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Impact of High-Speed Rail on Social Equity—Insights from a Stated Preference Survey in Vietnam

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Abstract: This study investigated the impact of high-speed rail (HSR) on social equity, utilizing information from a stated preference survey conducted in Vietnam. Social equity was examined across the population of four cities representing the northern, central, and southern areas of Vietnam. In general, the high price of HSR is one of the barriers to using HSR over inter-city buses and conventional trains. Low-income groups (less than VND 6 million per month) have 4.894 and 4.725 times the likelihoods, compared to higher income groups, of retaining the use of an inter-city bus or conventional train, respectively, after introducing HSR. Our findings reveal the fact that social inequity may occur, with the low-income group being especially vulnerable, due to the existence of HSR in the future. Furthermore, our results indicate that the interest of people towards inter-city buses and conventional trains varied among the four cities before and after the presence of HSR. More specifically, low-income groups in Vinh and Nha Trang were observed to have a higher feeling of staying away from HSR, as they prefer to use inter-city buses. The findings of this study suggest that planners and policymakers need to consider various components of HSR ticket planning, in order to achieve sustainable evolution of the passenger rail system.

Keywords: high-speed rail; social equity; inter-city bus; conventional train; Vietnam

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1. Introduction

In many countries in Europe and East Asia, high-speed rail (HSR) has received increasing attention in transport policy, with China taking the leading position, having an HSR network of over 35,000 km by the end of 2019 [1]. Sharing its northern border with China, Vietnam is expected to learn about planning modern transportation infrastructure from China to serve its traffic needs. Policymakers in Vietnam have started rolling out the first HSR, which connects the north and south of the country. According to *the Pre-feasibility study for high-speed rail along the North-South corridor* in 2018 (presented by the consulting consortium TEDI-TRICC-TEDIS to submit to the Ministry of Transport, 2018), Vietnam will build one trunk line connecting all major provinces and cities, operating at a maximum speed of 320 km/h and making 5.20–6.55 h of traffic in one direction between two major economic hubs of the country (Hanoi and Ho Chi Minh City) and 1.5–2 h of one-way traffic within the major cities (Hanoi→Da Nang; Da Nang→Nha Trang; Nha Trang→Ho Chi Minh City). With rapid and extensive transportation across regions, many policymakers in Vietnam expect two major benefits of HSR: (i) Reducing pressure due to road traffic and (ii) improving urban accessibility and shortening the spatial and temporal distance between the two major economic hubs. Furthermore, many practitioners in countries with successful HSR claim that it offers additional benefits, such as increasing the mobility of the population, information, and technology, as well as enhancing the advantages of cities located along the HSR line [2]. The HSR can travel at a maximum speed of above 250 km/h; it is, therefore, generally regarded as a premium means of transportation, especially for travelers who highly value their time [3].

Despite the benefits claimed by some scholars, many recent studies have shown that HSR can significantly increase disparity [4–7] or that HSR sacrifices peripheral economies while improving the economy in core areas [8,9]. Some concerns have recently been raised regarding social equity. HSR has the potential to add new dimensions to the social exclusion of low-income groups or people with lower time value [10]. These studies have been carried out in the context of already existing HSR. Therefore, although the findings are interesting, they do not allow for an advance in understanding of the societal impact of HSR prior to the opening of the HSR. In other words, no previous studies have attempted to assess the impact of HSR on social equity in the planning process. In addition, from the Vietnamese HSR line shown in Figure 1, we can see that this line will connect the north and south of Vietnam, and it is likely to consolidate the spatial equity and may reduce the economic gap between the regions. However, it still has not been clarified how the allocation of HSR affects sub-populations that differ in terms of ability and needs, a concern of Bills and Walker [11].

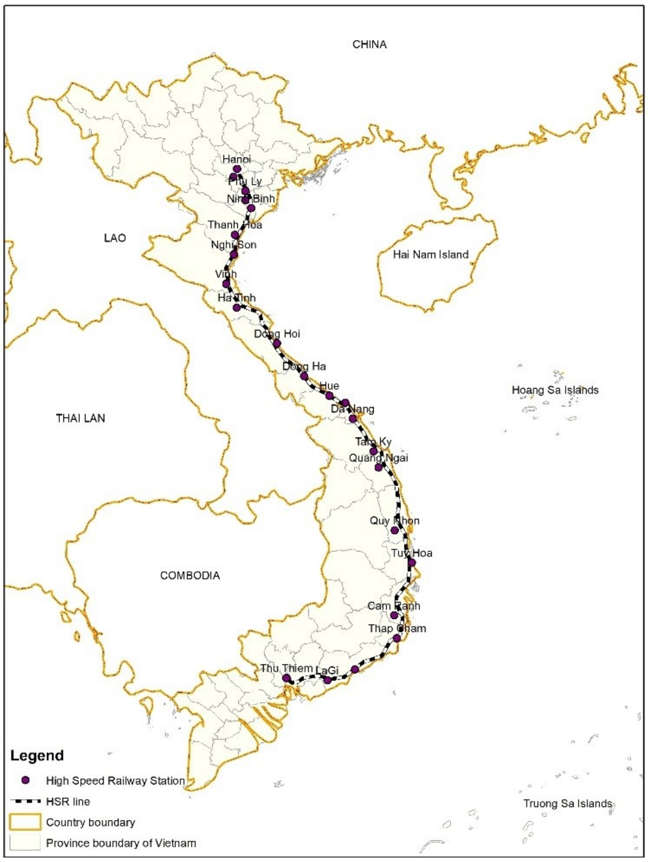

Figure 1. Vietnam high-speed-rail map.

The objective of this study was to provide insight into the impact of HSR on social equity in Vietnam. As HSR has not previously been present in Vietnam, data from a stated-preference (SP) survey were used to explore how the travel decisions of respondents would change with the presence of HSR. Our study contributes to the literature in several ways. First, our analysis focuses on the potential similarities and differences in the travel mode choice and the impacts under the presence of HSR in the total sample population to provide insight into long-distance-travel behaviors in Vietnam, a country featuring the limitation of generalized findings. Second, the factors excluding people from using HSR in different cities are explored in relationship to demographic characteristics and the features of transportation modes. Third, our findings provide implications for planners and policymakers to consider when planning the future development of HSR systems.

The remainder of this article is structured as follows: Section 2 provides a brief overview of social-equity studies. Section 3 describes the methodology, the data sources, and the descriptive statistics. Section 4 provides the results and discussion, considering the statistical analysis. Section 5 summarizes and concludes the article.

2. Literature Review

As our study aimed to introduce social-equity issues inherent to the introduction of a modern luxury transportation system, our literature review focused on factors influencing transport-mode choice and social equity. Therefore, Section 2.1. addresses transport-mode-choice studies, while some equity issues in transportation are discussed in Section 2.2.

2.1. Factors Influencing Transport-Mode Choice

Factors influencing transport-mode choice have been recognized in many studies. They can be summarized into two approaches: Macro- and micro-level. Several studies at the macro-level have focused on economical components, such as per capita GDP, the unemployment rate, fuel cost, and vehicle ownership [12–14]. Other researchers have identified factors at the micro-level, in order to understand how individuals make decisions regarding transport-mode choice with respect to their specific conditions, such as income, occupation, trip characteristics, or the built environment [15,16].

Income has been found to be a good predictor for transport-mode choice [15,17–20]. Giuliano [21] found that the use of public transport in high-income communities was lower than that in lower-income communities in the U.S, whereas Beimborn et al. [22] examined that public transport captivity often occurred in low-income users. Moreover, income was significant and positively related to car use but was negative with public-transport use [23,24]. While agreement is generally observed regarding the effects of income on transport-mode choice, it has been disputed by several researchers, whose studies found that income did not seem to affect modal choice for business journeys [25]; others examined that high-income groups had higher public-transport-mode share than lower-income groups [16]. These contradictory findings prove that different approaches to research contexts can lead to different—or even conflicting—results.

Apart from income, gender, and age have been found to significantly affect transport-mode choice [23]. Using a data set from Ohio, Kim, and Wang [18] found that males had a lower probability of using a car than females, while increases in age and income led to an increase in choosing cars. Elders used public transport more often [26]. However, de Witte et al. [27] have reviewed the literature and concluded that "there seems to be no real consensus on the impact of age and gender in mode choice." They observed contradictory findings in various studies, for example [25,26,28–30].

Considering long-distance travel, travel cost is one of the most-important predictors of transport-mode choice [4,31]. In addition, amenities equipped in the vehicles affect a passenger's transport mode choice [32]. Furthermore, safety, economy, convenience, comfort, and reliability have been associated with an increase in HSR ridership [33]. Another study has confirmed the determinants of HSR use, such as trip purpose, gender, and travel time [34]. Last, but not least, travel time savings, high frequency, and door-to-door accessibility should not be neglected when considering the factors influencing transport-mode choice [4,35–40]

2.2. Social-Equity Studies

In general terms, equity refers to the fair and appropriate allocation of benefits and costs [41]. Based on this definition, transportation equity can be viewed as the equitable distribution of transport costs and benefits among individuals, groups, or regions. There are three main elements of transportation equity: Benefits and costs, the population and social groups, and the principle of distribution [42]. The two main components of equity deemed in transportation planning are spatial equity and social equity [41,43]. Spatial equity refers to the conditions of accessibility to satisfy mobility needs [43,44], while social equity refers to the distribution of benefits among social groups based on their willingness or capability to pay for a certain service [44]. A particular policy may be equitable in terms of spatial equity but inequitable in terms of social equity [43]. For example, evidence from China provided in the studies of Guo [45], Wang [46], and Wang and Zhang [47] has verified that the efficient enhancement of the transportation system can increase social inequality, notably affecting vulnerable social groups.

Our literature review revealed that equity has been stressed in many transport studies. Previous scholars have focused on evaluating accessibility as an indicator of equity; for example, disadvantaged communities were found to have difficulties related to accessing jobs, health services, and community activities with the lack of public-transport services [48]. Vulnerable social groups, such as elders and low-income groups, are faced with even greater inequity in the allocation of transportation-mobility benefits [49,50].

Social inequity seems to be more clearly observed in long-distance travel than in urban mobility. Dobruszkes et al. [51] have summed up from previous studies that long-distance trips are associated with higher income, higher social-occupational subpopulations, and even higher diplomas. Turning to specific countries, Dargay and Clark [52] found that social inequities in transportation modes, gender, and age exist in Great Britain; for example, long-distance travel is the most income-elastic with air and the least income-elastic with coach; males travel more than females; and younger groups commute more than older groups. Using a 1995 American Travel Survey, Mallet [53] examined that low-income groups significantly depend on public transport, while higher-income groups prefer using cars for long-distance travel. Similarly, Georggi and Pendyaja [54] have revealed that low-income groups and the elderly are more likely to use buses for long-distance trips; they also undertake fewer long-distance trips, when compared to other groups.

The question of social inequity remains open when it comes to HSR. The importance of HSR needs to be highlighted in the aspect of fulfilling public needs, as it is often financed by the government and, thus, by taxpayers. However, little research has been conducted regarding the social equity related to HSR. Attention on HSR-related equity has focused mostly on spatial equity [46,55–63], while other works have concentrated on the impact of HSR fare on users [64,65]. Ren et al. [3] and Pagliara et al. [66,67] have recently pointed out several factors excluding users from using HSR. In China, an HSR hub, lower-income groups and lower education levels are vital predictors for choosing conventional trains over HSR, and people in less-developed regions were found to be more likely to be excluded from using HSR [3]. In Europe, inequity in using HSR has been observed, in the aspects of age, education, and occupation [66,67]. Based on global ex-post data, Dobruszkes et al. [51] have reviewed all of the factors that exclude people from using HSR and found that income, occupation, and education are key factors in the uneven use of HSR. It can be said that the above three studies are rare cases, focusing on the impact of HSR on social equity in the context of already-existing HSR. Although these findings are valuable to understand the social pattern of HSR and non-HSR users, they do not provide insights into the social-equity issues in the design and planning of HSR.

In the context of Vietnam, policymakers are likely to ignore social equity in the planning process, only emphasizing the importance of efficiency. As a result, the associated transportation-planning decisions are likely to have a significant impact on inequality. For example, due to the competition between HSR and conventional rails in the same corridor, the frequencies of conventional trains are more likely to be reduced; consequently, low-income groups will have no choice but to accept HSR and pay higher fares. Then, the development of HSR leads to an "involuntary use of HSR" as it was called by Zhang and Meng [10].

Overall, our literature review revealed that little attention has been paid to the societal impacts of HSR in the design and planning stage. In addition, although several studies have mentioned the change of transport-mode choice after introducing HSR in Vietnam [68], no studies have attempted to evaluate the associated equity aspects. To fill these research gaps, this study contributes by determining the impact of HSR on equity from the perspective of transport-mode choice using SP survey data.

3. Methodology

To understand the impact of HSR on social equity, we focused on comparing the similarities and differences in transport-mode choice among different social groups, such as those characterized by different socioeconomic conditions, different age levels, and special social groups. Mode-choice models are adopted to describe social inequity in the presence of HSR. In addition, we hypothesized that income disparities among regions may contribute to social inequity in using HSR. In summary, this study addresses two issues: (1) Factors excluding people from using HSR and (2) the societal impact of HSR among different cities.

3.1. Mode-Choice Model

Travel-related behavior has been traditionally modeled using a discrete-choice framework, with binary logit (BNL) or multinomial logit (MNL) models [69–82]. BNL and MNL are the most-important models for categorical data analysis, where MNL is a simple extension of BNL. A volume of available evidence has revealed that BNL and MNL generate appropriate and correct findings, in terms of model fit and correctness of the analysis. In addition, MNL provides more easily interpretable diagnostic statistics than linear regression and is more robust to assumption violations of multivariate normality [83]. In an empirical study, Bai et al. [84] showed that the MNL is the best estimation model when analyzing mode choice. Due to the various advantages of BNL and MNL, both of them were adopted for this study.

A basic form of a binary logit model with outcome y and independent variable $\mathrm{x_i}$ can be expressed as:

$$log\left[\frac{p_i}{1-p_i}\right] = a + b_t x_i \tag{1}$$

where p expresses the probability of choosing a mode ($y_i = 1$); $\mathrm{x_i}$ represents a set of predictors; a is a parameter not linked to x_i; and b_t is a vector of coefficients that reflects the relationship between the outcome y and each predictor (i.e., x_1, x_2, and so on). Parameters of a and b_t are estimated using the method of maximum likelihood with respect to the observed sample [85].

A basic form of the multinomial logit (MNL) model with the reference case can be expressed as:

$$log\left[\frac{p(y_i=2)}{p(y_i=1)}\right] = a_1 + b_1 x_i \tag{2}$$

$$log\left[\frac{p(y_i=3)}{p(y_i=1)}\right] = a_2 + b_2 x_i \tag{3}$$

$$log\left[\frac{p(y_i=n)}{p(y_i=1)}\right] = a_{n-1} + b_{n-1} x_i \tag{4}$$

To measure the effects of each independent variable on the likelihood of each mode choice, marginal effects were adopted. Marginal effects reflect how a marginal increase in an individual variable effects the change in the mode-choice probability [86].

The marginal effects inform about the change in predicted probabilities due to a change in a particular predictor. The marginal effects (ME) are defined as:

$$ME_{ij} = \frac{dp_{ij}}{dx_{ki}} = \frac{dPr(y=j|x_i)}{dx_{ki}} = p_{ij}(\beta_{kj} - \overline{\beta_i}) \tag{5}$$

where j represents an outcome category; x_{ki} represents the ith explanatory variable for individual k, ($I = 1, \ldots, I$; $k = 1, \ldots, n$); and β_{kj} is the parameter associated with the jth outcome for individual k. Furthermore $\overline{\beta}_i = \sum_{2}^{m} \beta_{km} Pr(y = j | x_i)$ is a probability weight average of the coefficients for different choice option, β_{km}, where m represents the reference outcome category.

3.2. Data Collection

SP survey data for 3000 travelers were collected in four cities—Hanoi, Vinh, Da Nang, and Ho Chi Minh City—in 2018, as described by Huyen and Ngoc [68]. The questionnaire consisted of three parts. The first part was a survey of individual information, such as gender, age, education, and income. The second part was travel information and the perception of travelers towards the most-important reasons for selecting their current transport mode. The third part was the stated mod-choice response after the implementation of HSR. A total of 2713 samples out of 3000 questionnaires were used in the analysis. The overall rate of validity was 90.4%. The definition and sample statistics of the explanatory variables are provided in Table 1.

Table 1. Summary statistics of independent variables (unit: %).

Variable	Variable Type	Total	Hanoi	Vinh	Da Nang	HCMC
Gender	Male	55.9	53.1	54.7	57.0	59.4
	Female	44.1	46.9	45.3	43.0	40.6
Age	Under 18 years old	0.9	0.4	2.4	0.9	0.9
	18–24 years old	30.2	24.3	35.6	35.0	25.4
	25–34 years old	34.1	35.1	32.2	35.4	32.5
	35–50 years old	24.1	27.5	20.4	19.8	28.9
	Above 50 years old	10.7	12.6	9.3	8.9	12.4
Education	High school and below	49.0	52.3	51.9	44.5	52.6
	Junior college	16.9	12.1	12.8	19.8	16.8
	Bachelor's degree	33.1	34.8	34.6	34.3	30.3
	Master's degree and above	0.9	0.7	0.7	1.5	0.3
Occupation	Office worker/gov. officer	20.8	24.1	17.0	19.8	21.6
	Worker	11.3	10.5	13.5	14.0	7.4
	Self-employed	28.6	28.1	28.4	25.4	33.1
	Student	20.1	15.2	25.6	24.8	14.8
	Seasonal worker	4.0	3.8	1.0	3.0	5.6
	Housewife/retired/jobless	5.4	6.7	7.3	5.0	4.7
	Other	9.9	11.6	7.3	7.9	12.8
Monthly income	Without any income	2.3	3.8	2.8	1.6	2.2
	Less than 6 mil. VND	22.2	22.3	32.5	29.1	16.2
	6–10 mil. VND	49.4	45.7	46.0	45.5	51.3
	10–20 mil. VND	19.7	21.0	11.1	18.2	23.3
	20–30 mil. VND	5.3	5.4	6.2	4.5	5.9
	More than 30 mil. VND	1.2	1.8	1.2	1.1	1.0
Distance	Less than 300 km	21.4	21.4	22.8	22.5	19.5
	300–500 km	21.1	24.5	22.1	22.4	17.3
	500–700 km	12.9	11.6	14.5	13.5	12.3
	700–1000 km	12.4	13.6	11.1	12.6	11.9
	1000–1500 km	25.1	20.8	22.8	23.2	30.7
	From 1500 km	7.1	8.2	6.6	5.9	8.3
Reason for choosing conventional rail	OD time	2.1	1.1	7.3	2.0	1.2
	Affordable fare	12.3	9.4	18.7	12.4	12.1
	Flexibility	2.2	2.5	4.8	2.0	1.6
	Comfort	3.2	2.9	5.2	2.9	3.1
	Reliability	3.3	2.0	5.2	3.9	2.7
	Safety	9.9	9.1	10.4	9.4	11.0
	Security	0.6	0.2	1.4	0.6	0.6
	Punctuality	0.6	0.9	1.4	0.4	0.4
	Frequency	2.8	4.0	4.5	1.8	2.9
	Directness	7.1	6.0	15.9	9.6	7.0
Reason for choosing inter-city bus	OD time	60.4	57.4	61.9	62.2	59.3
	Affordable fare	10.6	10.3	21.1	11.7	6.3
	Flexibility	59.9	56.9	47.8	61.9	62.3
	Comfort	21.7	11.2	26.3	27.4	18.3
	Reliability	12.6	11.2	13.1	16.1	8.6
	Safety	6.9	6.9	9.0	8.6	4.0
	Security	1.1	1.4	2.4	0.9	0.8

Table 1. *Cont.*

Variable	Variable Type	Total	Hanoi	Vinh	Da Nang	HCMC
Conditions for choosing HSR	Punctuality	19.5	28.3	18.7	21.1	12.8
	Frequency	12.7	18.7	23.9	12.4	6.7
	Directness	7.2	6.9	8.7	8.1	5.9
	Short journey time	70.3	71.6	72.0	67.1	73.5
	High fare	74.9	74.8	81.0	74.1	74.3
	High frequency	55.8	62.9	51.6	54.0	55.6
	High span of service	69.9	72.5	74.7	68.8	68.6
	Reduce frequency of inter-city bus	36.9	39.9	43.6	36.3	34.2
	Reduce frequency of conventional trains	46.0	46.4	52.9	46.0	43.7
	Installation of amenities (PIS, Wi-Fi, etc.)	57.9	59.4	60.6	61.0	52.2
	Convenience in ticket purchasing	66.7	72.5	61.9	69.4	61.3
	Providing facilities for handicapped people	89.1	92.2	79.9	90.6	88.0

There was not much difference among the respondents in the four cities, in terms of demographic characteristics. The number of male respondents was marginally higher than female respondents. The bulk of respondents were between 18 and 50 years old, comprising more than 85% of the total. Around 50% of respondents had only attained a degree from high school or below, showing that they may have some obstacles for earning extra money. Their income was in the range of VND 6–10 million (about USD 250–450). We can see that the average Vietnamese monthly income is still low, especially when compared to the transportation cost. The average expenditure on a one-way airplane ticket in 2019 was approximately VND 1.5 million (about USD 70) for the journey from Hanoi to Ho Chi Minh City, equivalent to one-third of a traveler's income.

The descriptive statistics of the dependent variables are presented in Table 2. Here, we presume that the choice of HSR reflected the modal preference of the respondents. A total of 86.4% of respondents stated that inter-city bus was their major travel mode before the introduction of HSR; 12.7% of the respondents considered conventional passenger trains for their trips; and less than 1% of respondents selected airplane for travelling. However, respondents were willing to switch to HSR when this mode went live. The share of choosing inter-city buses dropped to around 41% with the HSR operating, while the share of conventional trains and aircraft also fell to 8.2% and 0.5%, respectively. The change of transport mode choice likely confirms that HSR would be generally well-received by travelers in Vietnam when it comes into operation. Conversely, it is also evident that the inter-city bus continues to retain significant loyal customers, even with the introduction of HSR.

Table 2. Summary statistics of dependent variables.

Dependent Variable		Frequency	Percent
Before HSR	Inter-city bus	2344	86.39
	Conventional train	344	12.67
	Airplane	26	0.96
After HSR	Inter-city bus	1106	40.76
	Conventional train	222	8.18
	Airplane	13	0.48
	HSR	1372	50.57

4. Results and Discussions

Eight models for travelers, with four models considering the total sample population (inter-city bus before introducing HSR, conventional train before introducing HSR, inter-city bus after introducing HSR, and conventional train after introducing HSR) and the other four models considering locational segment (Hanoi, Vinh, Nha Trang, and Ho Chi Minh

City), were estimated. Prior to the introduction of HSR, the mode choices were evaluated using binary logit models. In the presence of HSR, the mode choices were re-evaluated using multinomial logit models. The results indicated that the choices of inter-city buses and conventional trains were significantly affected by several contributing factors, such as individual demographic characteristics and the attributes of vehicles.

4.1. Factors Influencing Inter-City Bus before and after Introducing HSR

The results of the binary and multinomial logit models are shown in Table 3. For the binary logit model, the test of the overall model (Chi-square = 237.5, $p < 0.05$) was significant, suggesting that the model fit the data well. In addition, the Nagelkerke R^2 value (0.628) was high, indicating a relationship of 62.8% between the explanatory and predicted variables. For the multinomial logit model, the test of the overall model (Chi-square = 1168.6, $p < 0.05$) was significant, while the Nagelkerke R^2 value was 0.353, showing a relationship of 35.3% between the predictors and the prediction—lower, when compared to the binary logit model.

Table 3. Factors influencing inter-city bus use with and without the presence of HSR.

Variables	Without HSR (BNL Model)		Within HSR (MNL Model)	
	Coef.	S.E.	Coef.	S.E.
Gender (male)	**0.368 ****	**0.154**	**0.203 *****	**0.079**
Age	**0.255 *****	**0.083**	0.012	0.043
Education	**−0.438 *****	**0.097**	−0.065	0.048
Occupation	**−0.205 *****	**0.045**	−0.028	0.022
Income	−0.159	0.127	**0.184 *****	**0.060**
OD time	**2.917 *****	**0.222**	**0.369 *****	**0.083**
Affordable fare	**1.537 *****	**0.406**	**0.429 *****	**0.123**
Flexibility	**2.763 *****	**0.201**	**0.415 *****	**0.083**
Comfort	**1.155 *****	**0.269**	**0.488 *****	**0.092**
Reliability	**1.068 *****	**0.362**	0.130	0.115
Safety	**−0.672 ****	**0.339**	−0.169	0.155
Security	−0.038	0.692	0.447	0.353
Punctuality	**0.872 *****	**0.319**	**0.256 *****	0.094
Frequency	**1.560 *****	**0.399**	**0.288 *****	0.111
Directness	**0.985 *****	**0.371**	−0.112	0.150
High fare of HSR			**0.086**	**0.050**
Short journey time of HSR			−0.056	0.050
High frequency of HSR			**−0.089 ***	**0.046**
High span of service of HSR			−0.002	0.048
Reduce inter-city buses frequency			0.042	0.044
Reduce conventional trains frequency			0.063	0.045
Installation of amenities (PIS, WiFi, etc.)			0.044	0.039
Convenience in ticket purchasing			**−0.088 ***	**0.048**
Providing facilities for handicapped people			0.047	0.052
Constant	0.438	0.469	−2.081	0.421
Model assessment				
-2LL		1213.017		3435.201
Cox and Snell R^2		0.344		0.297
Nagelkerke R^2		0.628		0.353
Chi-square		237.5		1168.6
p-value		0.000		0.000

Notes: *** denotes a significance level below or equal to 1%; ** denotes a significance level below or equal to 5%; and * denotes a significance level below or equal to 10%. Bold denotes that a factor has statistical significance.

Along with model evaluation, the results of the binary logit model showed that many factors had significant impacts on the choice of inter-city buses by travelers at the time of the survey. Attributes of respondents and vehicles were seen as the most-important predictors for bus choice. Overall, before introducing HSR, the selection of inter-city buses was more likely to depend on gender, age, origin-destination time (OD time), affordable fare, flexibility, comfort, reliability, safety, punctuality, frequency, and directness, as stated in the left side of Table 3. For example, a male had 1.44 times ($e^{0.368}$) the odds of a female for using the inter-city bus; moving up from one level of age to the next multiplied the odds of taking an inter-city bus by 1.29 ($e^{0.255}$); and travelers who highlighted the importance of travel time, affordable fare, flexibility, comfort, reliability, punctuality, frequency, and directness had 1749% ($e^{2.917} - 1$), 365% ($e^{1.537} - 1$), 1485% ($e^{2.763} - 1$), 217% ($e^{1.155} - 1$), 191% ($e^{1.068} - 1$), 139% ($e^{0.872} - 1$), 376% ($e^{1.560} - 1$), and 168% ($e^{0.895} - 1$), respectively, higher odds of using inter-city buses than travelers who did not have that sense. To the contrary, education, occupation, and safety were found to be negatively associated with choosing inter-city buses. For instance, a one-level increase in education from a high-school degree to a college degree decreased the likelihood of using inter-city buses by 35%; similarly, the odds of choosing an inter-city bus decreased by 19% and 15% with every level increase in occupation and income, respectively; and travelers who highlighted the importance of safety had 49% ($e^{-0.672} - 1$) lower odds of using inter-city buses. Among the contributing factors, travel time and flexibility were more important than others. These findings revealed that people are more likely to select inter-city buses as this kind of mode provides them a smooth, uninterrupted journey. A common phenomenon that can often be observed on the road is that inter-city buses stop at every location to pick up and drop off travelers, even if that location is not clearly noted in the approved timetable. Inter-city buses are also attractive for travelers as they require little time to check-in: travelers only need to arrive 5 min before departure, even if they come late, and they are often served quickly and easily, thanks to the availability of other providers. From observation, there is a journey departing from a bus station to neighboring cities along the north–south corridor every 10 min.

After introducing HSR, several factors continued to maintain their influence on the use of inter-city buses. More specifically, income became a predictor for the use of inter-city buses after introducing HSR. The likelihood that people with high income would choose an inter-city bus dropped by 16.8%. However, travelers earning less than VND 6 million were 4.894 times more likely than higher-income travelers to keep choosing an inter-city bus, even after introducing HSR. It is clear that people earning less than VND 6 million might not be willing to use HSR. A later variable, namely, "high fare of HSR" further confirmed this statement, as it was also proven to be statistically significant in the model. People who recognized the high cost of HSR were 9% ($e^{-0.086} - 1$) more likely to use inter-city buses. In addition to income and high fare of HSR, other variables, such as OD time, affordability, flexibility, comfort, punctuality, and frequency were associated with choosing inter-city buses. It turns out that inter-city buses will still attract a sizeable number of customers with the same service quality. The coefficient of the variable "convenience in ticket purchasing" was −0.088, suggesting that the likelihood of opting for HSR instead of inter-city buses will increase by 8.4% ($e^{-0.088} - 1$) if travelers perceive that purchasing HSR tickets is convenient.

Overall, by using the BNL and MNL models to explore the determinants of transport mode choice, we enhanced our insight into the way that certain social groups are interested in inter-city buses before and after the government's introduction of HSR. In both models, key determinants of inter-city bus choice included gender, income, OD time, affordable fare, flexibility, comfort, punctuality, and frequency. Furthermore, income was found not to be statistically significant in the BNL model, but this factor was highlighted as one of the predictors of inter-city bus use in the MNL model. This indicates that low-income groups are vulnerable in the presence of HSR.

4.2. Factors Influencing Conventional Train Use before and after Introducing HSR

Table 4 summarizes the results of both BNL and MNL models. The results of model assessment in Table 4 indicate the goodness-of-fit of both the binary logit model (Chi-square = 46.2, $p < 0.05$) and multinomial logit model (Chi-square = 1238.6, $p < 0.05$). Furthermore, a relationship of 65.2% between the predictors and the prediction was observed for the BNL model, while that for the MNL model was 37.5%.

Table 4. Factors influencing conventional train with and without the presence of HSR.

Variables	Without HSR (BNL Model)		Within HSR (MNL Model)	
	Coef.	S.E.	Coef.	S.E.
Gender (male)	**−0.666 *****	**0.172**	**−0.390 ****	**0.174**
Age	**−0.365 *****	**0.099**	**−0.252 ****	**0.099**
Education	**0.410 *****	**0.109**	**0.238 ****	**0.109**
Occupation	**0.352 *****	**0.051**	**0.215 *****	**0.054**
Income	−0.263	0.176	**−0.182 ***	**0.168**
Distance	−0.046	0.049	−0.051	0.050
OD time	**1.614 *****	**0.361**	**0.891 *****	**0.312**
Affordable fare	**2.203 *****	**0.197**	**1.419 *****	**0.200**
Flexibility	**1.296 *****	**0.368**	**0.726 ****	**0.307**
Comfort	**1.837 *****	**0.293**	**1.326 *****	**0.249**
Reliability	**0.685 ****	**0.284**	**1.028 *****	**0.245**
Safety	**1.695 *****	**0.200**	**1.181 *****	**0.187**
Security	0.122	0.673	0.457	0.557
Punctuality	1.141	0.742	0.048	0.618
Frequency	**1.060 *****	**0.321**	0.198	0.266
Directness	**1.273 *****	**0.214**	**0.920 *****	**0.193**
High fare of HSR			**0.174 ***	**0.102**
Short journey time of HSR			0.068	0.109
High frequency of HSR			−0.030	0.095
High span of service of HSR			−0.090	0.100
Reduce inter-city buses frequency			0.057	0.092
Reduce frequency of conventional trains			**0.013 ***	**0.098**
Installation of amenities (PIS, WiFi, etc.)			0.024	0.082
Convenience in ticket purchasing			0.054	0.101
Providing facilities for handicapped people			−0.082	0.107
Constant	−3.619	0.606	−3.240	0.925
Model assessment				
-2LL		1083.307	4708.643	
Cox and Snell R^2		0.347	0.315	
Nagelkerke R^2		0.652	0.375	
Chi-square		46.26		1238.6
p-value		0.000		0.000

Notes: *** denotes a significance level below or equal to 1%; ** denotes a significance level below or equal to 5%; and * denotes a significance level below or equal to 10%. Bold denotes that a factor has statistical significance.

Twelve factors had powerful effects on the choice of a conventional train over alternative modes before introducing HSR, including education, occupation, OD time, affordable fare, flexibility, comfort, reliability, safety, frequency, and directness. The results showed that the probability of selecting a conventional train increased by 51% ($e^{0.410} - 1$), 42% ($e^{0.352} - 1$), 402% ($e^{0.1614} - 1$), 806% ($e^{2.203} - 1$), 265% ($e^{1.296} - 1$), 528% ($e^{1.836} - 1$), 98% ($e^{0.685} - 1$), 445% ($e^{1.695} - 1$), 189% ($e^{1.060} - 1$), and 257% ($e^{1.27} - 1$), respectively, due to the influence above factors. To the contrary, it was found that gender and age had negative influences on the selection of a conventional train. The odds ratio for males was 49% ($e^{-0.666} - 1$) lower than the odds of females in choosing conventional trains. The coefficient for age indicated that the probability of choosing a conventional train decreased by 31% ($e^{-0.365} - 1$) for each one-level increase in age.

Apart from punctuality, the remaining eleven factors retained their influence on train choice, even with the introduction of HSR. However, the influence of these variables on the travelers before HSR were stronger than after introducing HSR. For example, the odds ratio of the gender variable reduced from 49% ($e^{-0.666} - 1$) to 32% ($e^{-0.390} - 1$), suggesting that, after introducing HSR, the likelihood of males selecting a conventional train decreased by 17%. Likewise, the odds of education, occupation, OD time, affordable fare, flexibility, comfort, safety, and directness were decreased by 24% ($e^{0.410} - e^{0.238}$), 18% ($e^{0.352} - e^{0.215}$), 259% ($e^{1.614} - e^{0.891}$), 492% ($e^{2.203} - e^{1.419}$), 159% ($e^{1.296} - e^{0.726}$), 251% ($e^{1.837} - e^{1.326}$), 219% ($e^{1.695} - e^{1.181}$), and 106% ($e^{1.273} - e^{0.920}$), respectively. To the contrary, the odds ratio of the reliability variable increased by 81% ($e^{0.685} - e^{1.028}$) after the introduction of the HSR.

In summary, there was a similarity in the factors contributing to the choice of inter-city buses and conventional trains before and after introducing HSR. However, the importance of each factor varied, depending on the transportation mode. While travelers indicated that OD time and flexibility were the top reasons for choosing an inter-city bus, affordable price was the most-important predictor for conventional train users. In addition, factors such as age, education, occupation, comfort, reliability, safety, frequency, and directness were also important for decisions on transport-mode choice. A high price is a significant barrier to choose HSR for low-income social groups. They might be either not willing to choose HSR, or they might stay away from HSR because of the fare issues.

4.3. Factors Influencing Inter-City Bus and Conventional Train Choice by Diffirent Cities

Before analyzing the main determinants of choices before and after introducing HSR in different cities, it is necessary to test for the economic disparities among cities, regarding the location of the surveyed travelers. The reason for testing the economic disparities derives from the hypothesis that a higher level of economic disparity is more likely to contribute to a higher level of inequality in using HSR. In this study, we adopt a Theil index [87] to measure economic inequity, as follows:

$$T = \sum \frac{I_i}{I} * \ln\left(\frac{I_i/I}{P_i/P}\right) \quad (6)$$

where T is the Theil index; I_i represents the GDP of the ith region; I represents the GDP of the country; P_i represents the population of the ith region; and P represents the total population. The economic inequity is lower if the value of T is smaller.

The results from the calculation of the Theil index are provided in Table 5. According to Theil [57], the disparity among cities is insignificant if the value of Theil index is low. The result from Table 5 shows small Theil index (0.009), implying that the economic disparity among the four considered cities was insignificant.

Table 5. Theil index results.

	GDP (bil. VND)	Population (Mil. Persons)	Theil Index
Hanoi	1,020,000	8246.5	
Vinh	22,194	344.5	
Nha Trang	41,301	426.2	0.009
Ho Chi Minh City	1,371,716	9224.8	
Total	2,455,211	18,242	

Note: Data in 2019 were used to estimate the Theil index. Source: [88].

Table 6 shows the results for the selection of inter-city buses before and after introducing HSR in different cities. It is clear that the factors affecting the choice of inter-city buses varied by city both before and after introducing HSR. Before HSR, the respondents in all four cities were in favor of inter-city buses, due to their perceived importance of OD time and the flexibility of inter-city buses. Hence, the similarities in choosing inter-city buses in the four cities were reflected in OD time and flexibility. On the other hand, it was found that education in Hanoi, Vinh, and Nha Trang was significantly associated with inter-city bus choice, but it did not have a relationship with inter-city buses in HCMC. In addition, the importance of comfort for people in Hanoi and Nha Trang was recognized, but it was not significant for the respondents in Vinh and HCMC. Furthermore, people in Hanoi and HCM emphasized the importance of safety when choosing inter-city buses, whereas the people of Vinh and Nha Trang did not find this factor important. Overall, before introducing HSR, the major determinants of inter-city bus choice in Hanoi, included education, OD time, affordable fare, flexibility, comfort, safety, security, punctuality, frequency, and directness, whereas people in Vinh chose inter-city buses because of education, OD time, and flexibility. Factors influencing the choice of respondents in Nha Trang included age, education, occupation, OD time, flexibility, comfort, safety, punctuality, and frequency, whereas gender, occupation, OD time, affordable fare, flexibility, reliability, safety, and directness were found to have significant impacts on the choice of inter-city buses among people in HCMC. However, the influence of factors varied slightly within the presence of HSR. For instance, only OD time, punctuality, and frequency retained their influences on selecting inter-city buses in Hanoi. New factors had strong impacts on choosing inter-city buses in Vinh, including occupation, income, and high fare of HSR. In the case of Nha Trang, nine factors were significantly associated with the choice of inter-city buses, namely, gender, income, distance, affordable fare of inter-city buses, flexibility, comfort, safety, and the reduction in conventional trains. Ultimately, it was found that distance, OD time, flexibility, comfort, reliability, security, and the high fare of HSR were important to the people who choose inter-city buses in HCMC. Among the cities, it appears that passengers from Vinh and Nha Trang were more sensitive to income. The low-income group was found to be 36% more likely to use inter-city buses than the higher-income groups. This finding provides evidence that, when the HSR service becomes available, low-income groups in Vinh and Nha Trang are more likely to be excluded from HSR than higher-income groups.

Similarly, Table 7 indicates the responses of travelers, with respect to choosing between conventional rail and HSR in Hanoi, Vinh, Nha Trang, and HCMC. The results from both BNL and MNL reveal that there were differences in choosing conventional train among four cities. Particularly, it was found that respondents from Vinh, Nha Trang, and HCMC were more sensitive to the fare cost of conventional trains; for instance, it was found that the importance of a conventional train fare was associated with an increase in the odds ratio when choosing a conventional train by 19.65, 4.27, and 10.36 times, respectively.

Table 6. Factors influencing inter-city bus with and without the presence of HSR by different cities.

Variables	Hanoi		Vinh		Nha Trang		HCMC	
	Without	**Within**	**Without**	**Within**	**Without**	**Within**	**Without**	**Within**
Gender (male)	0.487	0.075	0.119	0.159	0.323	**0.376** ***	**0.593** **	0.136
Age	−0.038	−0.043	0.630 *	−0.043	**0.399** ***	0.048	0.122	0.059
Education	**−0.593** ***	−0.004	**−0.665** *	−0.212	**−0.403** **	−0.097	−0.237	−0.014
Occupation	−0.112	0.046	−0.168	**−0.204** **	**−0.190** **	−0.034	**−0.299** ***	−0.009
Income	−0.314	0.084	−0.501	**−0.454** **	−0.321	**−0.186** *	0.222	0.139
Distance	0.131	0.006	−0.225	0.140	0.057	**−0.068** *	−0.032	**0.067** *
OD time	**3.143** ***	**0.612** ***	**2.863** **	0.635	**2.954** ***	0.126	**3.230** ***	**0.728** ***
Affordable fare	**2.973** ***	−0.270	1.712	0.543	0.243	**−0.957** ***	**2.413** **	0.113
Flexibility	**1.816** ***	0.091	**3.709** **	−0.224	**2.935** ***	**0.502** ***	**3.868** ***	**0.648** ***
Comfort	**1.521** **	0.455	1.423	0.598	**1.482** ***	**0.441** ***	−0.211	**0.477** ***
Reliability	0.099	0.106	17.717	−0.236	0.800	0.191	**1.446** *	**0.429** *
Safety	**−2.032** ***	0.229	0.777	−0.383	**1.716** *	**−0.636** ***	**−1.505** **	0.503
Security	**−3.173** ***	0.385	19.888	0.183	−1.158	0.129	19.893	**1.418** *
Punctuality	**3.137** ***	**0.568** **	0.227	0.412	**1.072** **	0.313 **	−0.366	0.073
Frequency	**1.938** ***	**1.030** ***	0.611	0.068	**1.598** **	−0.007	18.775	0.395
Directness	0.481	0.173	18.689	−0.413	0.590	0.297	**1.923** **	−0.430
High fare of HSR		0.384		**0.756** *		0.195		**0.297** *
Short journey time of HSR		−0.204		0.451		0.104		−0.029
High frequency of HSR		−0.244		0.174		**−0.216** *		−0.048

Table 6. *Cont.*

Variables	Hanoi		Vinh		Nha Trang		HCMC	
	Without	**Within**	**Without**	**Within**	**Without**	**Within**	**Without**	**Within**
High span of service of HSR		0.075		0.575		0.044		0.033
Reduce frequency of inter-city buses		−0.146		0.454		−0.018		0.203
Reduce frequency of conventional trains		−0.276		-0.384		**0.284** **		0.017
Installation of amenities (PIS, WiFi, etc.)		0.133		0.706**		0.073		0.098
Convenience in ticket purchasing		−0.341		0.615*		0.229		0.092
Providing facilities for handi-capped people		−0.508		0.534		0.176		−0.160
Constant	1.325	0.033	0.582	−3.39 ***	−0.259	−1.723 ***	0.311	−2.410
	Model assessment							
-2LL	229.384	765.084	81.626	343.4	459.089	1881.356	328.453	1457.549
Cox and Snell R^2	0.306	0.313	0.518	0.501	0.397	0.419	0.291	0.217
Nagelkerke R^2	0.565	0.318	0.814	0.591	0.699	0.491	0.600	0.147

Notes: *** denotes a significance level below or equal to 1%; ** denotes a significance level below or equal to 5%; and * denotes a significance level below or equal to 10%. Bold denotes that a factor has statistical significance.

Table 7. Factors influencing conventional train with and without the presence of HSR by different cities.

Variables	Hanoi		Vinh		Nha Trang		HCMC	
	Without	**Within**	**Without**	**Within**	**Without**	**Within**	**Without**	**Within**
Gender (male)	−0.298	−0.360	−0.450	−0.788	**−0.726** **	−0.180	**−0.851** **	−0.435
Age	−0.099	−0.385	**−1.371** **	**−0.968** **	**−0.438** ***	−0.121	−0.127	0.060
Education	**0.528** **	0.164	**1.343****	**−0.867** **	**0.323** *	**0.496** ***	0.256	−0.209
Occupation	**0.276** **	0.143	0.166	0.316	**0.259** ***	0.042	**0.508** ***	**0.260** **
Income	−0.675	0.086	−0.180	1.011	−0.214	0.010	−0.443	0.136
Distance	0.026	0.211	0.116	−0.054	−0.033	−0.151 *	−0.100	−0.001
OD time	−0.966	−1.893	**2.608** **	**1.906** *	1.354 **	**1.257** **	**3.591** ***	−0.653
Affordable fare	0.560	−0.459	**5.049** ***	**2.978** ***	2.383 ***	**1.453** ***	**2.802** ***	**2.338** ***
Flexibility	**3.229** **	−1.199	1.439	2.358 *	2.222 ***	0.852	0.906	−19.523
Comfort	**2.283** ***	**1.843** *	−1.493	0.414	1.127 **	**2.063** ***	**3.750** ***	**1.216** **
Reliability	0.058	**3.259** **	−0.626	**1.748** *	1.234 ***	**1.391** ***	0.023	0.434
Safety	**2.951** ***	**2.599** ***	1.688	**1.561** **	2.008 ***	**1.893** ***	**1.576** ***	0.485
Security	−20.750	−0.051	21.989	1.164	1.907	0.167	−0.098	1.281
Punctuality	0.191	−0.918	21.313	0.409	20.247	−0.453	0.945	−0.125
Frequency	**2.947** ***	−10.149	1.652	0.170	−0.317	−0.730	**1.191** **	−0.437
Directness	0.706	0.580	1.323	1.015	**1.903** ***	**1.494** ***	−0.186	0.288
High fare of HSR		−0.338		0.149		−0.185		0.075

Table 7. *Cont.*

Variables	Hanoi		Vinh		Nha Trang		HCMC	
	Without	Within	Without	Within	Without	Within	Without	Within
Short journey time of HSR		0.164		−0.845		−0.028		0.110
High frequency of HSR		0.027		1.031		0.404		0.039
High span of service of HSR		**−0.815 ***		−0.520		−0.159		−0.219
Reduce frequency of inter-city buses		0.270		−1.104		−0.342		−0.008
Reduce frequency of conventional trains		−0.104		0.874		0.718 **		−0.323
Installation of amenities (PIS, WiFi, etc.)		−0.123		−1.377 *		−0.547 *		0.289
Convenience in ticket purchasing		0.337		1.593 **		−0.072		−0.635
Providing facilities for handicapped people		−0.285		0.769		0.144		−0.140
Constant	−3.680	−2.250	−4.278	−4.06	−2.989	3.629 ***	−4.617 ***	−4.35 ***
	Model assessment							
-2LL	191.226		56.85	343.8	427.776	1900	272.208	1.411
Cox and Snell R^2	0.300		0.549	0.503	0.393	0.399	0.308	0.247
Nagelkerke R^2	0.594		0.872	0.593	0.708	0.468	0.657	0.304

Notes: *** denotes a significance level below or equal to 1%; ** denotes a significance level below or equal to 5%; and * denotes a significance level below or equal to 10%. Bold denotes that a factor has statistical significance.

5. Conclusions

In this study, we evaluated the social equity before and after the introduction of HSR in Vietnam through considering factors influencing the transport mode choice and analyzing the Theil index. Some key findings are summarized as follows: (1) Inter-city buses and conventional trains were considered attractive by people, due to their affordable fares, flexibility, and amenities before and after the introduction of HSR. In other words, many people would potentially be excluded from the use of HSR, as their incomes are insufficient to pay the high fares of HSR; (2) the social impacts of HSR were also indicated by the difference in preference of transportation modes among cities. Although economic disparity was not found to exist among the four selected cities, social inequity in choosing HSR was observed in these cities. More specifically, low-income groups in Vinh and Nha Trang were observed to have a higher tendency of staying away from HSR.

Findings from these research results may be useful for policymakers and practitioners. First, given that flexibility and comfort were evaluated as the most-important factors in using inter-city buses, rail companies should improve the interiors of trains and install various amenities—for example, by replacing iron seats with upholstered seats, installing WiFi, arranging entertainment services, designing parking, and planning feeder bus networks at railway stations. Second, as fare was the most motivator of train users, transport authorities and railway companies should establish pricing strategies to balance mobility needs and social equity; for example, they might provide lower prices during off-peak hours or in low-volume sections.

Furthermore, given that inter-city buses and conventional trains remained attractive for low-income groups, an integrated timetable among inter-city buses, conventional trains, and HSR should be deployed when HSR is put into operation, in order to ensure the connection between these modes, as well as ensuring equity in passenger transport. In fact, given that passengers from Vinh, Nha Trang, and Ho Chi Minh City were sensitive to the high fare of HSR, they may easily feel excluded from HSR. As such, policymakers and railway companies should pay more attention and efforts to these markets, in order to balance between the willingness-to-pay of travelers and the revenue of railway companies.

There were a few limitations to this study. First, we attempted to evaluate equity from the transport mode choice point-of-view; therefore, we did not consider factors of urban economic development and population as prominent parts. Second, the sample used in this study may not have been fully representative of the general population of all travelers who undertake long-distance travel. Future replications are warranted before definitive conclusions can be drawn. Third, we focused on examining the relationship between socio-economic factors and vehicle features for transport-mode choice. Future studies could include other factors such as infrastructure and accessibility factors in the model.

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