land

MDPI

Article

The Spatial Pattern and Influencing Factors of Traffic Dominance in Xi'an Metropolitan Area

Julin Li [1], Tongsheng Li [1,2,*], Bingchen Zhu [1], Yilin Wang [1], Xieyang Chen [1] and Ruikuan Liu [1]

1 College of Urban and Environmental Sciences, Northwest University, Xi'an 710127, China; 201910209@stumail.nwu.edu.cn (J.L.); 202133150@stumail.nwu.edu.cn (B.Z.); 202121516@stumail.nwu.edu.cn (Y.W.); 202110248@stumail.nwu.edu.cn (X.C.); liuruikuan@stumail.nwu.edu.cn (R.L.)

2 Shaanxi Institute of Provincial Resource, Environment and Development, Xi'an 710127, China

* Correspondence: leetang@nwu.edu.cn

Abstract: Metropolitan areas shoulder the crucial task of regional and even national economic development. Analyzing the spatial patterns and influencing factors of metropolitan traffic dominance can provide a scientific basis for the optimization of its transportation and industrial layout, which is conducive to the development of its economy. Previous studies on traffic dominance paid little attention to metropolitan areas and even less so to study these areas from the perspective of town units, even though these are the basic units that narrow the gap between urban and rural areas and thus achieve regional economic integration. The traffic dominance model can comprehensively and wholly reflect regional traffic conditions, due to its multidimensional characteristics (including traffic network density, traffic arterial influence and accessibility). Consequently, taking the Xi'an metropolitan area as an exemplar and the town as the basic unit, this paper employs this model and other methods to study the spatial pattern and influencing factors of its traffic dominance. The results show the following: (1) the traffic network density, traffic arterial influence and accessibility had different distribution patterns; however, they were the same in that their superiorities were relatively high in the main urban area of Xi'an city or along and on both sides of the high-speed railways (HSRs), whereas relatively low in the peripheral areas; (2) the integrated traffic dominance consistently displayed a "point-axis" pattern, with greater superiority in the east–west axis areas within 30 km of Xi'an city, especially in the main urban area of Xi'an city; (3) the integrated traffic dominance between towns had stable agglomeration correlation in the global areas and formed three major modes in the local areas: high–high, low–low and low–high aggregation. High–high mode was concentrated in the main urban areas of Xi'an and Xianyang city, low–low mode was mainly distributed in the Weibei hilly and gully areas and the Qinling mountain areas and low–high mode always nested on the edge of high–high areas; and (4) the location, GDP and elevation had a greater impact, whereas construction intensity, population and slope had a relatively small influence on the town's traffic dominance, and their influence ability had a decreasing trend from 2010 to 2022. Finally, this paper discusses the theoretical implications, practical values and some prospects based on the research results.

Keywords: traffic dominance; traffic network density; traffic arterial influence; accessibility; spatial pattern; influencing factor; town units; Xi'an metropolitan area

check for updates

Citation: Li, J.; Li, T.; Zhu, B.; Wang, Y.; Chen, X.; Liu, R. The Spatial Pattern and Influencing Factors of Traffic Dominance in Xi'an Metropolitan Area. *Land* **2023**, *12*, 1146. https://doi.org/10.3390/land12061146

Academic Editors: Bo Li and Muhammad Mohiuddin

Received: 28 April 2023
Revised: 25 May 2023
Accepted: 28 May 2023
Published: 30 May 2023

1. Introduction

The concept of the metropolitan area was proposed in the United States in 1910, however, it has been used extensively in Japan [1]. There are some differences in understandings and interpretations of the metropolitan area in different countries. In the United States, the metropolitan area that mirrors a current urban spatial structure [2] is a geographical statistical unit serving federal statistics and national surveys. It consists of an urban core with a certain population and its surrounding areas, where the economy and society are highly integrated into the former [3,4]. However, it reflects the theoretical model of urban spatial structure in Japan and represents the geographical scope of a certain aspect of functional services that can be accepted by the central city (population of over 100,000) with a cycle of 1 day [5–7]. In Europe, especially in France, Germany and the Netherlands, it is mainly a framework concept for the spatial development policies among European countries, and the purpose is to enhance international competitiveness and national strength [8] by means of joint coordination, consultation and resource sharing [9]. For China, it is a spatial form of urbanization within the urban agglomeration and centered on mega-cities or large cities with strong radiation-driven functions, with a one-hour commuter circle as the basic scope [10]. Even though some deviations are existent in various countries, there is a certain consensus that the metropolitan area plays the role of regional growth poles [11] and undertakes the important task of regional and even national economic development.

Transportation infrastructure is the strategic cornerstone of promoting regional economic growth [12]. After long-term traffic construction, the region will form a better traffic network; however, due to the influence of natural, economic, social and other factors, a spatial imbalance always prevails in its transportation situation [13]. Such spatial imbalance directly determines the flow capacity of production factors and the ability of industrial agglomeration, thus affecting the opportunities and potential of regional development [14]. Well-planned transportation networks can facilitate the efficient transportation of resources [15]. An area with good transportation infrastructure is attractive for companies [16], capital [17], population, etc., and further brings about industrial clustering, which will invigorate the regional economic vitality, competitiveness and economic growth [18–21]. However, if the transportation infrastructure in an area is underdeveloped, the spatial production component flow will not be smooth and lead to a lack of choice, innovation and intellectual opportunities for the development [22], which will limit its economic growth to a certain extent. Taking advantage of the transportation's superiority while avoiding the transportation's shortcomings is a key element of laying out an industrial enterprise and conducting economic activities [13]. Therefore, it is important to evaluate traffic dominance and analyze its spatial pattern, which could provide a scientific basis for the optimization of its transportation and industrial layout, so as to promote its economic development and further contribute to the regional or even national economy.

Existing studies mainly concentrated on countries, large regions, urban agglomerations or cities; however, they paid insufficient attention to metropolitan areas. For instance, Shih-Lung Shaw et al. (2014) employed a timetable-based evaluation approach to accessibility to analyze the changes in travel cost, travel time and distance accessibility for the main stages of HSR development in China [23]; Wang Zhiheng et al. (2021) used the traffic dominance model to investigate the spatial pattern of highway traffic dominance in the Qinghai–Tibet Plateau [24]; Juan Nicolás Ibáñez and Francesco Rotoli (2017) measured the impact of the Trans-European transportation network on the accessibility of European urban agglomerations [25]; Steven Farber and Liwei Fu (2017) used travel time cubes to analyze the dynamic public transit accessibility of the Wasatch Front, Utah and the Portland region in Oregon [26]; and Miao Yi et al. (2021) additionally constructed a comprehensive traffic dominance evaluation system to discuss the traffic dominance of Nyingchi City [27] and so on.

China announced the "Outline of the 14th Five-Year Plan for National Economic and Social Development of the People 's Republic of China and the Vision 2035" in March 2021. This outline proposed to give full scope to the leading role of central cities and urban agglomerations and build a modern metropolitan area [28]. Subsequently, the Chinese government approved six national metropolitan areas including Nanjing, Fuzhou, Chengdu, Changzhou-Zhuzhou-Tan, Xi'an, Chongqing and Wuhan. Among them, the Xi'an metropolitan area is the economic growth pole of Northwest China, and its gross domestic product (GDP) is almost one-fourth of the GDP of the five provinces in Northwest China [29]. However, compared with the other five metropolitan areas, its economic development strength is relatively poor [30]. Therefore, this paper chooses the Xi'an metropolitan area as a case to analyze the spatial pattern of traffic dominance and further explores its influencing factors. The purpose is to determine the advantages and problems of traffic development in the Xi'an metropolitan area and based on the research results, propose scientific traffic optimization measures as well as a guide to the rational layout of the industry.

The remainders of this paper are as follows: Section 2 describes related studies and proposes the entry point of this paper. The study area, data collection and methodology are introduced in Section 3. Section 4 shows the characteristics of the distribution pattern, correlation pattern and influencing factors of traffic dominance from 2010 to 2022, and Section 5 discusses the theoretical significance and practical implications of this paper. The conclusions of the analysis are summarized at the end.

2. Literature Review

Previous studies have two main perspectives for evaluating traffic superiority and analyzing its spatial patterns: accessibility and traffic dominance.

Accessibility is conceived from classical location theory [31]. Hansen (1959) pioneered the concept of accessibility in 1959 [32] and defined accessibility as potential opportunities for interaction [33]. Since then, many scholars have interpreted accessibility from various perspectives based on their research [22,34,35]. Regardless of which definition is used, it reflects the traffic dominance of the destination to some extent. Many scholars have studied traffic dominance from the perspective of accessibility, such as Dea Christine Melbye et al. (2015), who measured the accessibility of the international airport and city center (Posta) in Dar es Salaam from a time–distance perspective, and its results showed that accessibility to the international airport was extremely poor, and the expected travel time to the Posta was high [15]; based on the travel time method, Calvin P. Tribby and Paul A. Zandbergen (2012) additionally proposed a new and high-resolution spatio–temporal model of public transit accessibility and measured the accessibility of Albuquerque in New Mexico [36]; Jing Cao et al. (2013), Shaw S L et al. (2014) and Wang Lvhua et al. (2018) used weighted average travel time, travel cost or travel distance and other methods to analyze the traffic accessibility of major cities or counties in China with an HSR network as the object; however, the results were somewhat different because of differences in cities, research methods or research periods [23,37,38]; Javier Gutiérrez (2005) used methods such as weighted average travel time to evaluate the future impact of accessibility from the completion of HSR on the Madrid–Barcelona–France border [39]. Besides directly and objectively evaluating the accessibility, researches on the accessibility of medical facilities [40–43], employment [44,45], schools [46], tourism attractions [47,48], parks [49,50], etc., indirectly reflect traffic dominance as well.

The traffic dominance index was proposed by Jin Fengjun (2008) [13], who considered that the traffic superiority of a region could be reflected in three aspects: "quantity", "quality" and "advantage". In his view, "quantity" referred to the scale of transportation facilities, which can be expressed by traffic network density; "quality" meant the quality and ability of transportation facilities, which can be denoted by traffic arterial influence; and "advantage" indicated the advantage of a traffic location that represented the location condition of an area relative to the main city in a regional system, which could be expressed via accessibility. Thus, the traffic dominance is an integrated index, which is composed of traffic network density, traffic arterial influence and accessibility [51]. Some scholars used the traffic dominance index to evaluate regional traffic conditions. For example, Hu Hao et al. (2015) and Chen Shuting et al. (2022) used this index to study the traffic superiority of China based on the county units, respectively [51,52]; Sun Hongri et al. additionally took the county as basic units to analyze the pattern of traffic dominance in Northeast China, and the results showed that its distribution pattern presented a "core-periphery" structure [53]; in order to adapt to the actual situation of a region, some scholars adjusted the traffic dominance index; however, they additionally comprehensively reflected transportation superiority from multiple dimensions. For example, Guo Zheng et al. (2020) constructed a traffic dominance index from the aspects of traffic network connectivity and accessibility to analyze Kenya's traffic conditions and its spatial differentiation pattern [54]; Miao Yi et al. (2021) believed that the traffic dominance index should include four aspects: internal traffic function, external traffic function, traffic system stability and location and then used this index to conduct an empirical discussion on the traffic dominance in Nyingchi City [27].

Generally speaking, we find that there are some deficiencies in previous studies. Above all, in terms of a study area, they focused on countries, large regions, urban agglomerations or cities, whereas metropolitan areas received less attention; in terms of study units, most concentrated on the counties and cities and paid insufficient attention to town units. However, towns are the basic units to narrow the gap between urban and rural areas and thus achieve regional economic integration. In addition, accessibility merely reflects a single dimension of traffic conditions: traffic location advantage; however, the traffic dominance index reveals the traffic conditions from multiple dimensions including traffic network density, arterial influence and accessibility. Therefore, compared with accessibility, the traffic dominance index is more comprehensive in evaluating traffic conditions. Moreover, accessibility mainly abstracts the spatial unit as a node, which reflects the traffic conditions of the node more; however, the traffic dominance index is mainly applied to those of regional areas. Therefore, it is more suitable to use the traffic dominance index to evaluate regional traffic conditions. In view of this, this paper utilizes the traffic dominance index and uses towns as the basic units to analyze the traffic superiority pattern in the Xi'an metropolitan area and further explore its influencing factors.

3. Research Data and Methodology

3.1. Study Area

The Xi'an metropolitan area (Figure 1), which belongs to Shaanxi Province, is located in the inland center of China and covers an area of approximately 20,600 km^2. It is composed of 4 cities and 1 district, namely Xi'an city, Xianyang city, Weinan city, Tongchuan city and Yangling district, including a total of 26 counties and 337 towns. It should be noted that the Xi'an metropolitan area includes just some counties of Weinan city and Tongchuan city.

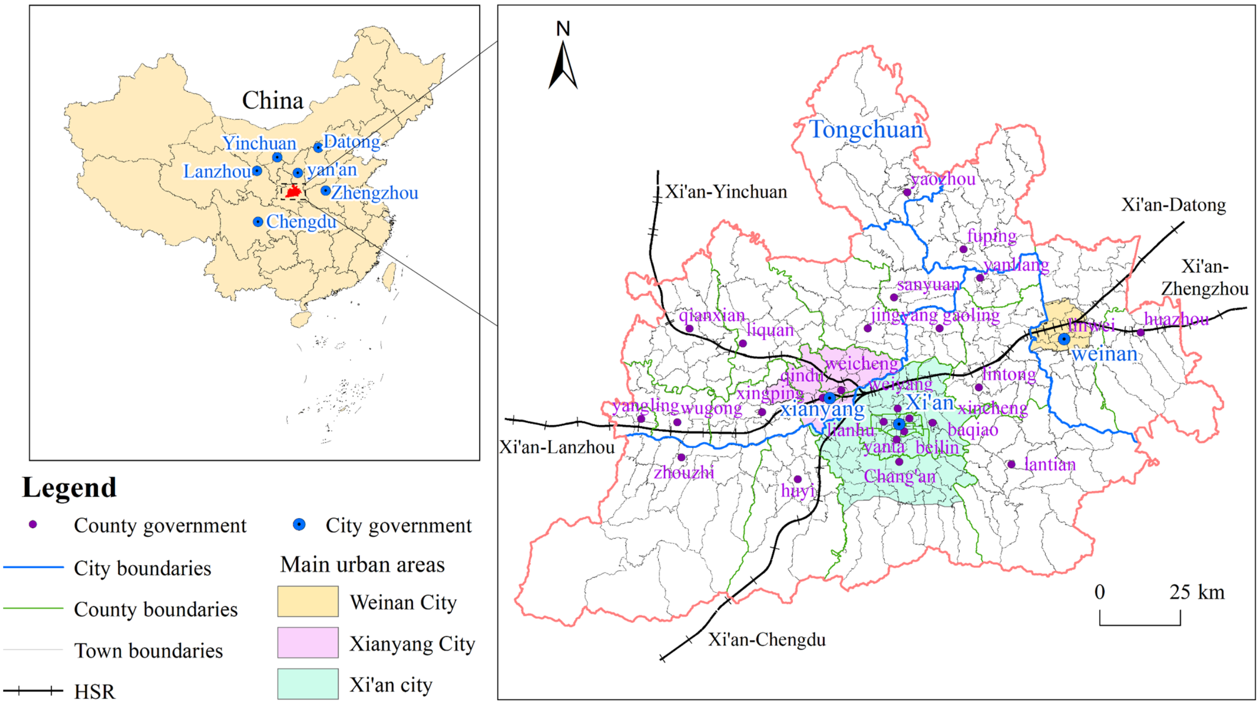

Figure 1. Map of study area.

In 2020, the permanent population in the Xi'an metropolitan area was approximately 18.02 million, with an urbanization rate of 72% [29]. Currently, HSRs, expressways and subways have an operation mileage of 606.21, 2297.66 and 259 km in the Xi'an metropolitan area, respectively.

3.2. Data Collection

Firstly, a comprehensive traffic network system is adopted, including railways, expressways, ordinary roads and subways (Table 1) in the calculation of regional traffic dominance. The traffic network data are mainly from OpenStreetMap in January 2010 and October 2022 and is revised in accordance with Amap. Secondly, the data of county boundaries and their government locations are from the National Geographic Information Resources Services Directory System (www.webmap.cnn, accessed on 22 February 2023) which provides the vector map data on a 1:1 million scale, and the data of town boundaries and their government locations are obtained by vectoring, coordinate registering and correcting their county maps. Finally, we additionally use the data of the elevation, slope, GDP, population, construction intensity and location (Table 2) to detect the influencing factors of regional traffic dominance. It should be noted that taking into account the impact of COVID-19 and the availability of data, the GDP and construction intensity in 2022 use the relevant data from 2019 and 2022, respectively, which are able to better reflect the real situation of the region.

Table 1. Types and descriptions of traffic data.

Type	Subtype	Description
Railway	High-speed railway	/
	Conventional railway	/
Expressway	Expressway	/
Ordinary road	Primary road	Including national roads and urban main roads
	Secondary road	Including provincial roads and urban secondary roads
	Tertiary road	Including county roads and urban branch roads
	Fourth-class road	Including township roads and other urban streets
	Other roads	Including village roads or other unknown roads
Subway	Subway	/

Table 2. Data collection of influencing factors.

Data	Source
Population	Mainly derived from China's 6th and 7th National Censuses data; some missing data are provided by the local county government.
GDP	Using the data of China's 1 km Grid GDP in 2010 and 2019 [55], which are provided by the Resource and Environment Science Data Registration and Publishing System of the CAS (www.resdc.cn, accessed on 22 February 2023).
Elevation	Extracted from 30 m DEM data based on ArcGIS, and the DEM data are from the Geo-data Cloud platform (www.gscloud.cn, accessed on 22 February 2023).
Slope	Extracted from 30 m DEM data based on ArcGIS, and the DEM data are from the Geo-data Cloud platform (www.gscloud.cn, accessed on 22 February 2023).
Construction intensity	Expressed by construction land areas, which are extracted from the data of China's Land-Use and Land-Cover Change (CNLUCC) based on the 1 km Grid in 2010 and 2020 [56], and the data are provided by the Research and Environment Science and Data Center of the CAS (www.resdc.cn, accessed on 22 February 2023).

3.3. Methodology

When analyzing the regional traffic dominance pattern, we use two analysis methods: the traffic dominance index and Moran's index. The former is designed to analyze the spatial distribution pattern of traffic dominance in the Xi'an metropolitan area, and the latter is used to detect its correlation pattern. Following this, we further use the geo-detector model to explore the influencing factors of the traffic dominance. "Town" is the basic unit in this paper.

3.3.1. Traffic Dominance Index

The traffic dominance index is composed of three dimensions (Figure 2): traffic network density, traffic arterial influence and accessibility, and its value can be obtained by weighting and summing each dimension after normalization [57]. The calculation formula is the following:

$$TD_i = \sum(TND_i \times w_1 + TA_i \times w_2 + LD_i \times w_3) \quad (1)$$

where i represents the town units; TD_i represents the traffic dominance in the town unit i; and TND_i, TA_i and LD_i denote traffic network density, traffic arterial influence and accessibility in the town unit i, with w_1, w_2 and w_3 as their weights, respectively. Based on the previous research [53], we set the weight value as follows: $w_1 = w_2 = w_3 = 1/3$.

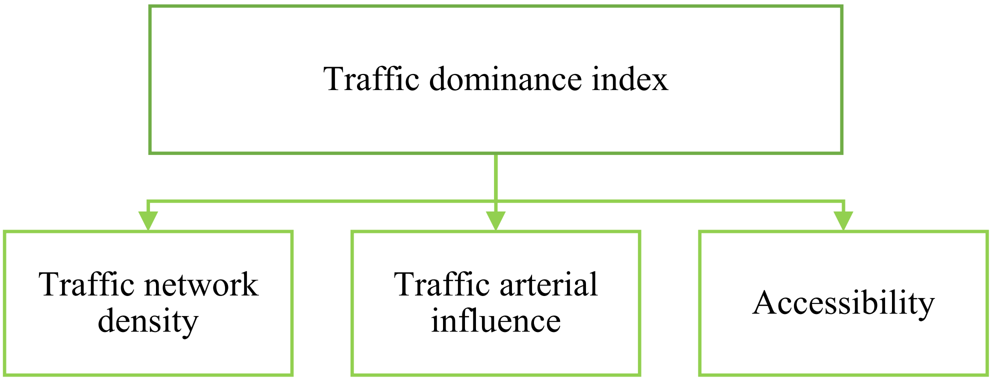

Figure 2. Traffic dominance index system.

Traffic Network Density

Traffic network density refers to the ratio of the length of traffic infrastructures to the area in a region [58], which reflects the regional traffic dominance in quantity. The greater the road network density, the stronger its ability to serve social and economic activities within the region. The calculation formula is the following:

$$TND_i = \frac{L_i}{S_i} \quad (2)$$

where TND_i represents traffic network density in the town unit i; L_i represents the length of the traffic infrastructures (including ordinary roads and subways) in the town unit i; and S_i represents the area in the town unit i.

Traffic Arterial Influence

Traffic arteries mainly refer to large or important transportation infrastructures [59], including the HSRs, conventional railways, expressways, primary roads, secondary roads and tertiary roads. They play an important role in the regional external linkages and industrial layout locations, which reflect the regional traffic dominance in terms of quality. Their influence value could be assessed by whether a town unit owns its arterial roads, or the geographic distance to those arteries from its geometric center. Firstly, each type of traffic artery will assign an influence value to a town unit and then add together all of the assigned values of each artery to obtain the whole influence degree of traffic arteries for a town unit. There are a total of 337 town units, and each town unit needs its traffic arterial influence calculated. In view of the technical and economic characteristics of traffic arteries of different types, as well as on the basis of the research by Jin Fengjun et al. [13] and Sun

Hongri et al. [53], the assignment criterion of a traffic artery for the town unit is established as follows (Table 3):

Table 3. The assignment criterion of traffic arteries.

Type	Subtype	Distance (km)	Score
Railway	HSR	0	2.5
		≤20	2
		20–40	1
		>40	0
	Conventional railway	0	1.5
		≤20	1
		20–40	0.5
		>40	0
Expressway	Expressway	0	2.5
		≤20	2
		20–40	1
		>40	0
Ordinary road	Primary road	0	1.5
		>0	0
	Secondary road	0	1
		>0	0
	Tertiary road	0	0.5
		>0	0

In the “distance” column, where it is 0, it indicates that a particular type of infrastructure is within the examined unit; where it is >0, it indicates that there is not a particular type of infrastructure in the examined unit; and where it is ≤20, 20–40 or >40 km, it indicates that the distance between the geometric center of the examined unit and the traffic arteries is less than or equal to 20 km, 20–40 km or more than 40 km, respectively.

Accessibility

Key node cities often play a leading role in the development of their surrounding areas [59]. Accessibility, which reflects the local traffic dominance in terms of traffic location, indicates the convenience of the study units to the key cities and additionally shows the radiation opportunities and development potential of these units for key node cities. Its value is determined by the average shortest travel time from the town to each node city, based on the comprehensive traffic network system, and it is a reverse indicator. When calculating travel time, different types of road speed assignments are shown in Table 4. Among them, we set the walking speed to 5 km/h according to the research of Chen Shuting et al. (2022) [52] and Wang Degen et al. (2018) [60]. The key node cities include the cities and counties in this paper. Therefore, the accessibility of a town unit consists of two parts: LD_{ui} represents the accessibility of cities, and LD_{vi} represents the accessibility of counties. Firstly, in the calculation of accessibility, we abstract the town units, cities and counties into spatial nodes where the places are used for the location of their government. Their numbers are 337, 4 and 26, respectively (Figure 1). Furthermore, the average shortest travel time (accessibility) from each of the town nodes to all 4 city nodes needs to be calculated and additionally for each of the town nodes to all 26 county nodes. Finally, the accessibility of town units can be obtained by weighting and summing both parts. According to both the expert scoring method [61] and the importance of node cities, the weight values of these 2 parts are set at 0.4 and 0.6, respectively. The calculation formula is as follows:

For cities:

$$LD_{ui} = \sum_{i=1}^{n} \sum_{u=1}^{m} W_u T_{iu} \tag{3}$$

For counties:

$$LD_{vi} = \sum_{i=1}^{n} \sum_{v=1}^{m} W_v T_{iv} \tag{4}$$

Accessibility:

$$LD_i = 0.4\sum_{i=1}^{n}\sum_{u=1}^{m} W_u T_{iu} + 0.6\sum_{i=1}^{n}\sum_{v=1}^{m} W_v T_{iv} \quad (5)$$

where LD_i represents the accessibility of town unit i; u, v represent cities and counties, respectively; T_{iu} and T_{iv} respectively represent the shortest travel time from the town unit i to city u or county v; W_u represents the weight of city u; and W_v represents the weight of county v. According to the expert assessment method, when u represents the cities of Xi'an, Xianyang, Weinan and Tongchuan, W_u are determined to be 0.15, 0.25, 0.3 and 0.3, respectively; W_v is carried out by the method of uniform weighting, and its value is the following: $W_1 = W_2 = \ldots = W_v$.

Table 4. Speed assignment of different types of roads.

Type	HSR	Conventional Railway	Expressway	Subway	Primary Road	Secondary Road	Tertiary Road	Fourth-Class Road	Other Roads	Walk
Speed (km/h)	300	120	100	40	80	60	40	30	20	5

3.3.2. Moran's Index

Moran's index reveals the spatial aggregation and anomalies of geographical phenomena [62], which could mirror the spatial correlation of traffic dominance between areas. The index includes the Global Moran's I and Local Moran's I. The Global Moran's I is utilized to investigate the global spatial correlation characteristics of traffic dominance between areas, and its positive values indicate a positive agglomeration, negative values indicate a negative agglomeration and a value of 0 indicates a random distribution; furthermore, we use the Local Moran's I to identify their local correlation features that could be divided into four types according to their value: high–high agglomeration (H–H), high–low agglomeration (H–L), low–high agglomeration (L–H) and low–low agglomeration (L–L) [63]. The calculation formulas of the Global and Local Moran's I are as follows:

Global Moran's I:

$$\text{Global Moran's I} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(x_i - x')(x_j - x')}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \quad (6)$$

$$S^2 = \frac{\sum_{i=1}^{n}(x_i - x')^2}{n} \quad (7)$$

where n is 337, which represents the number of town units; X_i and X_j represent the traffic dominance of town units i and j; x' represents the mean value of traffic dominance; and W_{ij} represents the weight.

Local Moran's I:

$$\text{Local Moran's I} = \frac{(x_i - x')\sum_{j=1} W_{ij}(x_j - x')}{S^2} \quad (8)$$

A positive I means that areas with the same type of attribute values are adjacent, and a negative I means that areas with different types of attribute values are adjacent. The larger the absolute value of I, the higher the degree of proximity.

3.3.3. Geo-Detector Model

The Geo-detector model is a set of statistical methods for analyzing the spatial differentiation of geographic phenomena and its driving factors [64]. This model includes four analysis modules: factor, interaction, risk and ecological detection. Factor detection is the most popular module and can be employed to detect whether the factor variable has a statistically significant impact on the regional traffic dominance and its explanatory power q. The calculation formula of q is as follows:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h {\sigma_h}^2}{N\sigma^2} \quad (9)$$

where L represents the hierarchy of dependent variables or independent variables; N, σ^2 represent the number of town units and the variance of the dependent variables, respectively; and $N_h, {\sigma_h}^2$ represent the number and variance of layer h.

4. Results and Analysis

4.1. Distribution Pattern of the Traffic Dominance

4.1.1. Traffic Network Density

The traffic network density in each town was calculated on the basis of ordinary roads and subways. According to the statistical distribution, the density in the 337 towns can be divided into 5 grades (Figure 3). Major characteristics are shown as follows:

(1) The traffic network density went through a "core-periphery" pattern to a "point-axis" pattern. The density progressively declined from the core to its peripheries in 2010 and from the point to its surrounding areas and the axis to its sides in 2022;

(2) The density of only a small number of towns was greater than or equal to 12 km/km^2, whereas the density of a large proportion of towns was less than or equal to 2 km/km^2. The proportion of towns with a density greater than or equal to 12 km/km^2 did not exceed 7% from 2010 to 2022, concentrated in Xincheng District, Lianhu District, Beilin District Yanta District and Weiyang District of Xi'an city. However, a large proportion of towns with a density less than or equal to 2 km/km^2 occupied the periphery of the metropolitan area, accounting for 79.82% in 2010 and 42.43% in 2022, respectively;

(3) In the density pattern, the towns with the rising grades were mainly distributed along the Zhengzhou–Xi'an, Xi'an–Yinchuan and Xi'an–Yan'an HSRs, and the reason may be that the development of these HSRs stimulated the economy in the areas along the railways and increased the demand for traffic construction.

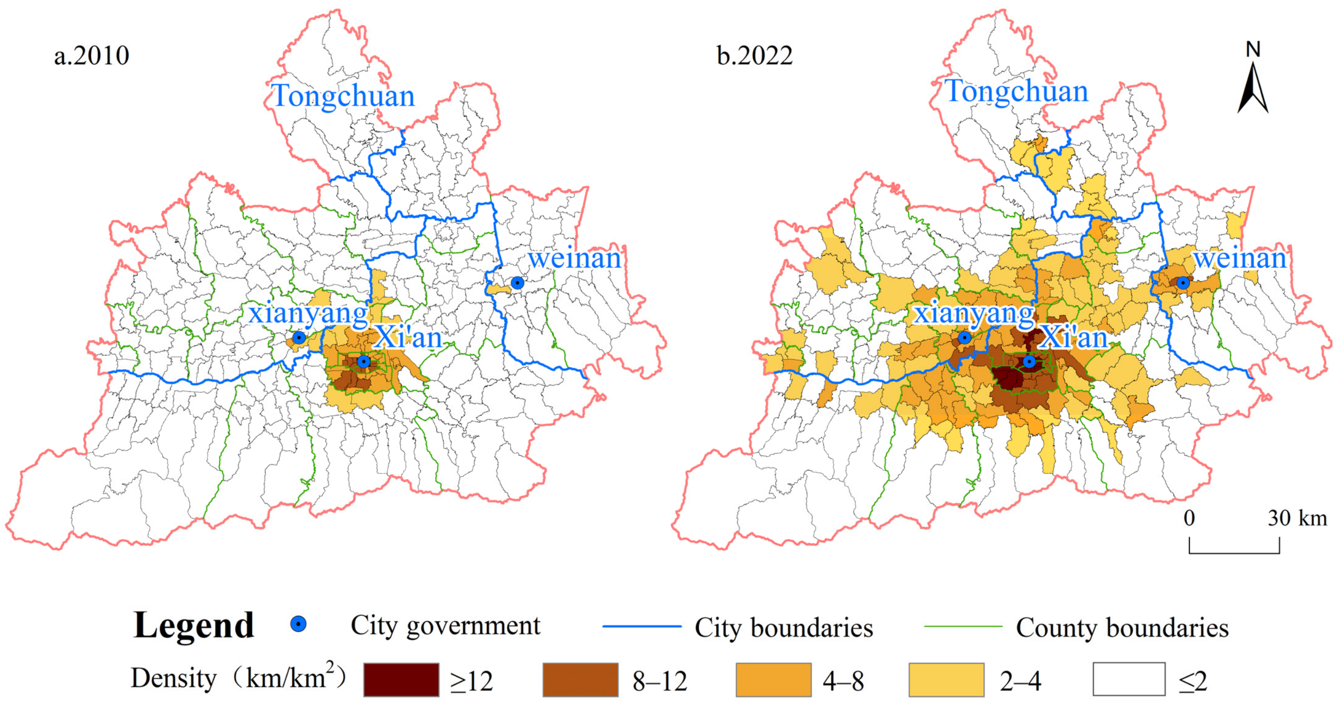

Figure 3. The distribution diagram of town traffic network density.

4.1.2. Traffic Arterial Influence

According to the calculation results of the traffic arterial influence, we divided them into five grades (Figure 4). Figure 4 shows the distribution pattern of the traffic arterial influence in 2010 and 2022 based on railways, expressways, primary roads, secondary roads and so on. Several results are summarized as follows:

(1) The traffic arterial influence always showed an "axis-spoke" pattern, gradually weakening from the axis to both sides. In 2010, only the axis of Xi'an–Weinan was included, and by 2022 there were two more, Xi'an–Yinchuan and Xi'an–Chengdu;

(2) Towns with a traffic arterial influence of over or equal to 6.5 linearized in space, which had high spatial coupling with the development of HSR. In 2010, these towns were mainly distributed along the Xi'an–Zhengzhou HSR, accounting for approximately 5.64%. With the construction of the Xi'an–Yinchuan and Xi'an–Chengdu HSRs, the traffic arterial influence increased significantly in the areas along the HSRs, and the proportion of these towns increased to 19.88% in 2022;

(3) Towns with a relatively low impact on traffic arteries were mainly distributed in the periphery of the metropolitan areas, such as Zhouzhi County, Lantian County, Huazhou District, Fuping County, Yaozhou District, etc.; however, their numbers decreased from 2010 to 2022. The proportion of towns with an arterial influence of 3.0–4.5 and less than or equal to 3 decreased from 29.67% and 11.57% in 2010 to 9.20% and 1.19% in 2022, respectively.

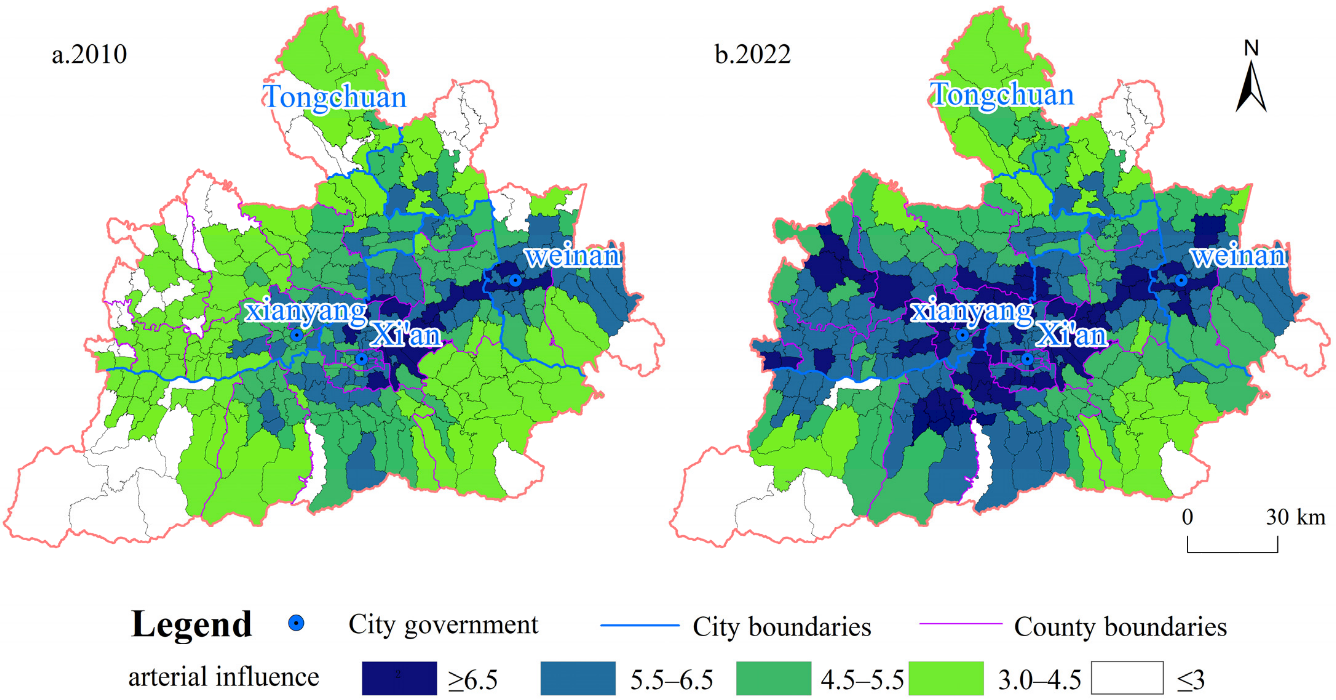

Figure 4. The distribution diagram of town traffic arterial influence.

4.1.3. Accessibility

Accessibility is usually measured by the travel time or distance from origin to destination [65–67]. We selected cities and counties to represent key node cities and adopted the average travel time to key node cities to calculate the accessibility of town units. The 337 towns can be classified into 5 grades, based on a statistical distribution of accessibility (Figure 5). Figure 5 illustrates the distribution pattern of accessibility in 2010 and 2022, and its features are observed as follows:

(1) Accessibility has always been a "core-periphery" pattern; however, the "core" evolved from a "double-core" structure in 2010 to a "single-core" structure in 2022. Furthermore, accessibility decreased from the core to its peripheries;
(2) Towns with an accessibility of less than or equal to 30 min were mostly distributed in the main urban areas of Xi'an city, such as Xincheng District, Lianhu District, Beilin District, Weiyang District, Lintong District and so on. However, its scope expanded to Sanyuan County in the northwest, to Huyi District southward, to Xingping City westward and to Linwei District eastward, and the proportion of towns increased from 19.88% in 2010 to 34.42% in 2022;
(3) Accessibility to most towns was within or under 60 min; however, there were still a few towns whose accessibility was over 60 min or even more than 90 min. There were 247 towns whose access times were less than 60 min, accounting for 73.29% in 2010. By 2022, the number of towns whose access times were less than 60 min increased to 309, and the proportion increased to 91.69%. The towns whose access times were more than 90 min were mainly located in the periphery of the metropolitan areas, and their proportion reduced from 6.82% in 2010 to 1.19% in 2022.

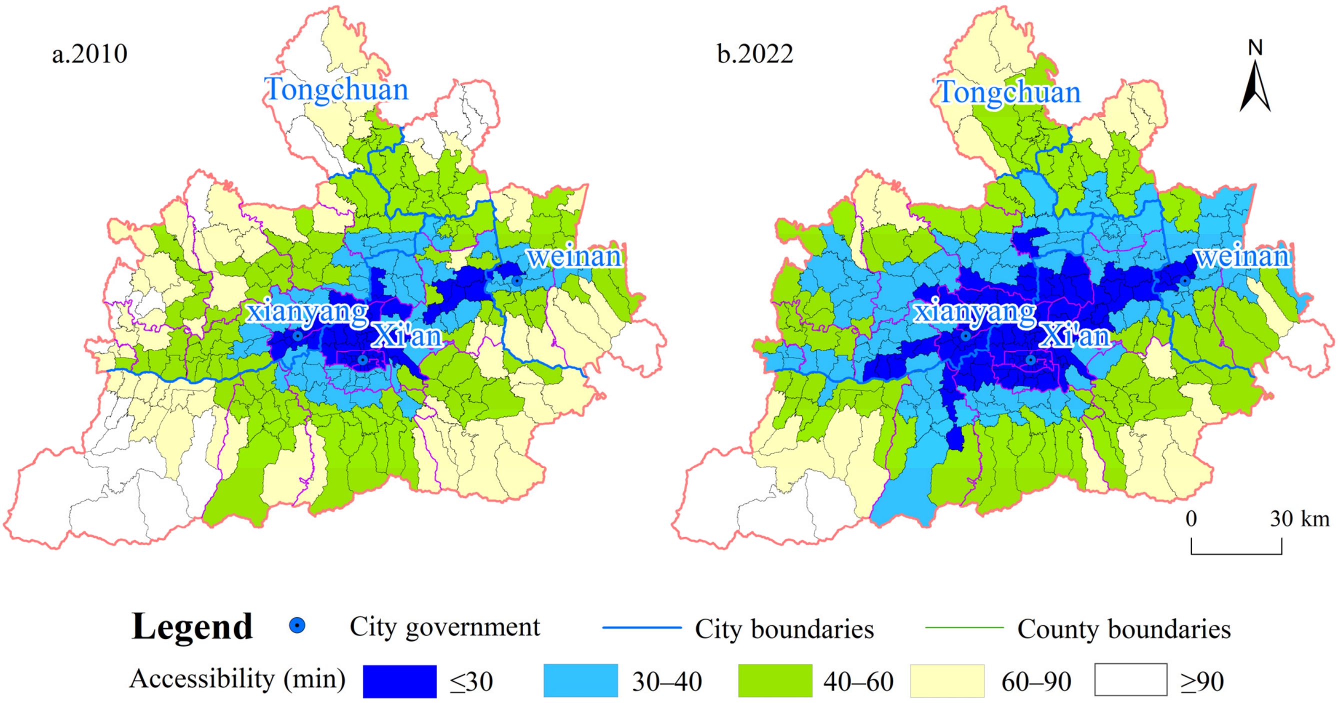

Figure 5. The distribution diagram of towns' accessibility.

4.1.4. Integrated Traffic Dominance

The traffic network density, traffic arterial influence and accessibility can embody the traffic dominance in different dimensions of the region. The traffic dominance index integrates three dimensions to comprehensively reflect the integrated traffic dominance and development potential of the region. According to the statistical distribution of its values, the 337 towns can be classified into 5 grades (Figure 6): very poor (≤0.25), poor (0.25–0.4), fair (0.4–0.55), good (0.55–0.7) and excellent (≥0.7). The distribution pattern of the integrated traffic dominance can be characterized as follows:

(1) The traffic dominance patterns showed an unbalanced distribution feature that consistently displayed a "point-axis" pattern. The "point" was situated in the main urban area of Xi'an city in 2010; however, by 2022 its scope had gradually expanded in this area, and at the same time, some small-scale "points" additionally formed in Linwei District, Yangling District and other counties or districts as well;

(2) Towns with excellent grades (≥0.7) in 2010 were mainly clustered in the districts of Xincheng, Lianhu, Beilin, Yanta, Weiyang and Baqiao of Xi'an city in a block style. By 2022, they were still concentrated in the six districts of Xi'an city; however, Linwei County, Yangling District, Xingping City and other counties or districts were additionally partially involved. Furthermore, the proportion of towns increased from 7.72% in 2010 to 25.82% in 2022, which indicated that the traffic dominance in the main urban area of Xi'an city had the strongest support ability for economic society; meanwhile, the abilities of Linwei District, Yangling District, Xingping City, etc., additionally had increasing trends;

(3) Towns with good grades (0.55–0.7) were clustered on the east–west axis, further broadening to the eastern and northern areas from 2010 to 2022, with the percentage of towns growing from 7.72% to 25.82%. Overall, the towns were mainly distributed on the east–west axis within 30 km, indicating that the east–west axis within 30 km had relatively strong comprehensive supporting capabilities for economic and social development in the future;

(4) Towns with very poor (≤0.25), poor (0.25–0.4) and fair (0.4–0.55) grades were mostly distributed in the fringes of their metropolitan areas that had already shown declines in their numbers. Of those, the proportion of towns with poor grades decreased significantly; it dropped from 19.29% in 2010 to 4.15% in 2022. Although the number of towns with very poor grades had been the lowest, there were still 1.48% of towns scattered in Zhouzhi County, Huazhou District and Fuping County on the edge of their metropolitan areas in 2022.

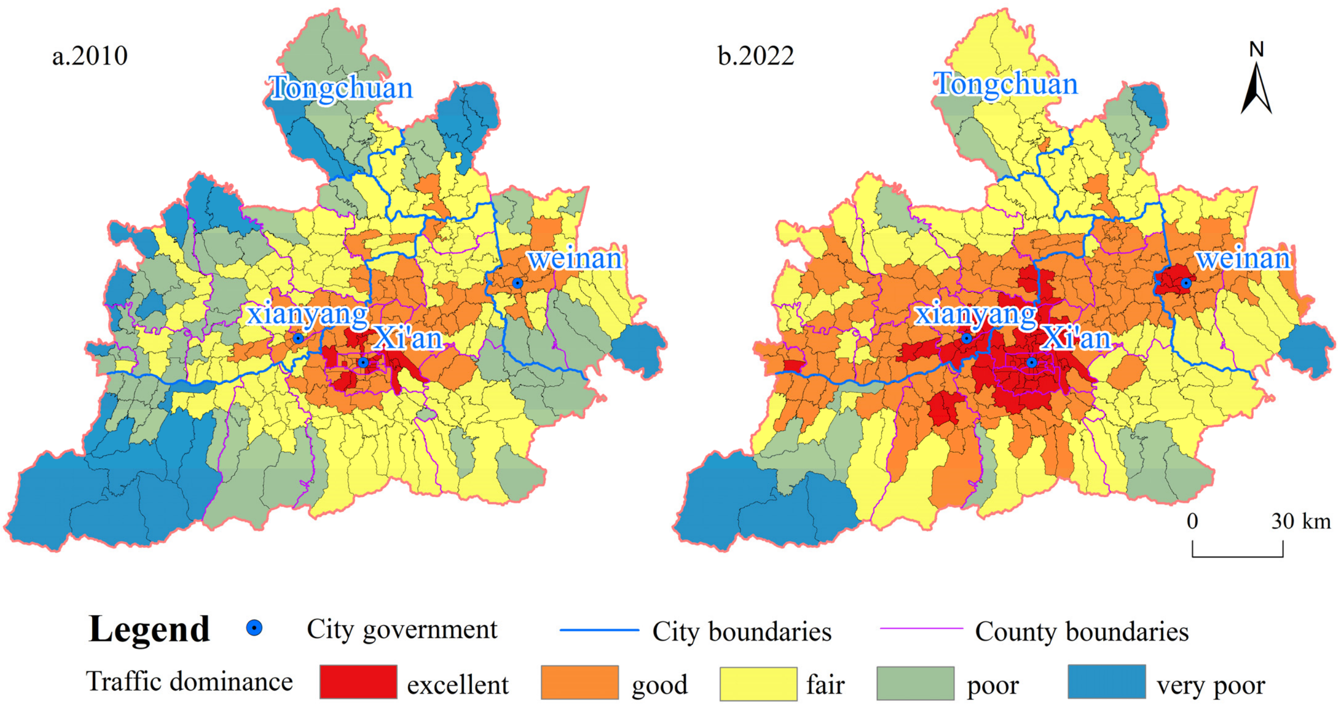

Figure 6. The distribution diagram of towns' integrated traffic dominance.

4.2. Correlation Pattern of the Traffic Dominance

4.2.1. Global Correlation Pattern

The first law of geography says that geographical objects or phenomena are related in spatial distribution, marked by random, clustering and regularity distribution [62]. Table 5 shows the Global Moran's index of integrated traffic dominance in the Xi'an metropolitan area, which can reflect the spatial correlation characteristics between towns. As we can see in Table 5, the Global Moran's I of traffic dominance was greater than 0 and passed the significance test at the 1% level, indicating that the traffic construction and development of towns positively correlated in the Xi'an metropolitan area from 2010 to 2022, which was characterized by an agglomeration distribution in space. The Global Moran's I, which ranged from 1.13 in 2010 to 1.14 in 2022 changed little, illustrating that the traffic dominance of towns in the Xi'an metropolitan area had a stable global relationship from 2010 to 2022.

Table 5. The Global Moran's I of integrated traffic dominance.

Year	Global Moran's I	Z	P
2010	1.13	70.08	0.00
2022	1.14	69.59	0.00

"P" represents the significance level. When P is very small, it means that the observed spatial patterns are unlikely to be randomly distributed. "Z" represents the standard deviation of the data set and reflects the degree of the dispersion of elements.

4.2.2. Local Correlation Pattern

Through the study of the Global Moran's I, it is found that the integrated traffic dominance between towns was an agglomeration in space. Hence, we did more with the Local Moran's I to discover where the agglomeration was located. Figure 7 maps the traffic dominance pattern by the Local Moran's I in 2010 and 2022. From Figure 7, it can be found that most towns with traffic dominance passed the significance test, accounting for 69.44% in 2010 and 57.86% in 2022, respectively, and they mainly formed 3 kinds of agglomeration types: high–high aggregation, low–low aggregation and low–high aggregation.

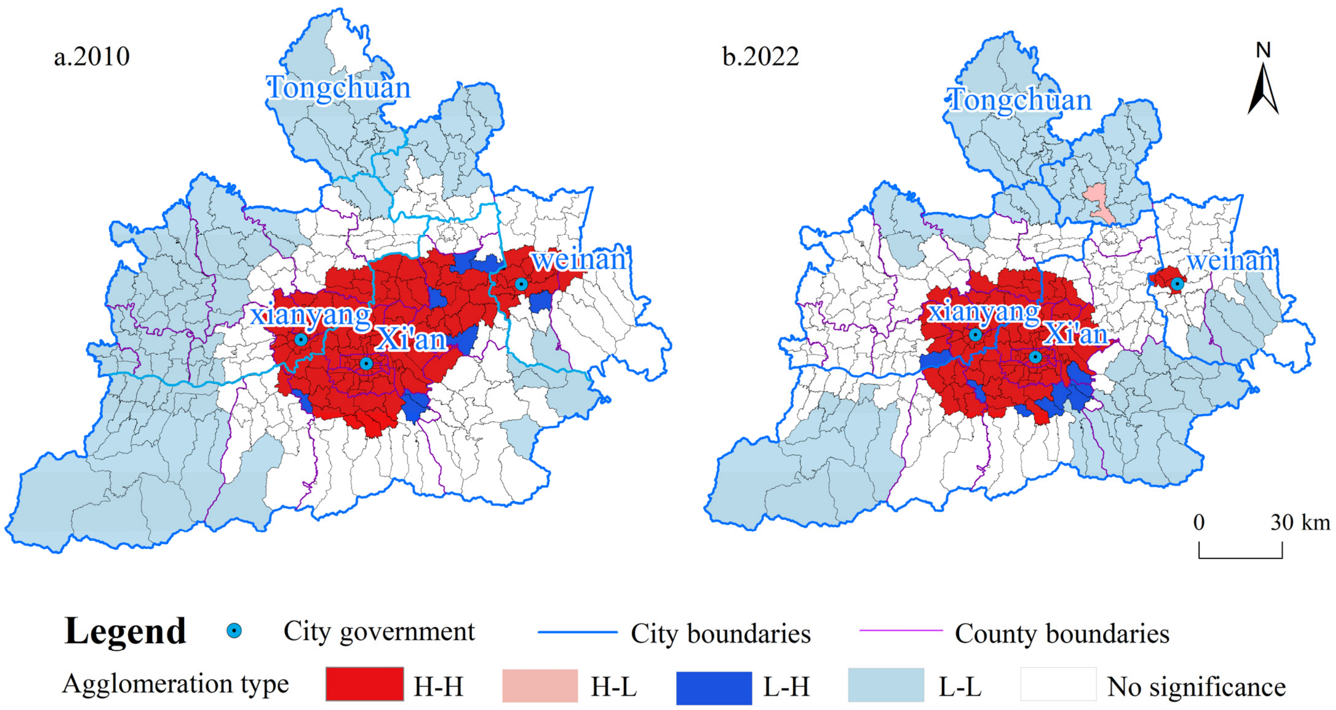

Figure 7. The local correlation pattern of integrated traffic dominance.

The ratio of towns with high–high agglomeration areas was 39.17% in 2010 and 34.12% in 2022, and they were mainly located in the main urban areas of Xi'an and Xianyang city, which indicated that these areas were hot spots of transportation construction in the Xi'an metropolitan area. Although the main urban area of Weinan City still formed a high–high agglomeration area, the scale significantly reduced from 2010 to 2022.

The low–low agglomeration areas were mainly distributed in the Weibei hilly and gully areas in the north of the Xi'an metropolitan area and the Qinling mountain areas in the south of the Xi'an metropolitan area, such as Yaozhou District, Fuping County, Zhouzhi

County, Lantian County, Huazhou District and so on; however, the ratio of towns involved decreased from 27.89% in 2010 to 21.07% in 2022. It showed that the hilly and gully areas of Weibei and the mountainous areas of Qinling Mountains were the zones with weak traffic conditions, and the transportation construction and development of the Xi'an metropolitan area should be paid more attention in the future.

The low–high agglomeration areas always nested on the edge of high–high agglomeration areas, and the ratio of towns involved remained stable: 2.37% in 2010 and 2022. Some towns had changed agglomeration type, whereas Lingzhao Town, Mingdu Town and Paoli Town still maintained low–high agglomeration status.

The high–low agglomeration pattern was not apparent in the Xi'an metropolitan area, and a single town showed the agglomeration pattern in 2022.

4.3. Influencing Factor

The regional traffic dominance is affected by multiple factors, such as the natural environment, economy, population and so on. Referring to the research of Sun Hongri et al. [53] and considering the principle of data availability and operability, the elevation, slope, GDP, population and construction intensity (Table 6) are selected to analyze the influencing factors of town traffic dominance. In the meantime, Section 4.1.4 found that the traffic dominance in the main urban area of Xi'an city and its surroundings is relatively high; therefore, this paper speculates whether the closer to Xi'an city, the higher the traffic dominance. Therefore, we further introduce the location index (Table 6). After, this paper uses the geo-detector model to find the factors in 2010 and 2022 by taking the integrated traffic dominance as the explanatory variable and factor indices as the explanatory variables. The results are shown in Table 7.

Table 6. The Global Moran's I of integrated traffic dominance.

Factor Index	Code	Description	Unit
Elevation	X_1	Average elevation in the town	m
Slope	X_2	Average slope in the town	degree
GDP	X_3	Gross domestic product in the town	million yuan
Population	X_4	Number of permanent residents in the town	person
Construction intensity	X_5	Construction land area in the town	km^2
Location	X_6	The distance between the town and Xi'an city	km

Table 7. Factor detection results based on the geo-detector model.

Factor Index	Code	q	
		2010	2022
Elevation	X_1	0.57 *	0.49 *
Slope	X_2	0.21 *	0.16 *
GDP	X_3	0.71 *	0.61 *
Population	X_4	0.26 *	0.19 *
Construction intensity	X_5	0.35 *	0.29 *
Location	X_6	0.90 *	0.85 *

* Represents that the significance test at the 0.01 level is passed.

The q values of the factor represent their ability to influence town traffic dominance, as shown in Table 7. We can then see that the order of q values between the various factors was the same in 2010 and 2022. Moreover, location, GDP and elevation had a greater impact on town traffic dominance, whereas construction intensity, population and slope had a relatively small influence.

Specifically, the q value of location (X_6) was the largest among all factors, and its values were 0.90 in 2010 and 0.85 in 2022, respectively, indicating that location had the strongest influence on town traffic dominance, and the closer a town was to Xi'an city, the higher the traffic dominance.

The q value of GDP (X_3) was positive in 2010 and 2022, and its values were relatively high. This result showed that GDP had a greater positive impact on traffic dominance, which may be because areas with higher economic levelshave a greater traffic demand to meet daily production and life. The q value of elevation (X_1) was additionally relatively large, which was 0.57 in 2010 and 0.49 in 2022, respectively. Since the elevation has been reversely standardized, it reflected that the higher the elevation, the lower the traffic dominance. The q value of construction intensity (X_5) was 0.35 in 2010 and 0.29 in 2022, respectively. Compared with location and GDP, it had a limited impact on town traffic dominance. In a further comparison with GDP, population (X_4) had a relatively small impact on traffic dominance, and its q values were only 0.26 in 2010 and 0.19 in 2022, respectively, which indicated that the town's traffic development was less dependent on the regional population. The q value of slope (X_2) was the smallest, indicating that its influence strength was the lowest; however, similar to the elevation, it had a reverse effect on town traffic dominance.

In addition, the q value of each index showed a decreasing trend from 2010 to 2022, showing that the ability of each index to act on the town traffic dominance declined. The primary reason was the fact that the economic integration development of the Xi'an metropolitan area required internal traffic integration, which drove the development of traffic construction in various towns. Of course, they were additionally affected by other reasons; for example, the weakening effect of elevation and slope was additionally related to the advancement of transportation technology. The advancement of technology reduced the ability of the natural environment to limit traffic development, and the reasons for the decrease in the impact of GDP were additionally linked to the country's strategic policies such as targeted poverty reduction and poverty alleviation, which accelerated the construction of the industrial roads and poverty alleviation roads for poor areas in recent years.

5. Discussion

There are a few theoretical implications to this paper. On the one hand, as far as study areas are concerned, previous studies of traffic dominance were focused on countries [23,54], large regions [24,53], urban agglomerations [25] or cities [15,27], and little attention has been given to the metropolitan areas; moreover, as far as study units are concerned, most of them concentrate on county units [24,51,59] and city units [68] and do not pay much attention to town units. Furthermore, naturally, there is less literature to study the traffic dominance of a metropolitan area based on town units. Therefore, this paper uses towns as the basic units to research the traffic dominance in the Xi'an metropolitan area, which will enrich the case choice and study units to a certain extent. On the other hand, the research results further supplement and improve theoretical research of regional traffic dominance.

From the practice viewpoint, this research mainly includes two aspects. The first aspect is that the study results can provide a scientific basis for the formulation of traffic optimization strategies in the Xi'an metropolitan area. For example, in view of accessibility dimensions, a travel time of less than 60 min is an important criterion in the boundary delimitation for China's metropolitan areas; however, by the end of the study period, 8.31% of towns still took longer than 60 min, of which 1.19%, including Hou Zhenzi, Ban Fangzi and other towns, had a travel time of over 90 min. This finding implies that relevant governments should focus more on these areas in the future and strengthen the accessibility between them and their surrounding key node cities by constructing rapid roads to improve the road network connectivity, so as to make these areas better integrated into the construction and development of the Xi'an metropolitan area. From the perspective of integrated traffic dominance, we can find that the Weibei hilly and gully areas in the north of the Xi'an metropolitan area and the Qinling mountain areas in the south of the Xi'an metropolitan area, especially Fuping District, Zhouzhi County and Huazhou

District, have relatively poor traffic conditions and show the correlated characteristics of low–low agglomeration. Because these regions have more complex topographic factors, ecological protection is of higher importance, and there are more serious constraints on traffic construction; we recommend that these areas are not suitable for large-scale transit construction, and the green economy should be used as the guide to build industrial channels to improve their traffic dominance which could serve the development of regional ecology, agriculture, tourism and other industries.

The other aspect is that it is additionally beneficial to guide the rational layout of regional industries, based on the study results. Traffic construction provides access and media for spatial activities of production factors [69]. Areas with higher traffic dominance are more likely to attract the aggregation of labor, capital, land, technology and other production factors, which provide the basis for industrial economy aggregation [70], making it easier to form industrial agglomeration areas and industrial scale development. According to the research results, it can be found that the regional traffic dominance is higher in the main urban area of Xi'an city and its east–west axis areas within 30 km; in other words, these areas have a stronger agglomeration ability for industrial development. Therefore, considering the regional functional orientation in the development planning of the Xi'an metropolitan area [29], we suggest that the main urban area of Xi'an city should disperse the general manufacturing and logistics industries in an orderly manner and strengthen the guidance for financial business, the digital economy, R and D and design and other services industries. Simultaneously, its east–west axis areas within 30 km should actively undertake the industrial transfer from the main urban area of Xi'an city and the eastern coastal cities and strive to promote the manufacturing, logistics, e-commerce, food processing and other industries to gather along the axis areas.

It is noted that the main urban area of Xi'an city is relatively excellent in traffic network density, traffic arterial influence, accessibility and its integrated traffic dominance; however, these areas are the agglomeration centers of the economy and population in the metropolitan area, and traffic congestion in these areas should be a concern. Accordingly, we hold that it is necessary to clear regional broken roads, broaden the bottleneck roads and improve the aging roads when formulating regional traffic optimization strategies in the future, so as to smooth the microcirculation pattern of regional transportation.

6. Conclusions

This paper used the traffic dominance index and other methods to analyze the spatial patterns and influencing factors of traffic superiorities on the foundation of the town division in the Xi'an metropolitan area. The results showed that integrated traffic dominance presented unbalanced distribution characteristics, which consistently displayed a "point-axis" pattern from 2010 to 2022, and traffic network density, traffic arterial influence and accessibility had different distribution patterns. The integrated traffic dominance among towns had stable spatial agglomeration features in the whole Xi'an metropolitan area, and it mainly formed three agglomeration patterns in the local areas: high–high aggregation, low–low aggregation and low–high aggregation. Furthermore, it was additionally found that location, GDP and elevation had a greater impact, whereas construction intensity, population and slope had a relatively small effect on town traffic dominance, and their influence abilities had a decreasing trend from 2010 to 2022.

The traffic dominance index could reveal the traffic condition of a certain area from multiple dimensions, including traffic network density, traffic arterial influence and accessibility. Among the three dimensions, traffic network density was the reflection of the "quantity" of transport infrastructure, traffic arterial influence reflected the "quality" of transport infrastructure and accessibility indicated the traffic location "advantage" of transport infrastructure. It is clear that the traffic dominance index is more comprehensive and generalized than the single-dimension accessibility index; thus, this index will be a good choice to evaluate the integrated traffic superiorities of metropolitan areas, urban agglomerations, countries or other regions in the future. However, it should additionally be noted that we adopted the weight assignment method of an equal-weighted, expert scoring or alternatively referred to the existing literature when calculating the traffic dominance index, traffic arterial influence or accessibility, the weight assignment of which was relatively subjective in general. Hence, further exploration and a combination of the objective weighting methods (analytic hierarchy process, entropy weight method and so on) need to be completed in the future. In addition, we set the same speed for the same road mode in the calculation of accessibility. However, the speed of the same road mode varied in the suburbs and urban areas, or in the peak period and off-peak period of traffic because of traffic congestion. It is, therefore, valuable to simulate microscopically the speed of the same road mode in different regions or different time periods so that the results are closer to reality when calculating accessibility.

It is worth mentioning that transportation development is closely related to urban land expansion. Noticeably, there was relatively high traffic superiority within 30 km of the east–west axis in the Xi'an metropolitan area. This means that these areas, additionally, can easily become high-intensity areas of land expansion. In order to avoid disorderly expansion and urban sprawl in the metropolitan area, it is desirable to formulate scientific urban planning to guide the rational layout of industries and to optimize the allocation of land resources in the future.

Author Contributions: Conceptualization, J.L. and T.L.; methodology, X.C.; software, X.C. and Y.W.; validation, Y.W. and R.L.; formal analysis, B.Z.; investigation, J.L.; resources, Y.W.; data curation, B.Z. and L.R; writing—original draft preparation, J.L.; writing—review and editing, T.L. and J.L.; visualization, B.Z.; supervision, T.L.; project administration, T.L.; funding acquisition, T.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China, grant number 41771129.

Data Availability Statement: Not applicable.

Acknowledgments: Thank you to all the experts for their help in the building of the model in this study. Thank you to the National Natural Science Foundation of China for supporting this research. All individuals included in this section have consented to this acknowledgment.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Li, G.P. *Metropolitan Area: Structure, Division and Construction Strategy*; China City Press: Beijing, China, 2004; pp. 1–8. ISBN 7-5074-1614-3.
2. Zhang, Y.S.; Wang, Q.X.; Hu, G.Y. A discussion on the concept of metropolitan region and its applications in China. *Planners* **2022**, *38*, 37–44. [CrossRef]
3. Office of Management and Budget. Standards for defining metropolitan and micropolitan statistical areas. *Fed. Regist.* **2000**, *65*, 82228–82238.
4. Qian, Z.H. The concept of metropolitan region and its delineation. *Planners* **2022**, *38*, 152–156.
5. Chen, H.Y.; Luo, H.S.; Song, J.P. Population distribution and industrial evolution of the Tokyo metropolitan area. *Prog. Geogr.* **2020**, *39*, 1498–1511. [CrossRef]
6. Yuan, J.D.; Zhou, J.; Huang, W. Some misunderstandings in the theoretical research and planning practice of metropolitan area in China. *Geogr. Res.* **2006**, *1*, 112–120. [CrossRef]
7. Li, L.S.; Roger, S.S. *Metropolitan Area Development: Theoretical Evolution, International Experience and Chinese Characteristics*; Science Press: Beijing, China, 2006; pp. 25–35. ISBN 9787030169013.
8. Zimmermann, K.; Heinelt, H. *Metropolitan Governance in Deutschland: Regieren in Ballungsräumen Neue Formen Politischer Steuerung*; Springer: Berlin/Heidelberg, Germany, 2012; ISBN 3-531-19159-4.
9. Chen, R. Spatial Structure's Economic Performance of Metropolitan Regions in China. Ph.D. Thesis, Peking University, Beijing, China, 16 February 2007.
10. Fang, C.L. China's urban agglomeration and metropolitan area construction under the new development pattern. *Econ. Geogr.* **2021**, *41*, 1–7. [CrossRef]
11. Fricke, C. Metropolitan regions as a changing policy concept in a comparative perspective. *Raumforsch. Raumordn. Spat. Res. Plan.* **2017**, *75*, 291–305. [CrossRef]

12. Crescenzi, R.; Di Cataldo, M.; Rodríguez-Pose, A. Government quality and the economic returns of transport infrastructure investment in European regions. *J. Reg. Sci. Reg. Sci.* **2016**, *56*, 555–582. [CrossRef]
13. Jin, F.J.; Wang, C.J.; Li, X.W. Discrimination method and its application analysis of regional transport superiority. *Acta Geogr. Sin.* **2008**, *63*, 787–798. [CrossRef]
14. Liu, C.L.; Yu, R.L.; Xiong, J.P. Spatial accessibility of road network in Wuhan metropolitan area. *Acta Geogr. Sin.* **2010**, *64*, 1488–1498. [CrossRef]
15. Melbye, D.C.; Møller-Jensen, L.; Andreasen, M.H.; Kiduanga, J.; Busck, A.G. Accessibility, congestion and travel Delays in Dar Es Salaam—A time–distance perspective. *Habitat Int.* **2015**, *46*, 178–186. [CrossRef]
16. Jiang, H.N.; Xu, W.; Zhang, W.Z. Transportation accessibility and location choice of Japanese-funded electronic information manufacturing firms in Shanghai. *Sustainability* **2018**, *10*, 390. [CrossRef]
17. Siong, H.C.; Konno, A. Integrated land use transportation planning in facilitating and guiding the industrialization process in developing countries: The case of the Johor Bahru metropolitan area. *J. Adv. Transp.* **1993**, *27*, 279–291. [CrossRef]
18. Diao, M. Does growth follow the rail? The potential impact of high-speed rail on the Economic Geography of China. *Transp. Res. Part A Policy Pract.* **2018**, *113*, 279–290. [CrossRef]
19. Jia, S.; Zhou, C.; Qin, C. No difference in effect of high-speed rail on regional economic growth based on match effect perspective? *Transp. Res. Part A Policy Pract.* **2017**, *106*, 144–157. [CrossRef]
20. Wang, C.; Lim, M.K.; Zhang, X.; Zhao, L.; Lee, P.T.-W. Railway and road infrastructure in the Belt and Road initiative countries: Estimating the impact of transport infrastructure on economic growth. *Transp. Res. Part A Policy Pract.* **2020**, *134*, 288–307. [CrossRef]
21. Magazzino, C.; Mele, M. On the relationship between transportation infrastructure and economic development in China. *Res. Transp. Econ.* **2021**, *88*, 100947. [CrossRef]
22. McCann, P.; Shefer, D. Location, agglomeration and infrastructure. *Pap. Reg. Sci.* **2003**, *83*, 177–196. [CrossRef]
23. Shaw, S.-L.; Fang, Z.; Lu, S.; Tao, R. Impacts of high-speed rail on railroad network accessibility in China. *J. Transp. Geogr.* **2014**, *40*, 112–122. [CrossRef]
24. Wang, Z.; Fan, H.; Wang, D.; Xing, T.; Wang, D.; Guo, Q.; Xiu, L. Spatial pattern of highway transport dominance in Qinghai–Tibet Plateau at the county scale. *Isprs Int. J. Geo-Inf.* **2021**, *10*, 304. [CrossRef]
25. Nicolas Ibanez, J.; Rotoli, F. Measuring the impact of the Trans-European Road transport network on the accessibility of European urban agglomerations. *Transp. Res. Rec.* **2017**, *2605*, 72–82. [CrossRef]
26. Farber, S.; Fu, L. Dynamic public transit accessibility using travel time cubes: Comparing the effects of infrastructure (dis) investments over time. *Comput. Environ. Urban Syst.* **2017**, *62*, 30–40. [CrossRef]
27. Miao, Y.; Lu, W.Q.; Dai, T.Q.; Song, J. Comprehensive traffic advantage degree and its spatial characteristics at the prefecture level on the Qinghai-Tibet Plateau: A case study of Linzhi City. *Prog. Geogr.* **2021**, *40*, 1332–1343. [CrossRef]
28. Xinhua News Agency. Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Vision 2035. 13 March 2021. Available online: http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm (accessed on 27 April 2023).
29. The People's Government of Shaanxi Province. Notice of the People's Government of Shaanxi Province on Printing and Distributing the Development Plan of Xi'an Metropolitan Area. 27 April 2021. Available online: http://www.shaanxi.gov.cn/zfxxgk/zfgb/2022/d12q/202207/t20220711_2228359_wap.html (accessed on 27 April 2023).
30. First Finance. Who is the Strongest in the Six National Metropolitan Circle? 30 August 2022. Available online: https://m.thepaper.cn/baijiahao_19681545 (accessed on 27 April 2023).
31. Lu, H.P.; Wang, J.F.; Zhang, Y.B. Models and application of transport accessibility in urban transport planning. *J. Tsinghua Univ. (Sci. Technol.)* **2009**, *49*, 781–785. [CrossRef]
32. Hansen, W.G. How Accessibility shapes land use. *J. Am. Inst. Plan.* **1959**, *25*, 73–76. [CrossRef]
33. Bruinsma, F.R.; Rietveld, P. Accessibility of cities in European infrastructure networks: A comparison of approaches. *Netco* **1994**, *8*, 203–224. [CrossRef]
34. Shen, Q. Spatial technologies, accessibility, and the social construction of urban space. *Comput. Env. Urban* **1998**, *22*, 447–464. [CrossRef]
35. Kwan, M.P.; Murray, A.T.; O'Kelly, M.E.; Tiefelsdorf, M. Recent advances in accessibility research: Representation, methodology and applications. *J. Geogr. Syst.* **2003**, *5*, 129–138. [CrossRef]
36. Tribby, C.P.; Zandbergen, P.A. High-resolution spatio-temporal modeling of public transit accessibility. *Appl. Geogr.* **2012**, *34*, 345–355. [CrossRef]
37. Cao, J.; Liu, X.C.; Wang, Y.; Li, Q. Accessibility impacts of China's high-speed rail network. *J. Transp. Geogr.* **2013**, *28*, 12–21. [CrossRef]
38. Wang, L.; Liu, Y.; Mao, L.; Sun, C. Potential impacts of China 2030 high-speed rail network on ground transportation accessibility. *Sustainability* **2018**, *10*, 1270. [CrossRef]
39. Gutiérrez, J. Location, economic potential and daily accessibility: An analysis of the accessibility impact of the high-speed line Madrid–Barcelona–French border. *J. Transp. Geogr.* **2001**, *9*, 229–242. [CrossRef]

40. Song, Y.Z.; Tan, Y.; Song, Y.M.; Wu, P.; Cheng, J.C.; Kim, M.J.; Wang, X. Spatial and temporal variations of spatial population accessibility to public hospitals: A case study of rural-urban comparison. *Gisci. Remote Sens.* **2018**, *55*, 718–744. [CrossRef]
41. Zhao, M.F.; Liu, S.H.; Qi, W. Spatial differentiation and influencing mechanism of medical care accessibility in Beijing: A migrant equality perspective. *Chin. Geogr. Sci.* **2018**, *28*, 353–362. [CrossRef]
42. Zheng, Z.C.; Xia, H.M.; Ambinakudige, S.; Qin, Y.; Li, Y.; Xie, Z.; Gu, H. Spatial accessibility to hospitals based on Web Mapping API: An empirical study in Kaifeng, China. *Sustainability* **2019**, *11*, 1160. [CrossRef]
43. Boisjoly, G.; Deboosere, R.; Wasfi, R.; Orpana, H.; Manaugh, K.; Buliung, R.; El-Geneidy, A. Measuring accessibility to hospitals by public transport: An assessment of eight Canadian metropolitan regions. *J. Transp. Health* **2020**, *18*, 100916. [CrossRef]
44. Di Paolo, A.; Matas, A.; Raymond, J.L. Job accessibility and iob-education mismatch in the metropolitan area of Barcelona. *Pap. Reg. Sci.* **2017**, *96*, S91–S112. [CrossRef]
45. Tilahun, N.; Fan, Y. Transit and job accessibility: An empirical study of access to competitive clusters and regional growth strategies for enhancing transit accessibility. *Transp. Policy* **2014**, *33*, 17–25. [CrossRef]
46. Rosik, P.; Pulawska-Obiedowska, S.; Goliszek, S. Public transport accessibility to upper secondary schools measured by the potential quotient: The case of Krakow. *Morav. Geogr. Rep.* **2021**, *29*, 15–26. [CrossRef]
47. Li, W.; Guan, H.; Han, Y.; Zhu, H.; Zhao, P. Accessibility of multimode transport facilities to Suburban tourist attractions: Analysis based on Meso- or Microcommunity Scale in Beijing. *J. Urban Plan. Dev.* **2021**, *147*, 04021026. [CrossRef]
48. Szymanska, E.; Panfiluk, E.; Kiryluk, H. Innovative solutions for the development of sustainable transport and improvement of the tourist accessibility of peripheral areas: The case of the Bialowie (z) over Dota forest region. *Sustainability* **2021**, *13*, 2381. [CrossRef]
49. Zhang, Z.; Ma, G.; Lin, X.; Dai, H. Accessibility in a multiple transport mode urban park based on the "D-D" model: A case study in park city, Chengdu. *Cities* **2023**, *134*, 104191. [CrossRef]
50. Mohamed, A.A.; Kronenberg, J.; Laszkiewicz, E. Transport infrastructure modifications and accessibility to public parks in Greater Cairo. *Urban For. Urban Green.* **2022**, *73*, 127599. [CrossRef]
51. Hu, H.; Wang, J.; Jin, F.; Ding, N. Evolution of regional transport dominance in China 1910–2012. *J. Geogr. Sci.* **2015**, *25*, 723–738. [CrossRef]
52. Chen, S.T.; Li, Y.R.; Pan, W.; Wang, W.; Jin, F. Evolution of China's overland transportation dominance and its economic effect: A county-level analysis. *Acta Geogr. Sin.* **2022**, *77*, 1937–1952. [CrossRef]
53. Sun, H.R.; Liu, Y.J.; Zhou, G.L. The evolution pattern and influence mechanism of transportation superiority in Northeast China. *Acta Geogr. Sin.* **2021**, *76*, 444–458. [CrossRef]
54. Guo, Z.; Chen, S.; Yao, S.M.; Xiong, C.H. Transportation superiority degree and its spatial differentiation pattern in Kenya. *Sci. Geogr. Sin.* **2020**, *40*, 956–964. [CrossRef]
55. Xu, X.L. China GDP Spatial Distribution Kilometer Grid Dataset. 2017. Available online: https://www.resdc.cn/DOI/DOI.aspx?DOIID=33) (accessed on 27 April 2023). [CrossRef]
56. Xu, X.L.; Liu, J.Y.; Zhang, Y.S.; Li, R.D.; Yan, C.Z.; Wu, S.X. China Multi-Period Land Use Remote Sensing Monitoring Data Set. 2018. Available online: https://www.resdc.cn/DOI/DOI.aspx?DOIID=54) (accessed on 27 April 2023). [CrossRef]
57. Yang, Y.N.; Alimujiang, K. Relationship between regional transportation advantage and development of reginal economy in Xinjiang under the background of the national strategy of the Belt and Road. *Arid. Land Geogr.* **2017**, *40*, 680–691. [CrossRef]
58. Zhang, W.N.; Hu, B.L.; Lu, Q.S. Appraisal of transport degree in Changsha-Zhuzhou-Xiangtan Urban Group based on major function regionalization. *Econ. Geogr.* **2014**, *34*, 63–68. [CrossRef]
59. Jin, F.; Wang, C.; Li, X.; Wang, J. China's regional transport dominance: Density, proximity, and accessibility. *J. Geogr. Sci.* **2010**, *20*, 295–309. [CrossRef]
60. Wang, D.G.; Sun, F. Geographic patterns and coupling-coordination between urbanization and land transportation accessibility in the Yangtze River economic zone. *Sci. Geogr. Sin.* **2018**, *38*, 1089–1097. [CrossRef]
61. Wang, C.Z.; Si, Q. A study of data statistical processing method of Delphi method and its application. *J. Inn. Mong. Financ. Econ. Coll.* **2011**, *9*, 92–96. [CrossRef]
62. Li, J.L.; Li, T.S.; Yang, L.P.; Song, Q.; Zhao, M.L. Spatio-temporal patterns and influencing factors of agricultural science and technology parks in the Yellow River Basin from 2001 to 2021. *Geogr. Res.* **2023**, *42*, 191–208. [CrossRef]
63. Anselin, L. Interactive Techniques and Exploratory Spatial Data Analysis. 1996. Available online: https://researchrepository.wvu.edu/rri_pubs/200/ (accessed on 27 April 2023).
64. Wang, J.F.; Xu, C.D. Geodetector: Principle and prospective. *Acta Geogr. Sin.* **2017**, *72*, 116–134. [CrossRef]
65. Geurs, K.T.; van Wee, B. Accessibility evaluation of land-use and transport strategies: Review and research directions. *J. Transp. Geogr.* **2004**, *12*, 127–140. [CrossRef]
66. Vale, D.S.; Saraiva, M.; Pereira, M. Active accessibility: A review of operational measures of walking and cycling accessibility. *J. Transp. Land Use* **2016**, *9*, 209–235. [CrossRef]
67. Jiao, H.; Li, C.; Yu, Y.; Peng, Z. Urban public green space equity against the context of high-speed urbanization in Wuhan, Central China. *Sustainability* **2020**, *12*, 9394. [CrossRef]

68. Tiran, J.; Viskovic, N.R.; Gabrovec, M.; Koblar, S. A spatial analysis of public transport accessibility in Slovenia. *J. Mech. Eng. Sci.* **2022**, *16*, 105–121. [CrossRef]
69. Ding, X.J. The mode path of coordinated development of transportation and industry under the new development pattern. *Macroecon. Manag.* **2023**, 42–49. [CrossRef]
70. Pang, M.; Qing, M.L.; Zhang, Z.M. The influence analysis and countermeasure research of rail transit development on urban-rural integration development in metropolitan area. *Rural. Econ.* **2022**, 137–144.