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How to Promote the Coordinated Development of Beijing, Tianjin and Hebei Under the Background of Digitalization?

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Abstract. The digitalization of the economy has promoted the further transformation of regional coordinated development. In 2014, the coordinated development of the Beijing-Tianjin-Hebei region became a major strategy of China. It is the core strategy to ease the capital's non-core functions. Beijing in the wholesale market, regional logistics base as the main content of management has made great progress and a variety of non-core functions of ease is an important indicator of logistics related changes since 2014. Based on the improved gravity model of logistics, we through the comprehensive quality and logistics radiation range of each city in the region of Beijing Tianjin Hebei, the overall spatial layout of Economic Zone regional center city logistics spatial contact occurred in 2018-2022 years. We found that the non-core functions of the capital reduced the freight and traffic burden in Beijing and the volume of logistics connections decreased from 4.54 to 4.39 in 2018. The main logistics of Beijing are Langfang, Tianjin, Shijiazhuang and Tangshan. the degree of connection with Langfang increased by 0.5, with Tianjin increasing by 0.14, and the connection with Shijiazhuang increased by 0.05, and the logistic connection with Tangshan increased by 0.11 from 2021 and 2022. Comparatively speaking, the degree of logistics connection between Beijing and other cities has declined. The problems of uneven logistics linkage in each city are prominent, and the logistics function of Baoding and Zhangjiakou is relatively weak, showing the phenomenon of logistics development, fracture and collapse, and being marginalized in the logistics development of Beijing Tianjin Hebei Economic zone. Accordingly, we put forward policy recommendations to promote the integration of logistics development in Beijing Tianjin Hebei Economic zone under the background of digitalization.

Keywords. Digitization, Beijing Tianjin Hebei, gravity model, non-core function, ease

1. Introduction

Coordinated development of the Beijing, Tianjin and Hebei region has become a major national strategy since 2014. The central government set up a leading group for the coordinated development of the Beijing, Tianjin and Hebei region to strengthen

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centralized and unified leadership over related work. Over the past decade, the coordinated development of the Beijing, Tianjin and Hebei region has been deepened, and the economic aggregate of the three regions has exceeded 10 trillion yuan. Among them, more than 3000 general manufacturing enterprises in Beijing have withdrawn, nearly 1000 regional professional markets and logistics centers have been relocated and upgraded, and the distribution of public service resources has been continuously optimized. Eight municipal universities and 15 municipal medical and health institutions have been relocated to the outside world, more than 7700 commercial outlets for the convenience of the people have been precisely renovated, and more than 9200 hectares of green space have been used to remove non-core functions of the capital, urban and rural construction land was reduced by 130 square kilometers. The main framework of the Beijing, Tianjin and Hebei region on track has basically taken shape, and an interconnected highway network has been fully built, the core area of Beijing, Tianjin and Xiongan can be reached in half an hour, and the traffic circle of major cities in Beijing, Tianjin and Hebei has been formed in 1 to 1.5 hours, a new regional traffic pattern with four vertical, four horizontal and one ring transportation channel as the main skeleton, multi-node and grid-like has been basically formed, and a modern high-quality comprehensive three-dimensional transportation network has been initially constructed.

The digitalization of the economy has promoted the further transformation of regional coordinated development. Orderly dispersal of non-capital functions of Beijing and continuous optimization of spatial development pattern of Beijing, Tianjin and Hebei region. So, what is the impact of the logistics link and layout between Beijing, Tianjin and Hebei? What are the trends affecting logistics links and spatial layout? Based on this, this paper sorts out the current situation brought by the deregulation of non-core functions of the capital, and then selects 13 samples from Beijing, Tianjin and 11 cities in Hebei province. Then, this paper uses the relevant data from 2014 to 2022, according to the gravity model, empirically analyses the changes brought by the non-core function evacuation, especially the logistics related industry evacuation, to the Beijing-Tianjin-Hebei logistics connection and spatial layout and makes the trend prediction. Finally, the paper puts forward some policy suggestions on the non-capital core functions and the integrated development of Beijing, Tianjin and Hebei logistics under the background of digitalization.

2. Review of literature

As the core of the coordinated development strategy of the Beijing-Tianjin-Hebei region, the alleviation of non-capital functions is of great significance to solve the problems of Beijing's big city and realize the sustainable development of the Beijing, Tianjin and Hebei region (Liu Xiaoxiao and Wu Kang, 2020). [1] Liu Na and Wang Hongpeng (2023) pointed out that based on the new development stage, in order to promote the coordinated development of the Beijing, Tianjin and Hebei region to continue to expand in depth and reach a higher level, it is necessary to firmly grasp the trunk of the non-capital function of Beijing, and work hard to innovate the mode of industrial transfer and docking and cultivate new driving forces by agglomeration. [2] Sun Jiuwen (2023) emphasized that the evacuation of the headquarters of central enterprises is the top priority, through marketization and rule of law to enhance the endogenous power of outward mobilization, we will continue to leverage the advantages of the Beijing, Tianjin and Hebei region and form synergy for coordinated

development. [3] Li Guoping and Lu Shuang (2024) proposed that joint efforts should be made in both alleviation and undertaking to create a new spatial pattern of one core and two wings. [4] In April 2015, the Outline of the Beijing, Tianjin and Hebei Coordinated Development Plan emphasized that the Beijing, Tianjin and Hebei region has a clear positioning and coordinated development, and one of the important tasks is to alleviate and solve the urban disease in Beijing. Wen Kui (2014) believed that Beijing can mainly relieve non-capital core functions, but not all non-capital core functions can be relieved, it is necessary to see not only its removability, but also the problems and challenges that may be brought by its removability. [5]

How to relieve the non-capital functions of Beijing has attracted more and more attention and become a research hotspot. Wu Jianzhong and Zhan Shengze (2018) emphasized the importance of the central government's top-level design and implementation of the integrated plan for the Beijing, Tianjin and Hebei region, scientifically establishing the strategic focus of evacuation, coordinating and regulating the development of Beijing's urban area, and scientifically implementing the mechanism of industrial upgrading, transfer and exit. [6] Zhang Keyun and Shen Jie (2017) believed that there was a ladder fault structure in the economic development of Beijing, Tianjin and Hebei, with a large gap within the region, so the mode of industrial gradient transfer at the present stage is more suitable for the development of the Beijing, Tianjin and Hebei region. [7] Liang Shuang (2020) believes that the decentralization of non-capital functions is a long-term and comprehensive project involving more stakeholders, which cannot be adjusted only through simple administrative measures, but also needs to do a good job in the decentralization of top-level design and docking with the surrounding bearing sites. [8] Zhu Jing (2023) believes that under the new development pattern, Beijing should grasp the strategic positioning of the capital city and optimize the function layout of Beijing, strengthen core functions, accelerate the construction of an international science and technology innovation center, promote the digital transformation of the service industry, increase the density of rail transit in the core area, adhere to the combination of centralized and decentralized decentralization, overall planning and classified policies, adjust the economic structure and spatial structure, and find a new way to optimize the development of densely populated areas. [9]

Many scholars have proposed that the Beijing-Tianjin-Hebei coordinated development of transportation and logistics should take the lead (Zhu Xianying, Dun Lei, Liu Na, 2017). [10] Chen Shuzhi (2017) pointed out that as the Beijing, Tianjin and Hebei coordinated development strategy entered the implementation stage, the establishment of an efficient and convenient regional integrated transportation service system was an important basis for promoting industrial cooperation and realizing industrial upgrading in the Beijing, Tianjin and Hebei region. [11] Li Hui, Ren Qilong and Zhang Chunmai (2022) believed that Beijing gradually distributed non-core functions of the capital including logistics to surrounding areas, which was a process of logistics pattern reconstruction for the Beijing, Tianjin and Hebei region, and proposed to formulate reasonable regional logistics development plans to guide the coordinated and mutual development of regional logistics. [12] Liang Chen (2021) proposed that efficient and smooth logistics channels are an important support for regional economy and the coordinated development of Beijing, Tianjin and Hebei. Emphasis should be placed on speeding up the construction of regional logistics channels, strengthening regional logistics cooperation in Beijing, Tianjin and Hebei, and promoting regional coordinated development. [13] Li Yanwei and Chen Rong (2022) pointed out that in

order to further improve the agglomeration degree of the Beijing, Tianjin and Hebei logistics industry, all cities should strengthen regional linkage development, reasonably adjust the industrial structure, strengthen the construction of logistics information platform and the construction of logistics talent training mechanism. [14] Bing Xingguo (2024) proposed that in promoting the coordinated development of Beijing, Tianjin and Hebei region, the construction of transport infrastructure should be vigorously promoted, the integrated development of transport ecological industry should be promoted, and new breakthroughs should be made in the coordinated development of key areas. [15]

Digital development plays an important role in promoting the synergy of urban agglomeration (Ke Yang, Qi Han, Bauke de Vries, 2024). [16] Relevant studies have analyzed digitalization and regional development. Kai Yuan et al (2023) point that Exploring the interaction and coupling effects within the digital economy and eco-economic system resilience in urban agglomeration areas is conducive to promoting high-quality sustainable urban development. [17]Yangyang Yang et al (2023) based on the panel data of 13 cities in the Beijing-Tianjin-Hebei (BTH) region from 2011 to 2019, this study investigates the direct effect, intrinsic mechanism, and spatial spillover effect of digital technology development (DTD) on urban green development efficiency (GDE).[18] Runde Gu et al (2023)reveals the influence mechanism of industrial digitalization and regional collaborative innovation on urban green development efficiency (GDE) and show that industrial digitalization significantly improves urban GDE and regional collaborative innovation can directly enhance urban GDE.[19] Yuxing Yan et al (2024) taken the Beijing-Tianjin-Hebei (BTH) region of China as a typical case, this study measures the URT(urban-rural transformation) from the population-land-industry perspective and elucidates the influence of each index of URT on ESs (ecosystem services) at different stages.[20]

To sum up, the research on the coordinated development of Beijing, Tianjin and Hebei region and the alleviation of non-core functions of the capital has achieved rich results. However, more focus on the connotation definition, policy suggestions and qualitative description of non-core function allocation, lack of quantitative analysis of the effect of non-core function allocation of the capital and need in-depth theoretical analysis of the transfer and undertaking process among Beijing, Tianjin and Hebei. Based on the improved logistics gravity model theory, this paper empirically calculates the comprehensive quality of logistics and the scope of logistics radiation of each city in the Beijing, Tianjin and Hebei Economic Zone from 2018 to 2022, and plans the spatial pattern change of logistics links in the Beijing, Tianjin and Hebei Economic zone, especially quantitatively analyzes the logistics links between Beijing, Tianjin and 11 cities in Hebei. To preliminaries the effect of non-core function easing and the integrated development of Beijing, Tianjin and Hebei, and provide reference for promoting the integrated development of Beijing, Tianjin and Hebei under the background of digitalization.

3. Current Situation of Logistics under the Background of Beijing, Tianjin and Hebei Integration

In the context of Beijing, Tianjin and Hebei integration, since 2014, the Beijing Municipal Party Committee and government have attached great importance to the decentralization of non-capital functions and introduced relevant decentralization measures according to the Outline of the Beijing, Tianjin and Hebei Coordinated

Development Plan, focusing on four categories of decentralization subjects such as the commodity market, and achieved positive results. According to statistics, since 2014, the number of commodity trading markets has decreased from 728 to 422, especially in the core area of the capital (Table 1). Moving batch, Da Hongmen and other commodity trading markets have mostly completed the overall relocation. Moreover, fixed asset investment in wholesale and retail was only 1.7 billion yuan in 2019, down 46.1% (Table 2). At the same time, Beijing has formulated and implemented the country's first list of new industry bans and restrictions aimed at controlling the big city disease, with 55% of the city and 79% of the city's six districts banned. Since the catalogue was implemented in 2014, the total number of industrial and commercial registration businesses not handled in the city has reached 25,000. Complete the task of withdrawing 3,200 general manufacturing and polluting enterprises. Implement the policy of controlling people by industry and transfer low-end industries to the outside, Through the Beijing, Tianjin and Hebei coordination mechanism, the enterprises that have been dispersed out find corresponding development space in Hebei and Tianjin.

The cumulative permanent resident population of Beijing has shown a steady decline, and the permanent resident population of the city's six districts has achieved the target of decreasing by 15% compared with 2014. By the end of 2021, the number of market players in the city's six industries related to deregulation, such as manufacturing, wholesale and retail, decreased by 17.8% compared with the same period in 2016, among which the number of market players in the city's six districts decreased by 35.3%, twice the city's average decline, the proportion of newly established business entities in science and technology, commerce, culture and information increased from 40.7% in 2013 to 65.6% in 2022, achieving remarkable results.

Table 1. Changes in the number of commodity trading markets in Beijing, Tianjin and Hebei from 2014 to 2022

	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of commodity markets in Beijing	728	719	612	631	529	483	453	430	422
Number of commodity trading markets over 100 million yuan in Beijing	131	125	136	114	94	86	88	73	65
Number of commodity trading markets over 100 million yuan in Tianjin	65	56	55	44	43	42	41	47	44
Number of commodity trading markets over 100 million yuan in Hebei Province	244	236	225	217	200	190	178	168	161

Data source: the 2014-2022 statistical yearbook of the Beijing, Tianjin and Hebei region and the statistical communiques of the central cities of the region for 2014-2022.

Table 2. Changes in fixed investment in wholesale and retail in Beijing, Tianjin and Hebei from 2014 to 2022

(Unit: RMB 100 million)

	2014	2015	2016	2017	2018	2019	2020	2021	2022
Beijing wholesale and retail fixed asset investment	33.9	60.8	30	30.7	31.5	17.0	10.2	10.6	10
Year-over-year growth rate	-34.1%	79.3%	-50.7%	2%	2.5%	-46.1%	-40.0%	3.9%	-5.9%
Tianjin wholesale and retail fixed asset investment	323.74	471.45	868.67	740.7	572.56	341.82	323.7	193.25	142.43
Year-over-year growth rate	25.6%	45.6%	84.3%	-0.9%	-22.7%	-40.3%	-5.3%	-40.3%	-26.3%

Hebei wholesale and retail fixed asset investment	875.89	967.4	851.67	795.28	913.78	830.62	675.3	574	625.66
Year-over-year growth rate	4%	10.4%	-12%	-6.6%	14.9%	-9.1%	-18.7%	-15%	9.0%

Data source: the 2014-2022 statistical yearbook of the Beijing, Tianjin and Hebei region and the statistical communiques of the central cities of the region for 2014-2022.

With the rapid development of non-capital core functions, it can be inferred that the absolute amount of freight in Beijing should decrease, and the relative total amount of logistics will also decrease. The freight volume of Hebei and Tianjin, where the industry is mainly undertaken, should increase, and the relative total logistics volume will also increase. The total freight volume in Beijing from 2014 to 2022 shows a downward trend on the whole, especially the railway and road transportation. That is to say, with the transfer of backward production capacity and market, freight volume, especially road freight volume, has decreased significantly. Of course, in fact, Beijing's GDP and total retail sales of consumer goods have steadily increased, which further highlights the role of non-core functions (Table 3).

Beijing is mainly to ease the non-core functions of the capital, accelerate industrial transfer and population diversion, while Tianjin and Hebei are to do a good job in the relocation of functions and industrial transfer undertaking and cooperation. The enthusiasm of Tianjin and Hebei to undertake the urban functions and industrial deregulation of Beijing is very high. The implementation of the coordinated development strategy of Beijing, Tianjin and Hebei, on the one hand, effectively alleviates the non-capital functions, and on the other hand, it also brings huge development dividends and far-reaching impacts to Hebei and Baoding. Cities in Hebei Province, such as Baoding, Shijiazhuang and Tangshan, are striving to build industrial undertaking parks and platforms. In the coordinated development of the Beijing, Tianjin and Hebei region, Tianjin will undertake the main functions of the capital and take advantage of Beijing's technological advantages and its own advanced manufacturing capabilities to develop high-tech industries, producer services, high-end equipment manufacturing, biomedicine, port industry, financial industry and other industries. From 2014 to 2022, the total volume of freight transport in Tianjin showed an overall upward trend. In fact, Tianjin has made great progress in eliminating backward production, and the annual reduction task of 3.7 million tons of crude steel production capacity in the iron and steel industry has been completed ahead of schedule by overcapacity reduction (Table 3).

Hebei's freight volume has not changed much in recent years, one is Hebei's efforts to reduce capacity. Since 2013, Hebei has reduced steel, cement, coal and glass production capacity. In 2015, Hebei province closed down 58.9 percent of the country's iron making capacity and 76.6 percent of the country's steelmaking capacity. In 2016, Hebei reduced its steelmaking capacity by 16.24 million tons, iron making by 17.61 million tons, cement by 2.86 million tons and flat glass by 21.89 million weight boxes, shut down 54 coal mines and reduced its coal production capacity by 14 million tons. Compared with the reduction of freight volume caused by overcapacity reduction, the increase of freight volume caused by the dredging of non-core functions of Hebei's capital is insignificant. As a result, Hebei's freight volume has decreased since 2014 (Table 3).

Table 3. Changes in total freight volume in Beijing, Tianjin and Hebei from 2014 to 2022

(unit: ten thousand tons)

	City	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total amount of transportation	Beijing	26551	20078	20734	20110	20873	22808.4	22202.9	23424.8	18918
	Tianjin	49753	48779	50506	51800	52221	50093.3	52519.2	56435.4	52898
	Hebei	238749	199192	210994	229211	249650	242866	247783	261679	232136
railway	Beijing	1135	1034	762	736	596	483.6	413.9	349.7	368
	Tianjin	8874	8378	8149.16	8736	9249	9888.2	11124.2	11749.7	11754
	Hebei	48063	17843	16313	17100	19580	26823	30806	29205	30212
highway	Beijing	25416	19044	19972	19374	20278	22324.8	21789	23075.1	18549
	Tianjin	31130	30551	32841	34720	34711	31250.2	32261	34527	30382
	Hebei	185286	175637	189822	207309	226334	211461	211942	227203	196727
water transport	Tianjin	9749	9850	9514.53	8345	8261	8954.9	9134	10158.7	10761
	Hebei	4041	4542	4458	4413	3352	4160	4575	4800	5197
civil aviation	Hebei	2.52	2.60	2.33	2.10	2.19	2.58	2/48	2.67	2.41
pipeline	Hebei	1356	1168	399	386	382	419	455	469	485

Data source: the 2014-2022 statistical yearbook of the Beijing, Tianjin and Hebei region and the statistical communiques of the central cities of the region for 2014-2022.

In general, the coordinated development of Beijing, Tianjin and Hebei and the relaxation of non-core functions of the capital will eventually be reflected in the change of logistics pattern, which will also lead to great changes in the logistics pattern of cities in Beijing, Tianjin and Hebei. However, it is difficult to see what effect Beijing, Tianjin and Hebei integration and non-core functions of the capital city have achieved from the deregulation of market players and the change of freight volume. How does the logistics pattern between Beijing, Tianjin and Hebei change after all? What kind of changes have taken place in the logistics links between various cities in Beijing, Tianjin and Hebei and so on. The laws and processes of these changes have not received in-depth discussion and attention. Therefore, based on the improved logistics gravity model theory, this paper empirically calculates the comprehensive quality of logistics and the scope of logistics radiation of each city in the Beijing, Tianjin and Hebei Economic Zone from 2014 to 2022, and plans the spatial pattern changes of logistics links in the Beijing, Tianjin and Hebei Economic zone, especially quantitatively analyzes the logistics links between Beijing, Tianjin and 11 cities in Hebei. This paper preliminarily explores the effect of non-core function easing and the integrated development of Beijing, Tianjin and Hebei, and gives evidence of promoting the integrated development of Beijing, Tianjin and Hebei under the background of digitalization.

4. Data Sources

The Beijing, Tianjin and Hebei region is an important part of Beijing and its strategic position is very important, but it is also faced with prominent problems such as the continuous deterioration of the ecological environment, the imbalance of the development of urban system, and the widening gap between regional and urban development. To realize the coordinated development of Beijing, Tianjin and Hebei region and innovation-driven development, and to promote the innovation of regional development system and mechanism, it is necessary to build a new capital economic

circle and realize the national development strategy in the future. The Beijing, Tianjin and Hebei urban agglomeration covers two municipalities directly under the Central Government, Beijing and Tianjin, and 11 cities in Hebei, namely Tangshan, Shijiazhuang, Handan, Xingtai, Hengshui, Cangzhou, Zhangjiakou, Chengde, Qinhuangdao, Langfang and Baoding. The land area is 218,000 square kilometers, and the resident population is about 140 million, of which 17.5 million are migrants. The Beijing, Tianjin and Hebei urban agglomeration accounts for 2% of the country's land area, but 7.98% of the country's total population. In 2022, the total GDP of the Beijing, Tianjin and Hebei urban agglomeration will reach 10,029.3 billion yuan, accounting for 8.3% of the country's GDP.

Considering the actual development of each city, district and county, we select two core cities in the Beijing, Tianjin and Hebei urban agglomeration: 16 districts each of Beijing and Tianjin, and 11 prefecture-level cities such as Baoding, Tangshan, Langfang, Qinhuangdao, Zhangjiakou, Chengde, Shijiazhuang, Cangzhou, Handan, Xingtai and Hengshui in Hebei Province, so there are 13 regional research objects in total. The research data were derived from the 2014-2022 statistical yearbook of the Beijing, Tianjin and Hebei region and the statistical communiques of the central cities of the region for 2014-2022. The traffic distances and freight modes between the regions were derived from Google Maps and the Beijing, Tianjin and Hebei Traffic Information Network, respectively, and the data were dimensionless processed by using the range method.

5. Research Methods

This paper adopts the modified gravity model, which is derived from Newton's classical physics law. With the continuous expansion of model significance, this model has been widely used in the study of economic spatial connection, such as the study of urban economic connection pattern, the analysis of spatial structure of metropolitan circle and the study of regional development pattern, etc. Most of the above studies use indicators such as economic aggregate, population and fixed asset investment as the quality of the research objects, take the linear distance or economic distance between the two objects as the distance between the research objects, and make use of the improved gravity model to obtain a series of empirical research results.

It is necessary to measure the quality of logistics and the distance of logistics between cities to calculate the value of logistics connection between cities by using gravity model. In order to ensure the accuracy of the research, this paper revises the gravity model of inter-city logistics connection on the basis of literature review and reference to existing achievements, so as to make it more reasonable to evaluate the comprehensive strength of regional logistics and make the estimation of logistics distance more realistic.

5.1. Logistics quality evaluation

The quality of logistics represents the comprehensive strength of regional logistics development. At present, researchers mainly use factor analysis, entropy value, central function strength evaluation and AHP to evaluate the development level of logistics. Among them, the center function strength evaluation method can not only realize the multi-index measurement of logistics quality, but also can be used to evaluate the city centrality and comprehensive strength level. Therefore, this paper adopts this method to

measure logistics quality and divide the spatial pattern of logistics connections in the central cities of Beijing, Tianjin and Hebei economic zone. Based on the actual development of 13 cities and districts and considering the principle of comparability, this paper selects six indicators: per capita GDP, per capita freight turnover, market prosperity (ratio of total retail sales of consumer goods to total regional economy), highway network density, per capita number of mobile phones, and average number of households with Internet access to calculate the functional strength of urban centers. K_i represents the quality value of regional logistics, calculated as follows:

$$K_i = (K_{1i} + K_{2i} + K_{3i} + K_{4i} + K_{5i}) / 5 \quad (1)$$

Where, K_{1i}, K_{2i}, K_{3i}, K_{4i} and K_{5i} represent the economic development level index, logistics supply level index, logistics demand level index, logistics basic development index and informatization level index of the city respectively. The average per capita GDP, per capita freight turnover, market prosperity, road network density, per capita number of mobile phones and average number of Internet access households are taken for calculation respectively. See reference for the calculation process. K_i represents the intensity of regional center functions, and this value is used as the quality value of urban logistics.

5.2. Logistics distance measurement

The logistics distance between two cities should not only consider the length of the spatial distance between them, but also consider the influence of the transportation mode and economic gap between the two cities. In order to measure the logistics distance between two cities, correction weights α and β are introduced to correct the spatial distance between cities.

The calculation formula is as follows: $R = \alpha \times \beta \times d$ (2)

Where, d is the spatial distance between the two cities, α is the modified weight of transportation mode, β is the economic gap between the two cities, and R is the logistics distance between the two cities. The values of the two weights are shown in Table 4 below:

Table 4. List of correction weights for distance of logistics between cities

Mode of transportation	train	automobile	steamship	train, automobile	train, steamship	automobile, steamship	train, automobile, steamship
α	1	1.2	1.5	0.7	0.8	1.1	0.5

5.3. Modified gravity model of logistics linkages

According to the above description of logistics quality and logistics distance, the revised gravity model of logistics connection can be expressed as:

$$F_{ij} = GK_iK_j \Big/ R^2 \tag{3}$$

In the above formula, F_{ij} represents the quantity of logistics connections between two cities i and j, K_i and K_j respectively represent the logistics quality of cities i and j, R represents the logistics distance between i and j, and the coefficient G is set as 1 for convenience of calculation because it does not affect the comparison result.

5.4. Logistics quality measurement

By referring to the Statistical Yearbook of Chinese Cities from 2013 to 2016 and the statistical bulletin of each district and county from 2012 to 2016, the square of logistics quality (K) value of 13 cities was calculated by substituting formula (1), as shown in Table 5 below:

Table 5. List of logistics quality K of each city

The year	Bei jing	Tian jin	Shi Jia zhuang	Cheng de	Zhang Jia kou	Qin Huang dao	Tang shan	Lang fang	Bao ding	Cang zhou	Heng shui	Xing tai	Han dan
2018	4.14	7.39	5.75	4.70	4.28	4.84	10.58	5.37	3.92	7.91	2.88	4.07	6.90
2019	4.19	7.20	6.91	5.23	4.49	5.24	11.93	6.04	4.59	8.96	3.29	4.36	7.35
2020	4.54	7.71	6.91	5.17	4.50	5.20	11.85	6.07	4.73	8.92	3.32	4.37	7.33
2021	4.16	7.58	7.09	2.92	5.07	3.95	9.46	5.06	2.38	5.53	3.23	5.01	7.82
2022	4.39	7.89	7.75	1.01	3.41	5.87	10.14	5.26	1.85	5.92	2.71	5.81	7.32

From the above data, it can be analyzed that Tangshan, Tianjin, Handan, Cangzhou, Shijiazhuang and other cities in the Beijing, Tianjin and Hebei urban agglomeration have a high proportion of secondary industries dominated by manufacturing, good logistics infrastructure conditions, strong demand for logistics services, and a high value of logistics quality K, among which Tangshan has the most fully played its logistics function. On the one hand, Tangshan has a large freight volume of steel, coal, agricultural products and other bulk commodities, and on the other hand, Tangshan has formed a logistics industry cluster area including ports and logistics parks. However, Tangshan's logistics function was relatively weakened in 2021 and 2022, which may be related to the macro economy. The logistics function of Tianjin begins to become prominent, especially under the background of Beijing, Tianjin and Hebei integration, the logistics function of Tianjin reaches the highest value of 7.89 in recent years in 2022, which shows that Tianjin benefits significantly from the Beijing, Tianjin and Hebei integration process. The logistics function of Cangzhou declined after 2020 and turned to a growth trend in 2022. Tangshan, Tianjin, and Cangzhou together constitute the eastern logistics corridor of the Beijing-Tianjin-Hebei region, becoming the eastern logistics base of the Beijing, Tianjin and Hebei region. Handan's logistics function is also fully played, and together with Xingtai, it forms the logistics corridor in the southwest of Beijing, Tianjin and Hebei. In recent years, the logistics function of Shijiazhuang has been gradually strengthened, surpassing Handan

and closing in on Tianjin. According to speculation, Shijiazhuang is also a beneficiary of the integration of Beijing, and a large part of the logistics function transferred from Beijing has been transferred to Shijiazhuang. In contrast, the logistics functions of Langfang, Zhangjiakou and Baoding around Beijing have been significantly weakened, and they have not been able to effectively undertake the logistics functions of Beijing. In general, under the background of Beijing, Tianjin and Hebei integration, Beijing, Tianjin and Hebei presents a dumbbell logistics function layout with strong at both ends and weak in the middle. It is a logistics industry gathering area dominated by the east and west axes, with Tangshan, Tianjin and Cangzhou as logistics nodes in the east and Shijiazhuang, Handan and Xingtai as the main logistics nodes in the west. The logistics functions of Langfang, Zhangjiakou and Baoding centered on Beijing have been significantly weakened, and Beijing has become a logistics node. Since 2014, the logistics function of Beijing has been significantly relieved, but Baoding, Zhangjiakou and other places have not effectively undertaken the logistics function of Beijing.

5.5. Calculation of logistics spatial connection quantity

The spatial distance between the 13 cities is consulted through Google Map, and the square of the logistics distance between the 13 cities can be calculated by Formula (2) considering the economic gap and freight mode between the cities. By substituting the logistics quality and logistics distance calculated above into Formula (3), the third power of the amount of logistics links between cities can be obtained. Table 6 shows the amount of logistics links between Beijing, Tianjin and 11 cities in Hebei Province.

Table 6 show that under the background of Beijing-Tianjin-Hebei integration, the distribution of logistics links among central cities is obviously unbalanced, roughly forming the following trends: (1) Beijing and Langfang have the closest logistics links, followed by Tianjin, Tangshan and Shijiazhuang. That is to say, the logistics function of Beijing is mainly dispersed in Langfang, Tianjin, Shijiazhuang and Tangshan. In 2021 and 2022, the connection degree with Langfang increased by 0.5, the connection degree with Tianjin increased by 0.14, the connection degree with Shijiazhuang increased by 0.05 and the logistics connection degree with Tangshan increased by 0.11. In contrast, the logistics connection degree between Beijing and other cities has decreased. (2) Tianjin has a close logistics connection with Tangshan, Langfang and Cangzhou, and its logistics connection degree with Tangshan and Langfang increased in 2021 and 2022, but the connection degree with Cangzhou decreased. In fact, Tianjin, Tangshan and Cangzhou constitute the eastern logistics industry base of Beijing, Tianjin and Hebei. (3) Shijiazhuang has a close logistics connection degree with Baoding, Xingtai and Handan, but a low logistics connection degree with Tianjin, Zhangjiakou and Chengde. Shijiazhuang, Baoding, Xingtai and Handan constitute the western logistics industrial belt of Beijing, Tianjin and Hebei. (3) In the central part of Beijing, Tianjin and Hebei Economic Zone, the large-scale logistics network structure has not been formed, and the logistics connection among cities is loose, which makes the development of logistics in the economic zone show an obvious central break phenomenon. Beijing played the role of central logistics hub in the past, under the background of relieving non-core functions, it is necessary to clarify the layout of logistics industry in the central part. (4) The logistics connection degree among cities in northwest China, mainly Chengde and Zhangjiakou, is small, and the logistics development is seriously collapsed, which is the weak area of logistics integration in Beijing, Tianjin and Hebei Economic Zone.

Table 6. The number of logistics links between Beijing and Tianjin and 11 cities in Hebei Province

The year	Tian jin	Shi Jia zhuang	Cheng de	Zhang Jia kou	Qin Huang dao	Tang shan	Lang fang	Bao ding	Cang zhou	Heng shui	Xing tai	Han dan
2018	1.42	0.24	0.37	0.48	0.06	0.97	5.53	0.54	0.64	0.13	0.09	0.14
2019	1.40	0.29	0.41	0.51	0.07	1.11	6.30	0.64	0.74	0.16	0.10	0.16
2020	1.62	0.31	0.44	0.55	0.07	1.20	6.86	0.72	0.79	0.17	0.11	0.17
2021	1.46	0.29	0.23	0.57	0.05	0.88	5.24	0.33	0.45	0.15	0.12	0.17
2022	1.60	0.34	0.08	0.41	0.08	0.99	5.74	0.27	0.51	0.13	0.14	0.16

6. Conclusions and Suggestions

6.1. Discussion

During the COVID-19, due to the impact of epidemic prevention policies, the integration of Beijing Tianjin Hebei logistics into the city was limited at the initial stage. In the later stage, due to the needs of economic development, especially material support, the three regions have increased logistics integration cooperation. Overall, the epidemic has had little impact on the integration of logistics in the three regions. On the contrary, digital construction has greatly promoted the integration of logistics in the three regions.

6.2 Conclusions

The integration of Beijing, Tianjin and Hebei, especially the non-core functions of the capital, has brought new adjustments and changes to the integration of Beijing, Tianjin and Hebei logistics. The changes of logistics connection degree and logistics function can also fully reflect the changes of non-core function of the capital. Since 2014, the logistics function of Beijing has indeed changed, and the logistics quality K value, which represents the logistics function, has undergone positive changes and adjustments. In 2021, it decreased by 0.38 compared with 2014, and in 2022, it recovered somewhat, but it is also less than that in 2020. The main reason for the improvement is the advance of logistics function brought by the digitalization of the economy. The main undertaking of logistics dredging in Beijing is Tianjin, Shijiazhuang and Tangshan. That is to say, the logistics function of Beijing is mainly dispersed in Langfang, Tianjin, Shijiazhuang and Tangshan. In 2021 and 2022, the connection degree with Langfang increased by 0.5, the connection degree with Tianjin increased by 0.14, the connection degree with Shijiazhuang increased by 0.05 and the logistics connection degree with Tangshan increased by 0.11. In contrast, the logistics connection degree between Beijing and other cities has decreased. The northwest of Beijing, Tianjin and Hebei region shows the phenomenon of logistics development fracture and collapse and is gradually marginalized in the logistics development of Beijing, Tianjin and Hebei Economic Zone.

6.3. Suggestions

Therefore, in order to relieve the non-core functions of the capital, promote the integrated development of logistics in the Beijing, Tianjin and Hebei Economic Zone

and give full play to the urban cluster effect of the economic zone, we can start from the following aspects:

(1) Focus on creating a strategic digitalization framework of overall layout.
The integrated development of logistics and the coordinated digitalization planning and construction of urban agglomeration are complementary to each other, and the construction and development of urban agglomeration have an important impact on regional industry driving and economic growth mode transformation and are an important driving force for the coordinated development of regional logistics. By improving the four Beijing, Tianjin and Hebei logistics centers in Tianjin, Tangshan, Langfang and Shijiazhuang, we will create three logistics industrial belts in the east, west and middle. Through the construction of four logistics centers, the non-core functions of Beijing can be alleviated, and the industrial cluster advantages of the industrial belt can stimulate the development vitality of the logistics industry in the Beijing, Tianjin and Hebei Economic Zone, and enhance the cohesion of the development of logistics within the region.

(2) Pay attention to the realization of logistics multi-format development.
Multi-format refers to the diversification of modern logistics formats. As far as the current situation is concerned, the logistics of many areas in the Beijing, Tianjin and Hebei Economic zone still stays in the traditional business mode of material transportation, and the level of logistics development is low. In the future, Langfang, Shijiazhuang and Tangshan should seize the strategic opportunity of industrial transfer in the Beijing, Tianjin and Hebei region, carry out procurement, packaging, transit, export, warehousing and other kinds of logistics business, and realize the diversification of regional logistics development. This can not only improve the overall benefits of the logistics industry in the Beijing, Tianjin and Hebei Economic Zone, but also further enhance the status of the regional logistics center of the above cities, expand the scope of logistics radiation, make the logistics link between regions closer, so as to promote the integration of regional logistics.

(3) Actively integrate into the industrial chain to improve the strength of logistics development.
The economic level of cities in the Beijing, Tianjin and Hebei Economic Zone is extremely uneven, especially Chengde, Zhangjiakou and other central and northern cities are relatively backward in economic development and low in logistics development. We should take active measures to make full use of the characteristics of the market close to Beijing and Tianjin, do well in the upstream market of the supply chain, form the supporting manufacturers of the core enterprises of the supply chain of Beijing and Tianjin, and according to the comparative advantages of the regional central cities, carry out the division of labor, cooperation and complementary development in the industrial chain, and gradually eliminate the boundary with the core area from passive to active, so as to promote the integration of the whole region.

(4) Break through administrative boundaries to carry out comprehensive planning for logistics development.
With the continuous development of Beijing, Tianjin and Hebei Economic Zone, the competition among cities in the region is becoming increasingly fierce, and many cities are scrambling to become the central city of regional development. Under the background of the integration of Beijing, Tianjin and Hebei and the easing of non-core functions of the capital, the Beijing, Tianjin and Hebei Economic Zone should carry out

the alliance according to the principle of geographical proximity rather than administrative boundaries, establish the concept of resource sharing and win-win cooperation, establish the coordination mechanism of equal distribution of interests, coordinate the development of the opening and construction of routes and railways.

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