

Understanding Commuting Mode Choices in Bangkok: The Role of Sociodemographics and Urban Structure in Shaping Transportation Preferences

Wichan Choorat^{1*}, Yothin Sawangdee¹, Sureeporn Punpuing¹, and Martin Piotrowski²

¹ Institute for Population and Social Research, Mahidol University, Thailand

² Department of Sociology, Oklahoma University, USA

* Wichan Choorat, corresponding author. Email: w_ch007@hotmail.com

Submitted: 3 November 2024. Accepted: 12 March 2025. Published: 25 April 2025

Volume 34, 2026. pp. 217–235. <http://doi.org/10.25133/JPSSv342026.012>

Abstract

This study investigates commuting patterns in Bangkok between 2015 and 2023 and examines the influence of demographic, socioeconomic, and spatial factors on commuting mode choices. The microdata from the 2015 and 2023 Migration Survey from the Thailand National Statistical Office were used to identify significant shifts in age distribution, educational attainment, and employment status among commuters. The findings reveal a growing preference for private transport among older, higher-education, and higher-skilled individuals, while public transport continues to serve as a vital mode of commuting for women, employees, and lower-skilled commuters. Therefore, the development of basic infrastructure and transport systems is needed to ensure that they are equally accessible, convenient, and safe for all people. It is also essential to expand public transport routes such as buses, BTS Skytrain, and MRT subway system to the outskirts of Bangkok to reduce reliance on private cars.

Keywords

Bangkok; commuting mode choices; commuting patterns; sociodemographics

Introduction

Pursuing better economic opportunities primarily drove the rapid urbanization of the 20th century. Cities, especially capital towns, attracted migrants with the chance to more jobs, higher incomes, and access to superior services like healthcare and education. This influx has diversified the urban populations (Punyamurthy & Bheenaveni, 2023). Bangkok's rapid urbanization has significantly influenced commuting behavior, and balancing private and public transport usage is a significant challenge. Unlike cities with successfully integrated public transport systems, such as Tokyo and London, Bangkok continues to struggle with reliance on private cars, leading to severe, terrible traffic congestion, environmental degradation, and socioeconomic disparities in commuting access (Wilinski & Pathak, 2022). Previous studies have examined Bangkok's transportation infrastructure and commuting patterns and explored a comparative analysis of commuting mode choice over time, particularly in response to demographic, socioeconomic, and urban structure change (Iamtrakul et al., 2023). Understanding how sociodemographic factors influence private and public transport preferences between 2015 and 2023 is crucial for identifying policy solutions that promote sustainable and equitable urban mobility.

Thailand's population surged from 26.3 million in 1960 to more than 66 million in 2018, according to Prasartkul et al. (2018). This urbanization accelerated over time, with a 254% rise in the urban population over the past five decades. Initially, Thailand's development plans heavily focused on Bangkok, driving its expansion. However, subsequent plans have shifted attention to decentralizing industrial growth. As a result, urban growth in Bangkok and its surrounding provinces has been profound (Losiri et al., 2016). As the capital and the primary hub for government, finance, and commerce, Bangkok has attracted waves of migration. Bangkok experienced an annual population growth rate of 0.70% between 2014 and 2015, followed by a slightly lower rate of 0.64% between 2015 and 2016 (Thongchaithanawut & Tangchonlatip, 2019).

As the city expands, so do the commuting patterns of its inhabitants. Affordable housing and job opportunities are increasingly found in suburban areas like Nonthaburi and Pathum Thani, leading to more extensive travel for work. This urban expansion has created a mismatch between residential areas and job locations, known as the 'job-housing mismatch' (Rahman & Ashik, 2020). Urban sprawl has transformed land-use patterns, shifting from agriculture to residential and commercial uses (Verma et al., 2024). The demand for space, especially along transportation corridors, has driven up land prices, pushing many residents to the city's outskirts and significantly impacting commuting patterns.

The combined effects of industrialization, modernization, and transport development have led to a sharp increase in commuting, particularly in and around Bangkok. Car ownership in Bangkok far exceeds that of surrounding provinces, contributing to chronic traffic congestion, higher accident rates, and deteriorating air quality due to inadequate public transportation schemes and policies (Wilinski & Pathak, 2022). In addition, the environmental toll of increased commuting is significant. Decreased road travel speeds and worsening air pollution, particularly near main roads, are multifaceted issues influenced by increased traffic density and emissions. Traffic-related air pollution is a significant concern in urban areas, where vehicle emissions contribute to elevated levels of pollutants such as PM_{2.5}, NO₂, and SO₂, which are detrimental to air quality and public health (Khan, 2021). Jinawa and

Thepanondh (2016) highlighted that air pollution in Bangkok frequently exceeds international standards, mainly due to motor vehicle emissions.

Research on Bangkok's commuting patterns has identified various factors influencing these behaviors. Commuting modes are notably diverse and reflect the city's complex urban structure, varying by socioeconomic status, occupation type, and neighborhood characteristics. Bangkok's transportation system, characterized by a mix of public and informal modes—such as the Bangkok Mass Transit System (BTS) Skytrain, Mass Rapid Transit (MRT) subway system, buses, and motorcycle taxis—has diverse commuting options but also faces significant challenges, especially regarding accessibility, convenience, and affordability (Iamtrakul et al., 2023). Studies of commuting patterns in Bangkok thus provide valuable insights into the interplay between urban infrastructure and social equity, revealing how access to diverse transportation options can influence residential choice, economic participation, and overall quality of urban life (Wilinski & Pathak, 2022). These insights are crucial for Bangkok and other rapidly urbanizing cities in Asia and globally as they grapple with balancing efficient transportation with environmental and social goals.

Despite Bangkok's continued efforts to expand its public transportation network, car dependency remains high, particularly among certain sociodemographic groups. While previous research has analyzed urban transportation challenges (Zhou & Gao, 2020), limited attention has been given to how shifts in sociodemographic structures influence commuting preferences over time. This study addresses this gap by examining changes in commuting patterns between 2015 and 2023, identifying key demographic and socioeconomic determinants of transport mode choices, and assessing policy implications for improving Bangkok's transport system.

This study aims to investigate the changing dynamics of commuting behavior in Bangkok by analyzing the influence of demographic, socioeconomic, and geospatial factors on commuting mode preferences between 2015 and 2023. By examining public versus private transport usage differences across different population subgroups, the study provides insights into how urban and policy changes have shaped commuting choices. The findings aim to support sustainable transportation planning by identifying policy recommendations that address commuting disparities and promote an efficient, accessible transport system.

Literature review

Commuting patterns play a significant role in shaping urban mobility, influencing urban sustainability and the quality of life for its residents. As cities expand and populations grow, commuting patterns become increasingly complex, necessitating a deeper understanding of how individuals navigate their daily travels between home and the workplace. The commuting dynamics affect traffic congestion and have broader implications for environmental health, urban planning, and social equity. For instance, studies have shown that commuting behaviors are closely linked to air quality and psychological well-being, with prolonged exposure to traffic-related air pollution contributing to various health issues, including anxiety and mood disorders (Chairassamee et al., 2023; Wong et al., 2017). Furthermore, commuters' choices regarding their modes of transport can either exacerbate or alleviate urban congestion, thereby impacting overall urban sustainability (Wethayavivorn & Sukwattanakorn, 2019).

Demographic and family structure factors

Demographic characteristics, including age, gender, and household responsibilities, strongly shape commuting preferences. Witchayaphong et al. (2020) pointed out that younger individuals are more likely to use public transportation, such as rail transit, due to its affordability and convenience. In contrast, older commuters may prefer private vehicles for comfort and flexibility despite the higher costs associated with car ownership and operation. Several studies revealed that younger commuters were more likely to use public transportation or alternative modes of traveling.

Furthermore, studies indicate that women often opt for shorter commutes, primarily due to household and caregiving roles, aligning with the Household Responsibility Hypothesis, which suggests that domestic responsibilities frequently dictate women's preference for flexible transport modes, such as private vehicles (Neto et al., 2015). However, sex differences reveal that men are often more likely to commute longer distances and use private cars. In contrast, women tend to commute shorter distances, usually opting for public transportation due to household responsibilities and caregiving roles (Gimenez-Nadal & Molina, 2016). Family structure, including marital status and the presence of children, influences commuting choices due to the added need for schedule flexibility. Households with children favor private vehicles for convenience, flexibility, and control, especially when managing school or daycare drop-offs (Miao et al., 2015).

Socioeconomic factors

Socioeconomic variables, including income, employment status, and educational attainment, are critical in commuting mode selection. Education attainment influences commuting choices, as higher educational attainment is associated with higher-income employment, often in urban centers with developed public transport infrastructure. Thus, educated individuals working in urban areas may prefer public transport for cost-effectiveness in dense environments with better access to public transportation infrastructure. However, in less urbanized settings, car dependency remains prevalent among educated workers (Roos et al., 2020). Higher-income individuals frequently prefer private cars due to the associated comfort and reduced time traveling from home to the workplace. At the same time, those with lower incomes tend to rely on public transportation.

This reliance on transit, however, comes with challenges such as affordability and accessibility, especially in regions where public transit services are inconsistent or limited (Wilinski & Pathak, 2022). For example, in metropolitan areas like São Paulo and Bangkok, socioeconomic divides highlight disparities, with lower-income residents spending more time on public transit due to the increased distance to job centers and limited transit options (Pereira & Schwanen, 2015). Such patterns underscore how income disparities affect access to private transportation, impacting commuting efficiency and modal choice (Wilinski & Pathak, 2022). Homeownership is another factor impacting commuting mode choice. Homeowners in suburban or peri-urban areas often rely on private vehicles due to limited public transportation options and greater distances to urban employment centers. Conversely, renters and urban dwellers are more likely to rely on public transportation due to the higher availability of transit options in dense urban areas (Sun & Zacharias, 2020).

Geospatial and urban structure factors

Geospatial factors, including urban density and the spatial distribution of jobs and residences, influence commuting choices significantly. Individuals residing in high-density, transit-rich areas typically rely more on public transportation, while those in low-density or suburban areas favor private cars due to limited access to public transit and longer distances to work locations (Sharma & Chandrasekhar, 2016). In addition, dense urban environments with developed public transit systems encourage transit use by reducing the need for long-distance car travel. Conversely, suburban sprawl and low-density developments, where sparse public transportation often result in car dependency (Ashik et al., 2024). For instance, studies in cities like Shanghai and Beijing revealed that proximity to metro stations reduces car ownership and increases public transit use, highlighting the influence of urban design on commuting decisions (Zhang et al., 2017).

Urban structure and transportation infrastructure in Bangkok

Bangkok is not only the capital of Thailand but also the center of administration, economic activities, finance, commerce, communication, transportation, education, and health services. These pull factors attract many people from other areas to live and work in Bangkok. Also, as noted, the first three 5-year economic and social development plans focused on development in Bangkok. Consequently, Bangkok has become a primate city due to its political, economic, and commercial significance (Iamtrakul et al., 2023). Moreover, the urbanized degree of Bangkok differed from that of other provinces. The level of Bangkok's urbanization in 1960 was 82.4% and increased slightly to 86.6% in 1970. The 1980 Census found that Bangkok was 100% urban. After the decentralized development policy was formulated, other regions outside Bangkok were prioritized more. It should be noted that the greater Bangkok Metropolitan Region (BMR) includes the suburban provinces of Samut Prakan, Nonthaburi, Pathum Thani, Nakhon Pathom, and Samut Sakhon, and the BMR is also a target area for development (Chopyot & Samakeetham, 2024). As a result, the urban population in the BMR has also grown.

Bangkok's transportation infrastructure has been dramatically developing to solve problems caused by fast urban growth and more people living there. Bangkok Metropolitan Administration has developed a plan for public transport systems, road networks, and new mass transit projects to improve infrastructure and reduce traffic congestion. The roads in Bangkok include many highways, main roads, and local streets. However, Bangkok still has significant traffic jams, especially during busy times. The high number of vehicles and limited road space make it difficult, so there are always efforts to improve traffic control and road conditions (Gerdsri et al., 2022). The BTS Skytrain and MRT subway systems are Bangkok's leading public transport options. The BTS is an elevated train, while the MRT predominantly runs underground, and together, they cover large areas in the city. This makes commuting faster and more dependable for people who live in or visit Bangkok (Iamtrakul et al., 2024). These systems have been key in reducing traffic and providing other ways for people to travel without using cars.

The consequences of the rapid growth of the urban population and the number of cumulative cars registered in Bangkok reflect high population density, environmental problems, pollution, and traffic congestion. The traffic statistics report indicates that people who live in Bangkok spend more time on the road on both inbound and outbound journeys. The travel

speed on the main streets in Bangkok's outer, middle, and inner zones has slightly increased and peaked in 2021 (COVID-19 pandemic). Subsequently, the travel speed returned to normal level (Traffic and Transportation Department, 2024).

Data source and methodology

The study utilizes data from the 2015 and 2023 Migration Surveys (National Statistical Office, 2016, 2024) to provide a comparative perspective on the evolution of commuting mode choices over nearly a decade. These years were selected to capture demographic and infrastructural changes while ensuring data consistency, as methodologies and survey instruments may vary slightly across different years. Additionally, intervening years were excluded due to data availability constraints and the need to focus on two distinct time points.

The study population consists of 15–64 years commuters living in Bangkok, who worked outside of their home for at least one hour for wages/salary, profit, dividends, or any other kind of payment. Commuters aged 65 and older were excluded, as they may face health challenges or physical limitations that affect their commuting patterns, making travel less convenient. Additionally, older workers are less likely to commute regularly, often transitioning to part-time roles or flexible work arrangements that reduce the need for frequent travel. Consequently, this study focuses on the commuters aged 15–64 years. The total sample of this study was 4,653 cases in 2015 and 4,549 cases in 2023, respectively.

Table 1 presents the measurement of dependent and independent variables. The dependent variable, primary commuting mode, was determined based on the highest frequency use mode of transport. However, if multiple modes of transport were used equally, the one with the highest cost was recorded as the primary mode. Commuting modes of this study are divided into two types: private vehicles (including private cars and motorcycles) and public transport (comprising bus, train, BTS Skytrain, MRT subway system, motorcycle taxis, taxis, company buses, and boats).

The classification of commuting mode in 2015 differs slightly in 2023. In 2015, motorcycles were not categorized as private or for-hire vehicles; instead, they were generally grouped under private transport. Additionally, taxis were not explicitly classified as a distinct commuting mode but were instead included in the “other” vehicle category, which constituted a relatively small proportion. Consequently, the “other” vehicle category was excluded from the 2015 study. In contrast, the 2023 classification clearly distinguishes between motorcycles and taxis.

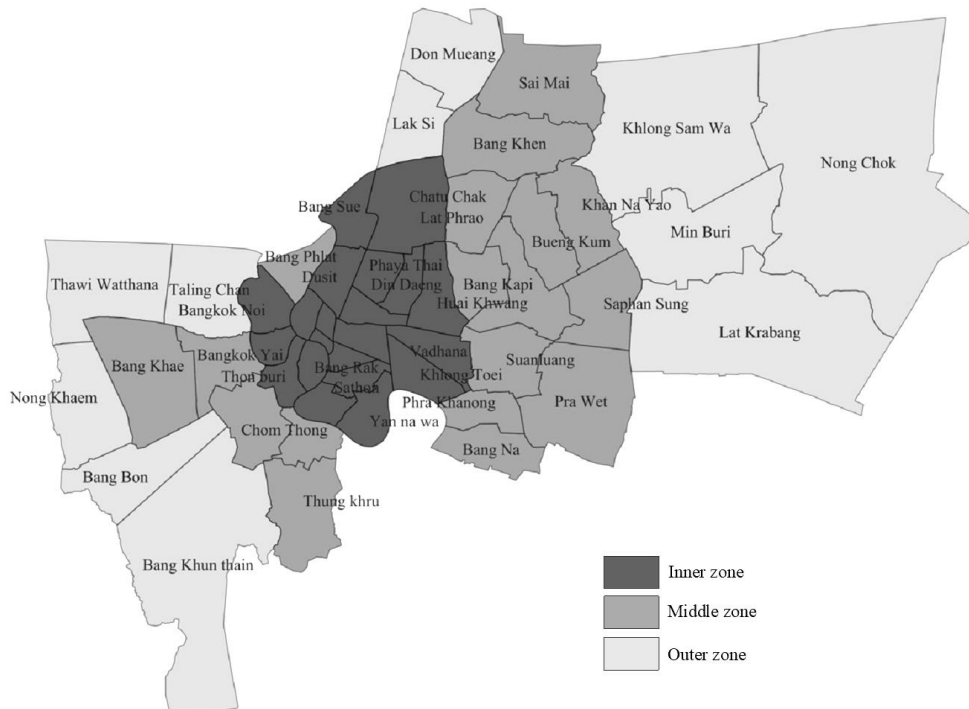
Furthermore, this study does not include active commuting modes like walking and cycling. Since the Labor Force Survey collects income data only from employed persons with employee status, other employment categories—such as employers, self-employed without employees, and unpaid family workers—are not asked about their income. Consequently, income-related variables are not included in this study.

The study's independent variables include demographic characteristics, such as age, sex, marital status, education attainment, occupational skill, employment status, dependents in the household, household ownership, Bangkok's zone, and commuter type.

Occupation is the main occupation held seven days before the survey date. The 2015 and 2023 Migration Survey used the International Standard Classification of Occupations (ISCO) as a framework (National Statistical Office, 2016, 2024), which was categorized into high, medium, and low-skilled labor professions. High-skilled labor includes those who work as legislators, senior officials and managers, professionals, technicians, and associate professionals. Medium-skilled labor includes clerks, service workers, shop/market workers, skilled agricultural and fishery workers, craft and related trades workers, and plant and machine operators and assemblers. Low-skilled labor refers to employment at the most basic level.

Figure 1 shows the inner, middle, and outer zones of Bangkok. The Department of City Planning and Urban Development, Bangkok Metropolitan Administration (BMA) divides Bangkok into inner, middle, and outer zones (Natchaphon, 2024). The inner zone is Bangkok's economic, administrative, commercial, and tourist centers, characterized by high-rise buildings, large shopping malls, convenient transportation, and important historical attractions. It comprises 21 districts. The middle zone, next to the inner zone, is a mixed residential and commercial area offering comprehensive amenities. There is continuous development, mainly residential projects such as new condominiums and housing estates. It comprises 18 districts. The outer zone, the area furthest from the inner zone, is usually suburban areas or near the border between Bangkok and neighboring provinces. However, these outer areas are continuously being developed into new housing estates and large-scale housing projects. They are, therefore, perfect for families or individuals seeking more privacy and a peaceful environment. It comprises 11 districts.

Figure 1: Bangkok Zones



Note: Authors' construction.

Furthermore, this study's commuters are classified into two categories: intra-provincial and inter-provincial. Intra-provincial commuters are employed persons who work outside the

home and whose place of residence and place of work are in Bangkok. On the other hand, the inter-provincial commuters are individuals employed outside the house, whose place of residence is in Bangkok, and whose workplace is in another province.

This study employs descriptive statistics to explore the general characteristics of commuters. At the same time, a binary logistic regression model examines the determinants of commuting mode choice, given the categorical dependent variable. The model estimates the probability (P) of using public transport ($Y = 1$) versus private transport ($Y = 0$):

$$\log \left(\frac{P(Y = 1)}{1 - P(Y = 1)} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon$$

Where X_n represents independent variables such as age, sex, marital status, education, occupation, employment status, presence of dependents in the household, household ownership, Bangkok zones, and commuter type.

Logistic regression results are reported using odds ratios rather than marginal effects because odds ratios provide an intuitive measure of how different factors affect the likelihood of choosing public transport. They make comparing findings across different research contexts easier and are more appropriate for estimating the likelihood of choosing one mode over the other.

Table 1: Measurement of Dependent and Independent Variables

Variable	Type of measurement
Dependent variable	
Commuting mode	Nominal scale 0 = Private vehicle 1 = Public transportation
Independent variable	
Age (years)	Ordinal scale 0 = 15–29 1 = 30–49 2 = 50–64
Sex	Nominal scale 0 = Male 1 = Female
Marital Status	Nominal scale 0 = Single 1 = Married
Educational attainment	Ordinal scale 0 = Primary or less 1 = Secondary 2 = Post-secondary
Occupation	Ordinal scale 0 = Low-skilled labor 1 = Medium-skilled labor 2 = High-skilled labor
Employment status	Nominal scale 0 = Employer 1 = Self-employed 2 = Employee 3 = Others

Variable	Type of measurement
Presence of dependents in the household	Nominal scale 0 = No 1 = Yes
Household ownership	Nominal scale 0 = Tenant 1 = Owner
Bangkok's zone	Nominal scale 0 = Outer zone 1 = Middle zone 2 = Inner zone
Type of commuter	Nominal scale 0 = Intra-provincial commuter 1 = Inter-provincial commuter

Results

The comparative analysis of Bangkok commuters in 2015 and 2023 highlights notable demographic and socioeconomic shifts in commuting patterns. The age distribution shows a gradual aging workforce, as the share of commuters aged 50–65 increased from 22.6% to 27.7%, while the 30–49 age group, the largest segment, declined from 56% to 51.5%. The proportion of commuters remained stable by sex, but there were significant marital status changes, with single commuters increasing from 34.5% to 39.5% and married commuters declining from 65.5% to 60.5%.

Educational attainment patterns indicate a growing diversity in commuter backgrounds. The share of commuters with secondary education increased notably from 30.3% to 38.7%, while those with primary or less and post-secondary education declined. Occupational trends reveal a rise in low- and medium-skilled labor, while high-skilled commuters declined from 33.1% to 26.4%, reflecting potential labor market shifts.

Household structures also changed significantly. The proportion of commuters without dependents increased sharply from 49% to 72.3%, while homeownership dropped from 58.4% to 43%, with tenancy rising to 57%. Geographically, outer-zone commuters declined, and intra-provincial commuting slightly increased, emphasizing a growing concentration of commuters within Bangkok's metropolitan areas. Shifting to commuting modes from home to the workplace, using private vehicles slightly increased from 74% in 2015 to 75.3% in 2023. On the other hand, using public transportation gradually decreased from 26% to 24.7%.

Table 2: Number and Percentage of Commuters Living in Bangkok, 2015 and 2023

Characteristic	2015		2023	
	Number	%	Number	%
Total	4,653	100.0	4,549	100.0
Age (years)				
15–29	993	21.3	948	20.8
30–49	2,608	56.0	2,343	51.5
50–65	1,052	22.6	1,258	27.7
Sex				
Male	2,429	52.2	2,378	52.3
Female	2,224	47.8	2,171	47.7

Characteristic	2015		2023	
	Number	%	Number	%
Marital Status				
Single	1,606	34.5	1,797	39.5
Married	3,047	65.5	2,752	60.5
Educational attainment				
Primary or less	1,233	26.5	1,050	23.1
Secondary	1,412	30.3	1,759	38.7
Post-secondary	2,008	43.2	1,740	38.3
Occupation				
Low-skilled labor	473	10.2	570	12.5
Medium-skilled labor	2,639	56.7	2,778	61.1
High-skilled labor	1,541	33.1	1,201	26.4
Employment status				
Employer	174	3.7	123	2.7
Self-employed	955	20.5	960	21.1
Employee	3,517	75.6	3,465	76.2
Others	7	.2	1	.0
Presence of dependents in the household				
No	2,278	49.0	3,291	72.3
Yes	2,375	51.0	1,258	27.7
Household ownership				
Tenant	1,937	41.6	2,594	57.0
Owner	2,716	58.4	1,955	43.0
Bangkok's zone				
Outer zone	1,426	30.6	1,225	26.9
Middle zone	1,909	41.0	1,902	41.8
Inner zone	1,318	28.3	1,422	31.3
Type of commuter				
Intra-provincial commuters	4,543	97.6	4,474	98.4
Inter-provincial commuters	110	2.4	75	1.6
Commuting mode				
Private	3,442	74.0	3,425	75.3
Public	1,211	26.0	1,124	24.7

Table 3 presents the commuting mode choices of Bangkok's workforce, highlighting notable shifts in transport preferences between 2015 and 2023. The results indicate a slight decline in public transport use, from 26% in 2015 to 24.7% in 2023, alongside an increase in private transport use from 74% to 75.3%. These changes, however, vary across demographic, socioeconomic, and spatial characteristics.

Age remains a key factor influencing commuting choices. Younger commuters, mainly those aged 15–29 and 30–49, were more likely to use public transport, though their reliance decreased slightly over time. Meanwhile, older commuters (50–65) remained highly dependent on private vehicles, increasing usage from 81.5% in 2015 to 82.2% in 2023. Gender differences in commuting mode were evident in both years. Males predominantly relied on private transport, with usage rising from 83.2% to 86.1%, whereas females were more likely to use public transport, maintaining a stable share of around 36%. Marital status also played a role, as single commuters were more likely to use public transport. At the same time, married individuals increasingly opted for private transport, likely due to family responsibilities requiring greater commuting flexibility.

Education attainment influenced commuting behavior as well. Public transport use increased slightly among those with primary education or less, whereas it declined among secondary-educated commuters from 27.1% to 21.5%. Interestingly, post-secondary commuters showed a marginal increase in public transport use from 26.8% to 27.6%. Occupational differences were also apparent, as low-skilled laborers increased their use of public transport while medium-skilled laborers shifted toward private transport. Household structure played a role in commuting mode, with public transport use declining among those with dependents. Additionally, geographic location influenced transport choices, as public transport use increased in the inner city while decreasing in the outer and middle zones, reflecting improvements in transit infrastructure and persistent long-distance commuting challenges.

Table 3: Percentage of Commuters Using Private and Public Transport, 2015 and 2023

Characteristic	2015			2023		
	Private (%)	Public (%)	Total (Number)	Private (%)	Public (%)	Total (Number)
Total	74.0	26.0	4,653	75.3	24.7	4,549
Age (years)						
15–29	62.7	37.3	993	63.4	36.6	948
30–49	75.2	24.8	2,608	76.4	23.6	2,343
50–64	81.5	18.5	1,052	82.2	17.8	1,258
Sex						
Male	83.2	16.8	2,429	86.1	13.9	2,378
Female	63.9	36.1	2,224	63.4	36.6	2,171
Marital Status						
Single	64.3	35.7	1,606	64.3	35.7	1,797
Married	79.1	20.9	3,047	82.4	17.6	2,752
Educational attainment						
Primary or less	76.5	23.5	1,233	74.7	25.3	1,050
Secondary	72.9	27.1	1,412	78.5	21.5	1,759
Post-secondary	73.2	26.8	2,008	72.4	27.6	1,740
Occupation						
Low-skilled labor	68.1	31.9	473	64.2	35.8	570
Medium-skilled labor	73.9	26.1	2,639	78.4	21.6	2,778
High-skilled labor	76.0	24.0	1,541	73.4	26.6	1,201
Employment status						
Employer	94.3	5.7	174	96.7	3.3	123
Self-employed	92.8	7.2	955	94.9	5.1	960
Employee	67.9	32.1	3,524	69.1	30.9	3,465
Presence of dependents in the household						
No	71.5	28.5	2,278	73.0	27.0	3,291
Yes	76.3	23.7	2,375	81.3	18.7	1,258
Household ownership						
Tenant	69.3	30.7	1,937	70.5	29.5	2,594
Owner	77.3	22.7	2,716	81.6	18.4	1,955
Bangkok's zone						
Outer zone	72.2	27.8	1,426	78.0	22.0	1,225
Middle zone	72.8	27.2	1,909	77.1	22.9	1,902
Inner zone	77.6	22.4	1,318	70.5	29.5	1,422
Type of commuter						
Intra-provincial commuters	74.0	26.0	4,543	75.5	24.5	4,474
Inter-provincial commuters	73.6	26.4	110	64.0	36.0	75

Factors affecting public transport use

We now present a logistic regression analysis of the demographic, socioeconomic, and geographic characteristics factors influencing the likelihood of using public transport compared to private transport for Bangkok's commuters in 2015 and 2023.

Table 4 indicates that the influence of the age group of commuters on public transport usage over time showed a different pattern over time. Compared to commuters aged 15–29, those aged 30–49 and 50–65 were significantly less likely to use public transport. The odds for these age groups were 0.825 and 0.862 times in 2015 and 0.747 times in 2023, with statistical significance at the .05 and .01 levels, respectively. These findings suggest that older commuters increasingly prefer private modes of transport. Thus, this could be attributed to higher disposable income, greater access to private vehicles, or a preference for flexibility, convenience, and offering as they advance in their careers and family responsibilities.

In addition, gender plays a significant role in predicting public transport use. In 2015 and 2023, female commuters were substantially more likely than male commuters to use public transport, with odds ratios of 2.958 and 3.737 times as high, respectively, both significant at the .001 level. This consistent and strong association highlights that women remain significantly more dependent on public transport than men. This could be due to socioeconomic factors, such as income disparities, practical considerations, convenience, fewer opportunities to own or use private vehicles, or household responsibilities.

Furthermore, marital status indicated a significant negative association with public transport use. Married commuters were considerably less likely to use public transport in 2015 and 2023, with odds ratios of 0.510 and 0.411 times, respectively, significant at the .001 level. The decreasing likelihood of using public transport among married individuals could reflect increased household incomes, enabling car ownership, or a need for greater flexibility in commuting, particularly for family-related responsibilities. Therefore, this trend reinforces the notion that married individuals may prioritize the convenience and autonomy of private transport as their household and work demands grow.

The influence of education on public transport usage shifted slightly between 2015 and 2023. In 2015, the odds ratios for those with secondary or post-secondary education showed no significant difference from the reference group (primary education or less). However, commuters with secondary and post-secondary education were significantly less likely to use public transport, with odds ratios of 0.72 and 0.77 times, respectively, in 2023. The decline in public transport use among more educated individuals suggests that education may be associated with higher-income jobs or access to private vehicles, mainly as educational attainment correlates with economic status. This shift highlights the potential impact of income and status on commuting choices, with more educated individuals increasingly favoring private transport.

In terms of occupation, high-skilled laborers were significantly less likely to use public transport in both years, with the odds being 0.647 times in 2015 and 0.687 times in 2023, both statistically significant. Medium-skilled laborers also showed a reduced likelihood in 2023, with odds being 0.749 times. These results suggest that as commuters move into higher-skilled or more specialized occupations, their reliance on private transport increases. This trend may be linked to the higher income levels associated with these occupations and the necessity for flexible work hours or travel routes.

Focusing on employment status, the results indicate that it substantially affected public transport usage. Compared with employers, employees were significantly more likely to use public transport, with the odds being 4.964 times in 2015 and 6.463 times in 2023, significant at the .001 level. Employees' strong preference for public transport is likely due to their fixed work locations and schedules, which align well with public transport routes and timetables. This consistent relationship across both years underscores the importance of public transport in serving Bangkok's working population, especially for those who may not have the means or need for private vehicles.

In 2015 and 2023, homeowners were less likely to use public transport than tenants, with odds ratios of 0.676 and 0.577, respectively, both significant at the .001 level. Homeownership is often associated with higher economic status and access to private transport. The decline in public transport use among homeowners may also reflect suburban living, where public transport infrastructure is less comprehensive, thus pushing homeowners towards private vehicles.

The zones of Bangkok in which commuters resided had varying effects on public transport use. In 2015, residents of the inner zone were significantly less likely to use public transport (odds ratio 0.697), but this association became positive, though not statistically significant, in 2023. The middle zone did not show a significant difference in either year. Furthermore, the intra- versus inter-provincial commuting patterns significantly differed in 2023. Inter-provincial commuters were significantly more likely to use public transport (odds ratio 1.867).

Table 4: Logistic Regression Models of Probabilities of Using Public Transport

Characteristic	2015		2023	
	Coefficients	Odds-ratios	Coefficients	Odds-ratios
Age (years) (Ref: 15–29)				
30–49	-0.192	0.825*	-0.291	0.747**
50–65	-0.149	0.862	-0.292	0.747*
Sex (Ref.: Male)				
Female	1.084	2.958***	1.318	3.737***
Marital Status (Ref.: Single)				
Married	-.673	.510***	-0.890	0.411***
Educational attainment (Ref.: Primary or less)				
Secondary	.088	1.092	-0.329	0.72**
Post-secondary	.042	1.043	-0.261	0.77*
Occupation (Ref.: Low-skilled labor)				
Medium-skilled labor	.097	1.102	-0.289	0.749*
High-skilled labor	-.435	.647**	-0.375	0.687*
Employment status (Ref.: Employer)				
Self-employed	-0.141	0.869	-0.073	0.93
Employee	1.602	4.964***	1.866	6.463***
Presence of dependents in the household (Ref.: No)				
Yes	-0.020	0.981	-0.130	0.878
Household ownership (Ref.: Tenant)				
Owner	-0.392	0.676***	-0.551	0.577***
Bangkok's zone (Ref.: Outer zone)				
Middle zone	-0.091	0.913	-0.038	0.963
Inner zone	-0.361	0.697***	0.175	1.191
Type of commuter (Ref.: Intra-provincial commuters)				
Inter-provincial commuters	0.004	1.004	0.625	1.867*

Characteristic	2015		2023	
	Coefficients	Odds-ratios	Coefficients	Odds-ratios
Intercept	-2.002		-2.048	
Chi-Square	708.226		920.619	
Degrees of freedom	15		15	

*Note: * Significant at the .05 level; ** .01 level; *** .001 level*

Study limitations

While this study provides valuable insights into commuting mode choices in Bangkok, several limitations must be acknowledged. First, the data are pooled cross-sectional, meaning that while comparisons between 2015 and 2023 offer essential insights into shifting aggregate commuting patterns, they do not track individual-level changes over time. As such, the observed trends should not be interpreted as causal shifts in individual preferences, requiring panel data and a difference-in-differences (diff-in-diff) model to correctly estimate longitudinal changes. Future research could adopt a panel-based approach to validate these findings further.

Second, while the sample is drawn from nationally representative surveys, it may not fully capture all the complexities of Bangkok's diverse commuting population, particularly informal transport users or those outside the formal labor market. The study focuses only on Bangkok, limiting its direct applicability to other urban contexts. However, the insights remain relevant to cities facing similar urban mobility challenges, such as Jakarta, Manila, and São Paulo, where rapid urbanization and congestion are persistent issues.

Discussion and conclusion

This study examines the demographic, socioeconomic, and geographic characteristics influencing the preference for public transport compared to private transport in Bangkok. However, the findings of this study could apply to cities globally with limited public transport infrastructure or high traffic congestion. The insights derived from Bangkok's commuting behaviors offer broader relevance, particularly for rapidly urbanizing regions where sustainable transportation is a growing concern. Key findings highlight the influence of age, gender, marital status, education, and occupation on the preference for using public versus private transport. The significant decline in public transport use among older commuters, particularly those aged 30–49 and 50–65, between 2015 and 2023, highlights the shifting preference towards private transport with increasing age.

This trend aligns with findings from similar European studies, suggesting that older commuters are often potentially due to rising incomes and lifestyle changes that prefer car ownership (Luiu et al., 2018; Truong & Somenahalli, 2015). Similar patterns are seen globally; older commuters prefer the comfort and convenience of private vehicles as they age (Yatmar et al., 2021; Zakaria et al., 2024; Zhang & Yang, 2024). Notably, this study highlights a growing gender disparity, where females were significantly more likely to use public transport than males in both years, further reflecting gendered differences in travel behavior, as women may be more likely to prioritize cost savings and safety associated with public transport (Pourhashem et al., 2022; Saigal et al., 2023). This trend has been highlighted in Ethiopia,

where women dominate using public transport because of financial considerations and safety concerns (Uteng, 2021).

The persistent effect of marital status, with married individuals consistently preferring private transport, underscores the complexities of household decision-making. Married commuters often have additional responsibilities, such as family logistics, that favor the flexibility of private cars (Whittle et al., 2022; Zhang, 2020). Additionally, the increasing association between higher educational attainment and private transport use over time indicates that more educated individuals might have better access to resources, enabling them to afford private vehicles (McDonald & Mirman, 2022; Rachele et al., 2015). This aligns with the study in Shanghai; higher education attainment may correlate with private transportation (Yue et al., 2024).

Occupational status also emerged as a critical factor, with high- and medium-skilled laborers increasingly shifting to private transport. This reflects broader socioeconomic dynamics, where individuals in higher-skilled occupations may have greater financial means to own and operate private vehicles, mirroring patterns observed in other urban environments (Aghdam et al., 2021). Meanwhile, the growing preference for public transport among employees, especially those in lower-skilled jobs, suggests that public transport remains essential for economically disadvantaged groups. A study in Cape Town also found a similar trend: higher-skilled individuals may have better access to private vehicles due to greater financial means (Aivinyhenyo & Zuidgeest, 2019).

Regarding spatial dynamics, the shift in public transport use in Bangkok's inner zone, especially the increased likelihood of using public transport by 2023, could indicate improvements in urban infrastructure. This aligns with similar trends in global cities, where improved accessibility fosters greater reliance on public transit (Kyaing et al., 2020). The growing use of public transport by inter-provincial commuters further underscores the role of expanded long-distance transport options, such as rail and bus networks, which have made public transport more appealing for longer commutes and improved satisfaction and efficiency (Zhao et al., 2022).

This study highlights the evolving nature of commuting preferences in Bangkok between 2015 and 2023, shaped by demographic, socioeconomic, and spatial factors. The findings reveal a growing preference for private transport among older, higher-education, and higher-skilled individuals, while public transport continues to serve as a vital mode of commuting for women, employees, and lower-skilled commuters. Therefore, the development of basic infrastructure and transport systems is needed to ensure that they are equally accessible, convenient, and safe for all people. It is also essential to expand public transport routes such as buses, BTS, and MRT to the outskirts of Bangkok to reduce reliance on private cars.

The findings highlight the need for targeted public transport policies to address disparities in commuting accessibility. Specifically, expanding last-mile connectivity options, such as park-and-ride systems and feeder buses, could encourage older commuters and high-income workers to increasingly rely on private vehicles to use public transport. Additionally, as public transport remains the dominant choice for women, employees, and lower-skilled workers, policies should prioritize affordability, safety, and service reliability to ensure continued accessibility. The expansion of MRT and BTS routes to Bangkok's outskirts, particularly in rapidly growing suburban areas such as Nonthaburi, Pathum Thani, and Samut Prakan, is also essential to reduce job-housing mismatches and commuting burdens on lower-income workers.

The insights from this study are relevant to Bangkok and other rapidly urbanizing cities with high traffic congestion and uneven public transport accessibility. In particular, cities in Southeast Asia and Latin America, such as Jakarta, Manila, and São Paulo, share similar urban sprawl dynamics and a high reliance on private vehicles due to limited public transit integration. Findings on the demographic disparities in commuting behavior, particularly the gendered use of public transport and the shift toward private vehicles among older and higher-income commuters, align with trends observed in cities facing comparable challenges (Uteng, 2021; Zhao et al., 2022). This suggests that targeted interventions – such as subsidized public transport schemes for vulnerable populations and incentives for carpooling or ride-sharing- could benefit Bangkok and similar urban contexts.

Although the statistical association between Bangkok's zones and commuting mode choice was weak, observable trends suggest potential implications. The slight increase in public transport use in the inner zone by 2023 may reflect improvements in transit accessibility, such as expansions in the metro and bus systems, or increased urban density that enhances the feasibility of public transport. Conversely, the lack of significant differences in the middle and outer zones suggests that challenges such as limited connectivity, travel time constraints, or continued reliance on private vehicles may persist.

These findings highlight the importance of considering long-term infrastructure developments and commuter preferences when analyzing transport mode choices. Future research could benefit from incorporating additional variables, such as transit service expansions, congestion levels, and commuter satisfaction, to understand better the evolving role of spatial factors in Bangkok's transport landscape.

Ethical considerations

The IPSR-Institutional Review Board (IPSR-IRB) of the Institute for Population and Social Research, Mahidol University (COE. No. 2017/08-175) reviewed and approved this study.

Acknowledgments

This work was supported by the Thailand Science Research and Innovation (TSRI) through the Royal Golden Jubilee (RGJ) Ph.D. Program (Grant no. PHD/0077/2557) with the help of Mr. Wichan Choorat and Mr. Yothin Sawangdee. We sincerely thank the Thailand National Statistical Office for approving and providing the microdata from the Migration Surveys conducted in 2015 and 2023. This valuable information has been instrumental to our study, and we appreciate the Office's generous support and assistance.

References

- Aghdam, F. B., Sadeghi-Bazargani, H., Shahsavarinia, K., Jafari, F., Jahangiry, L., & Gilani, N. (2021). Investigating the COVID-19 related behaviors in the public transport system. *Archives of Public Health*, 79(1), Article 183. <https://doi.org/10.1186/s13690-021-00702-4>
- Aivinhenyo, I., & Zuidgeest, M. (2019). Transport equity in low-income societies: Affordability impact on destination accessibility measures. In K. Lucas, K. Martens, F. Di Ciommo, & A. Dupont-

- Kieffer (Eds.), *Measuring transport equity* (pp. 111–128). Elsevier. <https://doi.org/10.1016/B978-0-12-814818-1.00007-X>
- Ashik, F. R., Rahman, H., Zafri, N. M., Antipova, A., & Labib, S. M. (2024). Car ownership, commute distance, and commute mode choice in the dense megacity of a developing country: The direct and indirect role of the built environment. *Transportation Research Record*, 2678(12), 1923–1938. <https://doi.org/10.1177/03611981241253578>
- Chairassamee, N., Chanchaoenchai, K., & Saraithong, W. (2023). How commuting choices affect physical and mental health: A case study of Bangkok, Thailand. *Kasetsart Journal of Social Sciences*, 44(4), 1257–1272. <https://doi.org/10.34044/j.kjss.2023.44.4.30>
- Chopyot, S., & Samakeetham, S. (2024). The discourse of decentralization in Thailand: A study of political, administrative, and financial aspects. *International Journal of Religion*, 5(12), 650–660. <https://doi.org/10.61707/rwrhfw54>
- Gerdasri, N., Sivara, K., Chatunawarat, C., Jaroonjitsathian, S., & Tundulyasaree, K. (2022). Roadmap for future mobility development supporting Bangkok urban living in 2030. *Sustainability*, 14(15), Article 9296. <https://www.mdpi.com/2071-1050/14/15/9296>
- Giménez-Nadal, J. I., & Molina, J. A. (2016). Commuting time and household responsibilities: Evidence using propensity score matching. *Journal of Regional Science*, 56(2), 332–359. <https://doi.org/10.1111/jors.12243>
- Iamtrakul, P., Padon, A., Chayphong, S., & Hayashi, Y. (2024). Unlocking urban accessibility: Proximity analysis in Bangkok, Thailand's mega city. *Sustainability*, 16(8), Article 3137. <https://www.mdpi.com/2071-1050/16/8/3137>
- Iamtrakul, P., Padon, A., & Klaylee, J. (2023). Measuring spatializing inequalities of transport accessibility and urban development patterns: Focus on megacity urbanization, Thailand. *Journal of Regional and City Planning*, 33(3), 345–366. <https://doi.org/10.5614/jpwk.2022.33.3.4>
- Jinawa, L., & Thepanondh, S. (2016). Success of fuel quality improving policy in reducing benzene air concentrations in Bangkok. *International Journal of GEOMATE*, 11(24), 2341–2347. <https://doi.org/10.21660/2016.24.1196>
- Khan, M. A. M. (2021). A review of traffic-related air pollution. *International Journal of Engineering*, 8(6), 11761–11766. <https://doi.org/10.34259/IJEW.21.806175179>
- Kyaing, T. A., Lwin, K. K., & Sekimoto, Y. (2020). An investigation of socioeconomic and land use influence on car ownership in Yangon City. *Journal of Disaster Research*, 15(3), 416–425. <https://doi.org/10.20965/jdr.2020.p0416>
- Losiri, C., Nagai, M., Ninsawat, S., & Shrestha, R. P. (2016). Modeling urban expansion in Bangkok Metropolitan Region using demographic-economic data through cellular automata-Markov chain and multi-layer perceptron-Markov chain models. *Sustainability*, 8(7), Article 686. <https://doi.org/10.3390/su8070686>
- Luiu, C., Tight, M., & Burrow, M. (2018). Factors preventing the use of alternative transport modes to the car in later life. *Sustainability*, 10(6), Article 1982. <https://www.mdpi.com/2071-1050/10/6/1982>
- McDonald, C. C., & Mirman, J. H. (2022). Achieving transportation equity: How can we support young people's autonomy and health in a rapidly changing society? *Journal of Adolescent Health*, 70(5), 701–702. <https://doi.org/10.1016/j.jadohealth.2022.02.007>
- Miao, Q., Bouchard, M., Chen, D., Rosenberg, M. W., & Aronson, K. J. (2015). Commuting behaviors and exposure to air pollution in Montreal, Canada. *Science of The Total Environment*, 508, 193–198. <https://doi.org/10.1016/j.scitotenv.2014.11.078>
- Natchaphon, B. (2024, September 13). Krung Thep baeng phuenthi yang ngai: Son nai yu? Khet chan nok, chan klang, chan nai, ma du kan [How is Bangkok divided? Which zones are outer, middle, and inner districts?]. *Sanook.com*. <https://www.sanook.com/campus/1426579/>
- National Statistical Office. (2016). *Rai-ngan kan samruat kan yai thi thi 2558* [The 2015 Migration Survey]. https://www.nso.go.th/nsoweb/storage/survey_detail/2023/20230501004434_35447.pdf
- National Statistical Office. (2024). *Rai-ngan kan samruat kan yai thin khong prachakon Phō.Sō. 2566* [The 2023 Migration Survey]. https://www.nso.go.th/nsoweb/storage/survey_detail/2024/20240308121915_29708.pdf
- Neto, R. S., Duarte, G., & Paéz, A. (2015). Gender and commuting time in São Paulo Metropolitan Region. *Urban Studies*, 52(2), 298–313. <https://doi.org/10.1177/0042098014528392>

- Pereira, R. H. M., & Schwanen, T. (2015). *Commute time in Brazil (1992–2009): Differences between metropolitan areas, by income levels and gender* (Discussion Paper No. 192). Institute for Applied Economic Research (IPEA). https://repositorio.ipea.gov.br/bitstream/11058/5140/1/DiscussionPaper_192.pdf
- Pourhashem, G., Malichová, E., Piscová, T., & Kováčiková, T. (2022). Gender difference in perception of value of travel time and travel mode choice behavior in eight European countries. *Sustainability*, 14(16), Article 10426. <https://www.mdpi.com/2071-1050/14/16/10426>
- Prasartkul, P., Thaweesit, S., & Chuanwan, S. (2018). Prospects and contexts of demographic transitions in Thailand. *Journal of Population and Social Studies*, 27(1), 1–22. <https://doi.org/10.25133/JPSv27n1.001>
- Punnamurthy, C., & Bheenaveni, R. S. (2023). Urbanization in India: An overview of trends, causes, and challenges. *International Journal of Asian Economic Light*, 11(1), 9–20. <https://doi.org/10.36713/epra12473>
- Rachele, J. N., Kavanagh, A. M., Badland, H., Giles-Corti, B., Washington, S., & Turrell, G. (2015). Associations between individual socioeconomic position, neighbourhood disadvantage and transport mode: Baseline results from the HABITAT multilevel study. *Journal of Epidemiology and Community Health*, 69(12), 1217–1223. <https://doi.org/10.1136/jech-2015-205620>
- Rahman, H., & Ashik, F. R. (2020). Is neighborhood-level jobs-housing balance associated with travel behavior of commuters? A case study on Dhaka City, Bangladesh. *GeoScape*, 14(2), 122–133. <https://doi.org/10.2478/GEOSC-2020-0011>
- Roos, J. M., Sprei, F., & Holmberg, U. (2020). Sociodemography, geography, and personality as determinants of car driving and use of public transportation. *Systems Research and Behavioral Science*, 10(6), Article 93. <https://doi.org/10.3390/bs10060093>
- Saigal, T., Vaish, A. K., & Rao, N. (2023). Gender gap in travel behaviour and public opinion on proposed policy measures: Evidence from India. *International Social Science Journal*, 73(247), 51–71. <https://doi.org/10.1111/issj.12391>
- Sharma, A., & Chandrasekhar, S. (2016). Impact of commuting by workers on household dietary diversity in rural India. *Food Policy*, 59, 34–43. <https://doi.org/10.1016/j.foodpol.2015.11.005>
- Sun, Z., & Zacharias, J. (2020). Do housing tenure and public transport provision matter in automobile use in bedroom suburban communities? Evidence from Beijing. *Journal of Housing and the Built Environment*, 36, 241–262. <https://doi.org/10.1007/s10901-020-09748-2>
- Thongchaithanawut, M., & Tangchonlatip, K. (2019). Population dynamics in the Bangkok Metropolitan Region during the period 2014–2016. *Journal of Demography*, 35(2), Article 1313. <https://doi.org/10.56808/2730-3934.1313>
- Traffic and Transportation Department. (2024). *Satiti charatrot pi 2566* [Traffic statistics in 2023]. Bangkok Metropolitan Administration. <https://traffic.bangkok.go.th/TrafficINFO/StatBook/2566/2566small.pdf>
- Truong, L. T., & Somenahalli, S. V. C. (2015). Exploring frequency of public transport use among older adults: A study in Adelaide, Australia. *Travel Behaviour and Society*, 2(3), 148–155. <https://doi.org/10.1016/j.tbs.2014.12.004>
- Uteng, T. P. (2021). Chapter Two – Gender gaps in urban mobility and transport planning. In R. H. M. Pereira & G. Boisjoly (Eds.), *Advances in Transport Policy and Planning* (Vol. 8, pp. 33–69). Academic Press. <https://doi.org/10.1016/bs.atpp.2021.07.004>
- Verma, P., Jangra, R., & Kaushik, S. (2024). Geospatial measurement of urban sprawl and land transformation using multi-temporal datasets: A case study of Sonapat-Kundli urban agglomeration. *Sustainable Environment*, 10(1), Article 2366556. <https://doi.org/10.1080/27658511.2024.2366556>
- Wethyavivorn, P., & Sukwattanakorn, N. (2019). Problems and barriers affecting sustainable commuting: Case study of people’s daily commute to Kasetsart University, Bangkok, Thailand. *IOP Conference Series: Earth and Environmental Science*, 329(1), Article 012011. <https://doi.org/10.1088/1755-1315/329/1/012011>
- Whittle, C., Whitmarsh, L., Nash, N., & Poortinga, W. (2022). Life events and their association with changes in the frequency of transport use in a large UK sample. *Travel Behaviour and Society*, 28, 273–287. <https://doi.org/10.1016/j.tbs.2022.04.007>

- Wilinski, K., & Pathak, S. (2022). Mobility in the developing country. The case study of Bangkok Metropolitan Region. *Communications - Scientific Letters of the University of Zilina*, 24(3), A112–A122. <https://doi.org/10.26552/com.C.2022.3.A112-A122>
- Witchayaphong, P., Pravinvongvuth, S., Kanitpong, K., Sano, K., & Horpibulsuk, S. (2020). Influential factors affecting travelers' mode choice behavior on mass transit in Bangkok, Thailand. *Sustainability*, 12(22), Article 9522. <https://doi.org/10.3390/su12229522>
- Wong, L. P., Alias, H., Aghamohammadi, N., Ghadimi, A., & Sulaiman, N. M. N. (2017). Control measures and health effects of air pollution: A survey among public transportation commuters in Malaysia. *Sustainability*, 9(9), Article 1616. <https://www.mdpi.com/2071-1050/9/9/1616>
- Yatmar, H., Ramli, M. I., Pasra, M., Gusfiadi, & Dharmowijoyo, D. B. E. (2021). The impact of socio-demographic and activity-travel participation variables on mode choice preference of sub-urban commuters: A case study on the new railway operation in Maros-Makassar line. In B. S. Mohammed, N. Shafiq, S. R. M. Kuty, H. Mohamad, & A.-L. Balogun (Eds.), *ICCOEE2020. Lecture Notes in Civil Engineering* (Vol. 132, pp. 945–955). Springer Singapore. https://doi.org/10.1007/978-981-33-6311-3_107
- Yue, L., Niedzielski, M. A., & O'Kelly, M. E. (2024). Modal disparity in commuting efficiency: A comparison across educational worker subgroups in Shanghai. *Cities*, 147, Article 104790. <https://doi.org/10.1016/j.cities.2024.104790>
- Zakaria, A. M., Kamaluddin, N. A., Hashim, W., & D'Agostino, C. (2024). Age-inclusive transit environments: An exploration of public transportation systems for elderly. *Environment-Behaviour Proceedings Journal*, 9(28), 149–158. <https://doi.org/10.21834/e-bpj.v9i28.5906>
- Zhang, J. (2020). Residential location and commuting mode choices: Intrahousehold interaction modeling and its implications for energy policy. In J. Zhang (Ed.), *Transport and Energy Research* (pp. 155–175). Elsevier. <https://doi.org/10.1016/B978-0-12-815965-1.00007-7>
- Zhang, N., & Yang, Q. (2024). Public transport inclusion and active aging: A systematic review on elderly mobility. *Journal of Traffic and Transportation Engineering (English Edition)*, 11(2), 312–347. <https://doi.org/10.1016/j.jtte.2024.04.001>
- Zhang, Y., Zheng, S., Sun, C., & Wang, R. (2017). Does subway proximity discourage automobility? Evidence from Beijing. *Transportation Research Part D: Transport and Environment*, 52, 506–517. <https://doi.org/10.1016/j.trd.2016.11.009>
- Zhao, X., Zhang, Z., Guo, W., Zhou, Y., Papaix, C., & Sun, Q. (2022). Evidence-based smart transition strategies for long-distance commuters in Beijing. *Frontiers in Future Transportation*, 3, Article 884949. <https://doi.org/10.3389/ffutr.2022.884949>
- Zhou, H., & Gao, H. (2020). The impact of urban morphology on urban transportation mode: A case study of Tokyo. *Case Studies on Transport Policy*, 8(1), 197–205. <https://doi.org/10.1016/j.cstp.2018.07.005>