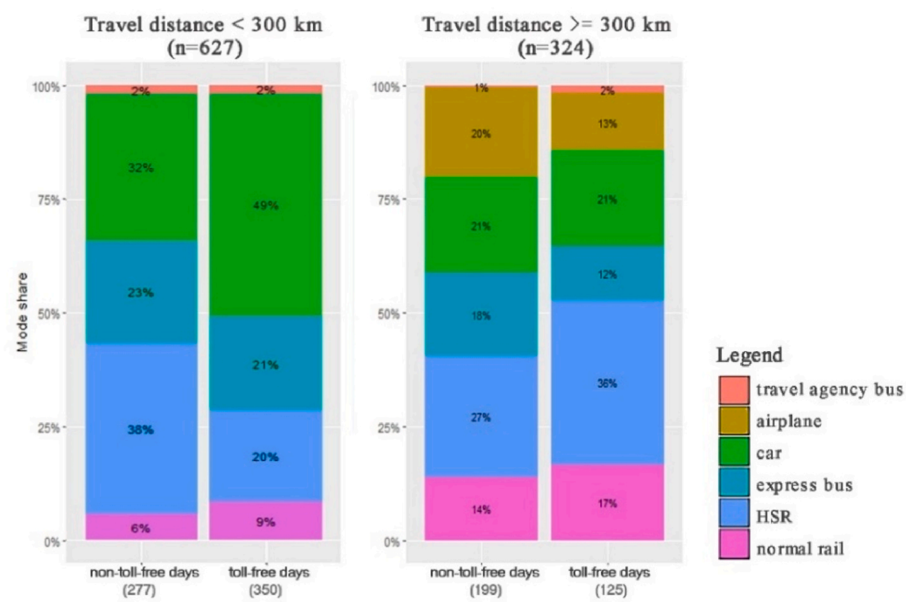

Fig. 6. Tourist primary travel mode during non-toll-free days and toll-free days.

from the temporary trains during peak periods.

5. Tourist travel mode choice estimation

Road transport is still the dominant mode of transport for tourists. In terms of the primary travel mode choice to Shaoxing (Table 1), the data showed that 34.5% of the tourists travelled by car and 19.7% travelled by express buses. HSR also attracts a substantial amount of tourists, with 28.6% of respondents travelling to Shaoxing by HSR. In our study, the city of Shaoxing mainly attracts domestic tourists from the adjacent areas, where the travel distance is less than 300 km. Therefore, relatively few people choose to visit Shaoxing by airplane. Since our study focus is on HSR and road transport, the dependent variable used in our study is the three main travel modes to Shaoxing, HSR, car and express bus (787

Table 1
Primary travel mode of respondents.

Primary travel mode	Frequency	Percentage
HSR	272	28.6%
Car	328	34.5%
Express bus	187	19.7%
Normal rail	95	10.0%
Airplane	55	5.8%
Travel agency bus	14	1.5%
Total	951	100%

out of 951).

5.1. Explanatory variables

Table 2 lists the explanatory variables considered in the estimation. Based on previous literature and preliminary correlation analysis, explanatory variables are selected to describe the vacation travel mode choices of Shaoxing visitors. In the study, travel cost was normalized by distance to a per-distance cost to alleviate the issue of possible potential multicollinearity with travel time. We also introduced the logarithm transformation to travel time to get a closer normal distribution.

Descriptive statistics for the variables are shown in Table 3 and Table 4, stratified by primary mode. On average, tourists travelling by automobile were older than those using HSR and express buses. Automobile users also had higher incomes and were more inclined to travel on a toll-free national holiday. Furthermore, driving was common for visitors who were travelling with family members. The per-distance cost was higher for HSR, and the longitude travel time by HSR was higher than that by express bus or automobile. More HSR passengers were students, and a larger proportion travelled with friends. Tourists choosing HSR for travel tended to use online booking services more than those riding express buses or driving cars did. This difference may be due to the fact that train ticket bookings account for a high market share of online tourism product bookings, as indicated in a report by the China Internet Network Information Center (CNNIC). By 2015 when the surveys were conducted, people could buy HSR tickets either through a telephone reservation, by going to train ticket counters/booking offices, or by using an automatic ticket machine inside the rail station.

5.2. Model specification

The model follows the formula mentioned in previous research (Greene and Hensher, 2007; Train, 2009). Three alternatives, car, HSR and express bus were allowed in our model ($j = 1, 2, 3$). For individual i, the utility function of choosing alternative j is specified as

$$U_{ij} = \beta_i^{'} x_{ij} + \varepsilon_{ij} \tag{1}$$

where x_{ij} are the observed variables relating to alternative j, β_i is a vector of estimable parameters of these variables denoting respondents' tastes, and ε_{ij} is a random term that follows a Type-I extreme value distribution.

The Mixed Logit (MXL) model accommodates respondents' preference heterogeneity toward level-of-service attributes. A mixing density parameter $f(\beta_i|\theta)$, defined by θ (for example, mean and the standard deviation for normal distribution) is introduced to random parameters β_i. In doing so, $f(\beta_i|\theta)$ is specified to be continuous to represent respondents' preference heterogeneity. The study considers β_i to follow the normal distribution as in previous work by (Guo et al., 2020; Train, 2009).

Also, to capture possible unobserved alternative-specific heterogeneity, additional error components are added to grouped alternatives (Train, 2009; Walker, 2002). We assume these error components are independent and follow a standard normal distribution. Thus, the utility function becomes

$$U_{i1} = \beta_i^{'} x_{i1} + W_{i1} + \varepsilon_{i1} \; U_{i2} = \beta_i^{'} x_{i2} + W_{i2} + \varepsilon_{i2} U_{i3} = \beta_i^{'} x_{i3} + W_{i2} + \varepsilon_{i3} \tag{2}$$

where W_{i1}, W_{i2} denote the grouped error component of car, and mass transit nests in our model. Other possible groups (such as adding the

Table 2
Explanatory variables.

Explanatory variables	Description
Socio-economic factors	
Age (continuous)	
Gender male (dummy)	1 if an individual is male, 0 otherwise
Student (dummy)	1 if an individual is a student, 0 otherwise
Income level (ordinary)	Stated monthly salary at 5 levels: 1 if ≤ 3000 CNY, 2 if 3001–7000 CNY, 3 if 7001–11000 CNY, 4 if > 11000 CNY
Tourist travel factors	
Visiting only Shaoxing (dummy)	1 if only visit Shaoxing, 0 otherwise
Toll-free national holidays (dummy)	1 if travel on a toll-free national holiday, 0 otherwise
Length of stay (dummy)	1 if an individual stay less than 2 days, 0 otherwise
Travel with family (dummy)	1 if travel together with family members, 0 otherwise
Travel with friends (dummy)	1 if travel together with friends, 0 otherwise
Use online booking service (dummy)	The use of advanced booking through an online booking service for either hotel, transport, or entrance ticket bookings, 1 if use, 0 otherwise
Level-of-service factors	
Service frequency (continuous)	HSR train service frequency between origin city and Shaoxing
Travel time(h)	Total travel time from home city to Shaoxing by different travel modes
Per-distance cost (RMB/km)	Total travel cost divided by travel distance

Table 3
Descriptive statistics of categorical variables.

Categorical variables	Car (n = 328)		HSR (n = 272)		Express bus (n = 187)	
	Frequency	%	Frequency	%	Frequency	%
Gender male	176	**54%**	107	39%	75	40%
Student	30	9%	95	**35%**	56	30%
Income level						
1	76	23%	124	46%	100	**53%**
2	171	**52%**	105	39%	77	41%
3	49	**15%**	37	13%	9	5%
4	32	**10%**	6	2%	1	1%
Visiting only Shaoxing	224	68%	191	**70%**	126	67%
Toll-free national holidays	197	**60%**	115	42%	88	47%
Length of stay	201	**61%**	151	56%	114	61%
Travel with family	215	**66%**	65	24%	42	22%
Travel with friends	103	31%	172	**63%**	80	43%
Use online booking service	78	24%	146	**54%**	45	24%

Notes: Highest proportions among the three primary travel modes are presented in boldface.

Table 4
Descriptive statistics of continuous variables.

Continuous variables	Mean	S.D.	Min	Max
Age				
Car	34	9.84	16	70
HSR	28	8.88	16	80
Express Bus	29	9.78	16	64
Service frequency				
HSR	24	19	0	49
Log Travel time				
Car	1.18	0.93	−0.12	3.69
HSR	1.40	0.65	0.53	3.19
Express Bus	1.31	0.96	−0.11	3.42
Per-distance cost				
Car	–	–	–	–
HSR	0.44	0.10	0.25	0.72
Express Bus	0.39	0.08	0.20	0.58

Notes: The per-distance cost of car mode is fixed in the estimation. We estimated the money cost of driving to Shaoxing by assuming three persons per automobile as 97% of car users travel with family or with friends, and the average family consists of 3 persons in China.

same error components to car and coach since they are both road transportation) were tested, and the model with the better fit was kept. The conditional choice probabilities take the log formula as

$$P_i(j|W_n) = \frac{\exp\left(\beta_i^{'} x_{ij} + W_{in}\right)}{\sum_{j \in W_n} \exp\left(\beta_i^{'} x_{ij} + W_{in}\right)} \quad i\ \epsilon\ nest\ n \tag{3}$$

Conditioned on the error components, the unconditional probability that individual i will choose alternative j is

$$P_{ij} = \int_{E_n}^{s} \left(P_i(j|W_n)\ f(W_{in})\right) dW_{in} \tag{4}$$

Finally, integrate the heterogeneous preference of random parameter β_i, the choice probability that an individual i will choose alternative j in the MXL model becomes

$$P_i^{ML} = \int_{W_{in}}^{s} \int_{\beta_i}^{s} \left(\left(P_{ij}\middle|W_{in}, \beta_i\right)\ f(W_{in}, \beta_i|\theta)\right) dW_{in} d\beta_i \tag{5}$$

5.3. Model estimation results

As mentioned above, a Mixed Logit model (MXL) with random parameters and error components is estimated to identify the factors that affect the choice of car, express bus or HSR. We used 1000 Halton sequence draws to simulate the loglikelihood. In general, the MXL with random parameters and error components has a higher superiority in understanding tourist travel mode choice than a standard Multinomial Logit (MNL). The estimated parameters in MXL and standard logit have consistent signs and similar significance levels.

The standard deviation of random parameter per distance cost enters significantly, showing that the model provides a significantly better representation of tourist modal choice than standard logit, which assumes that coefficients are the same for all respondents. Also, the additional error component with a significant standard deviation effect for mass transit modes suggests the existence of a 'nest' structure in choosing the mass transit modes. It implies possibly switching between alternatives HSR and express bus within the mass transit 'nest'. Furthermore, the MXL has a better mode fit, with the loglikelihood (LL) increased from −559.21 to −548.06, and the McFadden Pseudo-R-squared improved from 0.26 in MNL to 0.28 in MXL. The estimation results are presented in Table 5, and for every estimator, the respective t-value follows. Some of the insignificant variables, such as length of stay, were retained due to these parameters being included in previous vacation travel research.

Age had a negative association with choosing HSR and express buses over cars, with young people being more likely to travel by HSR and express bus. This finding is consistent with the research by Lin et al. (2018), which considered both HSR and car mode in the choice set and concluded that age was positively associated with choosing car mode over HSR. Being a female was positively related to selecting HSR over cars in both models. Previous research usually found more HSR passengers were males (Xie et al., 2022). Interestingly, males were less inclined to choose HSR in tourist travel when considering car mode. The inclination to choose cars over HSR may result from males' enthusiasm for self-driving (Farag and Lyons, 2012). Being a student is not significantly related to choosing HSR over express buses in both models. Furthermore, our results showed that high-income groups preferred cars over express buses and HSR. This finding aligns with the results by Sperry et al. (2017), which indicated that households with high annual incomes prefer automobiles over HSR.

Regarding features relating to the journey and stay, people travelling only to Shaoxing were more likely to choose HSR over cars. It indicates that trips with multiple destinations were associated with higher probabilities of travelling by automobile. The dependency on automobiles also reveals that the current public transport system might not efficiently support extended travel beyond Shaoxing. Furthermore, people travelling on toll-free peak vacation periods were less likely to choose HSR over cars. The waiver of highway tolls, which made the travel cost of HSR even less competitive than cars, may explain the higher proportion of driving on toll-free holidays.

Travelling with family or friends significantly lowered the likelihood

Table 5
Estimated parameters of the tourist travel mode choice.

	MXL		MNL	
Explanatory variables	Estimates	t-stat	Estimates	t-stat
Alternative specific constant (ASC)				
Car	–	–	–	–
Express bus	12.12	2.49**	4.6	6.04***
HSR	10.88	2.16**	3.01	3.54***
Non-random parameters				
Age				
Express bus	−0.07	−1.67*	−0.03	−1.78*
HSR	−0.11	−2.30**	−0.05	−3.50***
Male				
Express bus	−0.73	−1.23	−0.22	−0.92
HSR	−1.13	−1.78*	−0.41	−1.83*
Student				
Express bus	1.14	1.29	0.4	1.11
HSR	1.29	1.48	0.62	1.76*
Income level				
Express bus	−1.05	−2.52**	−0.58	−4.11***
HSR	−0.68	−1.67*	−0.22	−1.99**
Visiting only Shaoxing				
HSR	1	2.52**	0.71	2.78***
Travel on toll-free national holidays				
Express bus	−0.62	−0.98	−0.08	−0.33
HSR	−1.15	−1.79*	−0.55	−2.51**
Length of stay				
Express bus	−0.32	−0.53	−0.01	−0.03
HSR	−0.73	−1.12	−0.19	−0.80
Travel with family				
Express bus	−8.38	−2.61***	−3.58	−8.15***
HSR	−7.36	−2.25**	−2.48	−5.46***
Travel with friends				
Express bus	−5.25	−2.59***	−2.5	−5.71***
HSR	−3.84	−1.85*	−1.09	−2.43**
Use online booking service				
Express bus	1.65	1.51	0.16	0.63
HSR	3.18	2.69***	1.31	5.84***
Service frequency				
HSR	0.02	1.75*	0.01	1.90*
Logarithm of Travel time			−1.44	−4.69***
Per-distance cost			−0.38	−0.46
Random parameters				
Logarithm of Travel time (mean)	−1.61	−2.32**		
Logarithm of Travel time (standard deviation)	−0.69	−0.47		
Per-distance cost (mean)	−2.79	−1.71*		
Per-distance cost (standard deviation)	6.91	2.70***		
Error Components for alternatives and nests of alternative parameters				
Mass transit nest (HSR, express bus)	1.62	1.96**		
Car nest	0.38	0.46		
Observations		787		787
Number of draws		1000		–
Loglikelihood (LL)		−548.06		−559.21
McFadden Pseudo-R-squared		0.28		0.26
Akaike Information Criterion		1152.13		1166.42
Bayesian Information Criterion		1282.84		1278.46

Note: *, **, ***: significance at 10%, 5% and 1%, respectively.

of choosing public transport over cars. This finding has also been reported in previous literature (Le-Klähn et al., 2015; Moyano et al., 2016; Wu et al., 2012). The current HSR ticketing system in China is rigid and does not offer special discounts for family or group trips; thus, the cost of group travel using HSR cannot compete with automobile travel.

Furthermore, online booking was a highly significant explanatory variable of HSR mode choice over cars. This finding could be explained by the convenience of the rail ticket booking system on the railway ticketing platform and other online travel service platforms. More than half of the HSR passengers in our study booked tourism products in advance through the Internet. Also, people willing to take public transport may need to plan their trips in advance and book the products when necessary. However, the relationship was not as significant as in the choice of express buses over cars. The reason might be the lack of a well-developed ticketing platform for express buses (Li et al., 2020). We further analyzed the main groups of online booking service users and found that most of them travelled with friends or family and chose BRT as a connecting mode from HSR station to hotel/tourist sites. To date, the attempts to combine online services and soft measures to guide mode choice toward more sustainable vacation travel are limited. Our observations indicate a possible market potential for developing online booking tourism products to increase tourists' use of HSR. Based on our survey sample, special tourism products such as group and family discounts and combined tickets for intercity and intracity transport could be considered.

For the level-of-service attributes, travel time, per-distance cost and HSR service frequency were examined in the MXL model. As expected, HSR service frequency significantly influences the choice of HSR over cars in both models. Although some of the research found time and cost to be insignificant for non-commute travellers (Losada-Rojas et al., 2019), the coefficient of logarithm travel time was found to be negative and highly significant in our study. It is noteworthy that when individual taste was considered in the MXL model, respondents showed a similar preference in their valuation of the travel time variable. This is exhibited by the estimated standard deviation being quite small compared to the mean in the model. Thus, competitive travel modes with lower total time were more attractive to travellers. Generally, travellers are more sensitive to travel time than cost (Gonzáles-Savignat, 2004; Yang et al., 2016). In our study, travel cost was normalized by distance to remove potential multicollinearity with travel time and to easily compare travel costs among different origin cities. The estimated mean for the per-distance cost was negative and statistically significant. However, the significant standard deviation of per-distance cost implies that tourists were heterogenous in their preference for low per-distance cost.

6. Conclusions and policy implications

To develop effective tourist travel management policies that can alleviate massive car traffic during peak holiday times, we have studied the effects of newly operated HSR on travel mode choice with a focus on the competition between HSR and alternative modes, especially the automobile. Previous studies related to the role of HSR on vacation travel mode choice were limited and rarely drew attention to the competition between HSR and cars. In China, the extensive HSR network within the metropolis provides an alternative travel mode for tourists to visit medium and small cities with tourist resources. A better understanding of the travel mode choice between HSR, express buses, versus cars for vacation travel can help alleviate traffic congestion during peak periods and promote sustainable tourism.

In summary, this study contributes to the literature from the perspective of modal change and modal choice in vacation travel with a focus on the competition between HSR and car. We examined the modal change before and after the introduction of HSR within different distance categories and the difference between toll-free and non-toll-free days to systematically evaluate the impact of HSR on tourist travel mode choice. A random-coefficients structure Mixed Logit (MXL) model with error components was proposed in our paper to analyze the factors influencing tourists' travel mode choice between HSR and express bus versus car. The model has the advantage of considering the possible heterogeneity of individual preferences on the level-of-service factors, which has not yet been tested before in vacation travel mode choice models. From a practical perspective, most previous research on the impact of HSR on intercity travel is based on corridor or national scale analysis. Our research contributes to the existing literature with a city-based analysis where targeted policies could be implemented to improve the attractiveness of using HSR to visit destination cities.

6.1. Conclusions

Our findings showed that the HSR modal share increased substantially at the expense of road transport, with more tourists changing from intercity buses (including express buses and travel agency buses) than from drivers. Descriptive statistics of returning tourists showed that only 19.6% of those who previously travelled by other modes chose HSR to travel after its introduction. The 783 first-time visitors, with longer average travel distances due to the expansion of the tourism market, showed a higher mode share for HSR. Previous studies regarding modal changes put forward that HSR passengers switch more from normal rail than road transport modes (Cascetta et al., 2011; Cascetta and Coppola, 2014b; Sun and Lin, 2018). However, the modal share of normal rails is low for tourists to Shaoxing, and few HSR passengers changed from previous normal rail passengers. Self-driving has already substituted normal rail before the introduction of HSR, leading to a low substitution effect from former rail passengers.

Results also show that most tourists travelled less than 300 km, and car mode was still dominant within the short distance range after the introduction of HSR. This is consistent with the results in Japan and the UK cases, where car mode dominates the travel distance range within 300 km (see **Appendix A**). However, there is still a substantial proportion of returning tourists (15%) and first-time visitors (31%) who chose HSR as the primary travel mode within 300 km after its introduction. This indicates a possible market to promote HSR within shorter distances to compete with cars. Li et al. (2020) reported that holiday travel is characterized by travel from a core city to its surrounding cities with relatively short distances, which may favour road and rail transport over airplanes. We further observed a higher proportion of car drivers and a lower percentage of HSR users on toll-free holidays within travel distances of 300 km. The waived highway tolls on holidays are deemed to induce car travel demand and undermine the cost-effectiveness of HSR during the toll-free period within the shorter distance range.

Unlike previous research, our paper considers socio-economic characteristics, travel attributes of tourists, pre-booking, and level-of-service factors that are typically partially tested in previous models. Estimated parameters in the mixed logit model shed light on the effects of explanatory variables in choosing HSR and express buses over cars. The study found that HSR was more likely to be used (1) by young people; (2) by the female; (3) with simple itineraries (one-destination); (4) by online booking service users, and (5) with high HSR service frequency. It was less likely to be used than an automobile (1) by higher income level groups; (2) on toll-free national holidays; and (3) when travelling with family or friends. We also found travellers with younger ages, lower income levels, and those not travelling with family or friends tended to choose express buses over cars. Currently, the HSR travel package and other service design target for vacation travel are still underdeveloped in China. Our results show the potential of pre-booking to promote HSR in vacation travel and the toll-free holidays' impeding impact on HSR travel.

Besides, travel modes with lower travel time and per-distance cost were preferred by tourists. When individual taste was considered, tourists showed a similar preference in their valuation of the travel time variable, while were heterogenous in their preference for low per-distance cost. Travel time and travel cost measured by fare price (a measurement similar to per-distance cost) were typically found to be negative in intercity choice modelling (Bhat, 1998; Román et al., 2010; Li et al., 2020). However, our findings show a varied individual preference for per-distance cost for tourists' vacation travel mode choice.

On the basis of the estimated model, it is possible to calculate how changes in reduced HSR per-distance cost and travel time will influence the probability of choosing different alternatives (Fig. 7). Express bus passengers were seen as more sensitive than car drivers to travel time changes in HSR. When HSR travel time reduces by 30%, the probability of choosing car decreases by 4.4% compared to a 15.8% decrease for express buses. When HSR per-distance cost reduces by 30%, the probability of choosing car decreases by 4.5%, while the probability of selecting express bus increases by 2.5%. The model results show that reduced travel time and per-distance cost of HSR may exert a positive effect on mitigating car traffic. However, due to the tourists' heterogeneous tastes for cost detected, the reduced per-distance cost may affect only certain segments of tourists who are more sensitive to it.

6.2. Policy recommendations

Current tourist travel management measures to alleviate automobile traffic were primarily implemented in resort areas or at the destination city scale. To ensure a shift towards mass transit modes, incorporating measures to constrain car dependency, targeted ticketing design and travel packages, and integration between various spatial scales of public transport is essential in practice.

First, policy measures reducing the need for and convenience of car use to historic cities are necessary to alleviate peak congestion. Our results show that the highway road toll-free policy, which initially aims at reducing congestion at toll stations, has encouraged self-drive and made HSR less competitive for cars during high-demand periods for short-medium distances less than 300 km. In transport corridors with HSR available, the road-toll rates should be adjusted to restrain car dependency during peak holidays.

Second, tourist-targeted programs should be considered by HSR operators to promote the attractiveness of HSR and increase its market share for vacation travel. It is found that group travel with family and friends and complex itineraries are related to higher car dependency. Travel costs via HSR under the current ticketing system are not competitive with driving. Therefore, the provision of family or group tickets for HSR travel, flexible tickets for multiple destinations, and other special discounts on the HSR ticketing system may promote a mode shift toward HSR among vacation travellers heading to tourist cities.

Additionally, we suggest the development of advanced booking systems and the design of tourist travel packages aimed at promoting the use of HSR. The use of online booking services was strongly associated with tourist travel by HSR. Pre-booking tourism products online is now widely adopted by HSR travellers thanks to the convenience of the web and mobile platforms for booking rail tickets. We also found a higher proportion of online users chose BRT as a connecting mode than their counterparts. These findings suggest that a convenient online reservation system with options for combined HSR and local transit tickets may help increase the attractiveness of public transport for vacation travel.

The homogeneous tourists' tastes in travel time suggest that improvements in reducing total travel time by HSR may increase its market share. For a typical trip from Shanghai to Shaoxing (around 200 km), the in-vehicle time accounted for less than half of the total travel time. Previous research has mentioned that the low accessibility of HSR stations may also have a detrimental effect on the choice of HSR (Moyano et al., 2018). For the current station location, time savings on station connecting journeys to smooth the chain of HSR can be expected to increase its market share on shorter travel distances. Furthermore, high-quality public transportation feeder service can help release the pressure on both intracity and intercity transport systems by sparking green vacation travel (Paix and Geurs, 2016). These possible planning efforts should be empirically examined in future research.

This study can be extended in several directions. First, the current study was based on the Revealed Preference (RP) data. Future research could consider using joint Revealed Preference (RP) and Stated Preference (SP) data to study the trade-off between HSR and other road transportation modes under different scenarios. In addition, the cost of car mode is fixed in our model. It is necessary to collect detailed data on car travel costs, both on toll-free and non-toll-free holidays, to further investigate the competitiveness of HSR over cars. Second, only the variables in our framework were tested in our study, which means that certain variables remain unexplained. Further investigation could include the service quality of transport transfer and the convenience of public transport within cities to increase our knowledge in promoting the attractiveness of HSR. Also, we only tested the attribute of using online reservation services in our study. Further research is needed to investigate the impact of different travel services and tourism products on tourists' travel mode choice. China can learn from other countries that have implemented effective measures to manage peak tourist travel demand (Delaplace and Dobruszkes, 2015; Gronau and Kagermeier, 2007). More detailed tourist travel information, such as whether tourists are travelling with young kids or elderly people, or interaction terms of variables such as having a car and travelling with luggage, could also be tested.

Author contribution statement

The authors confirm their contribution to the paper as follows: study conception and design: Haixiao Pan, Ya Gao, Qing Shen, Anne Vernez Moudon, Khandker Nurul Habib; data collection: Jian yi Tuo; analysis and interpretation of results: Ya Gao; draft manuscript preparation: Haixiao Pan, Ya Gao, Qing Shen, Anne Vernez Moudon, Khandker Nurul Habib. All authors reviewed the results and approved the final version of the manuscript.

Declaration of competing interest

The authors bear the sole responsibility for all results,

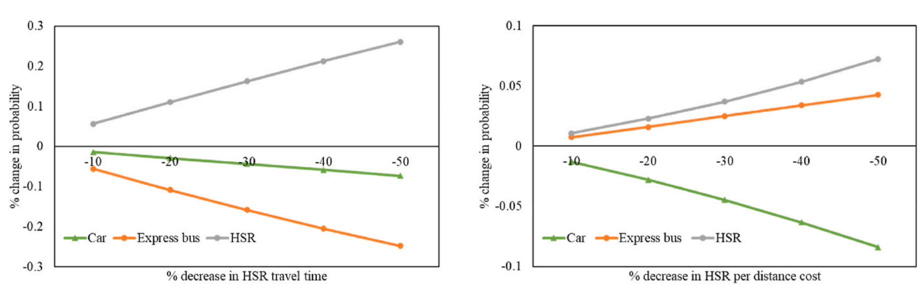

Fig. 7. Effects of HSR travel time (left) and HSR per-distance cost (right) change on car probability (from Mixed Logit model).

interpretations, and comments made in the paper. On behalf of all authors, the corresponding author states that there is no conflict of interest.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tranpol.2023.09.011.

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