The impact of transportation development on land price differences between cities: Widening or narrowing?—A case study based on the provincial level of Mainland China

Tianshu Li | Zhigang Chen

1School of Geography and Ocean Science, Nanjing University, Nanjing, China
2School of Government, Nanjing University, Nanjing, China

Abstract
Exploring the impact of transportation development on land price differences between cities is of great significance to help guide the optimal allocation of land resources and promote the coordinated and balanced development of regions. This paper first discusses how regional transportation development influences land price differences between cities at a theoretical level. Then, by taking 26 provincial regions in the Chinese Mainland as research units, the specific effects of provincial transportation development on land price differences between cities are examined empirically by constructing econometric models. The results show that: (a) in recent years, the price of urban land in China has increased significantly, and the land price differences between cities are increasing in most provinces; and (b) provincial transportation development has a narrowing effect on land price differences between cities, and the spatial spillover effect brought by transportation development deserves attention. In the future, the role of transportation development in narrowing regional land price differences should be taken into consideration to promote the balanced development of the land market and the coordinated development of regions.
Changes in urban land prices are an important aspect of economic and social change, especially in countries undergoing rapid economic growth and urbanization. In recent years, the rapid development of China's economy and society has coincided with, the price of urban land also rising sharply. For example, the average price of land transfer in China has increased from 122.47 yuan per square meter in 2000 to 2,251.40 yuan per square meter in 2017. At the same time, the differentiation trend of land prices between cities is also increasingly obvious. From the perspective of China, in recent years there have been large differences in land price levels between east and west regions and north and south regions, as well as between large, medium and small cities (Huang et al., 2018), and these differences are gradually increasing (Sun & Chen, 2018). Based on the urban land price data in the China Land and Resources Almanac (MLRC, 2001-2004) and China Land and Resources Statistical Yearbook (MLRC, 2005-2018), we found that the land price differences between the major cities in China was significantly greater in 2017 compared to 2000.

The widening of land price differences between cities is not only the result of the widening gap in economic development between different regions, it also leads to the flow of relevant economic factors and aggravates the unbalanced development between cities. Land price is an important economic signal. Cities with higher land prices will, to some extent, attract the inflow of production factors such as capital and labor, promote the agglomeration of higher-level industries and promote economic growth by forcing the upgrading of industrial structures (Chen et al., 2018; Song et al., 2020; Xu et al., 2020). These cities will also relocate backward industries to the surrounding cities while producing a siphon effect, thereby increasing the unbalanced development between cities.

It can be said that at present, land has become the dominant factor driving and influencing the economic development of China’s regional and urban areas. Therefore, identifying how to effectively balance the land price levels between regions and cities and narrow the land price differences is of great significance for guiding the optimal allocation of land resources and promoting the coordinated and balanced development of regions. The key to solving this problem is fully grasping the influencing factors and the mechanism of the land price differences between cities.

Transportation is an important influencing factor on urban land prices. At present, there is an intensive period of transportation development in China. In recent years, transportation has developed rapidly, which has greatly promoted the connections between Chinese cities. In September 2019, the Communist Party of China’s Central Committee and the State Council of the People's Republic of China issued an outline for building a powerful transportation country that emphasizes the role of transportation infrastructure in national construction and regional connection and development. With the increase in traffic network density and traffic volume, the economic connections and interactions between the central cities and surrounding cities are strengthening, and the flow of economic factors closely related to land, such as industry and population, is becoming more and more frequent, leading to new distribution patterns.

Although these factors will inevitably change the land-use status of different cities and lead to the change of land price differences between cities, there is little literature on the impact of transportation development on land price differences between cities and whether it will narrow or widen these differences. In view of this, the current study attempts to explore the specific impact of transportation development on land price differences between cities from both theoretical and empirical perspectives.
The main contributions of this paper can be summarized as follows: First, it reveals the temporal and spatial characteristics of land price differences between cities within provinces in China, thereby helping to understand urban land price changes in other countries going through rapid economic and social changes. Second, it explores the mechanism through which transportation development impacts land price differences between cities in China. This will provide a new perspective for international related research to comprehensively understand the impact of transportation development and the influencing factors on urban land prices.

This paper is arranged as follows: The second section provides a literature review that mainly analyses the existing relevant research. In the third section, based on the role of transportation development in changing land locations and the relationship between cities, as well as promoting factor flow in a region, the mechanism of its impact on land price differences between cities is discussed theoretically. In the fourth section, we build an econometric model to reflect the impact of transportation development on land price differences between cities and make a preliminary descriptive statistical analysis. Then, in the fifth section, we use the relevant statistical data of 26 province-level regions in Mainland China between 2000 and 2017 to estimate the model and analyze the relevant results. Finally, a brief conclusion is given and the relevant policy implications are discussed.

2 | LITERATURE REVIEW

The existing relevant literature mainly focuses on the factors that influence changes in land prices within a specific city (Song et al., 2011) and pay less attention to the land price differences between cities. As the spatial heterogeneity of land exists in two categories, micro and macro (Shen et al., 2014), the research on the influencing factors on land prices within a particular city is usually divided into these two perspectives. The impact of macro factors on urban land prices is general and universal and includes city size, economic and social development level, urbanization level, policies and regulations, infrastructure construction scale and other regional factors (Guo & Shi, 2018; Han et al., 2020; Hua et al., 2005; Yuan et al., 2019). The influence of micro factors on land price is targeted and individual and can be subdivided into location factors, neighborhood factors and individual factors (Zhou, 2005), including the influence of urban centers, environmental conditions, the attributes of land parcels and so on (Glaesener & Caruso, 2015; Hu et al., 2016; Kong et al., 2007).

In recent years, the impact of transportation development factors on urban land prices has attracted extensive attention. Various types of transportation have been looked at, such as high-speed rail, public transport, urban rail transit and so on (Li et al., 2020; Zhang & Yen, 2020). For example, Cervero and Kang (2011) studied the impact of BRT (bus rapid transit system) reform on land use activities and land value in Seoul, South Korea, and found that both residential land prices and commercial land prices along the BRT transportation line had significantly increased. Taking Jiangsu Province, China, as the research case, Wang et al. (2018) found that the opening of a high-speed railway and the increase in train frequency would have a positive impact on the transaction price of commercial land. Similarly, Sharma and Newman (2018) used the hedonic model to explore the impact of subway construction on land value in Bangalore and found that the massive investment brought by the new subway increased the real estate price of the whole city by 4.5%.

Different from other factors, transportation development not only has an important impact on the land prices in a specific city, but also a non-negligible impact on the land price...
differences between cities due to its role in promoting the flow of economic factors and urban connections in the region (Kim, 2000; Liang et al., 2020; Yu et al., 2013). The role of transportation development in promoting the flow of economic factors and urban connections in regions has long been of interest in academic circles, and certain theoretical consensuses have been formed.

The development of transportation infrastructure, such as roads and railways, has led to a decrease in transportation costs, and means the factors of production such as labor, capital and information technology can flow more freely within and between regions. Studies have pointed out that the construction of high-speed rail has achieved ‘space compression’, and the reduction of travel time between cities has increased the interaction between cities and regions, and promoted the circulation of production factors such as technology, talent, and information between regions (Diao, 2018; Lin, 2017).

The construction of transportation infrastructure even affects the location choice of economic entities, thus changing their spatial behavior and reshaping the economic spatial structure (Jia et al., 2017). According to Shao et al.’s (2017) study of 25 cities in China’s Yangtze River Delta, the development of a high-speed rail network would have a positive impact on the agglomeration of the service industry in cities along the line by affecting the spatial distribution of production resources. Also, related resources could be more easily distributed from core cities to surrounding small and medium-sized cities along the railway line. Indeed, research on the allocation of urban railways and highways in China has found that the construction of urban railways and highways promotes the flow of production factors, such as population, and decentralizes industry and service industries (Baum-Snow et al., 2017).

Transportation development also strengthens the relationships between cities, especially the interactions between central cities and the surrounding cities, changing the spatial pattern of the economy between different cities to a certain extent. Wang et al. (2020) found that under the ‘One Belt One Road’ policy, the development of basic transportation facilities in Eastern and Central Europe had a positive spatial spillover effect that promoted the economic growth of the whole region. Huang et al. (2020) took prefecture-level cities in mainland China as the research case and pointed out that the externality of urban transportation networks broke through the limitations of geographical proximity and could produce cross-space economic spillover effects. Chen and Hall (2012) also found that TGV (train àGrande Vitesse) in France strengthened the connection between the urban core area and the peripheral area, and made regional development more coordinated through the outward migration of population and industry. Similarly, Chen and Haynes (2017) studied the changes in regional economic differences in China under the influence of high-speed railways, and found that the construction of high-speed railways promoted the narrowing of regional economic disparity and increased economic integration in China. Yao et al. (2019) also pointed out that the space-time effect created by high-speed rail construction accelerates the spillover effect of big cities, promoting the convergence of regional economies. Some research has pointed out that the construction of transportation infrastructure, such as high-speed railways, can have a negative impact on marginal areas, however, and lead to the polarized development of regional economies (Deng et al., 2019; Jiao et al., 2017; Qin, 2017).

Although the influence of transportation on land prices in a particular city has been extensively studied and its impact on urban development differences within a region confirmed, there is less research that connects the two effects and explores if the impact of transportation on urban development differences within a region affects land price differences.
3 | THEORETICAL ANALYSIS

To further explore the impact of transportation development on land price differences between cities, this paper first refers to the relevant definitions of the white paper on China’s transportation development (SCIO, 2016), and defines transportation development as the development of related transportation capabilities that promote the movement of people and things in the management space within the region. By referring to the relevant literature (Luo & Sun, 2019; Wu et al., 2009), this paper jointly represents regional transportation development from two perspectives: the improvement of transportation infrastructure networks and the improvement of transportation efficiency. The former includes the increase in the number of highways, railways and other transportation lines, the enhancement of the density of transportation networks and the expansion of the transportation coverage area, while the latter includes the reduction of transportation costs and improvements in passenger and freight volume through the improvement of the relevant transportation technology and the transportation system.

As mentioned above, transportation development helps promote the flow of economic factors and increases coordinated development between regions and cities. Therefore, from the perspective of a large region, transportation development undoubtedly changes the relative location conditions of land by influencing the allocation of economic and social development factors in the region. This then, affects the land price differences between cities. Combined with the theoretical framework shown in Figure 1, we then can explain the impact of transportation development on land price differences between cities from the following three perspectives.

1. The development of transportation will narrow the location difference between cities and then lead to the narrowing of land price differences between cities. The differential rent theory points out that the land price will be affected by geographical location. Under the
condition of similar natural conditions, such as fertility, the land closer to the market will have a higher value due to lower transportation costs. In the case that the geographical location cannot be changed, reducing the migration cost and improving accessibility can improve the location advantage of the land and then raise its value. According to the central place theory, there are usually central cities that provide services to surrounding cities in a certain area. These central cities are the ‘market’. A central city has a higher level of development and the surrounding cities have a lower level of development (Christaller, 1966). Therefore, the land in the central city has a location advantage because it is close to the market and has a higher land price, while the marginal cities far away from the central city have a location disadvantage due to the rise in transportation costs and a lower land price. Under these circumstances, the development of regional transportation capacity will reduce the migration cost between the central city and the surrounding cities, increasing the accessibility of the surrounding cities. Therefore, the location of non-central cities is improved, and the location differences between central cities and peripheral cities are narrowed. This means that the differences in land price between a central city and a peripheral city due to their different locations can be reduced to a certain extent. Moreover, the reduction in transportation costs between non-central cities brought about by transportation development also narrows the location heterogeneity of cities, thus narrowing the land price differences and promoting the urban land price level in the region to a more balanced state.

2. The development of transportation will affect the economic development difference between cities in the region by strengthening the interaction between strong and weak cities. This then affects the land price differences between cities. Unbalanced development theory points out that the economy does not spread evenly in space and that there are growth regions with better development and lagging regions with poorer development. Two different regions interact in space, resulting in two effects. One is the agglomeration effect, which refers to the flow of production factors from underdeveloped regions to developed regions. This effect widens regional economic differences. The other is the spillover effect, which refers to the flow of production factors from developed to underdeveloped regions. This effect narrows regional development differences (Hirschman, 1958; Myrdal, 1957). The development of regional transportation will improve the flow efficiency of production factors and strengthen the interconnections between cities, promoting the above two effects. In the early stages of economic development, under the influence of the market mechanism, the core area with better development will support its own development by absorbing the production factors of the marginal area, thus widening the economic development differences between the core area and the marginal area. The development of transportation will intensify the flow of factors to some extent, leading to the further expansion of economic development differences between cities. Based on the relationship between land price and economic development, it is not difficult to infer that the widening of economic development differences between cities will inevitably lead to the widening of land price differences. There are limits to the economic polarization of central cities, however. When the agglomeration economy of the central city reaches ‘uneconomical congestion’, regional integration will weaken the agglomeration effect and promote the relocation of some production factors to surrounding cities, strengthening the spillover effect (Tabuchi, 1998; Williamson, 1965). The development of transportation will not only weaken the agglomeration effect by promoting regional integration but also lead to the acceleration of factor circulation and the expansion of coverage, which will also make the spillover effect stronger. In this case, the central city will have stronger spillover capacity.
and a larger spillover area in the surrounding cities, narrowing the development differences between the central city and the surrounding cities. This will even promote the formation of ‘cluster sub-centres’ and promote the ‘point-axis’ diffusion of cities within the region (Fujita et al., 1999; Lu, 2002). At the same time, the factor circulation and information exchange brought about by transportation development will reduce the differences in resource endowment and the regional heterogeneity among cities, thus promoting the balanced development of urban economy within the region. The balanced development of the urban economy in the region will affect the urban land price and bring about the narrowing of the land price differences between cities.

3. The reduction of transportation costs brought by transportation development will also drive changes in industry and population distribution and affect the land price differences between cities by affecting the scarcity of urban land use. The development of transportation will reduce the cost of commuting and even achieve the short-distance separation of people’s residences and workplaces. The reduction in transportation costs brought by the improvement in transportation capacity will also give the related industries (or enterprises) more possibilities regarding their locations (Hu et al., 2020). According to the relevant theories of new economic geography, in the early stages of economic development, based on the market proximity effect, manufacturers choose to be close to advantageous areas to reduce the transportation costs of their goods and obtain lower production costs and access to a larger market. Based on the living cost effect and the mutual strengthening effect between population and industry, the population also tends to go to the advantageous areas to obtain better commodities, lower consumption expenditure and more labor opportunities (Chen et al., 2021; Deng et al., 2019; Kancs, 2011; Su et al., 2021). The reduction in migration costs brought by transportation development will undoubtedly promote the agglomeration of industries and populations to central cities, and a large amount of agglomeration will bring a large demand for land. The land of central cities cannot expand indefinitely, however. Therefore, central cities need to make intensive use of land to accommodate more factors of production, which will cause land shortages. Under the dual effects of land economic efficiency improvement and land scarcity, land prices will rise and even polarize in central cities. In the surrounding cities, due to the loss of population and industry, a large amount of vacant land will appear, resulting in low land prices. The land price differences between strong and weak cities will widen. However, when urban crowding reaches a certain extent, the polarization of land prices and the increase in production and living costs will force some industries and some of the population to move out in pursuit of lower costs. The rapid development of transportation will create the conditions for relocation, which will give industries and the population more spatial distribution possibilities. They will move to cities with lower land prices that not only meet the need to reduce production and living costs but also help them maintain close ties with advantageous regions. It can be said that traffic development will alleviate the agglomeration and congestion of industry and population in central cities and make their distribution more dispersed and even, thus bringing about a relative balance in land use among cities in the region and narrowing the land price differences between cities.

Based on the above analysis, it is not difficult to understand that transportation development may theoretically lead to both the widening and narrowing of land price differences between cities. Based on the network and regional externality of traffic development, its related impact may not only be limited to the transportation infrastructure construction area but also have a spillover impact on the surrounding areas. Meanwhile, based on the first law
of geography (Tobler, 1970), geographical proximity of provinces may further strengthen the spatial effect of transport development. In view of China’s current development reality, what is the specific impact of transportation development on the land price differences between cities? Will it have a greater impact through the spatial spillover effect? Further empirical tests are needed. Based on this, the current paper introduced the spatial panel model to explore the correlation effect.

4 | METHOD AND DATA

4.1 | Spatial autocorrelation analysis

Before building the spatial panel model, spatial autocorrelation analysis of the related variables is needed to judge whether they are spatially interdependent. Spatial autocorrelation analysis includes global and local spatial autocorrelation analysis.

First, this paper uses global Moran’s $I$ to measure the global spatial autocorrelation of land price differences between cities and the relevant variables representing transportation development within the province and to characterize their overall degree of spatial correlation in the study area. The formula of global Moran’s $I$ is as follows:

$$
\text{Moran’s } I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}(X_i - \bar{X})(X_j - \bar{X})}{S^2 \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}}
$$

(1)

where $X_i$ and $X_j$ represent the observed values of region $i$ and region $j$, respectively; $\bar{X}$ represents the mean value of variable observations in the region; $W_{ij}$ represents the spatial weight matrix; $n$ is the sample number; and $S^2$ is the sample variance.

In terms of the construction of the spatial weight matrix, this paper uses the distance standard to define the spatial weight matrix. The specific construction method is as follows:

$$
W_{ij} = \begin{cases} 
\frac{1}{D_{ij}^2} & i \neq j \\
0 & i = j 
\end{cases}
$$

where $D_{ij}$ is the geographical distance between spatial unit $i$ and spatial unit $j$. This is calculated by using the longitude and latitude data of the capital city of each province.

Then, this paper uses local Moran’s $I$ to conduct spatial analysis on the relevant indicators and divides the spatial units into five types: high–high agglomeration, high–low agglomeration, low–high agglomeration, low–low agglomeration and insignificant. These characterize the spatial association mode between each spatial unit and its surrounding units. The formula of local Moran’s $I$ is as follows:

$$
\text{Local Moran’s } I = \frac{n(X_i - \bar{X})}{\sum_{j \neq i}^n (X_i - \bar{X})^2} \sum_{j \neq i}^n W_{ij}(X_j - \bar{X})
$$

(2)
where $X_i$ and $X_j$ represent the observed values of region $i$ and region $j$, respectively; $\overline{X}$ represents the mean value of the observed values of regional variables; $W_{ij}$ represents the spatial weight matrix; and $n$ is the number of samples.

4.2 Model construction

To empirically test the specific impact of transportation development on land price differences between cities, this paper took the provincial regions in Mainland China as the research unit and constructed an econometric model. The basic expression of the model is as follows:

$$L_{PEit} = C + \alpha_i TR_{it} + \beta_i CV_{it} + \mu_{it}$$

(3)

where $L_{PEit}$ represents the land price differences between cities in the year $t$ of province $i$; $TR_{it}$ represents the relevant variable that can represent the transportation development in the year $t$ of province $i$; $CV_{it}$ is a set of control variables that affect the land price differences between cities in the year $t$ of province $i$; $C$ is a constant term; $\alpha_i$ and $\beta_i$ are the model estimation coefficients of variable groups $TR_{it}$ and $CV_{it}$, respectively; and $\mu_{it}$ is the error term of the model.

It should be noted that according to the first law of geography, everything is related to everything else, but near things are more related to each other (Tobler, 1970). As for the explained variables, land price differences between cities in neighboring provinces may be correlated due to the similarity of resource endowment and the imitative and competition effects of governments among provinces. At the same time, the explanatory variable (transportation development) also has some spatial externalities; therefore, we need to pay attention to the spatial properties of the independent and dependent variables. As traditional econometric models ignore the spatial relations between different individuals, which may lead to deviation of the estimated results, this paper decided to build a static spatial econometric model based on the previous model to better reflect the influence of the independent variables on the dependent variables. The basic expression of the spatial panel model is as follows:

$$\begin{align*}
Y_{it} &= \alpha + \rho \sum_{j=1}^{n} w_{ij} Y_{jt} + \beta X_{it} + \varphi \sum_{j=1}^{n} w_{ij} X_{jt} + \gamma_i + \nu_i + \sigma_{it} \\
\sigma_{it} &= \lambda \sum_{j=1}^{n} w_{ij} \mu_{jt} + \epsilon_{it}
\end{align*}$$

(4)

where $Y_{it}$ represents the dependent variable; $X_{it}$ represents a variable group containing independent variables and control variables; $\rho$ is the spatial lag coefficient, which represents the spatial spillover effect of the dependent variable; $\varphi$ is the spatial lag coefficient of $X_{it}$; $w_{ij}$ is the spatial weight matrix; $\lambda$ is the spatial error term coefficient; $\gamma_i$ is the regional effect variable that does not change with time; $\nu_i$ is the time effect variable which does not change with the region; $\epsilon_{it}$ is a random disturbance term; $\mu_{jt}$ is the spatial error term; and $\alpha$ is a constant term.

For the explained variable $LPE$, we use the Gini coefficient to measure the comprehensive land transfer price differences between different cities in the province (see Equation 5).

For the independent variable $TR$, we referred to the definition of transportation development and the relevant literature (Cui & Yang, 2017; Gao et al., 2016; He et al., 2019) and adopted two indicators, traffic network density ($T_{HR}$, unit: km/km$^2$) and traffic volume index
(TPI), to jointly represent transportation development. The traffic network density was obtained by calculating the sum of the railway and road mileage in each province and dividing this by the area occupied by the administrative region (Liu & Hu, 2011; Liu & Su, 2021). This reflects the construction of provincial traffic infrastructure. The traffic volume index was obtained by summing the provincial freight volume and passenger volume data after dimensionless processing (see Equation 6; Cui & Yang, 2017). This reflects the provincial traffic efficiency.

As the dependent variable of the model is land price difference between the cities in each province, for the control variable, we selected the relevant influencing factors on land prices in specific cities from the perspective of characterizing the development differences between cities in the region (Kuang & Li, 2012; Liu et al., 2016; Shu et al., 2018) and used the Gini coefficient to measure the differentiation degree of relevant influencing factors between cities in the province. It should be pointed out that, according to the relevant principle of geographic detector (Wang & Xu, 2017), if an independent variable has an important impact on a dependent variable, the spatial distribution of the independent and dependent variable should be similar. We believe that there is a similarity between the spatial differentiation of urban land prices in each province and the spatial differentiation of the factors that influence urban land prices. The differences in the factors that influence land prices in the cities in each province will affect the differences in land prices between cities.

As the research object of this paper is whole provinces, we also selected variables that can characterize the overall development of each province as global control variables and added them into the model. Specifically, from the perspectives of economy, demand, investment and supply, this paper selected the population density (PPEOD, unit: person/km²), per capita GDP (PGDP, unit: 10,000 yuan/person), fixed asset investment (INV, unit: 100 million yuan) and built-up area (LAND, unit: 1,000 km²) of each province as the provincial global control variables. At the same time, the Gini coefficient was used to measure the population density differences (PPEODG), per capita GDP differences (PGDPG) and fixed asset investment differences (INVG) between the cities within each province (see Equation 5). These were used as control variables to represent the differences between cities within each province.

As for the measurement of the degree of difference in the relevant variables between cities within each province, this paper mainly referred to the Gini coefficient calculation model proposed by the Macmillan Dictionary of Modern Economics (1992). Taking the measurement of land price differences between cities as an example, the measurement formula is as follows:

\[
L_{PE} = 1 + \frac{1}{n} - \frac{2 \times (P_1 + 2P_2 + 3P_3 + \ldots + nP_n)}{n^2 \times P} (i = 1, 2, 3, \ldots, n)
\]  

(5)

where \(P_1, P_2, P_3 \ldots P_n\) is the comprehensive land transfer price of different cities in the province (ratio of total land transfer amount to transfer area, unit: yuan/m²; in descending order of actual value); and \(P\) is the mean value of the comprehensive land transfer price of different cities in the province. \(L_{PE}\) is the Gini coefficient reflecting the degree of difference in urban land prices within the province and has a value ranging from 0 to 1. The higher the value of \(L_{PE}\), the greater the difference in land prices among different cities in the province, and the more unbalanced the land price level.

Taking the dimensionless treatment of freight volume as an example, the standardized formula for the dimensionless treatment of the relevant variables is as follows:
\[ X_{it}' = \frac{X_{it} - \min X_i}{\max X_i - \min X_i}, \quad 0 \leq X_{it}' \leq 1 \]  

where \( X_{it}' \) is the dimensionless standardized value of the freight volume of province \( i \) in year \( t \), \( X_{it} \) is the freight volume data of province \( i \) in year \( t \), \( \min X_i \) is the minimum value of freight volume in all provinces in year \( t \) and \( \max X_i \) is the maximum value of freight volume in all provinces in year \( t \).

The final model expression is as follows:

\[
L_{PEit} = \alpha + \rho \sum_{j=1}^{n} w_{ij} L_{PEij} + \alpha_1 T_{HRit} + \alpha_2 T_{PLit} + \beta_1 P_{EODit} + \beta_2 P_{GDPit} + \beta_3 L_{ANDit} \\
+ \beta_4 I_{NVit} + \beta_5 P_{EODGi} + \beta_6 P_{GDPGi} + \beta_7 I_{NVGi} + \phi \sum_{j=1}^{n} w_{ij} X_{it} + \gamma_i + \nu_i + \sigma_{it} \\
\sigma_{it} = \lambda \sum_{j=1}^{n} w_{ij} \mu_{it} + \epsilon_{it}
\]

When \( \rho, \lambda \neq 0, \phi = 0 \), it is the generalized spatial autocorrelation model (SAC). When \( \rho, \phi \neq 0, \lambda = 0 \), it is the spatial Durbin model (SDM). When \( \rho \neq 0, \lambda, \phi = 0 \), it degenerates into the spatial autoregression model (SAR). When \( \lambda \neq 0, \phi + \beta \rho = 0 \), it degenerates into the spatial error model (SEM).

### 4.3 Data sources

The estimation of the above model is mainly based on the relevant panel data of 26 provinces in Mainland China (including 22 provinces and four autonomous regions) from 2000 to 2017. Due to a large number of missing urban land price data in Tibet, the land price differences between cities could not be measured. There were also a large number of missing data from the traffic-related and control variables. Therefore, Tibet was excluded from the study. The data used to calculate the land price differences between cities (\( L_{PE} \)) came from the 2001–2004 China Land and Resources Almanac (Ministry of Land and Resources of China, 2001–2004) and the 2005–2018 China Land and Resources Statistical Yearbook (Ministry of Land and Resources of China, 2005–2018). Data related to transportation network density (\( T_{HR} \)) and transportation volume index (\( T_{PL} \)) came from the China Economic and Social Big Data Research Platform (https://data.cnki.net/) and the Ministry of Civil Affairs of China (http://www.mca.gov.cn/). Data related to the control variables came from the China Economic and Social Big Data Research Platform (https://data.cnki.net/), China Statistical Yearbook (NBSC, 2001–2018) and statistical yearbooks of provinces and cities over the years. Missing data were accounted for using the moving average method. Table 1 describes the statistical values of the sample data for each of the above variables.

### 4.4 The relationship between TR and \( L_{PE} \): descriptive statistical analysis

In this paper, the land price differences between cities within each province in 2000, 2009 and 2017 were selected to conduct a preliminary analysis. Most provinces had experienced the land price differences between their cities decreasing and then increasing over time, and the degree of the land price differences between cities in most provinces in 2017 was lower than in 2000. This
shows that although the land price differences between the cities in most provinces expanded in recent years, they were still relatively balanced compared to 2000. On a spatial scale, there were significant differences in the degree of land price differences between cities in various provinces. Taking the 2017 data as an example, the land price differences between cities in Xinjiang was as high as 0.66, while in Hainan it was only 0.11 (see Table 2 for details).

Furthermore, this paper briefly analyzed the relationship between provincial transportation development and the land price differences between cities. First, the average values of the land price differences between cities ($L_{pe}$), the traffic network density ($T_{hr}$) and the traffic volume index ($T_{pi}$) were calculated for 26 provinces between 2000 and 2017. Then, the scatter-plots of $L_{pe}$ and $T_{hr}$ and $L_{pe}$ and $T_{pi}$ were drawn to make a preliminary judgment regarding the correlation between the land price differences and transportation development within each province. According to the trend lines in Figures 2 and 3, it can be preliminarily judged that traffic network density and traffic volume index, which represent traffic development status, are negatively correlated with the land price differences between cities.

## 5 | EMPIRICAL TEST RESULTS

### 5.1 | Global spatial correlation of related indicators

The $N \times N$ space weight matrix constructed above can only be applied to cross-sectional data. This paper referred to the practice of Wang and Shen (2007) to establish the panel space weight matrix by constructing the block diagonal matrix, and calculated the global Moran's $I$ of the relevant variables. The results show that there is a significant positive spatial autocorrelation between land price differences, traffic network density and traffic volume index in the provinces (see Table 3).

### 5.2 | Local spatial correlation of relevant indicators

Due to space limitations, this paper lists the local spatial correlation calculation results of the relevant indicators in 2001, 2007, and 2017 and focuses on the high–high and low–low spatial
clusters. From the perspective of the spatial cluster of land price differences between the cities within each province, the high–high cluster is mainly distributed in Northwest China, while the low–low cluster is mainly distributed in the eastern coastal areas of China. From the perspective of the spatial cluster of the relevant variables related to the provincial transportation development, the low–low cluster is mainly distributed in Northwest China, while the high–high cluster is mainly distributed in the eastern coastal area of China, with a trend of extending to the central region. The spatial agglomeration characteristics of the relevant variables show that provinces with lower land price differences between cities and better transportation development form an agglomeration in the more developed eastern region and have a certain spatial spillover effect on the surrounding areas. The provinces with higher land price differences between cities and poorer transportation development are clustered in the less developed western regions. The land price differences between cities and the related variables representing transportation

### Table 2: Provincial land price differences between cities by time period

<table>
<thead>
<tr>
<th>Province</th>
<th>$L_{PE}$ 2000</th>
<th>$L_{PE}$ 2009</th>
<th>$L_{PE}$ 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hebei</td>
<td>0.329</td>
<td>0.246</td>
<td>0.311</td>
</tr>
<tr>
<td>Shanxi</td>
<td>0.386</td>
<td>0.282</td>
<td>0.429</td>
</tr>
<tr>
<td>Inner Mongolia</td>
<td>0.601</td>
<td>0.361</td>
<td>0.384</td>
</tr>
<tr>
<td>Liaoning</td>
<td>0.416</td>
<td>0.359</td>
<td>0.386</td>
</tr>
<tr>
<td>Jilin</td>
<td>0.385</td>
<td>0.354</td>
<td>0.307</td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>0.338</td>
<td>0.409</td>
<td>0.494</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>0.195</td>
<td>0.233</td>
<td>0.437</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>0.192</td>
<td>0.238</td>
<td>0.338</td>
</tr>
<tr>
<td>Anhui</td>
<td>0.451</td>
<td>0.224</td>
<td>0.260</td>
</tr>
<tr>
<td>Fujian</td>
<td>0.462</td>
<td>0.464</td>
<td>0.549</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>0.377</td>
<td>0.153</td>
<td>0.303</td>
</tr>
<tr>
<td>Shandong</td>
<td>0.349</td>
<td>0.260</td>
<td>0.344</td>
</tr>
<tr>
<td>Henan</td>
<td>0.358</td>
<td>0.233</td>
<td>0.240</td>
</tr>
<tr>
<td>Hubei</td>
<td>0.381</td>
<td>0.242</td>
<td>0.431</td>
</tr>
<tr>
<td>Hunan</td>
<td>0.356</td>
<td>0.145</td>
<td>0.194</td>
</tr>
<tr>
<td>Guangdong</td>
<td>0.518</td>
<td>0.483</td>
<td>0.492</td>
</tr>
<tr>
<td>Guangxi</td>
<td>0.552</td>
<td>0.253</td>
<td>0.347</td>
</tr>
<tr>
<td>Hainan</td>
<td>0.195</td>
<td>0.112</td>
<td>0.108</td>
</tr>
<tr>
<td>Sichuan</td>
<td>0.564</td>
<td>0.266</td>
<td>0.356</td>
</tr>
<tr>
<td>Guizhou</td>
<td>0.250</td>
<td>0.200</td>
<td>0.207</td>
</tr>
<tr>
<td>Yunnan</td>
<td>0.451</td>
<td>0.221</td>
<td>0.305</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>0.544</td>
<td>0.429</td>
<td>0.313</td>
</tr>
<tr>
<td>Gansu</td>
<td>0.453</td>
<td>0.386</td>
<td>0.401</td>
</tr>
<tr>
<td>Qinghai</td>
<td>0.466</td>
<td>0.703</td>
<td>0.653</td>
</tr>
<tr>
<td>Ningxia</td>
<td>0.627</td>
<td>0.232</td>
<td>0.269</td>
</tr>
<tr>
<td>Xinjiang</td>
<td>0.542</td>
<td>0.282</td>
<td>0.659</td>
</tr>
</tbody>
</table>
development both have a certain spatial autocorrelation, and their spatial aggregation distribution has obvious dislocation phenomenon (Figures 4–6).

5.3 | Results and discussion

5.3.1 | Regression results

The results of the spatial autocorrelation test show that there is a strong spatial autocorrelation in the provincial related variables. Based on this, this paper selected the spatial panel model for the empirical test, and the spatial weight matrix used was consistent with the above matrix.
The results of the Hausman test showed that the random effect model was more reasonable in this study. This paper then referred to Elhorst’s test ideas on space model selection (Elhorst, 2014) and used a Lagrange multiplier (LM) test to judge the selection of spatial model in combination with the relevant literature (Shao et al., 2016; Zhang & Yang, 2016). This paper first conducted

<table>
<thead>
<tr>
<th>Variable</th>
<th>I value</th>
<th>Z value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPE</td>
<td>0.178</td>
<td>6.832</td>
<td>.000</td>
</tr>
<tr>
<td>THR</td>
<td>0.554</td>
<td>21.079</td>
<td>.000</td>
</tr>
<tr>
<td>TPi</td>
<td>0.344</td>
<td>13.160</td>
<td>.000</td>
</tr>
</tbody>
</table>

FIGURE 4  Local Moran’s I of LPE, THR, and TPi in China in 2001

FIGURE 5  Local Moran’s I of LPE, THR, and TPi in China in 2007

FIGURE 6  Local Moran’s I of LPE, THR, and TPi in China in 2017
an OLS estimation without considering spatial effects, the results of which showed that the independent variables of traffic network density ($T_{HR}$) and traffic volume index ($T_{PI}$) both had significant and negative effects on the land price differences ($L_{PE}$) between the cities in a province at the level of 1%. Then, an LM test was used to select the model. The results of the LM lag test and LM error test were both significant at the 1% level, indicating that the spatial lag and spatial error effects of the model existed at the same time. The robust LM-lag passed the test, but the robust LM-err did not, indicating that the SAR model was more suitable (see Table 4). The model estimation results are shown in Table 5.

According to the model estimation results, the spatial lag coefficient $\rho$ in the SAR model was 0.396, which is significant at the level of 1%, indicating that there is a spatial interaction between the land price differences between cities in neighboring provinces. This may be because the resource endowments of neighboring provinces and the economic structures within a region are more similar. Therefore, the distribution of land prices between cities within a region are also more similar. At the same time, there may have been some competition and imitation between the governments’ land transfer behavior in neighboring areas, which led to the convergence of urban land price differentiation.

**TABLE 4**

<table>
<thead>
<tr>
<th>Test</th>
<th>Statistic</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM-spatial error</td>
<td>19.746</td>
<td>.000</td>
</tr>
<tr>
<td>Robust LM-spatial err</td>
<td>.048</td>
<td>.826</td>
</tr>
<tr>
<td>LM-spatial lag</td>
<td>25.684</td>
<td>.000</td>
</tr>
<tr>
<td>Robust LM-spatial lag</td>
<td>5.985</td>
<td>.014</td>
</tr>
</tbody>
</table>

**TABLE 5**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variable ($L_{PE}$)—SAR</th>
<th>Estimated coefficient</th>
<th>Direct effect</th>
<th>Indirect effect</th>
<th>Total effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{HR}$</td>
<td>$-7.209e^{-2}$*** ($2.226e^{-2}$)</td>
<td>$-7.311e^{-2}$*** ($2.325e^{-2}$)</td>
<td>$-3.896e^{-2}$*** ($1.401e^{-2}$)</td>
<td>$-0.112$*** ($3.452e^{-2}$)</td>
<td></td>
</tr>
<tr>
<td>$T_{PI}$</td>
<td>$-0.983$*** (0.332)</td>
<td>$-1.026$*** (0.333)</td>
<td>$-0.561$** (0.239)</td>
<td>$-1.587$*** (0.540)</td>
<td></td>
</tr>
<tr>
<td>$P_{EODG}$</td>
<td>$0.428$*** (0.074)</td>
<td>$0.448$*** (0.073)</td>
<td>$0.247$*** (0.084)</td>
<td>$0.695$*** (0.144)</td>
<td></td>
</tr>
<tr>
<td>$P_{GDPG}$</td>
<td>$6.691e^{-3}$ (8.302e^{-2})</td>
<td>$3.264e^{-3}$ (8.083e^{-2})</td>
<td>$1.077e^{-3}$ (4.688e^{-2})</td>
<td>$4.341e^{-2}$ (0.126)</td>
<td></td>
</tr>
<tr>
<td>$I_{AVG}$</td>
<td>$-1.813e^{-2}$ (7.065e^{-2})</td>
<td>$-1.868e^{-2}$ (7.009e^{-2})</td>
<td>$-1.023e^{-2}$ (4.065e^{-2})</td>
<td>$-2.891e^{-2}$ (0.110)</td>
<td></td>
</tr>
<tr>
<td>$P_{EOD}$</td>
<td>$5.220e^{-5}$ (6.750e^{-5})</td>
<td>$6.020e^{-5}$ (6.900e^{-5})</td>
<td>$3.300e^{-5}$ (3.920e^{-5})</td>
<td>$9.320e^{-5}$ (1.068e^{-4})</td>
<td></td>
</tr>
<tr>
<td>$P_{GDP}$</td>
<td>$-7.749e^{-5}$ (4.427e^{-3})</td>
<td>$-8.032e^{-5}$ (4.514e^{-3})</td>
<td>$-4.369e^{-5}$ (2.861e^{-3})</td>
<td>$-1.240e^{-2}$ (7.173e^{-3})</td>
<td></td>
</tr>
<tr>
<td>$I_{NV}$</td>
<td>$2.430e^{-6}$ (1.060e^{-6})</td>
<td>$2.470e^{-6}$ (1.050e^{-6})</td>
<td>$1.310e^{-6}$ (6.040e^{-7})</td>
<td>$3.780e^{-6}$ (1.580e^{-6})</td>
<td></td>
</tr>
<tr>
<td>$L_{AND}$</td>
<td>$4.459e^{-2}$*** (1.333e^{-2})</td>
<td>$4.633e^{-2}$*** (1.335e^{-2})</td>
<td>$2.566e^{-2}$*** (1.110e^{-2})</td>
<td>$7.199e^{-2}$*** (2.299e^{-2})</td>
<td></td>
</tr>
<tr>
<td>_cons</td>
<td>$8.029e^{-2}$*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rho</td>
<td>$0.365$***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sigma2_e</td>
<td>$6.096e^{-3}$***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-sq</td>
<td>0.105</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>468</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***Significance levels of .01.; **Significance levels of .05.; *Significance levels of .1.
Regarding the estimation results of the control variables, for the variables reflecting the differences between cities within a province, the impact of population density difference ($P_{EODG}$) on land price differences between cities within a province was significant and positively correlated at the level of 1%, while the impact of per capita GDP differences ($P_{GDPG}$) and fixed asset investment differences ($I_{NVG}$) on land price differences were not significant. This shows that the tension between population and land caused by the population distribution difference was still the main factor driving the changes in land price differences between cities. For the variables reflecting the global status of a province, except for the population density ($P_{EOD}$) of a province, all the variables were significant. The effect of per capita GDP ($P_{GDP}$) on land price differences between cities was significant and negative, which may be the result of the spillover effect of central cities after the development of the regional economy reached a certain stage. Provincial fixed asset investment ($I_{NV}$) had a significant and positive impact on land price differences between cities, which may be related to the current regional imbalance of investment. After all, the more developed the economy and the higher the land price level, the more attractive the city is to investment. The built-up area ($L_{AND}$) of a province also had a significant and positive impact on land price differences between cities. This may be because in the case of large provincial areas, the positive spillover of central cities cannot reach marginal cities, resulting in the expansion of development differences between cities and the subsequent expansion of land price differences.

Regarding the estimation results of the explanatory variables, the independent variables of traffic network density ($T_{HR}$) and traffic volume index ($T_{PI}$) both had significant and negative effects on the land price differences between cities ($L_{PE}$) in a province at the level of 1%. That is to say, when other input factors remained unchanged, both an increase in transportation infrastructure and an improvement in transportation efficiency helped narrow land price differences between the cities in a province, making the land price level in the province more balanced.

First, as mentioned in the theoretical analysis above, the development of transportation reached ‘space compression’ to a certain extent. For the central and peripheral cities, although the actual geographical locations of the cities did not change, the development of transportation made it easier for the peripheral cities to reach the central city, and the increase in accessibility reduced the relative distance between the central and peripheral cities, narrowing the location differences between the peripheral cities and the central city. The increase in accessibility reduces the relative distance between the central and peripheral cities, thereby reducing their location differences. For different peripheral cities, the development of transportation has also strengthened their connections with each other, thereby reducing their geographic heterogeneity. The narrowing of the location differences between cities brought about by transportation development also leads to the narrowing of land price differences between them.

Second, the provincial central cities will have an agglomeration effect and spillover effect on the surrounding cities. At different stages of economic development, these two effects of the central cities on the surrounding cities will be different. In recent years, with the rapid development of the social economy, China’s dominant cities have gradually begun to have a spillover effect (Xie et al., 2020; Zhang et al., 2018). At the same time, the Chinese government has been vigorously promoting its ‘regional integration’ policy, which is aimed at strengthening the links and narrowing the differences between cities, and transportation construction is an important part of this policy (He et al., 2019). Due to China’s household registration policy, the cost of population migration is relatively high (Cai et al., 2002), which means labor cannot flow to central cities indefinitely, and the absorption of resources from surrounding cities by central cities has been limited to a certain extent.
Under the dual role of economy and policy, the spillover effect of stronger cities on their surrounding cities is greater than the agglomeration effect, and the radiating and leading role of dominant cities is becoming prominent. The strengthening of urban spatial linkage brought by transportation development has promoted the spillover effect, thus promoting the balanced development of the economy between cities within a region. This balanced development will bring about the balance of land use between cities, thus narrowing the land price differences between them.

Finally, transportation development will also promote changes in the spatial distribution patterns of production factors (such as industry and population) closely related to land use. Due to the consideration of production costs, China’s industries have a trend of transfer and diffusion (Wang & Li, 2019). The reduction of transportation costs brought by transportation development greatly reduces the difficulty of enterprise transfer, promotes its diffusion to the periphery and drives the peripheral diffusion of a large number of labor forces. Considering the cost of living, the current high house prices in central cities also inhibit the inflow of some people in China (Xie et al., 2020). At the same time, the ‘uneconomical congestion’ of central cities may cause the outflow of people. Under the condition of convenient transportation, labor starts to spread to surrounding cities in pursuit of higher utility while maintaining close connection with central cities, and the spillover effect of high-density employment cities gradually becomes prominent (Luo et al., 2020). The outward diffusion of industry and the population alleviates the scarcity of land in central cities and reduces the possibility of land price polarization. Moreover, it provides a certain development space for peripheral cities and increases land value. The balance of land use and value can reduce the land price differences between cities, and the development of transportation has promoted the migration, diffusion and even distribution of population and industries, thereby promoting the balance of land price between cities.

5.3.2 | Spatial effect decomposition

When there is spatial spillover, changes in the transportation development in a province will not only lead to changes in the land price differences between the cities in the province but also affect the land price differences between cities in the neighboring provinces. Therefore, to better explore the spatial impact of provincial transportation development on the land price differences between cities, this paper used partial differential equations to decompose the spatial effect into the direct effect, the indirect effect and the total effect. The direct effect refers to the impact of transportation development on land price differences between cities in the same province, while the indirect effect refers to the impact of transportation development in the province on the land price differences between the cities of neighboring provinces and the total effect is the sum of the direct effect and the indirect effect.

Regarding the results of the effect decomposition, the direct and indirect effects of traffic network density ($T_{HR}$) were significant at the level of 1%, and the coefficients were negative. The direct and indirect effects of traffic volume index ($T_{PI}$) were significant at the levels of 1% and 5%, respectively, and the coefficients were negative. To a certain extent, this shows that the development of transportation in a province not only promotes the narrowing of the land price differences between cities in the province but also promotes the narrowing of the land price differences between the cities in neighboring provinces.

The reasons for this are as follows: first, the neighboring provinces are likely to imitate each other (i.e. the transportation construction behavior of a province will promote transportation construction in the neighboring provinces), thus driving the mutual reinforcement of transportation
construction in neighboring provinces. Therefore, transportation construction can play a greater role in narrowing the land price differences between cities. Second, the transportation construction in a province is not performed independently of other provinces. The development of transportation in a province not only promotes connections between the cities within that province but also the connections between cities in neighboring provinces. This means that disadvantaged cities are not only affected by the central cities of the province but also the strong cities in other provinces. This then promotes the balanced development of larger regions and narrows the land price differences.

6 | CONCLUSIONS AND ENLIGHTENMENT

The relative change in land prices has an important impact on the allocation of regional land resources and the development of the entire regional economy and society, and exploring the relationship between transportation development and land price differences between cities is vital for better understanding changes in regional land prices. There is still little literature exploring the impact of regional transportation development on land price differences between cities, however. Therefore, this paper empirically tests the specific impact of provincial traffic development on land price differences between cities through the construction of econometric model. The results from 26 provinces in Mainland China show that: in recent years, the price of urban land in China has increased significantly and that the aggregation of people and other factors in large and medium-sized cities and developed areas has led to an increase in land price differences between cities in most provinces. The results also show that provincial transportation development has a narrowing effect on land price differences between cities and that the spatial spillover effect brought by transportation development should be paid more attention. In the future, the role of transportation development in narrowing regional land price differences should be fully considered to promote the balanced development of the land market and the coordinated development of regions.

This study enriches the existing literature by not only helping to expand the in-depth understanding of the impact of traffic development but also providing a new perspective for the analysis of changes in urban land prices and their driving factors. In addition, the research results have some policy implications as local governments must remain aware of the current impact of provincial transportation development on the narrowing of land price differences between cities in China and pay attention to its external effects. They need to continue the construction of transportation and supporting facilities within a reasonable range to further stabilize land prices, form a healthier land market and promote the balanced development of the regional economy.

Of course, it should be pointed out that this study mainly explores and verifies the comprehensive impact of transportation development on land price differences between cities at a macro level. Although we have discussed the relevant mechanism of the impact of transportation development on land price differences between cities on a theoretical level, the complex and uncertain path of the impact of transport development on land price differences between cities makes it difficult to fully verify the impact mechanism in this study. In the future, specific cases need to be selected for different impact paths to verify the specific impact of transportation development on land price differences between cities.

ACKNOWLEDGMENTS

This work was supported by the National Natural Science Foundation of China (No. 41671171; 42171244) and Major Project of the National Social Science Fund of China (No. 21&ZD174).
DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID
Tianshu Li  https://orcid.org/0000-0002-4447-2099
Zhigang Chen  https://orcid.org/0000-0002-7876-2414

ENDNOTES

1 Data from China Land and Resources Almanac (2001) and China Land and Resources Statistical Yearbook (2018).
2 We used the Gini coefficient to calculate the land price difference between 324 cities in China in 2000 and 2017 and found that the land price difference between cities was 0.517 in 2000 but increased to 0.561 in 2017. The difference expanded significantly.

REFERENCES


How to cite this article: Li, T., & Chen, Z. (2022). The impact of transportation development on land price differences between cities: Widening or narrowing?—A case study based on the provincial level of Mainland China. Growth and Change, 00, 1–23. https://doi.org/10.1111/grow.12614