Study on the Differences of Low-carbon Commuting Among Urban Residents in the Beijing-Tianjin-Hebei Region

- Considering Social Capital Factors

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Abstract. An important part of a city's carbon emissions is the carbon emissions from Beijing-Tianjin-Hebei urban agglomeration has uneven transportation development and is in different periods to achieve the "dual carbon" goal, it is of practical significance to explore the differences in the commuting patterns and related influencing factors of urban residents in Beijing-Tianjin-Hebei area and formulate appropriate policies to achieve the national dual carbon goals. A structural equation model was used to explore the impact of social capital and other factors on the commuting patterns of residents in the three places. Firstly, the exploratory factor analysis was used to grasp the social capital of the residents in the Beijing-Tianjin-Hebei region, and secondly, the exploratory factor analysis was used to summarize the traffic distress of the residents and the traffic accessibility of the place of residence, and finally the structural equation model was established to clarify the differences of the influencing factors of the commuting patterns of the residents in the three places. The results show that there are differences in traffic distress among the three places, social capital is significantly correlated with commuting patterns, and the influencing factor models of commuting patterns in the three places have both commonalities and differences.

Keywords: Beijing-Tianjin-Hebei agglomeration; “dual-carbon” strategy; Low-carbon commute for residents; Structural equation model; Differentiation.

1 Introduction

In the face of an increasingly severe environmental situation, the Chinese government has pledged to "strive to peak carbon emissions before 2030 and achieve carbon neutrality before 2060"[1]. At present, China's urbanization rate is 65.22%, which is still in the stage of rapid development, and cities will be the most important area for the implementation of the "dual carbon" strategy [2]. The low-carbon commuting behavior of urban residents refers to the use of low-carbon methods such as walking, cycling, and public transportation to complete commuting activities, thereby reducing the use

G. Zhao et al. (eds.), *Proceedings of the 2024 7th International Symposium on Traffic Transportation and Civil Architecture (ISTTCA 2024)*, Advances in Engineering Research 241,
https://doi.org/10.2991/978-94-6463-514-0_79

of cars, and reducing emissions in the transportation sector. The Beijing-Tianjin-Hebei urban agglomeration is a world-class urban agglomeration with the capital as the core in China and is an important part of realizing the dual carbon commitment. The Beijing-Tianjin-Hebei region is one of the regions with the tensest relationship between man and nature, the most prominent contradiction of resource and environmental overload, the most disparity in inter-regional development, and the most urgent requirements for ecological joint prevention and management [3]. In terms of carbon emissions caused by transportation, Beijing, Tianjin and Hebei have formulated several guidelines and policies to ensure the completion of the dual carbon goals. But the effect is not satisfactory enough.

2024 is the 10th anniversary of the coordinated development of Beijing-Tianjin-Hebei as a national strategy, as one of the regions with the most economic vitality, the highest degree of openness and the strongest innovation ability in China, the Beijing-Tianjin-Hebei urban agglomeration is an important carrier for China to promote the "dual carbon" goal. The main purpose of this study is to study the influencing factors of residents' commuting mode in the three places, scientifically formulate differentiated traffic management policies, further optimize residents' travel structure, and improve residents' travel preferences.

2 Factors Influencing Commuting Behavior

The research of domestic and foreign scholars on residents' commuting behavior can roughly summarize the influencing factors into the following categories: demographic factors, psychological factors, including environmental influences, subjective awareness, etc. And contextual factors, including the availability of transportation, travel distance, travel time, etc.

Li [4] established a commuting mode intention model based on psychological factors and low-carbon factors through the theoretical study of material ownership and found that low-carbon knowledge and low-carbon habits directly affect the choice intention of commuting mode. Fujii et al. [5] considered private car and bus travel as a group game, and proposed a way to increase the cooperation rate in the game, that is, to temporarily force private car travelers to use public transportation in some way. Based on the theory of planned behavior and the integration model of value-belief-norm theory, He Zhanqiong et al. [6] found that environmental attitudes directly and positively affect the choice intention of low-carbon travel. Wu Wenjing et al. [7] used the intuitionistic fuzzy C-means clustering algorithm to cluster the samples based on the existing SP data of residents' low-carbon commuting trips, identified the types of subjective attitudes held by residents towards low-carbon commuting trips, and determined the impact of subjective attitudes on travel intentions. Social capital has been proposed in the West since the mid-to-late 80s of the 20th century, and has been further defined by scholars [8], which can be considered as the sum of social resources that can be mobilized by actors embedded at all levels, which constructs social trust and promotes social participation through formal or informal norms and values to achieve the collective goals of

actors. According to the existing research results [9-10], social capital has a direct impact on residents' willingness to commute.

Guo et al. [11] determined that the density of the road network and the number of parking spaces directly affect the choice of commuting mode. However, Bo [12] modeled and analyzed the commuting data of Shanghai residents, and showed that the built environment of residential areas had a significant impact on residents' choice of commuting mode, while the built environment of workplaces had no significant impact on residents' commuting behavior. Research by Yang [13] proves that an appropriate commute time (about 5-25 minutes) can lead to a positive commuting effect for commuters. De Vos et al. [14] found that commuting patterns are closely related to commuting duration (the duration of self-service travel is shorter than that of public transport travel), and both affect commuting satisfaction.

After a comprehensive examination of the relevant factors, this study focuses on the commonalities and differences of residents' social capital, traffic distress, and the specific impact of traffic accessibility on low-carbon transportation behavior in Beijing-Tianjin-Hebei region.

3 Data Source

Data collection was conducted by anonymous online questionnaire, with 482 valid samples. It mainly includes the commuting behavior of residents in Beijing, Tianjin and Hebei, the traffic accessibility of the place of residence, and the existing traffic distress. and the basic information of the participants, including gender, age, occupation, family composition, income, etc., and the characteristics of the sample are shown in Table 1.

Table 1. Characteristics of samples

Item	Catalogue	Beijing(n=116)	Tianjin(n=125)	Hebei(n=299)
Gender	Male	52.6%	60.8%	33.4%
	Female	47.4%	39.2%	66.6%
Age	18-25years old	19.8%	7.2%	43.8%
	26-45 years old	71.6%	89.6%	43.1%
	46years above	8.6%	3.2%	13.1%
Family composition	Live alone	29.3%	27.2%	6.7%
	Not live alone	70.7%	65.6%	93.3%

4 The Social Capital of Residents

To grasp the social capital of the residents in the Beijing-Tianjin-Hebei region, SPSS ver23 was used for factor analysis, and a set of 16-item questionnaires were used to investigate the principal component method, and the questionnaire was surveyed on a Likert scale (completely non-conforming=1 to fully conforming=5).

Factor analysis was used to obtain the grouping of each component of social capital in Beijing, Tianjin and Hebei, all the Cronbach's alpha and KMO value are reliable. According to the results of factor analysis, three factors can be summarized, which is work connection(WC), sense of community belonging(CB) and participation(CP)and then the factors were used as variables in the structural equation for differential research. The social capital scale including the follow items: At work, you will take the initiative to do what needs to be done, even if no one asks for it (WC1), If you need information to make important life decisions, you know where to find this information (e.g. consult with parents, family, etc.) (WC2), At work, if you don't agree with other people, you'll be brave enough to speak up (WC3)、You are willing to help a colleague, even if it is not your job (assuming you are a paid worker) (WC4), When you need help at home, you can turn to your neighbors for help (CB1), You are content to live in your current community (CB2), You have friends or relatives who live in your neighborhood or a neighborhood near you (CB3), You will meet and greet neighbors and others (CB4), Your community feels like home (CB5), In the past 6 months, you have participated in community activities (health awards, community basketball games, community party activities, etc.) (CP1), You are an active member of a community organization or team (CP2), You are willing to volunteer in your community (CP3).

5 Beijing-Tianjin-Hebei Residents' Traffic Distress and Traffic Accessibility

A set of 14-item questionnaires were surveyed in the Beijing-Tianjin-Hebei region to grasp the traffic distress of residents. Exploratory factor analysis was carried out on the questionnaire results to explore the internal factors of the current situation of traffic distress. The Cronbach's alpha of this group of scales was .896, and the appropriateness of KMO sampling was .891, indicating that the reliability and validity of the scales were satisfactory and suitable for factor analysis. The principal component method was used to extract three factors, and the total variance contribution rate was 66.07%. The factors are named according to the content of the factors and the load and consistency, and the results are shown in Table 2, with factor 1 named as "human factor", factor 2 named as " environmental and ecological factor", and factor 3 named as "transportation infrastructure factor".

This paper compares the traffic distress of residents in Beijing, Tianjin and Hebei across the three regions. In general, in terms of traffic ecological factors, the degree of distress is ranked as Hebei> Beijing> Tianjin. In terms of transportation infrastructure factors, the degree of distress is ranked as Hebei> Tianjin> Beijing, and in terms of human factors, the degree of distress is ranked as Tianjin> Hebei> Beijing.

A survey of the transportation accessibility of residents in the three places was conducted to examine their convenience to seven types of places: workplaces, shopping places (shopping malls, supermarkets, vegetable markets, etc.), schools, hospitals, leisure and entertainment venues (cinemas, teahouses, etc.), catering establishments and cultural venues (museums, libraries, etc.).

Data on social capital, transportation accessibility, and traffic distress were used as variables to establish structural equations to investigate their impact on commuting patterns.

6 The Structural Equation Model

The hypothesis of this study is that the commuting pattern is affected by three aspects: traffic distress factors, transportation accessibility, and social capital, and there is also a correlation between social capital and traffic distress factors and transportation accessibility. The objective variable is the commuting pattern, which contains two items: "You will try to choose a low-carbon commuting mode" and "You will encourage the people around you to choose a low-carbon commuting mode". The variable value of 1 indicates that it "matches the situation described"; 0 is the situation described by "not compliant", "not quite compliant", "uncertain", and "somewhat compliant". Transportation situation、traffic accessibility and social capital are taken as the explanatory variables and were brought into the sample models of Beijing, Tianjin, and Hebei, and the meaningless influencing factors and correlations in the models were gradually screened out, and the final structural equation model results are shown in Figure 1-3. The results of the model show that residents' commuting patterns are affected by factors such as social capital, transportation accessibility, and existing traffic problems. Specifically:

(1) The commuting pattern of Beijing residents was affected by social capital-community belonging and transportation accessibility, among which community belonging was more affected (path coefficient was 0.84, p=0.030), traffic accessibility was 0.54 (p=0.074), transportation accessibility was positively correlated with transportation infrastructure factors (path coefficient was 0.29, p=0.039), and work connection and community belonging were positively correlated in social capital (path coefficient was 0.36, p=0.015).There was a negative correlation between job connection and human factors in social capital (path coefficient was -0.22, P=0.013). That is, with the weakening of the human factor in residents' lives, the residents' work connection will decrease, which may be explained by the fact that the residents' social capital is a complex two-way adjustment system, and the residents with higher work connections have a higher probability of living in a community that is prone to non-motorized lanes being occupied and illegal parking is more.

(2) The commuting pattern of Tianjin residents was affected by the sense of community belonging (path coefficient 0.73, p=0.002) and transportation accessibility (0.68, p=0.000) in social capital. There was a positive correlation between transportation accessibility and transportation infrastructure factors (path coefficient 0.20, P=0.062), social participation and community belonging in social capital (path coefficient 0.57, P=0.002), transportation infrastructure factors and human factors (path coefficient 0.32, P=0.005), and environmental and ecological factors (path coefficient 0.50, P=0.001).

(3) The commuting pattern of Hebei sample residents was affected by the factors of community belonging, transportation accessibility, human factors and transportation

infrastructure in social capital, among which the transportation infrastructure factor had the greatest influence (path coefficient was 0.67, P=0.006), followed by social capital-community belonging (path coefficient was 0.55, P=0.003), and human factors had a negative impact on the commuting pattern (path coefficient was -0.52, P=0.018). The impact of traffic accessibility ranked fourth (path coefficient was 0.48, p=0.004). There was a positive correlation between transportation accessibility and transportation infrastructure factors (path coefficient 0.12, P=0.040) and social capital-community belonging (path coefficient 0.17, P=0.000). It is worth noting that the negative correlation of human factors is very large, the path coefficient is -0.52, p=0.018, that is, because of the occupation of non-motorized lanes, the retrograde driving of electric vehicles and pedestrians, the traffic troubles of electric vehicles and pedestrians occupying motorized lanes and illegal parking, which has prompted Hebei residents to choose low-carbon commuting.

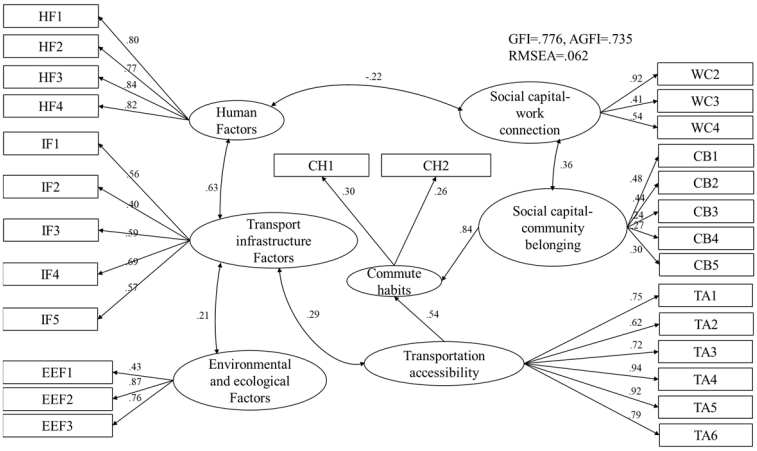

Fig. 1. Commuting structure equation model of Beijing sample residents

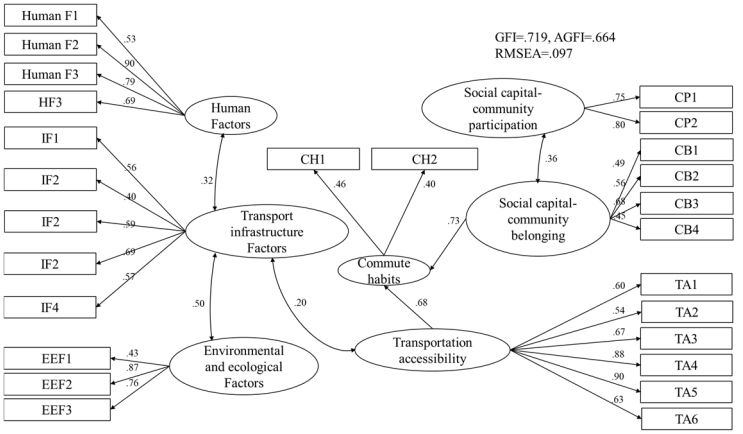

Fig. 2. Commuting structure equation model of Tianjin sample residents

7 Conclusion

In general, there are commonalities in the influencing factors of commuting patterns in Beijing, Tianjin, and Hebei, and improving residents' social capital and transportation accessibility can effectively promote residents' low-carbon commuting and reduce transportation carbon emissions. The improvement of existing traffic disruption factors has a complex effect on low-carbon commuting: although transportation infrastructure, human factors, and environmental and ecological factors are positively correlated, their impacts on low-carbon commuting are different. Improving the shortcomings of transportation infrastructure, flexibly setting up bus and subway stations, increasing bicycle sharing, marking parking spaces, and improving the mixed phenomenon of lanes can effectively promote residents' low-carbon commuting, but improving the traffic problems caused by human factors may reduce residents' low-carbon commuting behavior. For the sample residents in Beijing, improving traffic congestion, clarifying the location of parking spaces, and enhancing residents' sense of community belonging can promote low-carbon travel to the greatest extent. For Tianjin residents, the most troublesome traffic problem is the problem of electric vehicles, pedestrians driving in the wrong direction and occupying motor lanes, and the standardized driving of electric vehicles and the standardized use of pedestrians should be regarded as the long-term work of urban road traffic management, so as to improve the human factor at the same time, popularize the benefits of low-carbon commuting, so as to alleviate traffic problems and promote green travel. The main problems of Hebei residents are the serious air pollution caused by traffic, the mixed lanes, and the difficulty of finding parking spaces, so it is expected that targeted measures will improve residents' low-carbon commuting.

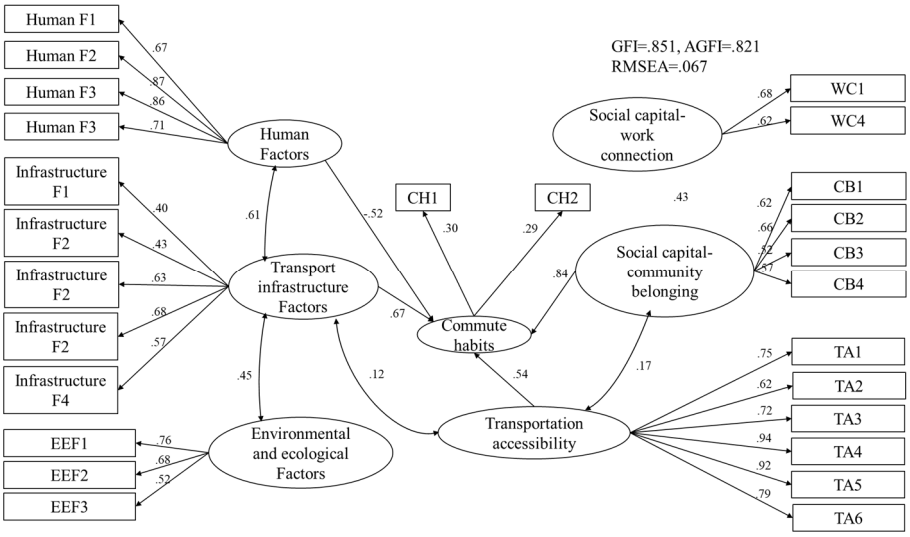

Fig. 3. Commuting structure equation model of Hebei sample residents

Table 2. Traffic distress of sample residents in Beijing, Tianjin, and Hebei

Items		Beijing	Tianjin	Hebei
Environmental and ecological Factors	Traffic congestion (EF1)	2.3534	2.1920	2.1003
	Severe air pollution caused by traffic (EF2)	2.0517	2.1680	2.2943
	Severe noise caused by traffic (EF3)	2.0172	1.9600	2.1204
Transportation infrastructure Factor	Far from public station (IF1)	1.6034	1.8720	1.7759
	Lack of bike-sharing (IF2)	1.4138	1.7360	1.7559
	Parking is hard to find (IF3)	2.4569	1.7360	2.3512
	Mixed lanes (IF4)	2.1121	2.3520	2.2274
	Restricted cars(IF5)	1.9310	1.9520	1.9833
	Traffic markings are not clear (IF6)	1.3103	1.7440	1.8094
	Difficult to see traffic lights(IF7)	1.1724	1.5360	1.6154
Human Factor	Non-motorized lanes are occupied (HF1)	2.0776	2.4880	2.2609
	Retrograde (HF2)	2.3966	2.8080	2.5117
	Electric vehicles and pedestrians occupy the motorized lanes (HF3)	2.1724	2.6880	2.4047
	Illegal parking (HF4)	2.2845	2.5280	2.2341

The darker the color, the more bothersome

Acknowledgements

Demonstration Project of Application and Scale-up Industrialization of Comprehensive Government Governance for High Score Special Project (66-Y50G03-9001-22/23), Tianjin Smart Manufacturing Special Funds for the Supporting Category of All-Industry Gathering and Development of Big Data in the Field of Net Information (20211109).

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