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Developing the Dataset of Shortest Railway Time from Beijing to 226 Cities in China (1996, 2003, 2009, 2016)

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Abstract: Beijing is one of the most important railway transportation hubs in China. The shortest railway travel times from Beijing to other Chinese cities throughout the years offer an important basis for studying the changes in the spatial pattern of Beijing's accessibility to other Chinese cities and the development of and changes in China's national railways. In the present study, the data were collected from the 1996, 2003, and 2009 China Railway Passenger Train Timetables and the official website of the China Railway Service Center (www.12306.cn). By sorting, calculating, and compiling these data, a dataset of changes in the shortest railway travel times from Beijing to 226 Chinese cities (1996, 2003, 2009, and 2016) was produced. Specifically, the dataset contains the spatial coordinates of 226 Chinese cities, their spatial distances from Beijing, their shortest railway travel times from Beijing in 1996, 2003, 2009, and 2016, their time-space conversion parameter values, and their deformed geographical coordinates. The dataset is stored in .xlsx format, contains 908 records, and has a size of 187 KB.

Keywords: spatial distance; time distance; shortest railway travel time; time space; time cartogram

Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2020.07.08.V1.

1 Introduction

From a conventional spatial perspective, geographic locations are critical for understanding the spatial relations of an object with other objects because the distance between any two objects on the earth's surface depends on their geographic locations. However, as modern modes of transportation and communication undergo constant changes and rapid development, basic concepts, such as space and distance, are being understood and represented anew. Differing from scientism, which states that space and distance are rigid and are the only un-

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changeable things, humanistic geography maintains that humans perceive this world through the tools they invent and make[1]. Time distance (TD) is gradually becoming an important measure with which people perceive distances in this world. The focus of people's concern has shifted from "how many kilometres are there between Beijing and Zhengzhou?" to "how long does it take to travel from Beijing to Zhengzhou?". Thus, examining this world from a TD perspective is more congruous with people's present cognitive needs. In the geographic field, TD is often used as an important metric to measure accessibility or economic relation intensity and analyse regional transportation accessibility, urban spatial distribution patterns, and social and economic processes[2–3].

Differing from the invariant nature of physical distance, TD is gradually changing with the continuous development of transportation technology. In addition, the relation between geographic space and time space, which is used to represent TD relations, is similarly undergoing changes. During the primeval stage of human society, as a result of simple means of transportation, geographic space, which was relatively homogeneous (excluding the effects of natural and terrain factors), and time space remained relatively similar to each another. However, the constant development of transportation systems gradually disrupted the stable relationship between geographic space and time space and increased their differences. On the one hand, the development of transportation conditions overall increasingly shortened absolute TDs and continuously "shrunk" the time space. On the other hand, the imbalance in transportation development across regions leads to an increase in their difference in relative TD. Changes in similarities or differences between regions can be measured based on the spatial differences between temporal and geographic maps.

As an important political, cultural, economic, and international exchange centre and the most important transportation hub, Beijing has a notable siphonic effect. In particular, the continuous development of high-speed railways has accelerated the flow and circulation of capital information and talents, increased Beijing's transportation accessibility, and strengthened its link with other cities. The effects of these changes on time and space may be exceedingly unbalanced. In this study, a dataset of changes in the shortest railway travel times (SRTTs) from Beijing to 226 cities in China (hereafter, the SRTT change (SRTTC) dataset) (1996, 2003, 2009, and 2016) was developed. The SRTTC dataset offers an important basis for examining the effects of railway transportation on the changes in the spatial pattern of Beijing's closeness and accessibility to other cities and the development of and changes in China's railways.

2 Metadata of the Dataset

The metadata summary of the "Dataset of the shortest railway time from Beijing to 226 cities in China (1996, 2003, 2009, 2016)"[4] is listed in Table 1, including title, authors, geographic region, time, data files, publishing and sharing service platform, and data sharing policy, etc.

3 Methods

3.1 Data Sources

The original spatial coordinates of the 226 Chinese cities were based on the data extracted from a 1: 4,000,000 vector map of administrative divisions of China and relevant geographic maps. The SRTTs from Beijing to the other cities were calculated based on authoritative data published by official railway agencies. The railway times in 2016 were determined by querying the official website of Railway Service Centre of China[6]. The time data from 1996, 2003, and 2009 were manually calculated based on the China Railway Passenger Train Timetables published by the China Railway Publishing House in the respective years[7–9].

Table 1 Metadata summary of the "Dataset of changes in the shortest railway travel times from Beijing to 226 cities (1996, 2003, 2009, and 2016)"

Item	Description
Dataset full name	Dataset of changes in the shortest railway travel times from Beijing to 226 cities (1996, 2003, 2009, and 2016)
Dataset short name	TheShortestRailwayTimeBJto226CitiesChina
Authors	Wang, L. N., College of Computer and Communication Engineering, Zhengzhou University of Light Industry, wln_map@126.com Li, X., Institute of Surveying and Mapping, Information Engineering University, lixiangzzchxy@163.com Yu, X. K., Institute of Surveying and Mapping, Information Engineering University, yuxinkai330521@163.com Hu, T., Institute of Surveying and Mapping, Information Engineering University, 1604599230@qq.com)
Geographic region	Rectangle enclosing 226 Chinese cities (18°14′02″N–52°58′08″N, 75°59′09″E–132°58’03″E)
Year	1996, 2003, 2009, 2016
Temporal resolution	1 Year
Spatial resolution	1:4,000,000
Data format	.xlsx Data size 187 KB
Data files	Four worksheets corresponding to data from four years (1996, 2003, 2009, and 2016)
Foundations	Zhengzhou University of Light Industry (0131-13501050061); National Natural Science Foundation of China (41401467)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing &Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[5]
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref

3.2 Technical Roadmap

Figure 1 shows the flowchart of the dataset development.

3.2.1 City Selection Criteria and Statistical Rules of SRTTs

The following describe the criteria for selecting cities across China. (1) Railway travel time data during the 1996–2016 periods are available for all selected cities. (2) Prefecture-level cities in each province are selected. (3) The selected cities basically cover entire China and play a role similar to "control points". (4) As cities are sparsely distributed in western China, some county-level cities in this region are added as supplements. Based on these criteria, in total, 226 Chinese cities were selected as control points. The longitude and latitude coordi nates of these cities were determined based on the data extracted from a 1:4,000,000 vector map of administrative divisions of China and relevant geographic maps.

To facilitate the determination and calculation of the SRTT from Beijing to each city, the following rules were used. (1) The SRTT from Beijing to each city selected for the statistical analysis was calculated by summing the SRTTs in all railway sections without considering the number of transfers and transfer wait times between urban stations. The following example illustrates how the SRTTs are calculated: if the direct railway travel time from Beijing

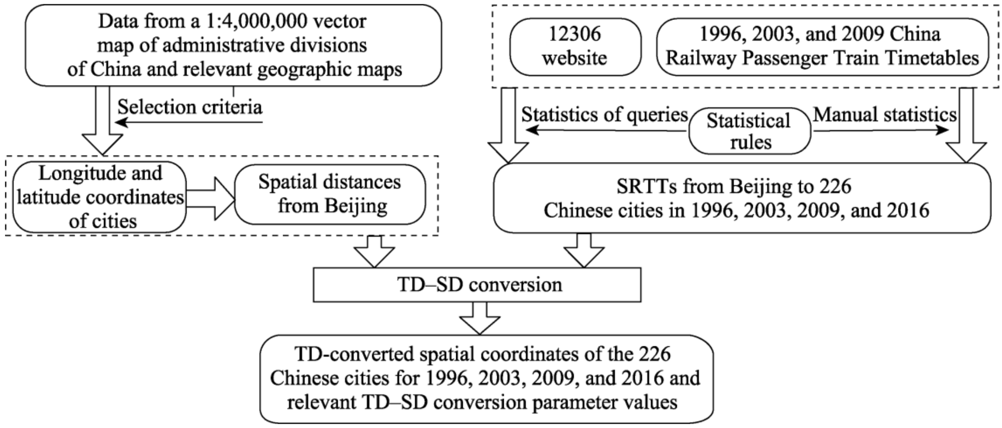

Figure 1 Flowchart of the dataset development

to city A is 230 min, the SRTT from Beijing to city B is 80 min, and the travel time from city B to city A is 120 min; then, the SRTT from Beijing to city A is determined by calculating the sum total of the railway travel times from Beijing to city B and from city B to city A, i.e., 80 + 120 = 200 min. (2) The spatial scale of this dataset was set to national. Thus, an approach that “uses a point to represent an area” was applied to all cities. The distances between different stations in the same city were not considered (e.g., both the Zhengzhou East Station and the Zhengzhou Station were viewed as “Zhengzhou”). (3) The time data for Hong Kong, Macau, and Taipei were calculated based on those for Guangzhou, Zhuhai, and Fuzhou, respectively, while considering the SD between the cities in each case.

3.2.2 TD–SD conversion[10]

TD–SD conversion is a process that converts TD data to SD data, which are representable on maps, and calculates new (i.e., TD-converted) coordinates for each point. When producing the SRTTC dataset, the following three principles were adopted during the TD–SD conversion:

(1) The direction between each city point and the central point (Beijing) remains unchanged after the conversion.

(2) For ease of calculation, the Euclidean distance between two points is calculated as their SD.

(3) The total SD is constant, i.e., the sum total of the SDs from the central point to all other points is constant, to ensure “scale consistency” between the original map (based on SDs) and the TD-converted temporal map (based on TDs) to facilitate the comparison and analysis. The following describes the TD–SD conversion:

Definition: Let $P=\{p_1, p_2, \cdots, p_n\}$, $p_i(x_i, y_i)\in P$ be a point set, (x_0, y_0) be the spatial coordinates of the central point *O*, s_i be the SD from the central point *O* to point p_i, t_i be the railway travel time from the central point *O* to point p_i, *S* be the sum total of the SDs from the central point *O* to all other points in point set P, and T be the sum total of the railway travel times from the central point *O* to all other points in point set P. Thus, we have

$$S=\sum_{i=1}^{n} s_i T=\sum_{i=1}^{n} t_i \tag{1}$$

Let d_i ($D=\sum_{i=1}^{n} d_i$) be the TD-converted SD from the central point *O* to point p_i. As the total SD is constant, $D = S$. d_i is calculated based on the proportion of t_i to T as shown in Equation (2).

$$\frac{t_i}{T} = \frac{d_i}{D}, \quad d_i = t_i S / T \tag{2}$$

Then, based on the fact that the direction remains unchanged, the new (i.e., TD-converted) spatial coordinates of point p_i are calculated as shown in Equations (3) and (4).

$$x_i' = x_0 + \left(x_i - x_0\right) d_i / s_i \tag{3}$$

$$y_i' = y_0 + \left(y_i - y_0\right) d_i / s_i \tag{4}$$

Here, a TD–SD conversion parameter r is introduced. r_i is the ratio of the TD-converted SD of a certain control point p_i to its original SD as shown in Equation (5). The value of r_i represents the extent to which point p_i moves towards or away from the central point along the direction between p_i and the central point after the conversion.

$$r_i = d_i / s_i \tag{5}$$

(1) If $0 < r_i < 1$ (i.e., $d_i < s_i$), point p_i moves towards the central point after the conversion. A small r_i value suggests that point p_i moves towards the central point to a large extent.

(2) If $r_i = 1$ (i.e., $d_i = s_i$), the coordinates of point p_i remain unchanged after the conversion.

(3) If $r_i > 1$ (i.e., $d_i > s_i$), point p_i moves away from the central point after the conversion. A high r_i value suggests that point p_i moves away from the central point to a large extent.

Therefore, based on the railway travel time data for the 226 cities in 1996, 2003, 2009, and 2016, the TDs were converted to SDs. Thus, the TD-converted coordinates and r values of the 226 cities were determined for each year. All calculations were completed in Microsoft Excel. Thus, the SRTTC dataset was produced.

4 Data Results

4.1 Data Composition

The SRTTC dataset consists of one .xlsx file, which is composed of four data sheets corresponding to data from four different years (1996, 2003, 2009, and 2016). The fields in the data sheets mainly include the longitudes and latitudes of the 226 cities, their SDs from Beijing, their SRTTs from Beijing, their TD-converted SDs, their r values, and their TD-converted spatial coordinates.

4.2 Data Results

Figures 2–5 visualize the changes shown in the SRTTC dataset in the spatial locations of the 226 Chinese cities after the TD–SD conversion in different years (1996, 2003, 2009, and 2016). Arrows are used to indicate the changes in the locations of the city points after the conversion. The tail and head of each arrow correspond to the original and TD-converted spatial coordinates of the cities, respectively. A red arrow indicates that a city moves away from Beijing along the direction between the city and Beijing. A blue arrow indicates that the city moves towards Beijing along the direction between the city and Beijing.

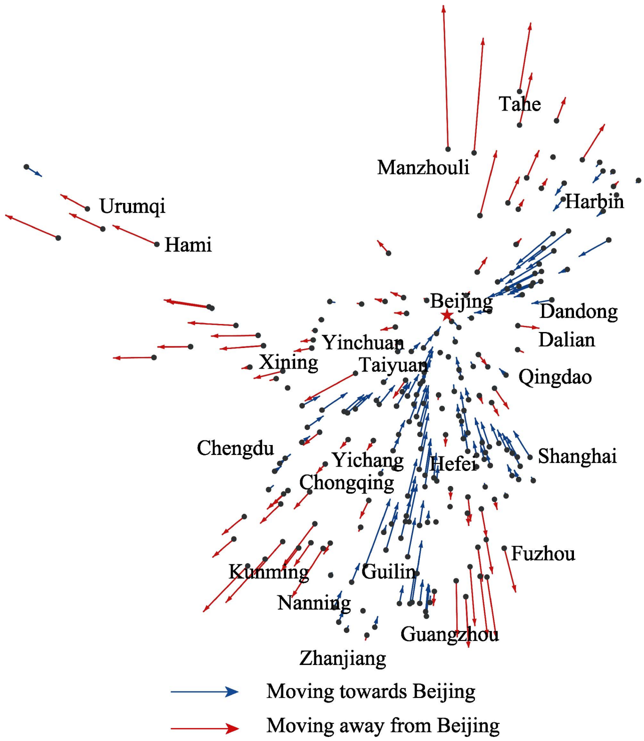

Figure 2 Schematic diagram of the changes in the spatial coordinates of 226 cities after the TD–SD conversion in 1996

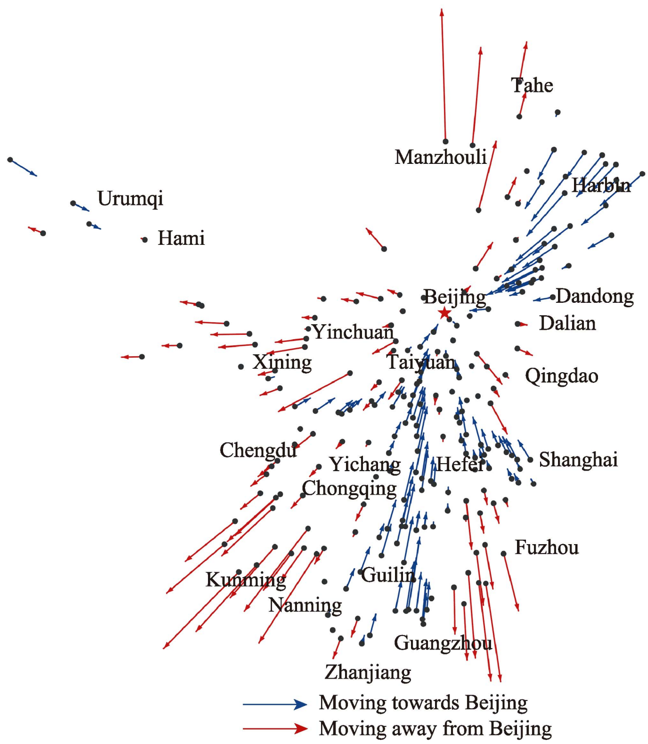

Figure 3 Schematic diagram of the changes in the spatial coordinates of 226 cities after the TD–SD conversion in 2003

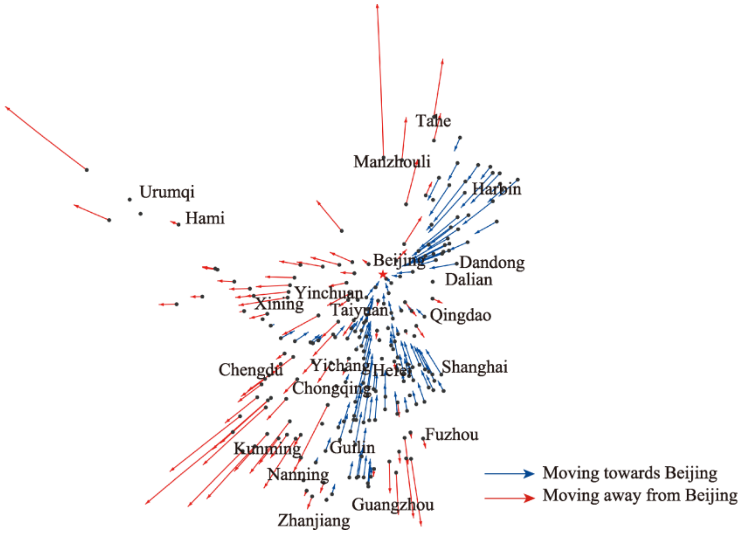

Figure 4 Schematic diagram of the changes in the spatial coordinates of 226 Chinese cities after the TD–SD conversion in 2009

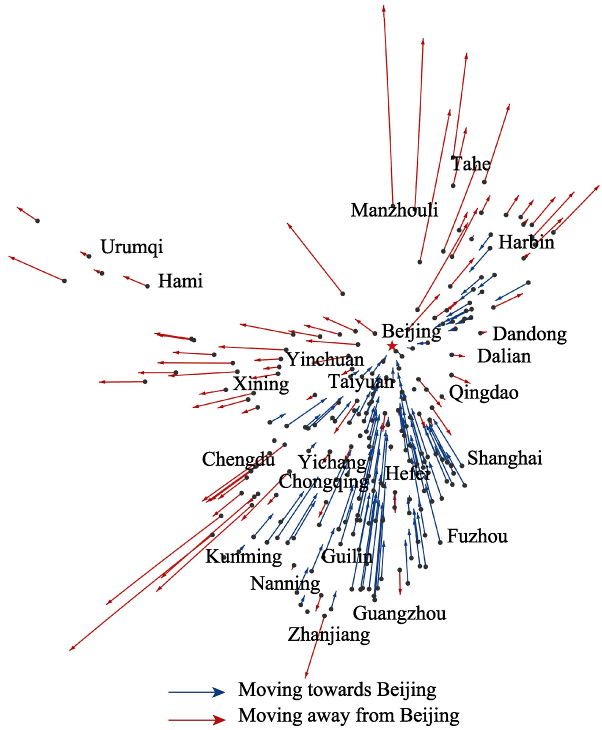

Figure 5 Schematic diagram of the changes in the spatial coordinates of 226 cities after the TD–SD conversion in 2016

At a deep level, whether a city moves away from or towards Beijing can reflect the city's transportation accessibility. A red arrow suggests that a city's transportation level is lower than the national average, whereas a blue arrow suggests that a city's transportation level is higher than the national average. Thus, as demonstrated in Figures 2–5, during the 1996–2016 period, transportation accessibility was predominantly lagging in most cities in northwestern and southwestern China and a small number of cities in northeastern China. Notably, the arrows of some cities in Fujian province shift from red to blue during the 2009–2016 period. This finding indicates a change in the TD-converted locations of these cities from moving away from Beijing to moving towards Beijing. This finding further suggests railway construction and development in Fujian province and a significant improvement in transportation accessibility between the cities in Fujian province and Beijing during the 2009–2016 period.

The length of each arrow indicates the extent of the change in the location of the city and reflects the extent of the change in the transportation accessibility of the city. The changes are shown in Figures 2–5 demonstrate that during the 1996–2016 period, most cities in southeastern China remained advantageous in terms of transportation accessibility, and this advantage gradually increased (as evidenced by the continuous increase in the lengths of the blue arrows during the 1996–2016 period). In addition, there was a notable change in the transportation accessibility of the cities in northeastern China. Overall, the transportation accessibility between most cities in northeastern China and Beijing gradually improved during the 1996–2009 period (as evidenced by the gradual increase in the lengths of the blue arrows) but significantly decreased during the 2009–2016 period (as evidenced by the significant decrease in the proportion and lengths of the blue arrows).

5 Discussion and Conclusion

The dataset of changes in the SRTTs from Beijing to 226 cities in China was produced by method of data integration for four temporal cross-sections (1996, 2003, 2009, and 2016). The dataset facilitated explorations and investigations of the changes in the transportation accessibility of cities across China at a national level, it will help our understanding of the temporal-spatial patterns of the railway transportation landscape. It is hoped that this dataset can provide a reference and data basis for deeper investigations and analyses of patterns in relevant fields, such as urban and economic geography and transportation.

Author Contributions

Wang, L. N. formulated the overall design for the development of the SRTTC dataset. Wang, L. N. and Li, X. collected and processed the data for the SRTTC dataset. Wang, L. N. and Li, X. designed the model and algorithm. Yu, X. K., validated the data. Wang, L. N., Li, X., Yu, X. K., and Hu, T. prepared the manuscript.

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