Research Paper

Understanding metro commuters' stopover behavior at commercial complexes around transfer stations

A case study of Shanghai, China

Xuejun BAI, Tongji University, China

Zhendong WANG, Tongji University, China

Abstract

As the night-time economy expands, the concept of the 24-hour city reshapes urban travel patterns and lifestyle. Digital service technologies affect travellers' decisions and awareness during mobility. Compact city and transit-oriented development (TOD) are key pathways for sustainable growth in high-density cities. Shanghai possesses the second largest metro network in China, with increasing number of transfer stations. Most of these stations are surrounded by commercial complexes. Understanding the changes of metro transfer commute help to transform transit hubs into life hubs. However, existing studies mainly focus on travel mode choice, overlooking stopovers of public transport. Researchers have discussed the impact of socio-demographic attributes and the built environment of residence and workplace on the stopovers. But few studies consider the attitudes of commuters and the spatial characteristic of stopover locations. Recently, metro smartcard data and mobile signalling data are increasingly used in travel research. However, these data cannot capture individual transfer paths due to limited granularity and privacy. The basic regressions cannot capture the complicated interactions between psychological and environmental factors. Thus, this research incorporates environment and policy variables into the Decomposed Theory of Planned Behavior (DTPB). Then, the study employs Structural Equation Modelling (SEM) and a Multiple Indicator Multiple Cause (MIMIC) model to explore the mechanisms shaping stopover intentions. This study conducted an online questionnaire survey of 721 Shanghai metro users between 2024 and 2025. The results of SEM model confirm that commercial complexes can attract metro commuters to make stops, primarily for shopping, catering, and using public facilities such as restroom. The findings reveal that attitude is the decisive factor influencing intention. The attitude can be improved by enhancing the convenience of stopover, perceived usefulness to commuters and the comfort of spaces, as well as optimizing transfer policies. Meanwhile, convenience condition, favourable evaluation, short distance, high accessibility, density and diversity also strengthen intention. Moreover, digital service platforms serve as components of perceived behavioral control and subjective norm significantly enhancing intentions. For instance, enhancing the availability of digital tools, the visibility of complexes on navigation platforms, and the perceptibility of complexes on social media. The results of MIMIC model confirm that there exists group heterogeneity across socio-demographic attributes, usage characteristic and psychological variables. Findings offer practical insights for governments, metro operators and commercial developers to promote rail transit-commercial synergy. The research supports compact and equitable urban development in the context of 24-hour cities.

Keywords

TOD, Stopover, DTPB, SEM, MIMIC

1. Introduction

Amid the rise of urban life rhythms and the expansion of the night economy, the concept of 24-hour cities is gradually evolving into an important strategy for global metropolises to enhance vitality and promote consumption. The rise in remote work and the demand for round-the-clock services have disrupted traditional work and lifestyle patterns. Improved basic service facilities and public transportation systems have changed the previous travel patterns, providing a safe and powerful travel system for 24-hour cities. What's more, digital service platforms can help citizens achieve efficient amd convenient travel, such as intelligent navigation and social media APP. They can assist travelers in shaping location and route decisions and enhance their perception of the surrounding environment and background information. Thereby transforming passive travel into an active experience.

With the accelerating pace of global urbanization, the transition toward compact cities has become a key strategy for achieving structural sustainability in urban development (Aoki, 2023). Compact city policies aim to mitigate urban sprawl and optimize the built environment through high-density spatial configurations, mixed land use, and efficient infrastructure systems (OECD, 2012). Meanwhile, TOD promotes high-density, mixed-use development centered around public transportation nodes, thereby fostering a healthy and low-carbon urban lifestyle (Calthorpe, 1993).

Recently, many high-density Asian cities have adopted TOD, making rail transit a dominant transport mode. In 1980, the share of rail travel in the Keihanshin metropolitan area of Japan reached 63.4% (Nishii and Kondo, 1992). Shanghai possesses the second longest urban rail transit operating mileage in China (Ministry of Transport of the People's Republic of China, 2025). Shanghai Municipal Transportation Commission stated that public transportation modes accounted for 17.5% of Shanghai's total travel in 2023. Besides, they also found that the share of rail transit in Shanghai's public transportation trips exceeded 70% by the end of September 2024. As shown in Figure 1, the number and proportiion of transfer stations of Shanghai keep rising. Accroding to the data of China Association of Metros (CAMET), the average transfer coefficient of urban rail transit networks in China reached 1.666 in 2024. In addition, most metro transfer stations are surrounded by shopping malls in Shanghai. Thus, explore the new travel behavior of metro transfer commuters in Shanghai is important to improve urban vitality.

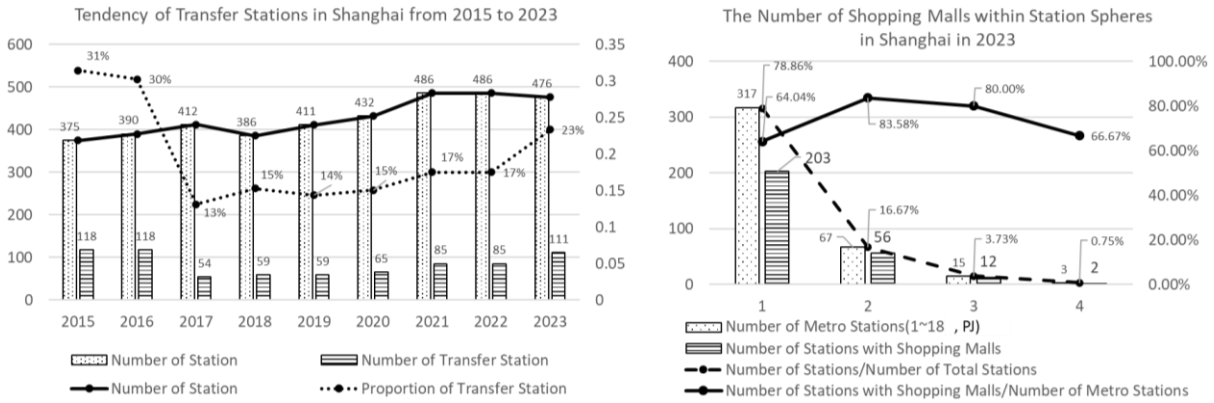


Figure 1. Tendency of transfer stations and the number of shopping malls within station spheres in Shanghai. Source: The left figure is visualized by Bai, X. J. based on China Association of Metros (CAMET, www.camet.org.cn), and the right figure is from Bai, X. J.

Lots of studies have found that non-work activities along the commuting chain from home to work are mainly located along the commuting path. Between 1995 and 2001, the proportion of U.S. commuters

incorporating trip chaining as part of their commuting mode increased by 9% (McGuckin, Zmud and Nakamoto, 2005). As China's urban populations and spaces continue to expand, travel demand rises and patterns become increasingly complex (Guan *et al.*, 2019). From 2014 to 2019, daily travel in Shanghai increased by 3.3%, with non-commuting, nighttime, and weekend trips rising by over 15% (Shanghai Municipal Transportation Commission, 2022). Therefore, research on non-work stops during commuting should consider the commuting path rather than only workplace and residence (Mao, Ettema and Dijst, 2018). In-depth study of trip chaining behavior will contribute to enriching the research on travel behavior, support policy-making in developing countries (Ma, Mitchell and Heppenstall, 2014). It also provides guidance for the development of activity-based commuting demand models (Guan *et al.*, 2019).

In recent decades, the phenomenon of adding non-work stops during the commuting journey has attracted widespread attention. However, existing studies mainly focus on travel mode choice, but not conduct specific research on rail transit. Scholors cares more about the influence between stopover behavior and individual attributes, but few of them talked about the attitude of commuters. In addition, they always discuss the environment of residence and workplace rather than stopover locations. Although metro card data and GPS data are widely used in travel study, they cannot identify actual stopover behaviors. Moreover, related studies always use basic regression analysis, which cannot reveal the complicated influence between psychological variables and built environment variables.

This study aims to find what influence metro commuters non-work stopover intention at commercial complexes around transfer station. This study augments the DTPB by incorporating built environment factors and preferential transfer policies, resulting in an innovative theoretical framework. A structured online questionnaire was distributed via social media platforms to collect data. Subsequently, SEM and MIMIC model were employed to comprehensively assess the factors influencing metro users' willingness to visit commercial complexes during their commutes. The findings of this study will contribute to the enhancement of the vitality of the transfer station area and promote low carbon mobility.

This research consists of 4 parts: 1) introduction talks the background, status and aims of stopover; 2) methodology constructs the theoretical framework and provides methods of data collection and analysis; 3) result summarizes socio-demographic attributes and analyzes the influences of attitude and group heterogeneity factors on the stopover intention; 4) conclusion summarizes the framework, main conclusions and significance of this research, and puts forward the prospects for future research.

2. Methodology

2.1. Theoretical framework

The definition of stopover is that commuters will make lots of activities during their travel. In this research, we maily focus on the stopover behavior of metro users during their transfer. For instance, metro commuters would like to go shopping or eatting in the commercial complexes near transfer stations during their transfer in the morning to the company or evening back to home (Figure 2).

More and more scholars related to the field of transportation behavior have recognized that studying attitudes contribute to understanding travelers' preferences and behaviors (Yuan *et al.*, 2023). In recent years, some studies have analyzed travel intentions or behaviors by employing the theory of planned behavior (TPB), the technology acceptance model (TAM), and SEM. Furthermore, the DTPB model can reveal the more deatiled reasons of behavioral intention.

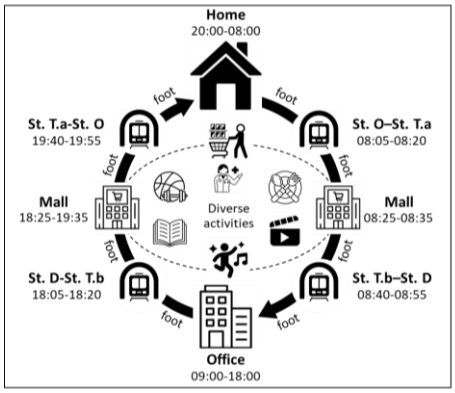


Figure 2. Example of stopover behavior of metro transfer commuters. Source: Bai, X. J.

This study added the built environment and transfer preferential policy variables based on the DTPB model. In this context, behavioral intention (BI) refers to metro commuters' intention to make non-work stopover at commercial complexes around transfer stations.

As shown in the Figure 3, the study put forward the following hypotheses:

- H1: Behavioral attitude (BA) reflects their overall evaluation and tendency toward BI.
- H2: Subjective norm (SN) has a significant positive influence on BI.
- H3: Perceived behavioral control (PBC) has a significant positive influence on BI.
- H4: Perceived ease of use (PEU) has a significant positive influence on BA.
- H5: Perceived usefulness (PU) has a significant positive effect on BA.
- H6: PEU has a significant positive effect on PU.
- H7: Perceptual fit (PF) has a significant influence on BA.
- H8: PF has a significant positive effect on PEU.
- H9: PF has a significant positive effect on PU.
- H10: Built environment (BE) has a significant positive influence on BI.
- H11: Preferential policy (PP) has a significant positive influence on BA.

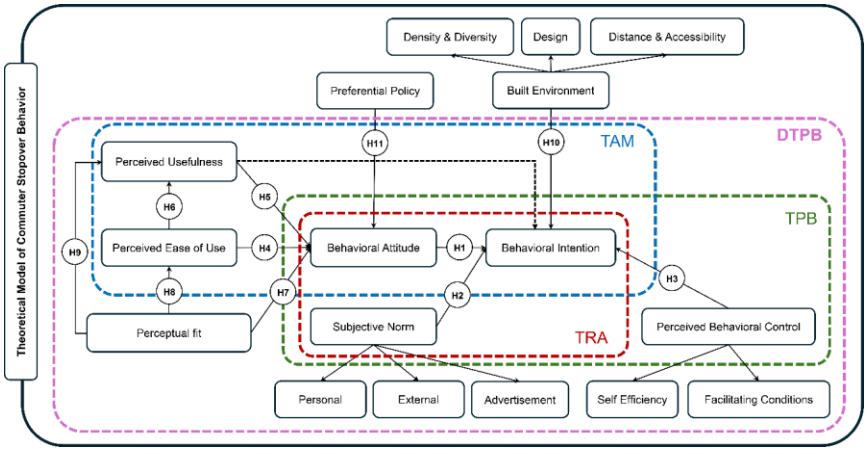


Figure 3. Theoretical framework. Source: Bai, X. J.

2.2. Questionnaire design and survey

The questionnaire consists of three sections. Section 1 captures socio-demographic characteristics such as gender and age. Section 2 addresses actual behaviors and preferences regarding metro and commercial complex use, as well as prior stopover experiences. Section 3 analyses the influence factors of stopover intentions rely on extending DTPB framework.

The survey targeted users of the social media platform named rednote from June 2024 to March 2025. The data collection were conducted via the wenjuanxing platform. We removed low-quality responses to improve data quality: 1) respondents did not take the subway or go to commercial complexes; 2) section 2 contains logical errors (e.g., function-use mismatch); 3) Section 3 contains identical or patterned answers; 4) completion time under 300 seconds.

The study used SPSS and AMOS software to perform reliability analysis, exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and SEM. We removed items with low discrimination and got a refined scale of 55 items (Table 1). All items rated on a five-point Likert scale from "very agree" to "very disagree". We finally collected 721 (78.9%) valid responses. The minimum sample size for complex SEM models, 10 participants per variable are recommended (Nunnally, 1978). Therefore, the final sample meets these requirements.

Table 1. Factors and corresponding measures. Source: Bai, X. J.

Constructs		Measure items
PU		PU1: It helps to enhance the economic vitality of stations and promote urban renewal
		PU2: It helps to make low carbon travel and improve the ecological environment
		PU3: It helps to centralize diversity facilities and reduce the waste of resources
		PU4: It gives you a lot of options
		PU5: It saves time
		PU6: It is a good idea
PEU		PEU1: Malls can be easily queried on social media APP
		PEU2: Stores inside malls can be easily queried on social media APP
		PEU3: Malls can be easily seen along the transfer path
		PEU4: The store or publicity of malls can be easily seen along the transfer path
		PEU5: Malls have a high coverage rate and a superior geographical location
PF		PF1: It similar with the usage mode of malls near residence or workplace
		PF2: It's more convenient and diverse than malls near residence or workplace
		PF3: It can replace the malls near residence or workplace
		PF4: It can complement the malls near residence or workplace
		PF5: It's in line with people's lifestyle and travel behavior
		PF6: It's in line with your lifestyle and travel behavior
SN	P	SN-P1: Positive sharing, recommendation and behavior from peers can increase BI
		SN-P2: Positive sharing, recommendation and behavior from leaders can increase BI
		SN-P3: Positive sharing, recommendation and behavior from elders can increase BI
		SN-P4: Publicity of government and public organizations can increase BI
	E	SN-E1: Posts with image and text of malls in APP can improve BI
		SN-E2: Posts with video of malls in social media APP can improve BI
		SN-E3: The evaluation and score of malls in social media APP can improve BI
	A	SN-A1: Displaying information about malls when using navigation APP can increase BI
		SN-A2: Stores' introduction or advertisement inside/outside malls can promote BI
		SN-A3: Stores' introduction or advertisement inside transfer stations can promote BI

PP		PP1: Free transferring to another line within 30 min can promote BI
		PP2: Increasing the discount duration during virtual transfer can promote BI
		PP3: Publishing the policy of metro joint ticket can promote BI
BE	DD	BE-DD1: The large size of malls can promote BI
		BE-DD2: Multiple malls around the transfer station can promote BI
		BE-DD3: Multiple functions of malls can promote BI
		BE-DD4: Multiple brands for the same function can promote BI
	DE	BE-DE1: The shading facilities from transfer station to malls can promote BI
		BE-DE2: Pleasant temperature from transfer station to malls can promote BI
		BE-DE3: Broad space from transfer station to malls can promote BI
		BE-DE4: Bright light from transfer station to malls can promote BI
	DA	BE-DA1: Short distance from transfer station to malls can promote BI
		BE-DA2: Malls are next to stations or connect with passageway can promote BI
		BE-DA3: Without much turns or stairs from station to malls can promote BI
BI		BI1: You want to make it
		BI2: You want to make it in the future
		BI3: You want to make it more frequetly
		BI4: You want to recommend it to your friends and family
PBC	SE	PBC-SE1: You can easily search the information about malls
		PBC-SE2: You can easily search the information about the functions inside malls
		PBC-SE3: You can get to the malls without any help
	FC	PBC-FC1: You have financial ability to spend money at the malls
		PBC-FC2: You have time to search for information of malls
		PBC-FC3: You have social media and navigation apps to search for information of malls
BA		BA1: It is very pleasurable
		BA2: It is very interesting
		BA3: It is very wise
		BA4: It is a benefit to you

Note: It means stopover behavior;BI means stopover intention.

2.3. SEM and MIMIC model

The SEM has been employed to investigate the influence of latent psychological constructs such as attitudes (Tao, He and Thogersen, 2019). By analyzing the covariance matrix of observed variables, SEM reveals potential causal relationships between each construct. The MIMIC model extends CFA and SEM to account for group heterogeneity in latent variables (Li *et al.*, 2022). Accordingly, this study applies SEM to identify and validate key factors affecting stopover intention of metro users. Meanwhile, this study employs MIMIC to examine the effects of demographic and usage characteristics on the latent variables.

As shown in Figure 4, MIMIC model includes both measurement and structural components. Explanatory variables (Xi) include 2 aspects. First is individual characteristics, including age (AGE), gender (SEX), education (EDU), child's age (KID), income (INC), and the ownership of bicycle (VEC2), car (VEC5), or motorcycle/e-bike (VECN). Second is the usage of complexes and metro, including the awareness of virtual transfer policy (VTP), access to malls near residence or workplace (ODMU), mall usage frequency (MU), shortest walking time to stations (OST), commuting status (TRA), and metro usage frequency (SUBN). It also includes location preferences, such as near workplace (MUP1), residence (MUP2), commute route (MUP3), or business districts (MUP4). Latent variables (ηk) represent psychological constructs like PU and PEU. Observed indicators (Yj) refer to 55 questionnaire items, such as PU1. This study used IBM SPSS Statistics 26 to analyze sample characteristics, and test data's reliability and validity. Furthermore, we used SPSS Amos 26 Graphics to conduct the SEM and MIMIC model estimation.

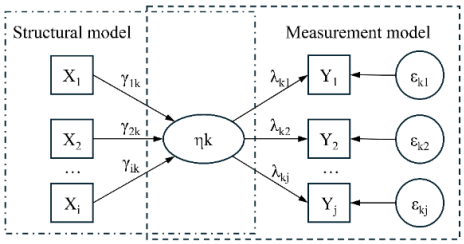


Figure 4. Diagram of MIMIC model. Source: (Li *et al.*, 2022)

3. Result and Discussion

3.1. Features of sample

As shown in the Figure 5~7, we conducted descriptive analyses of socio-demographic characteristics, metro and mall usage, and non-work stopover behavior. Results show that 61.3% of metro users made stopovers during commutes, confirming that stopover is common. This supports prior findings that commercial facilities near transfer or terminal stations encourage non-work stops (Nishii and Kondo, 1992). The main reasons for people to stopover are mostly for shopping and dining (over 60%), entertainment (over 30%), or using the restroom (about 20%), which is consistent with earlier studies (Currie & Delbosc, 2011). More than 40% of used facilities were on the same level or 1–2 floors from metro exits, and over 70% cited convenience as the reason for use. Thus, placing facilities near exits may promote stopovers. Although only 29.7% preferred malls along commute routes, over 40% used them after work on weekdays, echoing prior research (Mao et al., 2018).

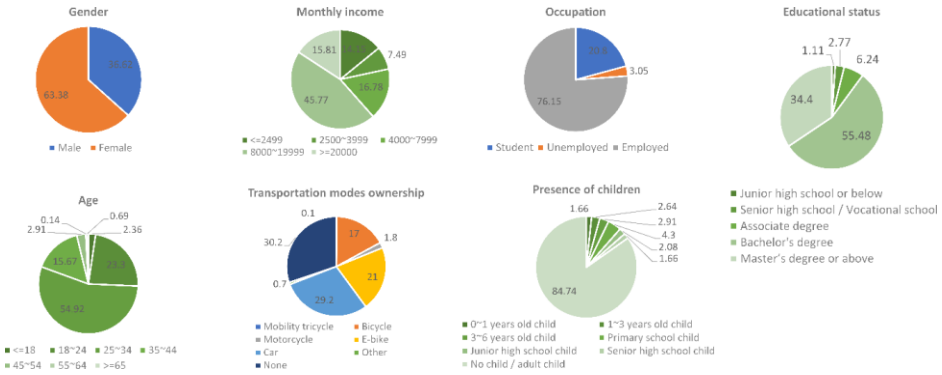


Figure 5. Statistical description. Source: Bai, X. J.

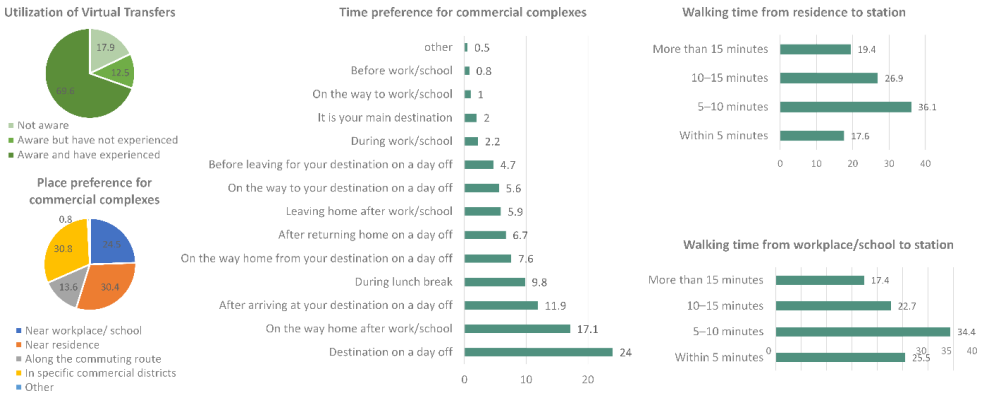


Figure 6. Usage and preferences. Source: Bai, X. J.

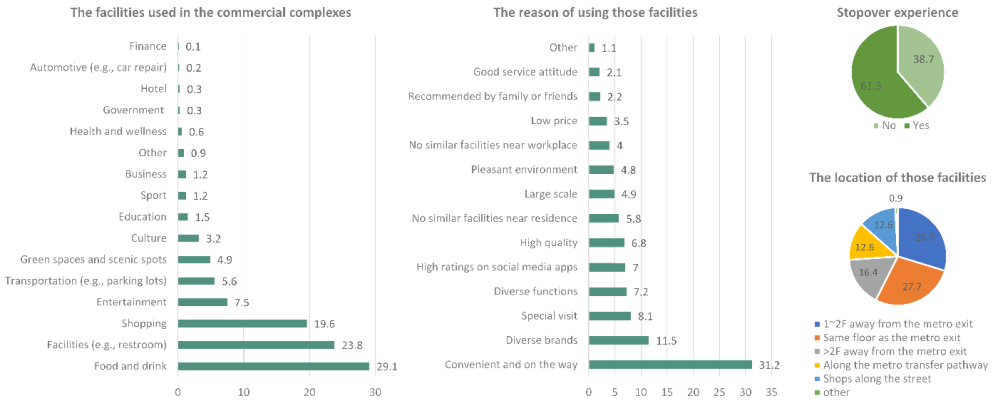


Figure 7. Actual stopover behavior. Source: Bai, X. J.

3.2. SEM model

The results show that SN, PBC, BA, and BE significantly and positively influenced stopover intention, with BA exerting the strongest effect (Figure 8). This highlights the importance of shaping positive attitudes toward stopover. PF, PEU, and PU were significantly interrelated, indicating that perceived convenience affects users' evaluations of usefulness and ease of stopover. PBCFC had the greatest weight on PBC, suggesting that time, cost, transport convenience and social media and navigation APP promote intention. Income positively correlated with stopover behavior, consistent with previous studies (Guan et al., 2019). Individuals with earlier end-of-day schedules were also more likely to make stops (Bhat, 1999). In the second order structure of BE, BEDD had the highest contribution, followed by BEDE and BEDA. This implied that density and diversity had slightly greater influence than distance, accessibility, and spatial design. Accessibility of residence and workplace also positively influenced stop-making (Krizek, 2003). Moreover, mixed land use in workplaces (Ma, Mitchell and Heppenstall, 2014) and residential neighbourhoods (Bautista-Hernández, 2022) increases both stop frequency and travel complexity. SNA and SNE contributed most to SN, suggesting that promoting commercial content online and offline can increase stop intention. PF, PU, and PP significantly affected BA, which also mediated the effects of PF and PP on BI. This underscores the role of spatial and policy differentiation in enhancing user attitudes and indirectly influencing stopover behavior. It similar with findings on discounted transit incentives (Cheng, Chen and Yang, 2016). However, PEU had no significant effect on BA, possibly due to measurement issues or low perceived usability of complexes.

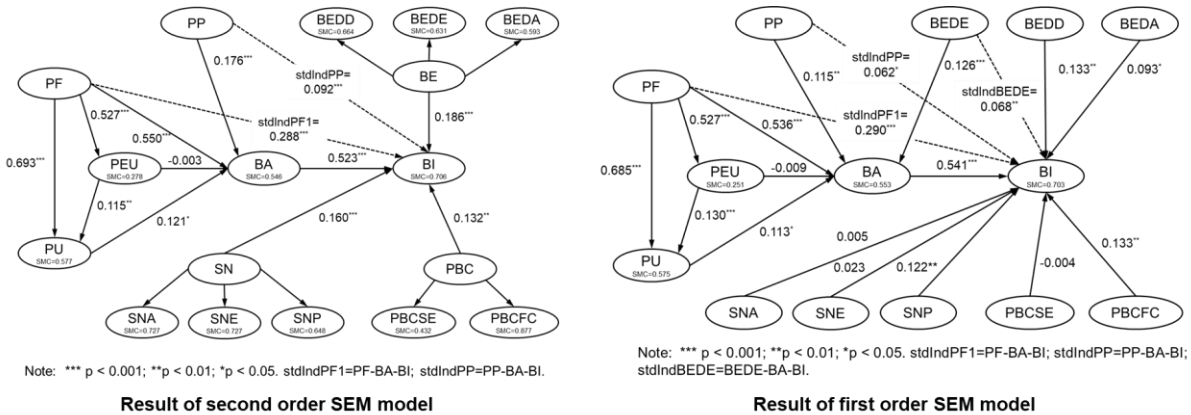
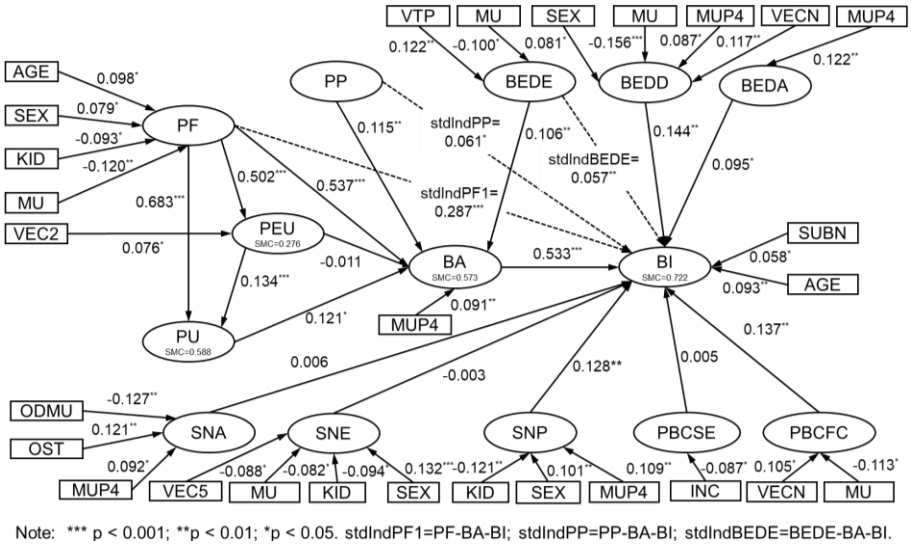


Figure 8. Result of SEM model. Source: Bai, X. J.

To clarify the roles of first-order constructs, we re-estimated the model using only first-order latent variables (Figure 8). The results showed that PBCFC, BEDD, SNP, and BEDA significantly and positively predicted BI, while BEDE significantly influenced BA. BA also mediated the relationship between BEDE and BI. These findings suggest that commercial complexes near transit stations can promote stopover by offering high density and diversity, short distance and accessibility, social encouragement (e.g., from peers or supervisors), and sufficient resources (e.g., time, income, transport tools). Spatial design indirectly affects stop intentions by shaping attitudes. In contrast, SNE, SNA, and PBCSE showed no significant association with BI, implying that media exposure, promotional content, and self-assessed capability had limited impact. Other path results remained consistent with the second order SEM findings.

3.3. MIMIC model

Finally, The MIMIC model confirmed key associations between socio-demographic and usage variables and latent constructs (Figure 9). Age positively influenced PF and BI, indicating middle-aged metro users perceived greater convenience compared to younger people and showed stronger stopover intentions. It supported by research on complex trip chains among elders (Ma, Mitchell and Heppenstall, 2014). Gender significantly affected PF, SNP, and SNE, suggesting that women were more receptive to social influences and convenience perceptions. However, gender had no direct effect on BI, possibly due to confounding factors such as marital status or employment (Bautista-Hernández, 2022). Having dependent children negatively impacted PF, SNP, and SNE but not BI, which consistent with prior research (Portoghese *et al.*, 2011). Lower income negatively influenced PBCSE, reflecting ease of access perceptions. However, it had no effect on BI, contrasting with past studies (Guan et al., 2019). Awareness and use of virtual transfer policies had positive effects on BEDE and BEDD, indicating greater appreciation for transfer space comfort and commercial diversity. Lack of commercial complexes near residences or workplaces increased SNA, suggesting targeted advertising was more effective under these conditions. The frequency of complex usage demonstrated significant positive effects on PF, BEDE, BEDD, PBCFC, and SNE. It indicates that frequent visitors care about the perceived convenience of stopover behavior, comfort of transfer space design, density and accessibility of amenities, availability of time and money, and the evaluation on social media. Similarly, metro usage frequency increased BI. In contrast, location preferences, vehicle ownership, and walking distance to metro stations had no significant effect on BI.



Note: *** p < 0.001; **p < 0.01; *p < 0.05. stdIndPF1=PF-BA-BI; stdIndPP=PP-BA-BI; stdIndBEDE=BEDE-BA-BI.

Figure 9. Result of First Order SEM and MIMIC Model. Source: Bai, X. J.

4. Conclusion

This study extends the DTPB framework by incorporating built environment and policy incentive dimensions and then analyzes the latent variables and exogenous variables by SEM and MIMIC. The purpose is to verify the theoretical model for the willingness of metro users to make stops during commuting to finish diverse behaviors in commercial complexes around metro transfer stations. Furthermore, the research emphasizes the function of digital service platforms in questionnaire survey and the promotion of stopover intentions. Building on our findings, local governments, metro operators, and commercial developers can implement targeted interventions to enhance the stopover intention during commuting. Thereby, it can boost the economic vitality of the transfer station area and promote sustainable and integrated development of the station and city. This study can be further extended to analyze the stopover behavior at stations that transfer inside the paid zone. Meanwhile, it can also be applied to analyze other travel behaviors in cities that emphasis the development of TOD. This research has certain limitations in terms of the selection of the research subjects and the scope of the influencing factors. In the future, we plan to conduct on-site surveys at specific transfer stations. Furthermore, we intend to use mobile phone location data and field survey data to objectively measure stopover frequency.

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