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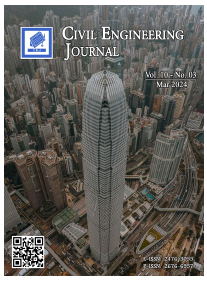

Measurement Model for Determining the Disparity Factors of Intercity Railway Transportation

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Abstract

Countries that are still developing experience significant disparities in access to railway services, as these nations also grapple with societal inequality issues that remain unaddressed. In developed countries, railway transportation systems serve as the primary mode of transportation for both passengers and goods. However, in recent years, studies on disparities in developed countries have increased, while literature concerning developing countries remains scarce. Therefore, this study takes place in Thailand, a developing country facing significant population disparities. The objective is to examine factors contributing to these disparities in access to railway transportation systems across cities, using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) to identify user disparities. The sample group comprises 1,252 randomly selected railway users from various regions in Thailand, obtained through Stratified Random Sampling. The results reveal seven dimensions of disparities: cultural, spatial, societal, political, knowledge-based, economic, and environmental. The CFA results also highlight cultural disparities as a significant factor in explaining access disparities among railway users. These findings can inform relevant organizations, aiding them in better understanding the actual needs of railway users and aligning railway development plans accordingly. Ultimately, this contributes to policy development aimed at reducing access disparities and fostering a more equitable society.

Keywords: Railway Disparity Factors; Railway Accessibility; Exploratory Factor Analysis; Confirmatory Factor Analysis.

1. Introduction

The transportation system is a key component in driving the tourism and travel industry of a nation, especially the railway transportation system, which is considered a safe, cost–effective, convenient, and punctual mode of transportation [1]. When compared to other transportation systems, rail travel is widely popular in many countries. For instance, developed countries like Japan and Germany have strongly supported rail transportation as a primary intercity mode of travel [2-4]. Furthermore, railway transportation is also regarded as a sustainable mode of transport [5, 6].

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However, access to railway services remains a significant issue, especially in developing countries. According to the CS Global Wealth Report 2018, Thailand, as a developing country, has the third highest inequality in the world and is the country that suffers from the greatest population inequality problem in the world [7]. The most significant challenge of inequality in Thailand is the need to manage the public transportation services, including railways, that meet the needs of the population across the country.

The current inequality situation in Thailand is related to the accessibility of train services. According to the latest statistics on intercity trains, Thailand has train stations in only 47 out of the country's 77 provinces, covering 61.04 percent. This information is based on the most recent data on railway networks, as shown in Figure 1 [8]. This means that there are still 30 provinces without railroads passing through them. Even in provinces with railroads, not every district is covered. Thailand has a total of 928 districts [9], but there are only 442 railway stations [10], covering just 48% of all districts. This lack of coverage leads to inequality in access to train services among various population groups. Access to train services is a fundamental factor in daily life, and expanding access to railway stations can provide nearby residents and those with travel needs more suitable transportation options. Wang et al. [11] have pointed out that building a railway network can help address population inequalities.

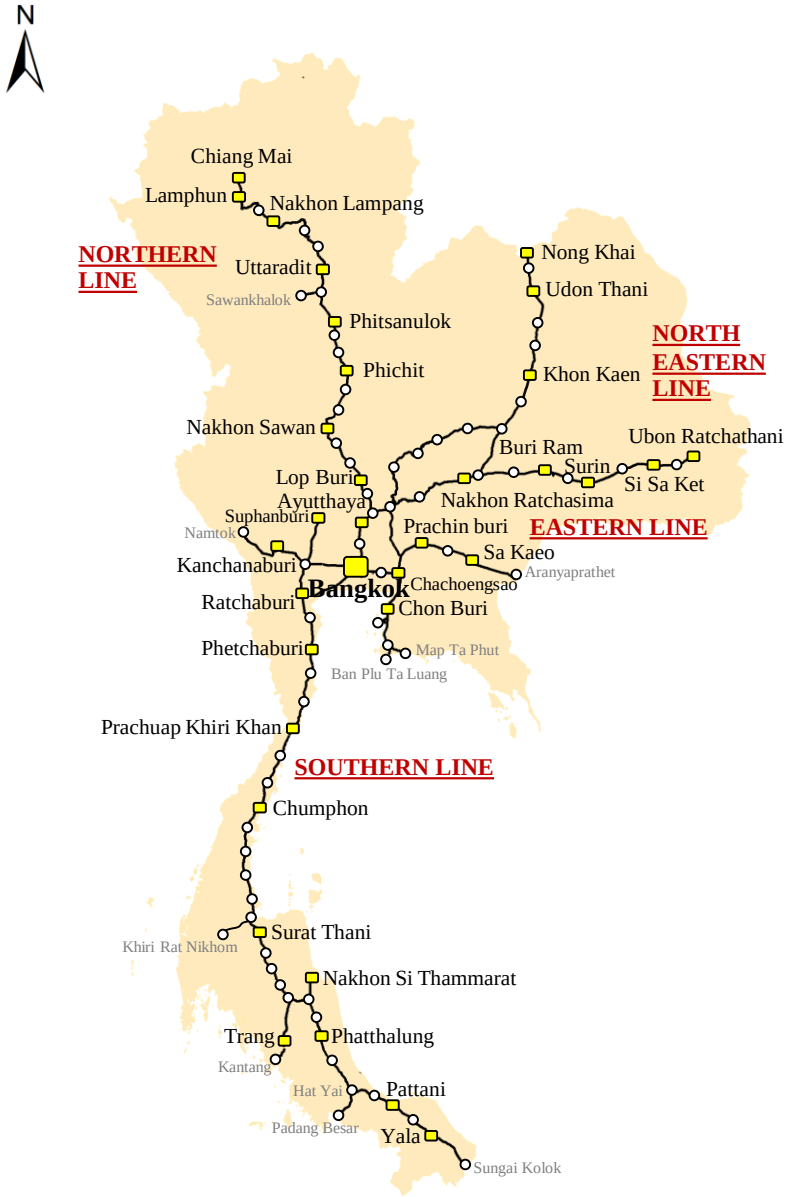

Figure 1. Railway Routes in Thailand

Furthermore, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) have also been applied extensively in analyzing the development of railway transportation systems. There are numerous studies that have attempted to explore factors influencing railway service usage in various dimensions. Examples include factors affecting the quality of railway services [12-14], factors influencing passenger satisfaction with railway services [15, 16], factors

affecting railway employees' job performance [17], factors influencing perceptions of railway safety [18, 19], and factors related to weather conditions affecting railway safety [19]. Although previous studies have examined the development of Thailand's rail transportation system, they have primarily focused on enhancing the quality of train services and identifying factors influencing service quality [20], as well as evaluating spatial inequality solely for analyzing accessibility to train stations [21]. However, there is currently a dearth of research on factors impacting inequality in people's utilization of train services across all dimensions. Inequality assessment can encompass various factors, including cultural, spatial, social, political, knowledge, economic, and environmental dimensions [22]. Therefore, this study aims to fill this gap by comprehensively examining all factors contributing to inequality among train users in a developing country context. By including all relevant dimensions, the study seeks to effectively address the issue of inequality in the railway transportation system.

In addition, in developed countries, there have been numerous studies attempting to examine factors contributing to inequality in various dimensions. For instance, in the United States, there has been a study investigating cultural sources of racial inequality, particularly inequality between whites and blacks. This study focused on two dimensions of explanation, or attribution: internal (regarding shortcomings in black motivation and capability); and external (regarding the socioeconomic context), using survey experiments. The results indicated the need to change public perceptions and beliefs regarding racial inequality [23]. Furthermore, studies have been conducted on inequality in accessing public transportation services and land use in the Washington, D.C. metropolitan area. This research emphasized analyzing social and spatial factors, proposing a framework that disaggregates mobility and access components to identify areas potentially affected by inadequate transportation services and limited job opportunities. The findings of this study serve as crucial data for developing regional mass transportation system plans [24]. Similarly, in France, there has been a study examining regional disparities in railway transportation investment to assess regional balance in railway line planning and financial models. The results of this study led to an analysis of data from the Ministry of Infrastructure Budgets to monitor the development of regional inequality in terms of public sector expenditure [25]. Moreover, in Italy, a study explored the impact of high-speed railways (HSR) on income inequality. This research focused on analyzing economic and social factors related to income inequality at the provincial level using the Gini index and a two-way fixed-effects model to measure relationships. The findings suggested that HSR could stimulate a reduction in household income inequality, with positive effects on GDP per capita and employment levels [26]. Lastly, in China, a study investigated intra-regional inequality and urban-rural divides using a differentiated model to examine whether high-speed railways affected intra-regional inequality. The findings indicated that high-speed rail operations expanded income gaps between urban and rural areas by promoting population aggregation, financial capital, and economic activities in urban areas adjacent to high-speed railway stations [27].

Absolutely, this research can be considered a novel study in the context of education in a developing country like Thailand. Its objectives are to study the factors influencing disparities in accessing intercity railway transportation in Thailand and to analyze the factors contributing to disparities in cultural, spatial, social, political, knowledge, economic, and environmental dimensions. This is done by considering the perspectives of current railway users through questionnaires. Subsequently, the data is analyzed using the CFA tool, which is suitable for identifying factors that can accurately confirm the nature of relationships, leading to the development of effective solutions to address disparities and meet the needs of railway users efficiently. Furthermore, this study proposes policies to reduce disparities among the Thai population for railway service providers. These policies would help relevant agencies or stakeholders involved in railway development better understand the actual needs of railway users and apply disparity indicators to create development plans that efficiently and sustainably meet the passengers' needs.

2. Literature Review

Inequality has become essential for understanding society. Frances (2016) posits that "Disparity has its roots in inequality" and "The origins of inequality in each dimension are interrelated, with inequality arising in one dimension potentially affecting another dimension of inequality in the form of an influence pathway". The framework of factors influencing inequality is depicted in Figure 2 [28].

Figure 2 illustrates that from the structure of the influence pathways of inequality in each dimension, they can be categorized into three groups of factors that influence each other. These are: Root Factors: These include cultural inequality and spatial inequality, which are the initial factors influencing housing insecurity, transportation, education, and perception [21]. Intermediate Factors: These encompass social inequality, political inequality, and knowledge inequality. This group of factors is heavily influenced by root factors, while spatial inequality influences knowledge inequality. Factors such as geographical distance from information and understanding of development discourse due to educational disparities lead to a lack of bargaining power [29, 30]. End Factors: These consist of economic inequality and environmental inequality. These factors are influenced by intermediate factors, where knowledge inequality and social inequality affect economic inequality. As the cost of living increases, economic inequality intensifies [31], while environmental inequality is influenced by political inequality and knowledge [32]. Therefore, based on this framework, the researchers conducted a literature review and compiled studies related to factors influencing inequality in each dimension, as detailed below.

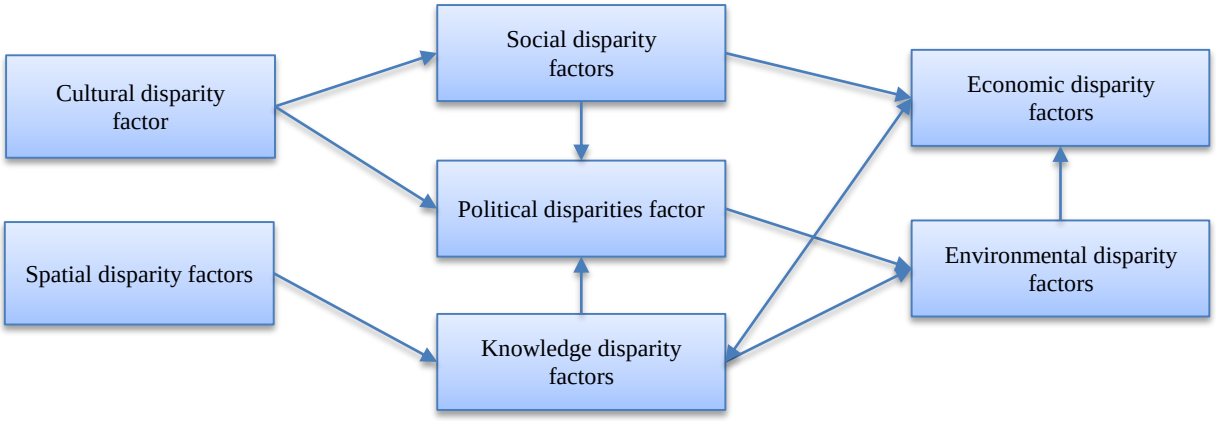

Figure 2. Framework of Factors Influencing Inequality

2.1. Cultural Inequality

For instance, O'Brien & Oakley (2015) [33] point out that there is a critical need to understand the relationship between culture and social inequality. These factors should be considered separately in both academic research and policy–making, according to customs and traditions. Furthermore, a study by Lareau (2015) [34] indicates that cultural factors affect knowledge disparities. Therefore, from the review, it can be concluded that factors related to cultural inequality include (1) ethnicity and race, (2) religion and class, and (3) gender status.

2.2. Spatial inequality

For instance, Levinson (2012) [35] points out that rail transit can have positive spatial benefits to cities near stations and has a negative impact on towns that are far from train stations. Furthermore, the studies by Cascetta et al. (2020) [31] and Luo & Zhao (2021) [36] focus on the issue of spatial access to trains. Therefore, from the review, it can be concluded that factors related to spatial inequality include (1) economic growth, (2) infrastructure and facilities, and (3) public connectivity systems.

2.3. Social inequality

For instance, Lucas et al. (2019) [37] point out that the transportation service system is unevenly distributed. It may affect different social factors. Furthermore, a study by Zhan et al. (2020) [38] emphasizes that social equality must take into account the affordability and needs of rail users. Therefore, from the review, it can be concluded that factors related to social inequality include (1) community size, (2) social roles and duties, and (3) income level.

2.4. Political inequality

For instance, Rodriguez (2018) [39] point out that political participation influences politicians in shaping policies and projects that define the quality of society. Furthermore, a study by Beaumont (2011) [40] indicates that the primary cause of political inequality stems from people's marginalization, leading to diverse political expressions. Therefore, from the review, it can be concluded that factors related to political inequality include (1) social and political participation and (2) living conditions of society.

2.5. Knowledge inequality

For instance, Wu & Zhao (2015) [41] point out that access to the education system has a positive influence on people's awareness. Furthermore, the studies by Viswanath et al. (2006) [42] and Robb et al. (2010) [43] indicate that increased knowledge development often leads to reducing the knowledge gap among groups of people. Therefore, from the review, it can be concluded that factors related to knowledge inequality include (1) awareness or perception and (2) technological systems.

2.6. Economic inequality

For instance, Di Matteo & Cardinale (2023) [26] point out that the unequal provision of rail transport services affects regional economic inequality. Studies by Knight & Song (1999) [44] also indicate that large rural–urban divides affect the economic well–being of the population. Furthermore, a study by Pokropek et al. (2015) [45] focused on studying the concept of socioeconomic conditions in a multidimensional manner through empirical investigation. Therefore, from the review, it can be concluded that factors related to economic inequality include (1) employment level, (2) wages or income, and (3) Gross Domestic Product (GDP).

2.7. Environmental inequality

For instance, Boyce (1994) [46] points out that economic activities impact environmental preservation and that power and wealth inequalities contribute to the degradation of natural resources. Furthermore, the studies by Song et al. (2016) [47] and Sun et al. (2020) [48] clearly indicate that rail transportation is the most efficient and environmentally friendly mode of transportation. Therefore, from the review, it can be concluded that factors related to environmental inequality include (1) access to natural resources and (2) environmental awareness.

From the literature review conducted previously, researchers found that studies related to factors associated with transportation inequality were considered and compiled. It was found that there were 20 studies from 13 countries, as shown in Table 1. Most research often considered inequality factors from only a few perspectives depending on the case study. However, no study was found that comprehensively assessed the inequality of railway access covering all factors. To fill this gap in the literature, researchers therefore gathered all relevant factors to examine and evaluate the inequality experienced by railway users. This would help understand the true opinions of those who genuinely require railway services. The research assumes that an appropriate model for assessing rail user inequality should have a multidimensional structure comprising seven dimensions: Cultural Inequality, Spatial Inequality, Social Inequality, Political Inequality, Knowledge Inequality, Economic Inequality, and Environmental Inequality.

Table 1. Summarizes the previous studies on factors related to inequality

Author	Country	Factors							Method
		Cultural	Spatial	Social	Political	Knowledge	Economic	Environmental	
Lope & Dolgun [49]	Australia		✓	✓					Gini coefficient and Lorenz curve
Sanchez [50]	US			✓			✓		Gini coefficient
Galaskiewicz et al. [51]	US	✓					✓		OLS
Clifton & Lucas [52]	UK and US		✓			✓			Empirical evidence
Zhao & Li [53]	Beijing		✓	✓			✓		Empirical evidence
Aasness & Larsen [54]	Norway							✓	Empirical evidence
Kim & Yi [55]	South Korea						✓		Transportation network analysis and Multi–regional CGE model
Chang et al. [56]	Hong Kong		✓						The gravity model
Benoussaïd et al. [57]	Paris		✓	✓				✓	OLYMPUS emissions model and the CHIMERE chemistry–transport model
Liu & Zhang [58]	China			✓			✓	✓	Hybrid MCDM Model
Wanke, et al. [59]	China				✓		✓	✓	RBSFA
Ongolo-Zogo & Epo [60]	Cameroon		✓		✓		✓		Regression function
Allen & Farber [61]	Canada			✓			✓		Simple correlation measures
Zhang et al. [62]	China					✓			SEM
Zhang & Zhang [63]	China		✓				✓	✓	SEM
Nadimi et al. [64]	Iran	✓							SEM
Wang et al. [65]	China		✓	✓	✓				SEM
Ali et al. [66]	Pakistan	✓		✓			✓		EFA, CFA and SEM
Loa et al. [67]	Canada			✓			✓		EFA and CFA
Li et al. [68]	China					✓			CFA
Present study	Thailand	✓	✓	✓	✓	✓	✓	✓	EFA and CFA

Note: OLS = Ordinary least squares regression; MCDM = Multi criteria decision making; RBSFA = Robust Bayesian Stochastic Frontier Analysis; SEM = Structural equation modelling; EFA = Exploratory factor Analysis; CFA = Confirmatory factor analysis.

3. Research Methodology

3.1. Research Framework

This study commences with a comprehensive literature review focusing on the factors contributing to inequality, with the aim of identifying gaps in previous research and introducing new findings on this aspect of inequality. Additionally, it explores potential statistical methods and theories relevant to the study. Subsequently, a questionnaire was developed based on these findings, and data were collected through face-to-face interviews with a total sample

group of 1,252 railway users. Following the completion of data collection from the railway user survey, two statistical methods were applied: EFA and CFA. Data from a subgroup of 374 participants, representing 30% of the total sample, were employed for EFA to categorize the variable components derived from users' responses to all 37 questions into 7 factors influencing inequality. The data from the remaining 878 participants, constituting 70%, were then employed for CFA to validate the factors affecting inequality identified from the EFA results. Finally, the study presents statistical results and discussion of the findings were presented along with policy recommendations for reducing inequality. The research process is illustrated in Figure 3.

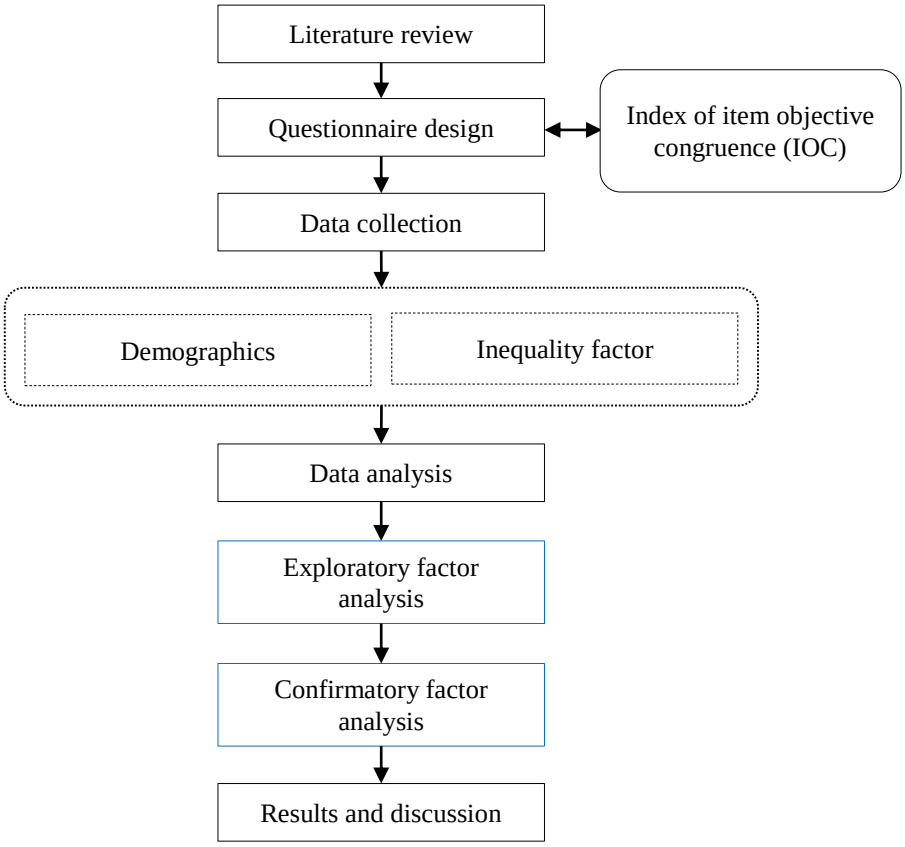

Figure 3. Research procedure

3.2. Questionnaire Structure

The questionnaire was structured into two main sections. Section 1: General Travel Behavior Information of the Survey Respondents, such as gender, age, education, occupation, income, frequency of train travel, and the purposes of train travel. Section 2: Measurement of Factors Affecting Disparities in Railway Access, consisting of 7 factors: Cultural Disparity Factor, Spatial Disparity Factor, Social Disparity Factor, Political Disparity Factor, Knowledge Disparity Factor, Economic Disparity Factor, and Environmental Disparity Factor. In this section, there are 37 questions, and the questionnaire responses are in the form of a 5–level Rating Scale [69, 70]. (Where 1 indicates strongly disagree and 5 indicates strongly agree).

We have conducted a validation of the questionnaire content using the index of item objective congruence (IOC), assessed by three experts. We considered questions with an IOC value higher than 0.50. The IOC values for the questions included in our questionnaire ranged from 0.67 to 1.00.

3.3. Participants and Data Collection

The sample group for this study consisted of railway service users within Thailand, located at 33 railway stations across four regions of the country (Northern Region, Northeastern Region, Eastern Region, and Southern Region). The sample selection was conducted using Stratified Random Sampling based on the geographical areas with railway stations to ensure that the sample represents the population effectively. Additionally, the interviews were conducted on an individual basis with respondents aged 18 and above. Furthermore, before conducting the interviews, respondents were asked for their willingness to participate. The interviews were carried out only with those who willingly agreed to participate in the survey. A total of 1,252 useful responses were obtained, which is considered sufficient for conducting CFA. According to Cangur & Ercan [71], they recommend that the sample size should be at least 15 times the number of observed variables. In this research, there are a total of 37 observed variables, so the minimum sample size required is 555. The survey received ethical approval from the Ethics Committee of Suranaree University of Technology on December 1, 2022 (COA No. 100/2565). Table 2 provides an overview of the characteristics of the survey participants.

Table 2. Participant Demographics

Characteristics	Category	Frequency	Percentage
Gender	Male	516	41
	Female	736	59
Age	18–20 years old	272	22
	21–30 years old	393	31
	31–45 years old	311	25
	46–60 years old	194	15
	Over 60 years old	82	7
Education	Primary education	88	7
	High school education	321	26
	Vocational education	277	22
	Bachelor's Degree	510	41
	Master's Degree	45	3
	Doctoral Degree	11	1
Occupation	Agriculturist/Agricultural Organization	126	10
	Entrepreneur	143	11
	Private Employee	349	28
	Government Employee	159	13
	Student	357	29
	Others	118	9
Income	Less than or equal to 10,000 Baht	447	36
	10,001–15,000 Baht	369	29
	15,001–20,000 Baht	248	20
	More than 20,000 Baht	188	15
Frequency of railway travel (per week)	Every day	108	9
	1–2 times	448	36
	3–5 times	223	18
	Occasionally	473	37
Objectives of railway travel.	Study/Work	474	38
	Rest/Travel	540	43
	Shopping	166	13
	Others	72	6

3.4. Analysis Methodology

To examine the relationship between the components derived from factors influencing inequality in railway access, covering all 7 factors, we used EFA and CFA with two main objectives:

Exploratory factor analysis (EFA) is utilized to generate indicator groups, focusing on factors. Exploratory factor analysis is a statistical method used for exploring and identifying factors to explain the relationships among observed variables. Additionally, EFA results can reduce observed variables by creating new variables in the form of common factors [72]. Therefore, researchers often employ this method when there is no well–established theory regarding the relationships among measurement components [73, 74].

Confirmatory factor analysis (CFA) is a technique used to test or confirm the relationships between observable and latent variables. CFA is employed when researchers know that the indicators are components according to theory or literature review [75, 76]. Studies have explored the components of service quality indicators for the Thai railway system [12, 20, 77]. However, there has been no research on the components of indicators of disparities in railway access in Thailand. Therefore, this study applies both EFA and CFA to analyze the indicators of disparities in railway access, considering the establishment of indicator groups and using the loadings obtained from the analysis to develop appropriate guidelines for improving disparities in railway access.

4. Research Methodology

4.1. Descriptive Statistics

The descriptive statistics of railway service users, totalling 1,252 individuals, are presented in Table 3. The preliminary statistical analysis includes measures such as mean and standard deviation. Prior to conducting CFA, it is essential to examine the descriptive statistics to confirm the appropriateness of the data for analysis. The criteria for adequacy are absolute value 2 for skewness and absolute value 7 for kurtosis [78, 79]. Table 3 illustrates that the skewness ranges from –1.367 to 0.612, and the kurtosis ranges from –1.09 to 1.385, respectively. Therefore, it can be concluded that our sample statistics follow a normal distribution and are acceptable for further analysis.

Table 3. Statistical summary: Mean, Standard deviation, Skewness and Kurtosis (N = 1252)

Variable	Description	Mean	SD	Skewness	Kurtosis
CI1	The Gender Disparities impact accessibility to railways.	2.32	1.304	0.583	–0.912
CI2	The Ethnicity Disparities impact accessibility to railways.	2.34	1.258	0.597	–0.753
CI3	The Physical Health Disparities Status of Vulnerable Groups impact accessibility to railways.	2.64	1.298	0.272	–1.090
CI4	The Religious Disparities impact accessibility to railways.	2.33	1.276	0.612	–0.798
CI5	The Cultural and Belief Differences impact accessibility to railways.	2.5	1.252	0.42	–0.915
SP1	Railway stations located within urban areas allow the population to access trains more easily compared to stations located outside urban areas.	3.83	1.181	–0.944	0.07
SP2	The Regional Income Disparities impact accessibility to railways.	3.69	1.181	–0.721	–0.282
SP3	The Spatial Resource Disparities impact accessibility to railways.	3.67	1.153	–0.705	–0.228
SP4	The Economic Growth in Specific Regions impact accessibility to railways.	3.75	1.149	–0.781	–0.175
SP5	Regional Infrastructure's impact accessibility to railways.	3.84	1.126	–0.896	0.073
SP6	The Interconnection Between Public Transportation and Railway Systems in the Area impact accessibility to railways.	3.88	1.151	–0.909	–0.008
SP7	The Physical Development of Communities impact accessibility to railways.	3.71	1.117	–0.644	–0.318
SO1	The Socioeconomic Challenges and Resilience of Communities impact accessibility to railways.	3.8	1.098	–0.897	0.233
SO2	Access to government resources (such as government agencies and community resources) impacts accessibility to railways.	3.77	1.107	–0.776	–0.029
SO3	The Social roles and responsibilities Disparities impact accessibility to railways.	3.75	1.126	–0.785	–0.057
SO4	Having a high level of social responsibility has an impact accessibility to railways.	3.66	1.129	–0.637	–0.303
SO5	Societal inequality is a crucial factor affecting access to railway routes.	3.65	1.167	–0.658	–0.415
PI1	The Socioeconomic Challenges and Resilience of Communities impact accessibility to railways.	3.9	1.08	–0.867	0.106
PI2	Access to government resources (such as government agencies and community resources) impacts accessibility to railways.	3.95	1.057	–0.876	0.126
PI3	The Social roles and responsibilities Disparities impact accessibility to railways.	4.02	1.068	–0.974	0.202
KI1	Access to educational systems and knowledge development impacts accessibility to railways.	3.82	1.127	–0.870	0.113
KI2	Access to educational resources (such as schools and universities) impacts accessibility to railways.	3.81	1.117	–0.828	–0.003
KI3	Promoting quality and beneficial knowledge impacts accessibility to railways.	4.04	1.027	–1.098	0.739
KI4	The use of modern technology and tools in daily life impacts accessibility to railways.	4.1	1.013	–1.046	0.509
KI5	Lack of information about railway routes can lead to missed opportunities to access the railway transportation system.	4.08	0.982	–1.067	0.78
KI6	Having comprehensive knowledge about railway routes enables you to access the railway transportation system.	4.09	0.995	–1.047	0.643
EC1	Unemployment or lack of job opportunities impact accessibility to railways.	3.59	1.199	–0.552	–0.645
EC2	If there are more job opportunities in your area, it will impact accessibility to railways.	3.7	1.163	–0.745	–0.197
EC3	Income or wages impact accessibility to railways.	3.76	1.185	–0.921	0.056
EC4	The difference in income levels between individuals impacts accessibility to railways.	3.74	1.185	–0.749	–0.332
EC5	The promotion of solutions to alleviate poverty impacts accessibility to railways.	3.91	1.117	–0.947	0.199
EC6	If there are solutions to alleviate poverty, it will impact accessibility to railways.	3.84	1.13	–0.893	0.132
EN1	The current pollution issues impact accessibility to railways.	3.45	1.15	–0.579	–0.431
EN2	Access to natural resources (such as tourist attractions) impacts accessibility to railways.	3.41	1.143	–0.487	–0.515
EN3	If there are current solutions to address pollution or environmental issues, it will impact accessibility to railways.	3.55	1.123	–0.500	–0.515
EN4	Maintaining a good environment impacts accessibility to railways.	4.12	1.07	–1.367	1.385
EN5	Appropriate allocation and efficient utilization of limited resources impact accessibility to railways.	4.03	1.088	–1.285	1.183

Note: SD = Standard deviation

4.2. The Exploratory Factor Analysis

We employed EFA to identify observable indicators representing each latent factor and calculate the main factors. Table 4 presents the factor analysis results. The EFA results are reliable and acceptable. We obtained a Kaiser–Meyer–Olkin (KMO) measure of 0.950, which is excellent. Additionally, Bartlett's test of sphericity yielded highly significant results, exceeding 99%. The EFA results identified 37 items, which were grouped into 7 clusters. Which can explain a total variance of 74.854%. The composite results include: (1) Cultural Disparity Factors, (2) Spatial Disparity Factors, (3) Social Disparity Factors, (4) Political Disparity Factors, (5) Knowledge Disparity Factors, (6) Economic Disparity Factors, and (7) Environmental Disparity Factors. Upon examining accuracy and reliability using Cronbach's alpha, the values for each variable ranged from 0.870 to 0.933, which surpasses the minimum threshold recommended in previous research, typically set at 0.70 [80, 81].

Table 4. Factor analysis results of exploratory factor analysis

Variable	Loading	Communalities	Eigenvalue	Item	Cronbach's α
Factor 1: Cultural disparity factor			15.873	5	0.929
CI1	0.885	0.802			
CI2	0.898	0.820			
CI3	0.849	0.746			
CI4	0.881	0.809			
CI5	0.862	0.767			
Factor 2: Spatial disparity factor			4.348	7	0.933
SP1	0.693	0.614			
SP2	0.748	0.769			
SP3	0.779	0.778			
SP4	0.788	0.789			
SP5	0.784	0.787			
SP6	0.728	0.705			
SP7	0.680	0.691			
Factor 3: Social disparity factor			2.522	5	0.907
SO1	0.670	0.728			
SO2	0.703	0.760			
SO3	0.700	0.745			
SO4	0.765	0.795			
SO5	0.717	0.698			
Factor 4: Political disparity factor			1.618	3	0.896
PI1	0.695	0.737			
PI2	0.725	0.805			
PI3	0.726	0.800			
Factor 5: Knowledge disparity factor			1.266	6	0.919
KI1	0.732	0.735			
KI2	0.698	0.722			
KI3	0.712	0.758			
KI4	0.713	0.749			
KI5	0.722	0.707			
KI6	0.704	0.682			
Factor 6: Economic disparity factor			1.102	6	0.920
EC1	0.707	0.744			
EC2	0.718	0.803			
EC3	0.686	0.811			
EC4	0.636	0.687			
EC5	0.529	0.745			
EC6	0.557	0.705			

Factor 7: Environmental disparity factor			0.967	5	0.870
EN1	0.787	0.740			
EN2	0.805	0.745			
EN3	0.798	0.753			
EN4	0.562	0.730			
EN5	0.587	0.734			
		SUM		**37**	**0.954**

Note: Goodness of fit for EFA: Bartlett's test approx. $\chi^2 = 11745.045$, Degrees of freedom (df) = 666, $p < 0.000$.

4.3. Theoretical Confirmation

The results of the EFA will be examined in this section to verify and explain the significance of each item, confirming that the indicators can be components of each factor. The results of the CFA were analyzed using Mplus 7 software.

In Table 5, it is evident that all indicators are statistically significant as components of the latent construct of maladjustment, with factor loadings ranging between 0.687 and 0.871. All seven factors have acceptable structural reliability (CR) values between 0.8662 and 0.9319, and the average variance extracted (AVE) ranges from 0.5232 to 0.6859. The statistical values of CR are greater than 0.7, and AVE is not less than 0.5, [82-84]. Which confirms that all factors are suitable for CFA.

Table 5. Model results of Confirmatory factor analysis

Variable	Loading	S.E.	t–Stat	CR	AVE
Factor 1: Cultural disparity factor				0.9160	0.6859
CI1	0.840	0.013	63.211		
CI2	0.835	0.013	62.230		
CI3	0.818	0.015	55.147		
CI4	0.861	0.013	66.936		
CI5	0.785	0.015	52.501		
Factor 2: Spatial disparity factor				0.9319	0.6621
SP1	0.741	0.017	43.667		
SP2	0.819	0.013	65.230		
SP3	0.795	0.014	57.904		
SP4	0.849	0.011	78.286		
SP5	0.866	0.010	86.421		
SP6	0.819	0.012	68.105		
SP7	0.801	0.014	55.501		
Factor 3: Social disparity factor				0.9011	0.6461
SO1	0.830	0.012	66.569		
SO2	0.835	0.013	65.897		
SO3	0.821	0.013	63.971		
SO4	0.767	0.016	48.858		
SO5	0.763	0.017	45.859		
Factor 4: Political disparity factor				0.8662	0.6838
PI1	0.776	0.016	48.890		
PI2	0.871	0.012	74.331		
PI3	0.831	0.013	62.156		
Factor 5: Knowledge disparity factor				0.8679	0.5232
KI1	0.687	0.022	31.461		
KI2	0.710	0.021	33.927		
KI3	0.785	0.018	44.788		
KI4	0.723	0.020	35.731		
KI5	0.717	0.020	35.512		
KI6	0.714	0.020	34.987		

Factor 6: Economic disparity factor				0.9162	0.6457
EC1	0.765	0.016	47.933		
EC2	0.810	0.014	59.003		
EC3	0.812	0.014	59.078		
EC4	0.816	0.013	61.733		
EC5	0.800	0.014	55.648		
EC6	0.817	0.013	61.352		
Factor 7: Environmental disparity factor				0.8664	0.5655
EN1	0.750	0.016	46.741		
EN2	0.790	0.016	48.212		
EN3	0.807	0.016	51.603		
EN4	0.706	0.015	45.607		
EN5	0.701	0.015	45.422		

Note: CR = Composite reliability, AVE = Average variance extracted.

For the overall model fit assessment (Goodness–of–fit statistics), this study used absolute and incremental fit indices [85] and considered the following indices: Chi–square or ratio between the chi–square and the number of degrees of freedom (χ^2/df) should be less than 3 [79, 86]; Comparative fit index (CFI) should be greater than 0.95 [71, 87]; Tucker–Lewis index (TLI) should be greater than 0.95 [85, 88]; Root mean square error of approximation (RMSEA) should be less than 0.05 [89, 90]; and Standardized root mean square Residual (SRMR) should be less than 0.08 [91]. The CFA estimation results show that the model measures inequality resulting from railway access. The results were as follows: Chi–square test of model fit χ^2= 1529.267, df = 580, χ^2/df = 2.637; CFI = 0.962; TLI = 0.956; RMSEA = 0.046; and SRMR = 0.068, p < 0.001. From inspection, all values comply with the specified conditions. Therefore, it can be concluded that this model aligns with the empirical data.

Cultural disparity factors: The 5 variables have standardized CFA loadings ranging from 0.785 to 0.861. Specifically, CI4, "The Religious Disparities impact accessibility to railways" has the highest loading factor (γ = 0.861, t = 66.936).

Spatial disparity factors: The 7 variables have standardized CFA loadings ranging from 0.741 to 0.866. Specifically, SP5, "Regional Infrastructure's impact accessibility to railways" has the highest loading factor (γ = 0.866, t = 86.421).

Social disparity factors: The 5 variables have standardized CFA loadings ranging from 0.763 to 0.835. Specifically, SO2, "Access to government resources (such as government agencies and community resources) impacts accessibility to railways" has the highest loading factor (γ = 0.835, t = 65.897).

Political Disparities Factor: The 3 variables have standardized CFA loadings ranging from 0.776 to 0.871. Specifically, PI2, "Policies set by the government regarding railway development impact access to railway routes" has the highest loading factor (γ = 0.871, t = 74.331).

Knowledge disparity factors: The 6 variables have standardized CFA loadings ranging from 0.687 to 0.785. Specifically, KI3, "Promoting quality and beneficial knowledge impacts accessibility to railways" has the highest loading factor (γ = 0.785, t = 44.788).

Economic disparity factors: The 6 variables have standardized CFA loadings ranging from 0.765 to 0.817. Specifically, EC6, "If there are solutions to alleviate poverty, it will impact accessibility to railways" has the highest loading factor (γ = 0.817, t = 61.352).

Environmental disparity factors: The 5 variables have standardized CFA loadings ranging from 0.701 to 0.807. Specifically, EN3, "If there are current solutions to address pollution or environmental issues, it will impact accessibility to railways" has the highest loading factor (γ = 0.807, t = 51.603).

Furthermore, we have presented the results of the second-order CFA, consisting of 7 variables identified as factors influencing inequality in access to railways. The analysis revealed that all 7 exogenous latent variables have weights in the range of 0.798 to 0.988, exceeding the threshold of 0.70 [92], indicating the confirmation of the perspective of inequality concerning the use of railway station services. All exogenous latent variables are statistically significant at the 0.001 level when considering the weights of the components separated by each exogenous variable. The cultural disparity factor has the highest component weight (γ = 0.988, t = 122.927), followed by economic disparity factor (γ = 0.938, t = 87.534), social disparity factor (γ = 0.885, t = 62.811), knowledge disparity factor (γ = 0.855, t = 48.175), political disparity factor (γ = 0.843, t = 56.843), spatial disparity factor (γ = 0.836, t = 59.108), and finally, environmental disparity factor (γ = 0.798, t = 27.440). The results of the second–order CFA are illustrated in Figure 4.

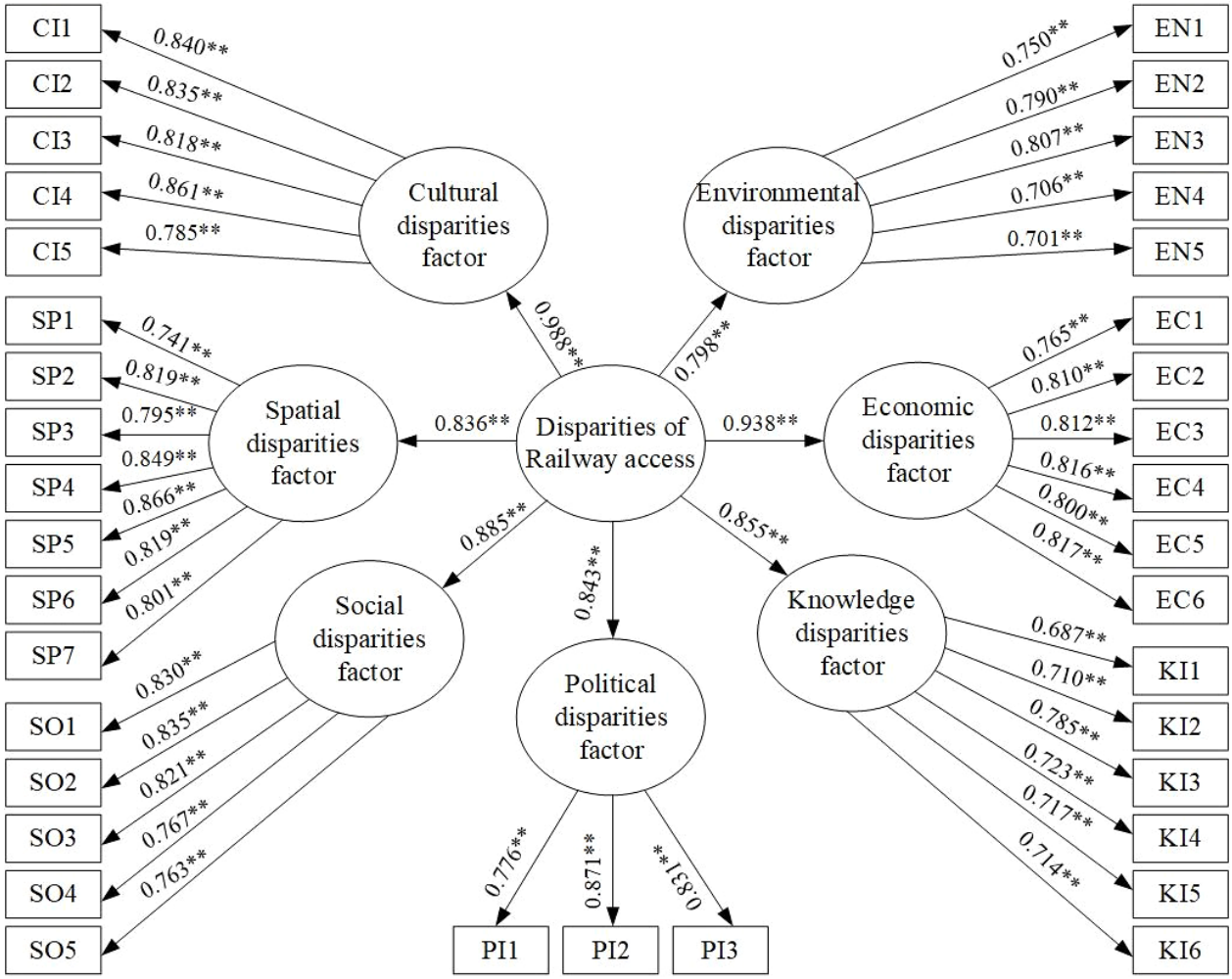

Figure 4. Results of the second–order Confirmatory factor analysis model

5. Discussion

The evaluation of the goodness-of-fit statistics for the model in this study was successful. It comprised the following indices: Chi-square or the ratio between the chi-square and the number of degrees of freedom (χ^2/df) with a value of 2.637, which is lower than 3 as per theory [79, 86]. Comparative Fit Index (CFI) with a value of 0.962, exceeding 0.95 as per theory [71, 87]. Tucker–Lewis Index (TLI) with a value of 0.956, exceeding 0.95 as per theory [85]. Root Mean Square Error of Approximation (RMSEA) with a value of 0.046, lower than 0.05 as per theory [89, 90]. Standardized Root Mean Square Residual (SRMR) with a value of 0.068, lower than 0.08 as per theory [91]. The results of all indices are consistent with the criteria and theoretically sound, confirming the consistency between the developed measurement model and both exploratory and confirmatory survey data.

When considering the results of CFA, it was found that the appropriate number of factors is 7 for assessing the factors influencing inequality in accessing railways. This study also revealed significant findings, detailed as follows:

Group 1: Cultural disparities factors have the highest composite weights, with a value of 0.988, which consists of variables from CI1 to CI5. This is related to previous studies that found cultural factors significantly influence societal changes [93, 94]. Cultural factors are also identified as a crucial strategy in addressing disparities issues [95]. Among the cultural disparity factors, the variable with the highest loading in the model is CI4, "Differences in religion affect the choice or access to railways." This finding is associated with studies indicating a strong relationship between inequality and religion, where societies with high levels of inequality have more diverse religions compared to those with low inequality [96]. Following that are CI1, "Differences in gender status affect access to railways." This finding is related to studies indicating that gender status differences influence the choice of public transportation [97]. And CI2, "Differences in race affect the choice or access to railways." This finding is related to studies indicating that inequality based on race/ethnicity affects access to public transportation [51].

Group 2: Economic disparity factor has the second composite weight, with a value of 0.938, which consists of variables from EC1 to EC6. This is related to previous studies that found railways play a crucial role in economic disparity development [58, 61, 98]. Among the economic disparity factors, the variable with the highest loading in the

model is EC6, "Having strategies to address poverty affects access to railways." This finding is associated with studies indicating that reducing addressing poverty positively impacts economic development, leading to increased utilization of railway transportation services [26]. Following that are EC4, "Differences between individuals with high income versus low income affect access to railways." This finding is related to studies indicating that railway systems affect income disparities between urban and rural residents [99]. And EC3, "Income or wages affect access to railways." This finding is related to studies indicating that income inequality affects the utilization of railway transportation services [100].

Group 3: The social disparity factor has the third composite weight, with a value of 0.885, which consists of variables from SO1 to SO5. This is related to previous studies that found social disparities influence the choice of railway transportation systems [101, 102]. Among the social disparity factors, the variable with the highest loading in the model is SO2, "Access to state resources (such as government agencies and community resources) affects access to railways." This finding is associated with studies indicating that developing state resources for railway network infrastructure expansion leads to greater equality in access [103]. Following that are SO1, "Issues of poverty and community strength affect access to the railway." This finding is related to studies indicating that the potential of communities from station-level factors and communities significantly impacts the development of railway transportation systems [104]. And SO3, "Social roles and responsibilities affect access to railways." This finding is related to studies indicating that social roles influence people's transportation service choices and travel behaviors [105].

Group 4: Knowledge disparity factor has the fourth composite weight, with a value of 0.855, which consists of variables from KI1 to KI6. This is related to previous studies that found that the development of knowledge in society influences the reduction of disparities [62, 68]. Among the knowledge disparity factors, the variable with the highest loading in the model is KI3, "Giving importance to promoting quality and beneficial knowledge affects access to railways." This finding is associated with studies indicating that advancements in providing information for transportation systems benefit reducing knowledge disparities [106]. Following that are KI4, "Utilizing modern technology and tools in daily life affects access to railways." This finding is related to studies indicating that connecting internet-enabled devices and technology tools to railway transportation services promotes significant innovations in accessing railway services [107]. And KI5, "Lack of information on train routes affects access to railways." This finding is related to studies indicating that a lack of knowledge impacts the understanding of public transportation users [62].

Group 5: Political disparity factor has the fifth composite weight, with a value of 0.843, which consists of variables from PI1 to PI3. This is related to previous studies that found factors related to political roles influence the development of disparities [108, 109]. Among the political disparity factors, the variable with the highest loading in the model is PI2, "Government policy related to trains set by the government affects access to railways." This finding is associated with studies indicating that policies benefiting certain groups in transportation contribute to disparities in accessing public transportation [108]. Following that are PI3, "Efficient train route development plans affect access to railways." This finding is related to studies indicating that strategic planning for railway route development reduces disparities in accessing railway services [109]. And PI1: "Giving importance to constructive feedback affects access to railways." This finding is related to studies indicating that genuine opinions and discussions among people enable the public to perceive the beneficial perspectives of others [110].

Group 6: Spatial disparity factor has the sixth composite weight, with a value of 0.836, which consists of variables from SP1 to SP7. This is related to previous studies that found spatial inequalities affect disparities in accessing railway transportation [36, 111]. Among the spatial disparity factors, the variable with the highest loading in the model is SP5, "Infrastructure factors in the area affect access to railways." This finding is associated with studies indicating that infrastructure networks are crucial for people's intercity travel [36]. Following that is SP4, "Economic growth in the area affects access to railways." This finding is related to studies indicating that economic growth impacts regional disparities in railway transportation development [31]. And SP6, "The connectivity pattern of the public transportation system with the rail system in the area affects access to railways." This finding is related to studies indicating that integrating bus transit systems with railways is a significant strategy for reducing disparities in accessing railway transportation [21].

Group 7: Environmental disparity factors have the lowest composite weights, with a value of 0.798, which consists of variables from EN1 to EN5. This is related to previous studies that found environmental inequalities are caused by disparities from other dimensions such as cultural, economic, and social disparities [54, 59]. Among the environmental disparity factors, the variable with the highest loading in the model is EN3, "Having strategies to address pollution and environmental issues affects access to railways." This finding is associated with studies indicating that improving environmental efficiency in cities impacts the choice of railway transportation systems [48]. Following that are EN2: "Access to resources (such as tourist attractions) affects access to railways." This finding is related to studies indicating that external resource factors, such as tourist attractions, impact travel planning and transportation system choices [112]. And EN1: "Current pollution issues affect access to railways." This finding is related to studies indicating that the risk of exposure to pollution varies by region and group, affecting environmental inequalities [113].

Furthermore, the findings of the analysis reveal that cultural disparity significantly influences the accessibility of Thailand's railway system, especially in the context of a developing nation. Through a confirmatory model evaluation

of all 37 questions, it was evident that religious differences emerged as the most influential factor affecting the choice or accessibility of railways. This finding is consistent with previous research highlighting the profound impact of religions on societal dynamics, individual behaviors, and decision-making processes related to transportation [114]. Additionally, religious considerations also shape the development of intercity railway networks [115]. Therefore, this study underscores the importance of addressing cultural disparities in railway accessibility, often rooted in religious factors. It is clear that religious differences significantly influence the decisions of railway users regarding their choice or access to railway services, particularly in the context of a developing country like Thailand. Consequently, the researchers recommend policy interventions aimed at mitigating these disparities within the study area. By doing so, valuable insights can be gained to enhance development efforts and promote equitable access to Thailand's railway system.

Therefore, based on the statistical data analysis mentioned, we have proposed a policy aimed at reducing disparities across all 7 dimensions to address and enhance the issue of disparity within the railway transportation system. The objective is to formulate policies that target the reduction of disparities and the promotion of equality in accessing railways, which is vital for fostering a sustainable society. Access to railway systems can have a significant impact on individuals' quality of life and their opportunities for advancement within communities. Additionally, the development of railway transportation systems necessitates collaborative efforts from all stakeholders, including government entities, the private sector, and the public, to ensure equitable access and utilization for all members of society. Our recommendations are derived from the critical variables identified within the model and are detailed as follows:

***Policy on Cultural Disparities*:** Based on our findings, we propose the following guidelines: (1) Policies should be in place to support train users with diverse religious backgrounds, such as providing designated seats for religious practitioners (e.g., Buddhist priests, votaries, and clergyman), having prayer rooms at train stations, and appropriate areas for prayer on trains for users of the Islamic faith. (2) Policies should address safety measures to manage concerns related to gender segregation, such as separating train carriages or seats between males and females, aligning with the findings that suggest implementing gender–segregation guidelines in public transportation policies [97], and (3) Policies should promote training on attitudes for railway staff based on the principles of fairness, such as providing service that does not discriminate based on race, disability, or gender expression [116].

***Policy on Economic Disparities*:** Based on our findings, we propose the following guidelines: (1) There should be a policy to diversify railway service fares to meet the needs of train users, and (2) there should be a policy to stimulate the economy by encouraging the public to choose rail transportation services more, such as increasing service frequency and establishing one–stop service centers [117]. These suggestions align with the results of the study that indicate transportation policies need to enhance the quality of rail services to stimulate the country's economic development [118].

***Policy on Social Disparities*:** Based on our findings, we propose the following guidelines: (1) Policies and measures should be established to reduce social gaps among people in society [119]. This can be achieved by exempting or reducing railway fares for disadvantaged groups or individuals, such as persons with disabilities and the elderly, and (2) Policies should ensure equal access to the railway transportation system, providing equitable access to services for all groups of people. For instance, railway routes should pass through educational areas like schools and universities for the convenience of students, and through employment areas like malls and industrial estates to facilitate commuting for the working population. These recommendations align with the study results, suggesting the need to enhance service coverage for various occupational groups to cater to diverse travel purposes [101].

***Policy on Knowledge Disparities*:** Based on our findings, we propose the following guidelines: (1) There should be policies for modernizing information development and information technology systems, such as developing the main website of the railway organization to serve as a tool for conveniently, rapidly, and efficiently disseminating information to railway service users. (2) Policies should be in place for providing useful knowledge to railway service users within railway stations, such as creating information dissemination points and signs with beneficial information, which should be developed to be more globally accessible (e.g., in English), and (3) Policies should promote activities related to the continuous development of knowledge for railway service personnel, such as exchanging knowledge and work experiences among employees, aligning with the study's results that suggest opening opportunities for employees to communicate, leading to the transfer of knowledge from external sources. This is important as employees may play a crucial role in exchanging valuable ideas and experiences beneficial for organizational development [120].

***Policy on Political Disparities*:** Based on our findings, we propose the following guidelines: (1) Policies should be formulated to benefit the development of railways, aiming to reduce disparities in railway accessibility at both national and local levels. These policies should ensure comprehensive railway coverage in all dimensions, and (2) Policies should promote inclusiveness in meaningful stakeholder participation for the development of collaborative railway access, involving contributions from the government, private sector, and the public. This approach aims to genuinely reduce disparities by granting equal political representation to everyone, regardless of differences or societal status [121].

***Policy on Spatial Disparities*:** Based on our findings, we propose the following guidelines: (1) Policies should focus on developing infrastructure that efficiently connects the railway transportation system (e.g., road network development) to enhance accessibility [122]. (2) Policies should emphasize the development of an integrated public transportation

system that seamlessly connects to the railway transportation system (e.g., public buses), and (3) Policies should prioritize the development of railway route networks to provide equal coverage and service across regions in Thailand. These proposals align with the government's ongoing study on the feasible development of a comprehensive and interconnected railway network covering and supporting various transportation modes across the nation [123].

***Policy on Environmental Disparities*:** Based on our findings, we propose the following guidelines: (1) Policies should be implemented to promote environmentally friendly transportation, and (2) Policies should be introduced to enhance the environmental conditions around railway stations by increasing green areas to create a pleasant atmosphere and leave a positive impression on railway service users. These suggestions align with the study results indicating that reducing perceived disparities through environmental improvements has a positive influence on railway service users' attitudes [124].

Indeed, all the policies mentioned have been directly informed by current user feedback from railway service users in Thailand. These policies aim to engage stakeholders involved in the development of railway transportation systems, enabling them to apply these policies in setting guidelines or devising strategies to address and mitigate disparities in railway accessibility. Ultimately, these policies are geared towards fostering a new era of equality and efficiency, ultimately fostering a more equitable society.

In light of the limitations of our study, it's important to acknowledge that our research focuses exclusively on the viewpoints of railway service users, disregarding users of alternative public transportation modes. Moreover, we have omitted railway service users under the age of 18 due to their status as minors, potentially leading to a gap in understanding perspectives and attitudes towards disparities that may not be adequately addressed. Additionally, our study solely examines disparities in railway access within Thailand. To address these limitations, future research should encompass a broader range of public transportation users and involve surveying individuals under the age of 18 to ensure a more comprehensive understanding of disparities. Researchers should also consider adapting survey questions to suit different age groups appropriately. Furthermore, the findings of our study can serve as a valuable groundwork for further research and implementation in other developing nations. Addressing disparities in railway transportation access remains crucial for such countries, as it can provide deeper insights and new discoveries from various angles for future researchers.

6. Conclusions, Implications, and Research Limitations

This study aims to explore the factors contributing to disparities in accessing intercity railway systems in Thailand. We have presented findings from a combination of EFA and CFA, revealing in-depth insights into the factors influencing disparities in railway accessibility. The study surveyed 1,252 railway service users nationwide using face-to-face interviews. This study demonstrates the evaluation of the alignment between all 7 dimensions of the model and leads to the formulation of policies aimed at reducing disparities in railway accessibility in Thailand.

The results of CFA reveal that all 37 observed variables significantly contribute to indicating inequality in access to railways across the 7 factors (cultural inequality, spatial inequality, social inequality, political inequality, knowledge inequality, economic inequality, and environmental inequality) at a statistical significance level of 0.001. [125, 126]. Furthermore, in examining the standard component weights of CFA in the second order, it was found that cultural inequality was identified as the most significant indicator contributing to the highest level of inequality in accessing railway routes.

Furthermore, for the additional 6 factors, they have been ranked in the following order of importance regarding their influence on inequality in railway access: economic inequality, social inequality, knowledge inequality, political inequality, spatial inequality, and environmental inequality. Therefore, it is evident that the structural model of this study can verify the characteristics of inequality in accessing railways. Moreover, the results from both EFA and CFA can be seen as accurately representing the opinions of railway service users. These findings can effectively reflect the issue of inequality in accessing the railway transportation system. However, it's important to note that these findings can serve as suitable guidelines for policy–makers involved in the development of railways (e.g., the Department of Rail Transport and the State Railway of Thailand). They can utilize these insights to formulate policies and development plans aimed at reducing inequality and enhancing access to the rail transportation system for the population in the country efficiently.

7. Declarations

7.1. Author Contributions

Conceptualization, K.T. and R.K.; methodology, K.T., P.W., and C.B.; software, K.T. and C.B.; validation, T.C., S.J., and P.W.; formal analysis, K.T. and R.K.; investigation, K.T.; resources, K.T. and M.S.; data curation, K.T. and M.S.; writing—original draft preparation, K.T. and R.K.; writing—review and editing, K.T., R.K., P.W., S.J., V.R., and T.C.; visualization, K.T. and R.K.; supervision, V.R., R.K. and S.J.; project administration, V.R., R.K. and S.J.; funding acquisition, V.R., R.K., and S.J. All authors have read and agreed to the published version of the manuscript.

7.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7.3. Funding

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7.4. Acknowledgements

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7.5. Institutional Review Board Statement

This research was approved by the Human Research Ethics Committee, Suranaree University of Technology (COA No. 100/2565, 01 December 2022).

7.6. Ethical Approval

The authors have obtained all the ethical approvals about this paper. The authors declare to obey all the academic ethical standards.

7.7. Conflicts of Interest

The authors declare no conflict of interest.

8. References

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