Research on the Development of Beijing Suburban Public Transportation Based on SEM

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Abstract. With the development of urbanization and the general of separation between working site and residence, suburb commuting has become an inevitable demand for the development of the metropolitan area. Existing literature has studied public transport transfer from the aspects of efficiency, accessibility, and satisfaction. This paper attempts to study passenger convenience during the transfer process from a more micro perspective. Based on a sample of 383 valid questionnaires for passengers in the suburbs of Beijing, a structural equation model was constructed to study the influencing factors of transfer convenience on travel choices. The empirical results show that passengers' perception of the convenience of transfer in the suburban commute is characterized by comfort, safety and quickness, with comfort coming first, then safety, and quickness the last.

1. Background
With the progress of the world's urbanization, on the one hand, the population is concentrated in large cities, and the proportion of population in large cities of countries and regions continues to increase; on the other hand, with the continuing emergence of large cities, megacities, and metropolitan areas, it is an inevitable process that the population moves to suburban area. With the development of urbanization, Beijing has gradually transformed from a central city to a metropolitan area. The suburban area is the key to alleviating the commuting pressure caused by separation of residence and working site, and the suburban bus system has become an important guarantee to meet the suburbanization.

In recent years, the New York commuter line has established a long-radiating network of suburban networks in peripheral areas, near and far suburbs and central areas, with 14,000 bus stops throughout 5 administrative districts of New York City. It plays an important role of assisting the subway public transportation. The Tokyo metropolitan area has more than 2,000 kilometers of rail transit lines that participate in public transportation. Most of the commuter passenger flow in large foreign cities and the transportation needs between urban and suburban areas are borne by the suburban commuter system.

2. Literature References
At present, in the field of public services, scholars usually use satisfaction or service quality to measure related indicators. For the former, convenience is usually used as a secondary indicator of satisfaction, and for the latter, convenience has similar meanings with service quality. The concept of convenience is being proposed step by step and is worthy of our discussion.
In 1975, Hensher proposed that convenience is related to ‘absence of effort’ in utilizing transport services that are ‘fit for purpose’ in the way they are operated. The concept is narrower than service quality, and transport analysts have long distinguished cost, time, convenience and comfort. Another early study (Stopher et al., 1974) pointed out the attractiveness of public transport can be decomposed into four generic elements; safety, cost, comfort and convenience. In 2007, Stradling et al. used travel surveys to identify transit service quality factors that affect transit ridership, including whether they felt safe, whether the fares were economical (cost), and whether they felt comfortable.

Mark WARDMAN’s research in 2014 showed that public transport travel time unit costs are highly variable. When travel conditions are favourable, the generalised journey time cost of public transport travel can be lower than that of car travel, since passengers experience minimal stress and can use their travel time productivity. However, if public transport conditions are unfavourable unit travel times tend to be higher than for car, which inevitably reduces public transport use. Therefore, it is necessary and important to study the convenience of public transportation.

Gou Xiaodi (2018) has studied the convenience level of convenience services in Lanzhou, which mainly uses objective indicators such as queuing time, location address, delivery service, and difficulty in complaints. Gu Tianhong et al. (2019) studied the convenience of urban transportation in Shanghai, and divided the convenience of urban public transportation into three indicators: economy, convenience and speed, and measured it with objective indicators. Zhu Jingzheng (2012) divides the service level of orbital transfer facilities: including comfort factors such as environmental quality; facility factors such as walking distance, information guidance system; safety factors such as congestion level, passenger flow, safe evacuation facilities, etc.; reliable factors: including the service status, lighting, and the degree of the transit transfer facilities.

3. Methods and Data
This paper mainly adopts the research method combining empirical research and field research, and collects first-hand data to quantitatively analyze the influence of multiple indicators of convenience on travel choice from multivariate perspective.

3.1. Structural Equation Model
According to the literature references, it is known that convenience can be measured by the five indicators of quickness, accessibility, economy, comfort, and safety. Therefore, this paper firstly adds the above five indicators plus the overall perception as the latent variable of the structural equation model. Secondly, according to the third-level support of each secondary indicator, the corresponding questionnaire question is designed as the measurable variable X of the latent variable. The objective travel choice is taken as the measurable dummy variable Y which is recorded as 1 when public transportation is selected, and recorded as 0 if not.

After the initial model is established, in the experimental stage, the initially set model cannot solve the equation solution smoothly. Therefore, we adjust the model to take the overall perception as the intermediate variable of the cause and effect, taking the five secondary indicators as the cause, selecting the travel choice Y as the result and the model is reset.

The convenience is decomposed into quickness, accessibility, economy, comfort, and safety. The five indicators and the overall perception are used as latent variables, X1-X19 are used to correspond to the measurable variables of six latent variables, and the virtual variable Y is used to represent the travel selection method. The specific model is shown below:
3.2. Data preprocessing
A total of 450 questionnaires were returned in this survey. Among them, there were 12 questionnaires that were not completed, 55 questionnaires that did not meet the requirements or were obvious logical abnormalities, including a) the worksite not in Beijing or the place of residence not in the suburbs; b) In the perceptual value evaluation table, except for the overall perception, the other 5 latent variables have higher scores, but the overall perceptual scores are lower; c) or the other 5 exogenous variables except the overall perceptual scores are lower, but the overall perceptual scores are higher. After removing the 67 questionnaires, 383 valid questionnaires were obtained, and the effective questionnaire rate was 85.1%.

4. Empirical analysis
The results of the questionnaire were substituted into the structural equation, and the structural equation model was empirically analyzed using AMOS.

The model GFI value Model GFI = 0.901, greater than 0.09, indicating that the result passed the fitness test. Therefore, the model is considered reasonable and there is no misconfiguration.

The standardized path of all valid data regressions to obtain latent and indicator variables is shown in the following figure:

![Figure 1. SEM path diagram](image-url)
Through the results, we obtained that the quickness, economy, comfort and safety have a positive impact on the overall perception of the choice of public transport, and all passed the significant test under the 1% confidence level. Moreover, they accounted for 18.4%, 14.7%, 29.2%, and 25.6% of overall perception, respectively. The P value of accessibility was 0.039, which passed the significance test at the 5% confidence level, explaining 18.4% of the overall perception. On this basis, the overall perception 57.8% explains that passengers’ willingness to choose bus travel mode, and the P value is much less than 0.01, which is very significant.

5. Conclusion
According to the empirical results, comparing the degree of interpretation of different indicators, it is not difficult to find out that comfort has the highest interpretation of overall perception, followed by safety and quickness. This is different from our original vision. First of all, on the one hand, commuting is a long-term problem that must be faced for commuters who daily commute to and from suburbs and city; on the other hand, long-distance suburban commuting is different from short-distance, the character of long distance and longtime means more energy is spent. Therefore, the working group no longer regards the quickness as the primary consideration for the choice of commuting transportation. In this situation, there are practical reasons that the comfort is more appreciated to the travel process. Secondly, in today's society of the new era, with improvement of the economic level, people's pursuit of quality of life is also increasing day by day. Compared with economy, most people appreciate comfort more, such as paying extra expenses to exchange for shorter-distant transfer or a more comfortable ride environment.

Therefore, raising the comfort of commuting is conducive to improving the convenience and overall perception of commuting of public transportation in the suburbs, and thus contributing to the development of public transportation, which plays a vital role.
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