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The impact of regional financial development on economic growth in Beijing–Tianjin–Hebei region: a spatial econometric analysis

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The impact of regional financial development on economic growth in Beijing–Tianjin–Hebei region: a spatial econometric analysis

Abstract: The Beijing–Tianjin–Hebei (BTH) integration project in China is ambitious which offers great potential with its promotion of sustainable and inclusive development. This study investigates the impact of regional financial development on economic growth in the BTH region, with panel data collected from 2007 to 2016. Two indicators namely, *CREDIT* (denoted as regional financial development depth) and *BRANCH* (denoted as regional financial intermediaries accessibility) are used to construct an integrated regional financial development indicator through the spatial econometrics approach. The spatio-temporal distribution characteristics of regional financial development and economic growth are analyzed. Afterwards, the global Moran's *I* and local Getis-Ord Gi* statistics are applied to detect the presence of spatial autocorrelation. Finally, a spatial Durbin model (SDM) is utilized to examine spatial distribution and spatial association. The research findings of this study suggest that the *CREDIT* has a positive effect on regional economic growth, while the *BRANCH* has no impact on regional economic growth. Moreover, it is found that the spatial autocorrelation of *CREDIT* and *BRANCH* are statistically significant. The *CREDIT* of the neighboring areas has a negative spatial spillover effect on economic growth of one area, while the *BRANCH* in the neighboring areas has a positive effect on the one area. The results and research findings reported in this article highlight the role of regional financial development in improving the economic growth not only for Chinese policy makers but also for other countries' researchers and practitioners in this field.

Keywords: Economic growth, financial development, spatial econometrics, the BHT region

1. Introduction

Since initiating market reforms in 1978, Chinese economy has grown at an amazing rate of 9.7% per year over the last forty years [1, 2]. Now, China is the world's second largest economy. With the economic development, villages morphed into booming cities and cities grew into sprawling megalopolises. The populated cities in China result in severe over-crowded population, and increasing apartment home prices, especially the capital city - Beijing. To deal with these issues, China's Central Government has launched a new project, known as Jing–Jin–Ji, developing the Beijing–Tianjin–Hebei (BTH) region into a mega-metropolis. Such efforts will phase out Beijing's non-capital functions, and boost infrastructure to provide more living space for residents in the BTH region. Achieving the coordinated development in the BTH region has become a hot topic in China that attracts considerable attention from policy-makers and scholars [3, 4].

Over the past few years, inter-city cooperation within the BTH region is encouraged, and all three regions have issued a series of policies concerning regional integration and the coordinated development in the BTH region. It is a common policy selection for the local governments in BTH region to assemble financial resources and adjust the financial structure to promote regional economic growth. However, the relationship between financial development and economic growth has always remained the debate focus among economists. Following the works by Gurley and Shaw [5], Goldsmith [6], Shaw [7] and McKinnon [8], a vast array of empirical evidence had investigated a number of plausible channels through which financial development can have positive effects on economic growth [9]. However, Lucas [10] regarded finance as an overvalued explanatory factor in growth process. Demetriades and Hussein [11] conducted causality tests between financial development and real GDP using developed time series techniques. The results provided little support on finance being a leading factor in the process of economic development.

The afore-mentioned literature studied the impact of financial development on economic growth in cross-country context. On the contrary, within-country heterogeneity with respect to the availability of financing has received less attention. Within this context, Jayaratne and Strahan [12] used cross-state variation in bank regulation within the US to study the link between financial development and growth, mainly over the 1970s and 1980s periods.

Dehejia and Lleras-Muney [13] exploited state-level variation in banking regulation in the US to study regulation, financial development, and growth over the period 1900-1940. Fafchamps and Schündeln [14] combined spatial data from the Moroccan census of manufacturing enterprises with information from a commune survey, and tested whether firm expansion was affected by local financial development. Sharma and Bardhan [15] investigated finance-growth relationship across 26 Indian states over the period 1981–2012 in a panel setting. These papers generally confirm the role of financial development at levels below that of the nation-state in developed economies and developing economies.

For the policy purposes, it is important to understand whether regional financial development efforts at regional level in the BTH region adds up to the economic growth. This region is complex in nature involving economic, social and spatial characteristics. Hence, it is necessary to incorporate the spatial dependence into any of our econometric models. The finding of the current study is particularly important for local governments in the BTH region to better understand the role of regional financial development on economic growth. The contribution of this paper lies within examining the impact of regional financial development on economic growth at the county level across the BTH region for Chinese policy makers. The materials and methods utilized in this study set the pace for other countries' researchers and practitioners in this field to better investigate the role of financial development on economic growth.

The rest of this paper is organized as follows. Section 2 focuses on materials and methodologies utilized in this study. Section 3 defines variables and describes data. Section 3 presents the results and findings regarding the impact of regional financial development on economic growth in the BTH region. Section 4 sets out the conclusions and policy implications.

2. Materials and methods

2.1 Study scope

The Beijing–Tianjin–Hebei region, with the population of 110 million in 2017, is in the national capital region of China, which includes two municipalities Beijing (pink area in Fig. 1) and Tianjin (yellow area in Fig. 1), and 11 prefecture-level cities in Hebei Province (green area in Fig. 1), e.g., Baoding, Tangshan, Shijiazhuang, Langfang, Qinhuangdao, Zhangjiakou, Chengde, Changzhou, Hengshui, Xingtai and Handan. In this study, we use county-level data, e.g. 174 counties (geographic units) in the BTH region. It is noted that Beijing's Dongcheng district and Xicheng district are merged into Beijing urban area. Accordingly, Tianjin's Heping district, Hexi district, Hedong district, Nankai district, Hebei district and Hongqiao district are merged into Tianjin urban area.

The BTH region covers around 216,000 square kilometers, occupying 2.3% of China's territory. In 2016, the GDP of BTH region was 7.5 trillion RMB, ranked as second place in the top 5 urban clusters in China, i.e. Yangtze River Delta, Beijing–Tianjin–Hebei, Pearl River Delta, city cluster along the Middle Reaches of the Yangtze River and Chengdu–Chongqing Urban cluster. The per capita GDP was 67,524 RMB, higher than the China's average of 53,980 RMB, ranking third among the top 5 urban clusters. The BTH region is currently experiencing urbanization that signals accelerated development. According to the historical data and future policy, urbanization and economic growth of the BTH region will continue to increase.

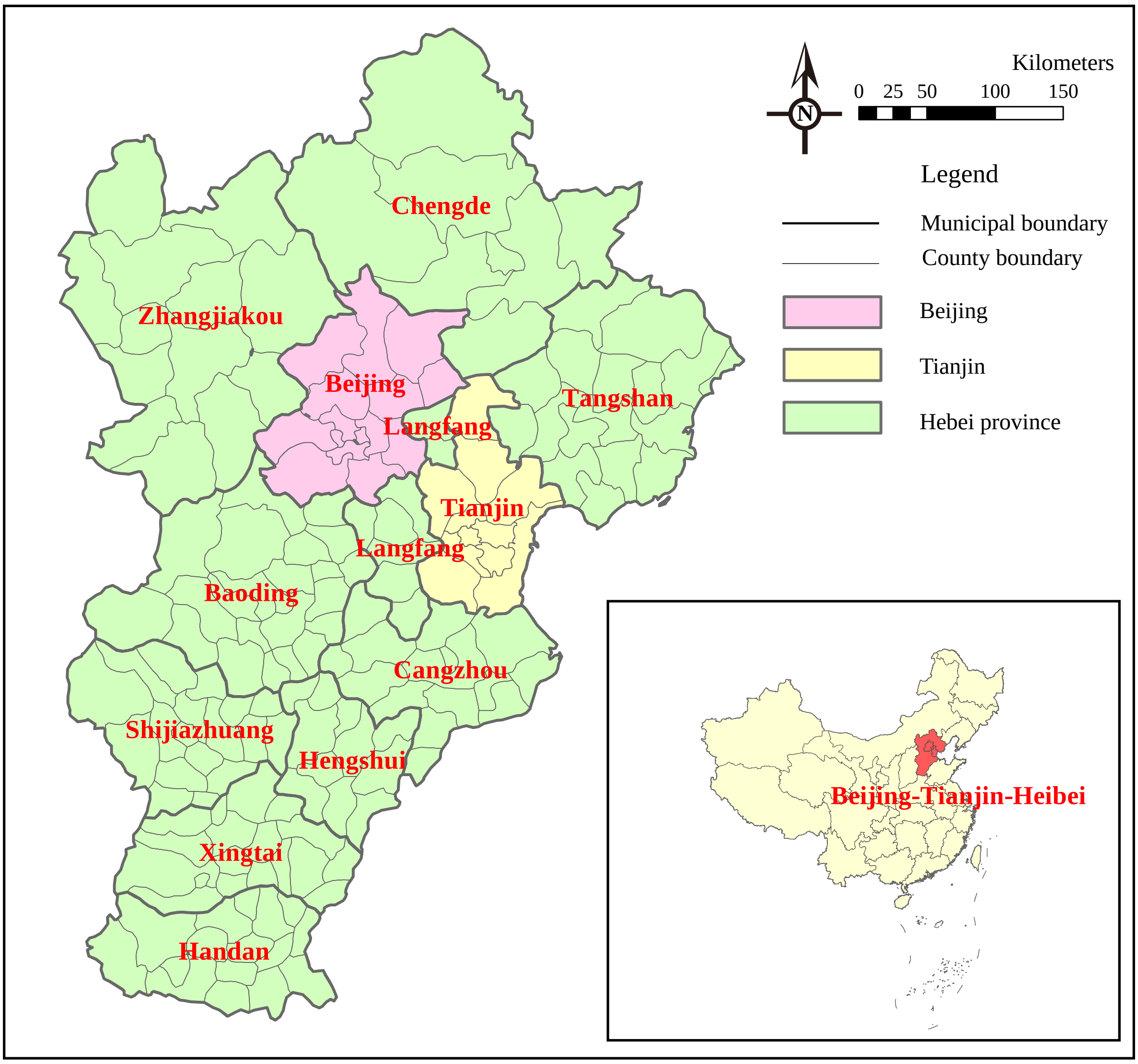

Fig. 1. Location and range of the BTH region, China.

2.2 Methods

Studies in spatial statistics typically distinguish between two different kinds of spatial effects - spatial interaction (spatial autocorrelation) and spatial structure (spatial heterogeneity). The examination of spatial characteristics of data is strongly affected by the location from which observations are made. The neighboring geographical units affect each other and approximate locations often share more similarities than widely-spaced locations [16]. In this section, we examine global Moran's *I*, local Getis-Ord Gi*, and three types of spatial econometric models.

2.2.1 The global Moran's *I*

The global Moran's *I* quantifies the similarity of observations among adjacent geographical units from a global perspective and is used to analyze the global spatial autocorrelation degree and spatial distribution pattern. The global Moran's *I* is defined as:

$$I = \frac{\sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{S^2 \sum_{i=1}^{n} \sum_{j=1, i \neq j}^{n} w_{ij}}, \quad (1)$$

where $i, j = 1, 2, ..., n$, $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, $S^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$, x_i and x_j are the observed value of location i and location j, respectively. $\bar{x}$ is the mean of the observed value across all locations, and w_{ij} is an element value in the $n \times n$ binary spatial weight matrix that describes the spatial relationship between location i and location j. One of the most frequently used spatial contiguity based weight matrices [17] is applied; where two counties share a geographical border $w_{ij} = 1$, otherwise $w_{ij} = 0$.

The global Moran's *I* ranges from –1 to 1 due to the use of the standardized spatial weight matrix. When $I > 0$, the regional financial development (or economic growth) has a positive spatial autocorrelation, which indicates that they tend to be clustered in space. Similarly, when $I < 0$, the spatial unit tends to be surrounded by adjacent geographical units with dissimilar values. When $I = 0$, the spatial pattern of the regional financial development (or economic growth) is random.

2.2.2 The local Getis-Ord G_i* statistic

G-statistics, originally developed by Getis and Ord, is used to study the evidence of spatial pattern [18, 19]. They represent a global spatial autocorrelation index. The Gi* statistic, on the other hand, is a local spatial autocorrelation index. It is more suitable for discerning cluster structures of high or low concentration. The formulation of the Getis-Ord Gi* statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{ij} x_j - \bar{x} \sum_{j=1}^{n} w_{ij}}{S^* \sqrt{\frac{n \sum_{j=1}^{n} w_{ij}^2 - (\sum_{j=1}^{n} w_{ij})^2}{n - 1}}}, \quad (2)$$

where x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features, $\bar{x} = \frac{1}{n}\sum_{j=1}^{n} x_j$, and $S^* = \sqrt{\sum_{j=1}^{n} x_j^2 / n - (\bar{x})^2}$. The Gi* statistics is a Z-score, and so further calculations are required. For statistically significant positive Z-score, the larger Z-scores mean that the clustering of high values (hot spots) are more intense. For statistically significant negative Z-score, the smaller Z scores indicate that the clustering of low values (cold spots) are more intense.

2.2.3 Spatial panel models

Spatial econometrics experts have proposed a variety of models to explore different spatial interaction effects among the dependent and independent variables. The spatial lag model (SLM), the spatial error model (SEM), and the spatial Durbin model (SDM) are the most widely used. Which model is selected is determined by whether the dependent or independent variables have spatial interaction effects.

The SLM is applied whenever there is an endogenous interaction among the dependent variables and is appropriate when the goal is to determine the existence and quantify the strength of spatial interaction. The specification of the spatial lag model is characterized in Equation (3).

$$y_{it} = \delta \sum_{j=1}^{N} w_{ij} y_{jt} + \boldsymbol{x_{it}\beta} + \mu_i + \xi_t + \varepsilon_{it}, \tag{3}$$

where i is an index for the cross-sectional dimension (spatial units), with $i = 1, ..., N$, and t is an index for the time dimension (time periods), with $t = 1, ..., T$. y_{it} denotes the dependent variable, $\sum_{j=1}^{N} w_{ij} y_{jt}$ denotes the endogenous interaction effects among the dependent variable, i.e. the spatial lag term of dependent variable, w_{ij} is an element of the $N \times N$ matrix describing the spatial configuration or arrangement of the units, $\boldsymbol{x_{it}}$ denote the *K*-dimensional independent variables, $\boldsymbol{\beta}$ represent the estimated parameters of independent variables, δ is the spatial autoregressive coefficient, μ_i denotes spatial specific effect, ξ_t

denotes time specific effect, and ε_{it} is a disturbance term.

The SEM is used when the spatial dependence works through omitted variables. It uses an error process utilizing errors from different regions displaying spatial covariance. The model is

$$y_{it} = \boldsymbol{x_{it}}\boldsymbol{\beta} + \mu_i + \xi_t + u_{it}, \\ u_{it} = \lambda \sum_{j=1}^{N} w_{ij} u_{jt} + \varepsilon_{it}, \tag{4}$$

where $\sum_{j=1}^{N} w_{ij} u_{jt}$ denotes the interaction effects among the disturbance terms of the different units, λ describes the spatial autocorrelation coefficient for the error lag, and the remaining symbols are the same as in the previous equation.

The SDM captures both endogenous and exogenous spatial interactions, where both the spatial lag term of the dependent variable and the spatial lag term of independent variable affect the dependent variable. The model is expressed

$$y_{it} = \delta \sum_{j=1}^{N} w_{ij} y_{jt} + \boldsymbol{x_{it}}\boldsymbol{\beta} + \sum_{j=1}^{N} w_{ij} \boldsymbol{x_{jt}}\boldsymbol{\theta} + \mu_i + \xi_t + \varepsilon_{it}, \tag{5}$$

where $\sum_{j=1}^{N} w_{ij} \boldsymbol{x_{jt}}$ denotes the exogenous interaction effects among the independent variables, i.e., the spatial lag terms of independent variables. The term $\boldsymbol{\theta}$, like $\boldsymbol{\beta}$, represent fixed and unknown parameters to be estimated.

The relationships between SDM, SLM and SEM are shown in Fig. 2. Imposing restrictions on one or more of the SDM parameters can result in either the SLM, SLX or SEM. The restrictions are shown next to each arrow. Theoreticians are mainly interested in the spatial autoregressive model (SAR) and SEM models [20]. They generally do not focus on spatial econometric models with exogenous interaction effects, because the estimation of such models does not pose any econometric problems. Consequently, the SLX (Spatial lag X regression) model is generally not part of the toolbox of researchers interested in the econometric theory of spatial models.

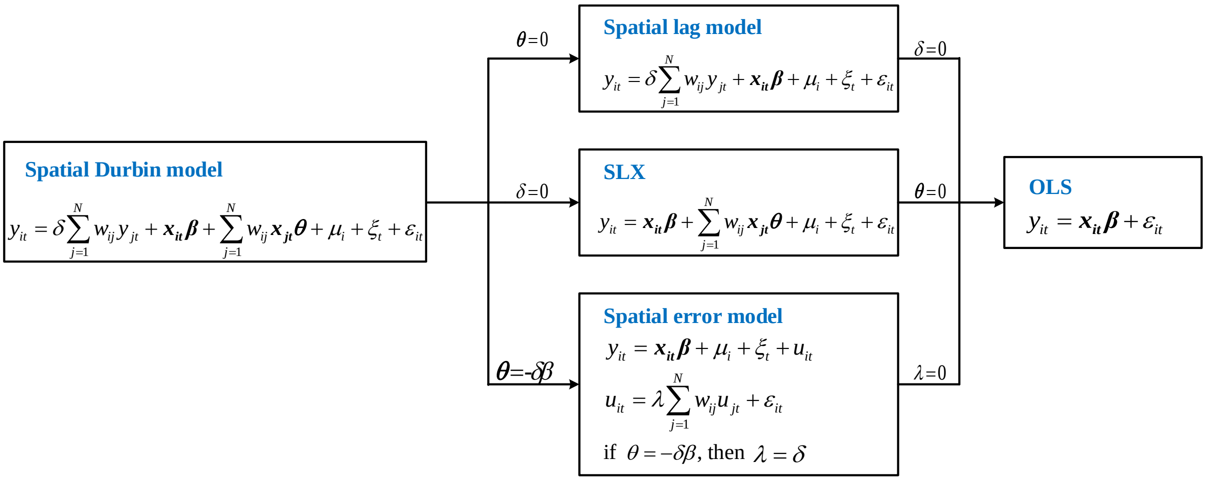

Fig. 2. The relationships between SDM, SLM and SEM.

2.2.4 Estimation and selection of spatial econometrics model

Due to the existence of variable spatial correlation in the model, the least squares parameter estimation may lead to the loss of validity and consistency of the estimated parameters. But the maximum likelihood estimation (MLE) for unbiased estimation can effectively solve endogenous problems. Therefore, the spatial econometrics model uses the MLE method to estimate the parameters.

For the selection of spatial econometrics model, the spatial econometrics literature suggests two distinct approaches i.e. the specific-to-general approach or the general-to-specific approach [21, 22]. Elhorst [20] proposed the testing procedure that mixed both approaches. First, the non-spatial model is estimated to test it against the spatial lag and the spatial error model by using Lagrange multiplier (LM) test (specific-to-general approach). In case the non-spatial model is rejected, the SDM is estimated to test whether it can be simplified to the SLM or the SEM (general-to-specific approach). We use the results obtained by estimating the parameters of SDM model to test the null hypotheses $H_0:\boldsymbol{\theta}=\mathbf{0}$ and $H_0:\boldsymbol{\theta}+\delta\boldsymbol{\beta}=\mathbf{0}$. The commonly used test methods are the likelihood ratio (LR) test and the Wald test. If both tests point to either the SLM or SEM, it is safe to conclude that that model best describes the data. Contrarily, if the non-spatial model is rejected in favor of the SLM or the SEM, while the SDM is not, one better adopts the SDM.

3. Variables and data

This section defines variables and describes associated data. The county-level data are extracted and used to examine the impact of regional financial development on economic growth in the BTH regions. Several financial indicators are constructed to measure the financial development.

3.1 Variables

Economic growth. To investigate whether the exogenous component of regional financial development positively influences economic growth, the indicator for economic growth is set up with the ratio of per capita GDP in each county to average per capita GDP in the BTH region as the dependent variable.

Financial development level. The following are two indicators to measure regional financial development from the perspective of depth and accessibility at the county level.

(1) *Credit*. The value of credits by financial intermediaries to the private sector divided by GDP [23] is the traditional indicators of financial development depth. However, China's statistical book does not provide these data required to calculate such indicator at the county level. We extracted the indicator, e.g. per capita total credit in the bank from Ref. [24], and applied the ratio of per capita bank credit in each county to per capita bank credit in the BTH region (denoted as *CREDIT*) to measures the "depth" of financial development.

(2) *Branch*. Asymmetric information and transaction cost considerations suggest that physical distance between lender and borrower is likely to affect the access to the finance [24]. Expansion of bank branches is also crucial for adequate provision of credit to micro and small enterprises as these enterprises have quite a limited access to capital markets. Hence, the number of branches per million inhabitants (denoted as *BRANCH*) is applied as "access" indicator of regional financial development. Typically, higher levels of access to and use of banking services can expand business opportunities.

Control variables. In this study, human capital (denoted as *EDU*), government expenditure (denoted as *GOV*) and fixed asset investment (denoted as *FAI*) are considered as control variables, supposedly affecting the economic growth of a county. The variable definitions are presented in Table 1.

Table 1. The variable type, variable name, symbol and definition.

Variable type	Variable name	Symbol	Definition
Explained variables (dependent variable)	Economic growth	*PCGDP*	Per capita GDP per county over per capita GDP in the BTH region
Explanatory variables (Independent variable)	Regional financial development	*CREDIT*	Per capita bank credit per county over per capita bank credit in the BTH region
		BRANCH	Number of branches per million inhabitants per county over number of branches per million inhabitants in the BTH region
Control variables	Human capital level	*EDU*	ENROL per county over ENROL in the BTH region
	Government expenditure	*GOV*	General budget per county over general budget in the BTH region
	Fixed asset investment	*FAI*	Fixed asset investment per county over Fixed asset investment in the BTH region

Note: ENROL denote number of children of 6-18 age enrolled in school/ population. The numerator contains the data from number of children enrolled in primary school, middle school and higher school.

3.2 Data

By the Chinese government administrative classification, there are three levels of cities in China: municipalities, prefecture-level cities, and counties. The BTH region includes two municipalities Beijing and Tianjin, and 11 prefecture-level cities in Hebei Province. The 13 cities are divided by 174 counties, which are also called geographical units.

Our sample includes 174 counties over the period 2007-2016. The data is from the *Beijing Regional Statistical Yearbook*, *Tianjin Statistical Yearbook*, *Hebei Economic Yearbook*, *Hebei Rural Statistical Yearbook*, *China City Statistical Yearbook*, *China City Social and Economic Statistical Yearbook* for various years, *Statistical Bulletin*, and website of China Banking Regulatory Commission[1]. Table 2 presents the summary statistics of variables.

[1] The website of China Banking Regulatory Commission: http://xukezheng.cbrc.gov.cn/ilicence/licence/licenceQuery.jsp

Table 2. Descriptive statistics and correlations.

	PCGDP	*CREDIT*	*BRANCH*	*EDU*	*GOV*	*FAI*
Descriptive statistics						
Mean	0.7648	0.5072	0.8416	0.8629	1.0078	0.9005
Median	0.4653	0.1593	0.7368	0.5113	0.9879	0.6206
Maximum	10.7327	13.5324	3.3988	7.3133	1.7860	10.8631
Minimum	0.1294	0.0332	0.0662	0.2538	0.3816	0.0714
Std. Dev	0.9534	1.1543	0.4880	0.8715	0.1956	1.0658
Observations	1740	1740	1740	1740	1740	1740
Correlations						
PCGDP	1.0000					
CREDIT	0.6710***	1.0000				
BRANCH	0.6420***	0.5849***	1.0000			
EDU	0.7537***	0.5925***	0.7374***	1.0000		
GOV	0.8576***	0.4866***	0.5135***	0.7461***	1.0000	
FAI	-0.0538***	-0.1433***	-0.1223***	-0.1640***	-0.0331	1.0000

*** Statistical significance at 1% level. ** Statistical significance at 5% level. * Statistical significance at 10% level.

4. Results and discussion

4.1 Spatio-temporal characteristics analysis

We employ ArcGIS 10.2 to obtain the spatio-temporal distribution characteristics of regional financial development and economic growth. The 174 counties are classified based on the Jenks natural breaks algorithm [25], which is shown in Fig. 3. The dark color denotes the higher level of financial development (or economic growth). If the value is greater than 1, it indicates that the level of financial development (or economic growth) in this county is superior to the average level of the BTH region, and its development can produce the spillover effects affecting its neighboring regions. Conversely, if the value is less than 1, this indicates that the level of financial development (or economic growth) in the region is at a disadvantage relative to the average level of the BTH region and does not have the ability to produce spillover effects.

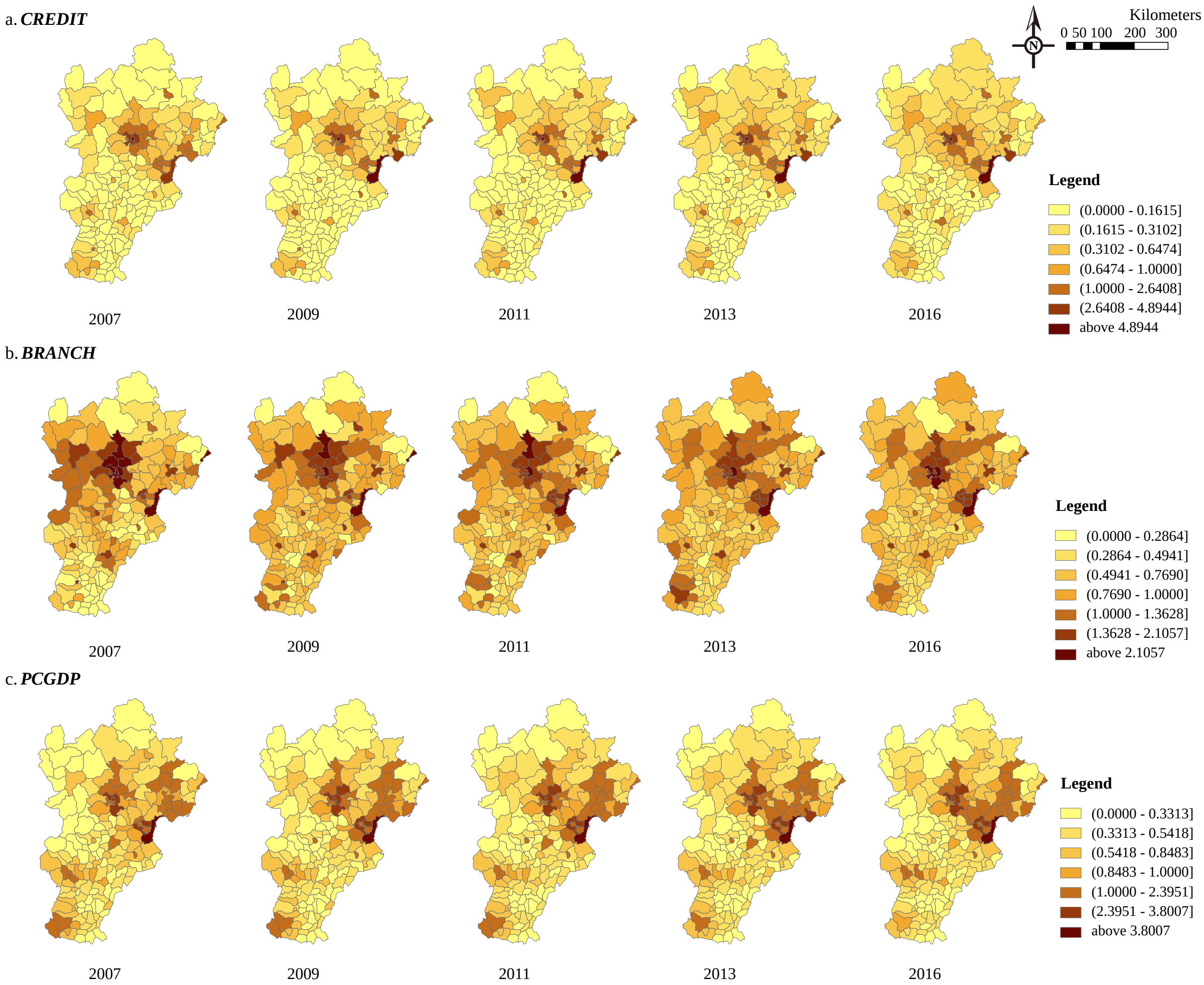

Fig. 3. *CREDIT*, *BRANCH* and *PCGDP* spatial distribution in the BTH region from 2007 to 2016.

Fig. 3 (a) shows the regional financial development level measured by *CREDIT*. It clearly shows that the regions with large credit amount are mainly concentrated in the Beijing–Tianjin urban areas, which forms a financial agglomeration area. Over time, the high-concentration area has a wider range of radiation in 2016. In addition, the urban areas in Hebei province also have high credit amount, but there is no obvious agglomeration area. Fig. 3 (a) indicates that there exists spatial linkage for *CERDIT* indicator in the BTH region.

Fig. 3 (b) shows the regional financial development level measured by *BRANCH*. It clearly shows that the Beijing–Tianjin urban areas have a higher distribution density of bank branches than other counties. In 2007, the number of bank branches in Zhangjiakou city and Baoding city exceeded the average of the BTH region, but over time, the density of bank branches in these areas falls below the average of the BTH region. This is partly due to the deepening of financial reforms in China. The establishment or closure of bank branches is more driven by free market, with less by administrative interventions.

Fig. 3 (c) shows the regional economic growth level measured by *PCGDP*. It can be observed that the counties with high economic growth level in the BTH region tend to concentrate, and the counties with low economic growth level are also contiguous, which prove the existence of spatial spillover effects of economic growth. In 2007, the development mode of the economic growth in the BTH region is similar to the "point-circle expansion" mode [26]. The Beijing urban area and Tianjin urban area are the growth poles in this BTH region. This evolves to "point-axis expansion" mode [27]. The regional structure in the BTH regions changed from two-core layered structure to two-core radiating layered structure. In addition, it can be observed that in the southern part of the BTH region, only the Shijiazhuang city, e.g., the provincial capital of Hebei province, maintained the economic growth above average of the BTH region from 2007 to 2016, and had the spatial impact on the neighboring counties. In 2007, Handan city also showed a strong economic growth, but in 2016 it fell below the regional average. It indicates that Shijiazhuang city and Handan city serve a role as the municipal growth centers in the BTH region, and play a point expansion mode. The two cities have the potential to become sub-regional growth center, and stimulate regional economic growth by point-circle expansion mode.

4.2 Spatial autocorrelation measures

4.2.1 Global Moran's *I* analysis

Fig. 3 shows the spatial autocorrelation of regional financial development indicators and economic growth indicator. Hence, the global Moran's *I* of the regional financial development level (*CREDIT* and *BRANCH*) and the economic growth level (*PCGDP*) are calculated to test the global spatial autocorrelation of the explanatory variables (*CREDIT* and *BRANCH*) and the explained variable (*PCGDP*). The results are summarized in Table 3.

Table 3. Global Moran's *I* test for regional financial development and economic growth in the BTH region.

Year	*CREDIT*	*p*	*BRANCH*	*p*	*PCGDP*	*p*
2007	0.4116	0.0000	0.5460	0.0000	0.4044	0.0000
2008	0.3517	0.0000	0.4286	0.0000	0.4421	0.0000
2009	0.3058	0.0000	0.4070	0.0000	0.4218	0.0000
2010	0.3429	0.0000	0.4235	0.0000	0.3821	0.0000
2011	0.3484	0.0000	0.5127	0.0000	0.3710	0.0000
2012	0.3409	0.0000	0.5291	0.0000	0.3850	0.0000
2013	0.3551	0.0000	0.5654	0.0000	0.4081	0.0000
2014	0.3435	0.0000	0.5750	0.0000	0.4322	0.0000
2015	0.3325	0.0000	0.6169	0.0000	0.4388	0.0000
2016	0.3285	0.0000	0.6167	0.0000	0.4373	0.0000

Note: *p* denotes *p*-value.

The results of the global Moran's *I* test in Table 3 indicate that the regional financial development in the BTH region has a significant positive spatial autocorrelation. The counties with high (or low) financial development level tend to concentrate, as displayed in Fig. 3. Financial development in one county will have a spatial spillover effect affecting the financial development of its neighboring counties. Specifically, the *CREDIT* values in the BTH region are stabilized at around 0.3, and the spatial autocorrelation is significant (p<0.01). The *BRANCH* values in the BTH region shows a stronger positive spatial autocorrelation (p<0.01), the maximum reaches to 0.6169. If the evolution of the Moran's *I* statistics over the period is considered, it can be observed that the value of the statistic increases over the period. If this scheme will persist in the future, the spatial distribution of *BRANCH* will remain clustered and will not tend toward a spatially random distribution. The economic growth indicator (*PCGDP*) also passed the hypothetical test at 1% significance level and the values are positive, indicating a global significant trend to the geographical clustering of similar counties.

4.2.2 Getis-Ord G_i* analysis

In this section, the Getis-Ord Gi* statistic for regional financial development and economic growth in the BTH region are analyzed, and the spatial clusters of hot spots (high values) and cold spots (low values) are identified. This is shown in the Fig. 4 to Fig. 6. The hotpot analysis for each year includes two values, i.e., Z-Score and *p*-Value. A Z-Score above 1.96 or below 1.96 means that there is a statistically significant hot spot or a statistically significant cold spot at a significance level of $p<0.05$. A high Z-Score and small *p*-Value for each year indicates a spatial clustering of high values where as a low negative Z-Score and small *p*-Value indicates a spatial clustering of low values.

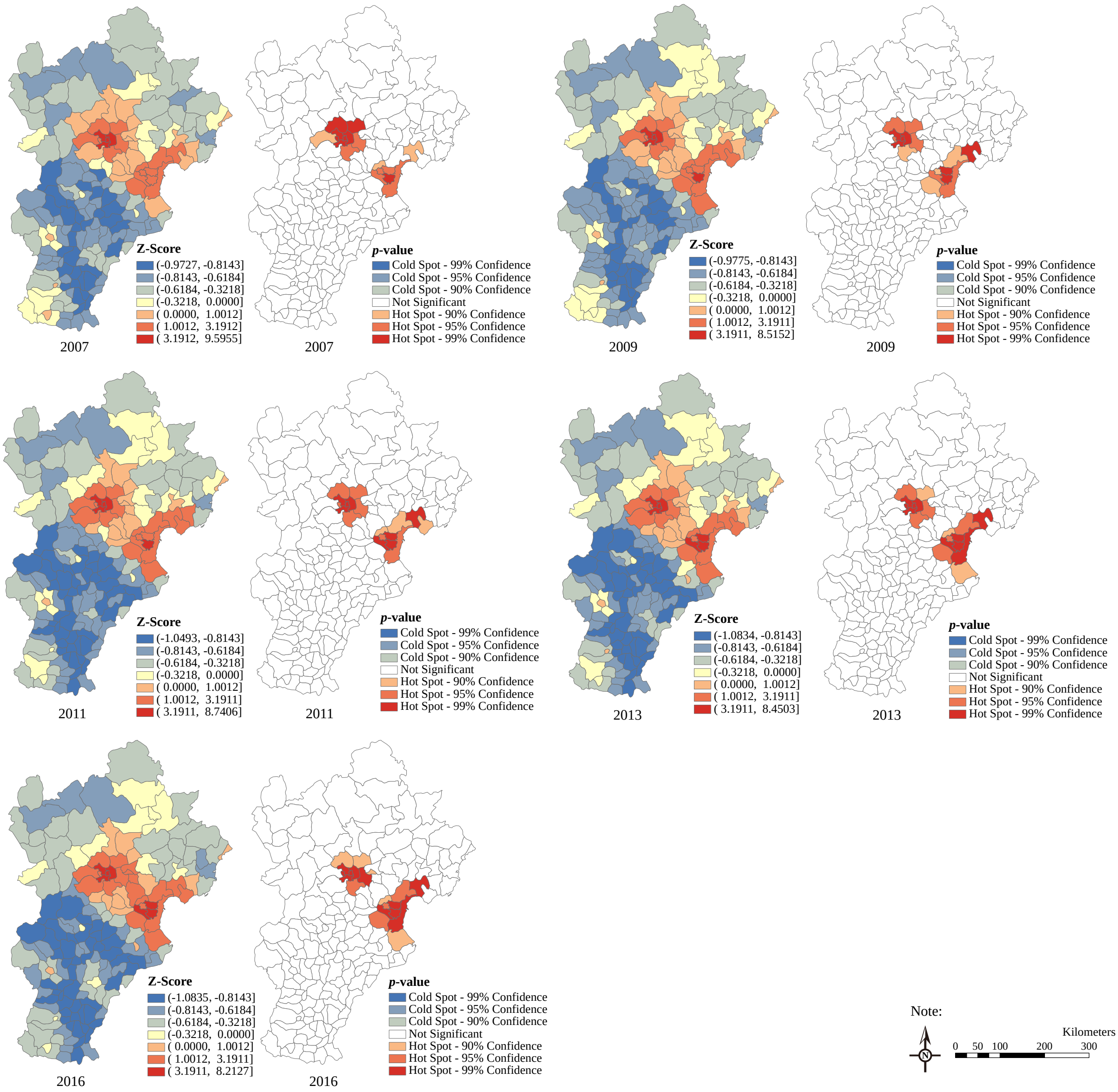

Fig. 4. The spatial clustering of *CREDIT* from 2007 to 2016.

It can be observed from Fig. 4 that there are two statistically significant hotspots according to the *CREDIT* in the BTH region, i.e., Beijing urban area and Tianjin urban area.

Over the period, the hotspots area adjacent to the Tianjin are expanding. This shows that the spatial spillover effect of regional financial development in Tianjin urban area is significant, and it has promoted the credit amount in the neighboring areas. Fig. 4 also displays that there are contiguous low-value areas in the southern part of the BTH region. The two high-value spots, i.e., Shijiazhuang city and Handan city, gradually disappeared over time, and they failed to drive the financial development of the neighboring areas. On the contrary, they were dragged down by the neighboring areas.

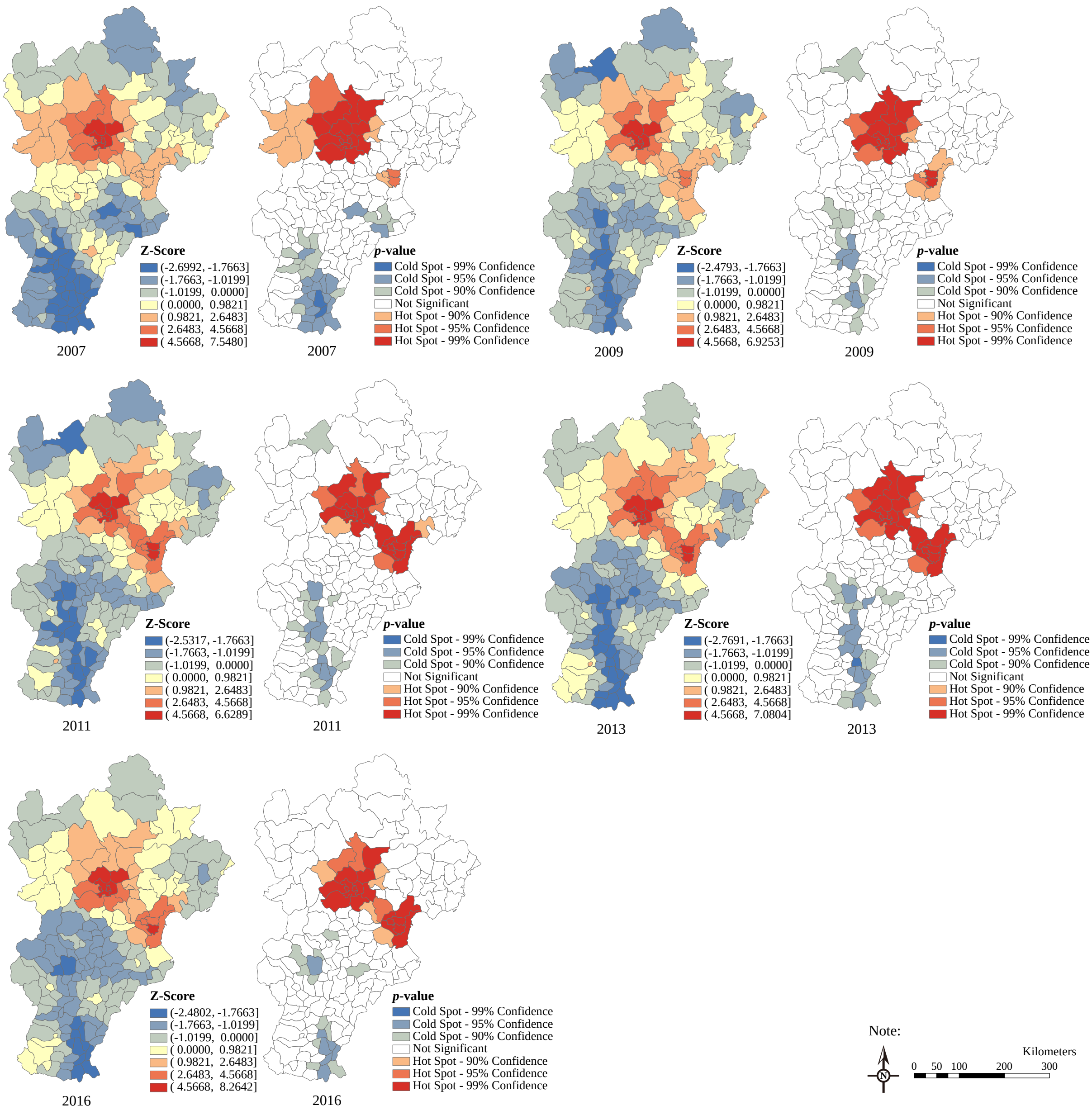

Fig. 5. The spatial clustering of *BRANCH* from 2007 to 2016.

Fig. 5 depicts that there are several statistically significant hotspots according to the *BRANCH* in the BTH regions. It indicates that there is a significant local positive spatial correlation (high agglomeration or low agglomeration) for the *BRANCH*. The hot spot areas are still centered on Beijing urban area and Tianjin urban area. In addition, it shows an interaction between the two hotspots, indicating that the axis between the two hotspots were radiated from the hotspots, which stimulated the financial development of these areas. However, the cold spots area mainly concentrated in the south central of the BTH region, which indicates that the spatial distribution of bank branches in this sub-region is sparse. However, this situation has changed in 2016 and the size of the cold spot area was decreasing. This is a good sign, suggesting that the allocation of financial infrastructure resources in the developing areas is gradually improving.

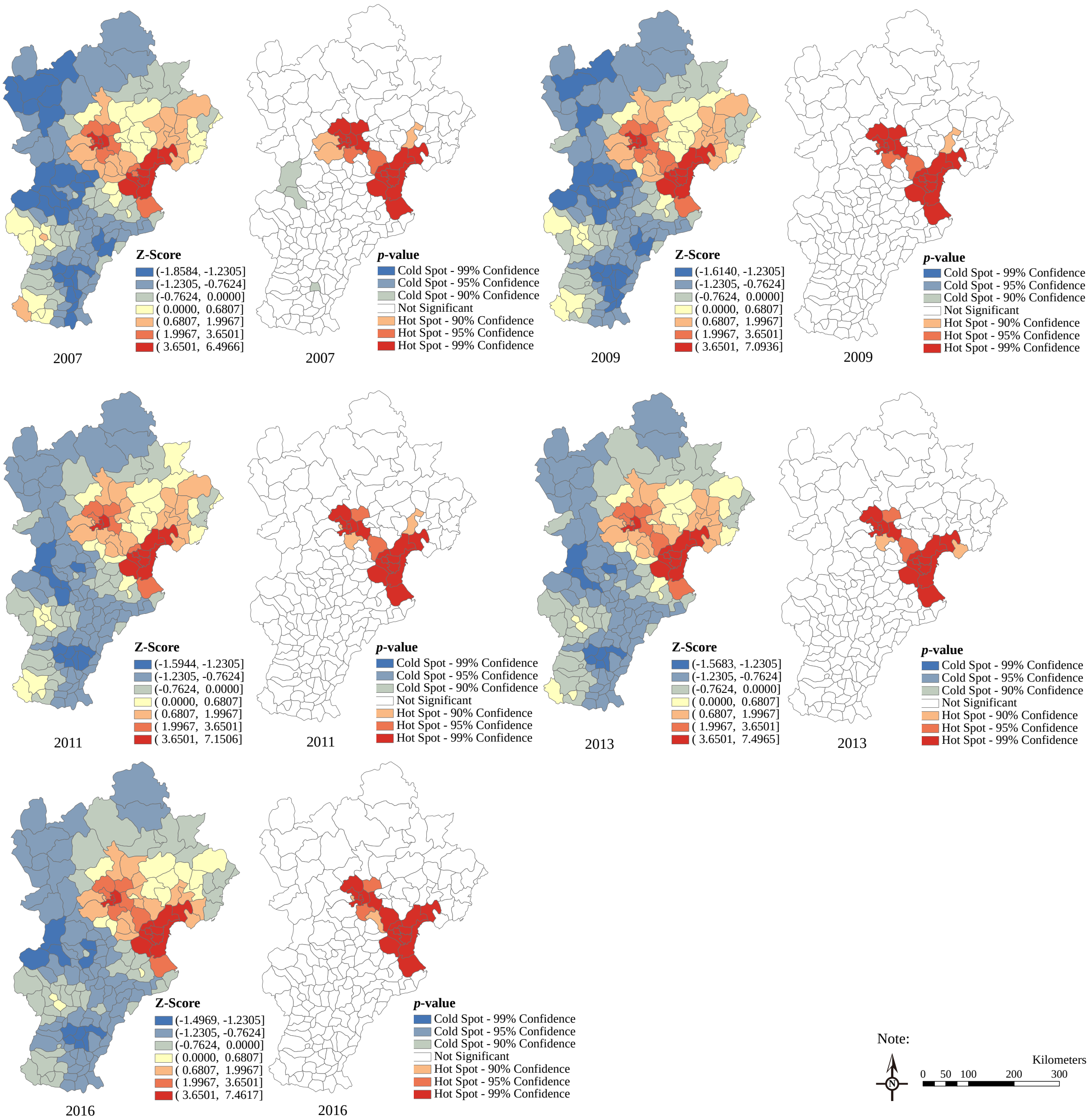

Fig. 6. The spatial clustering of *PCGDP* from 2007 to 2016.

Fig. 6 shows Beijing urban area and Tianjin urban area are two hot spots, and the axis-areas between these two areas are also hot spots. It shows a two-core axis-layered network structure. Although there is no statistically significant cold spot in the Fig. 6, a large blue low value area can still be observed from the Z-Score map, which reveals the reality of regional economic development imbalance, especially in the west and south of the BTH region.

4.3 Spatial panel model specifications

Using the spatial autocorrelation analysis in Section 4.2, it is found that all dependent variables and independent variables have spatial autocorrelation, which indicates that the spatial econometric model can be used to investigate the relationship between the economic growth and financial development. After introducing the spatial lag terms of the dependent variable and independent variables, a spatial Durbin model is presented with spatial and time-period fixed effects:

$$\begin{aligned} pcgdp_{it} &= \delta\sum_{j=1}^{N} w_{ij}\, pcgdp_{jt} + \beta_1 credit_{it} + \theta_1\sum_{j=1}^{N} w_{ij} credit_{jt} \\ &\quad + \beta_2 branch_{it} + \theta_2\sum_{j=1}^{N} w_{ij} branch_{jt} + \boldsymbol{\beta}_3 \boldsymbol{x}_{it} + \mu_i + \xi_t + \varepsilon_{it} \end{aligned} \tag{6}$$

where i, j and t respectively denotes the county and year, with $i, j = 1, 2, ..., N = 174$ and $t = 1, 2, ..., 10$. $\sum_{j=1}^{N} w_{ij} credit_{jt}$ and $\sum_{j=1}^{N} w_{ij} branch_{jt}$ are the spatial lag terms of the independent variables. $\sum_{j=1}^{N} w_{ij}\, pcgdp_{jt}$ is the dependent variable's spatial lag term. $\boldsymbol{x_{it}}$ is a set of control variables, μ_i is the spatial fixed effect, ξ_t is the time fixed effect and ε_{it} is the error component. In this study, it is assumed that μ_i, ξ_t, and ε_{it} are independent and identically distributed. δ is the spatial autoregressive coefficient and $\boldsymbol{\beta}$ and θ are the parameters to be estimated.

4.4 Spatial panel model selection

To detect whether the SLM or SEM can better describe the data, the LM test was first performed by estimating the non-spatial panel model of the bidirectional fixed effect. Table 4 shows the traditional LM test results and robust LM test results.

Table 4. The summary of spatial lag and spatial error for LM test.

Test	Statistics	*p*
Spatial lag by traditional LM test	138.9901	0.000
Spatial lag by robust LM test	19.2496	0.000
Spatial error by traditional LM test	127.2224	0.000
Spatial error by robust LM test	7.4819	0.006

Note: *p* denotes *p*-value.

The null hypothesis shows that the explained variable has no spatial lag term. Table 4 indicates that both the traditional LM test and the robust LM test reject the null hypothesis at a significant level of 1%. Another null hypothesis is that the explained variable has no spatial error term. Table 4 also indicates that both the traditional LM test and the robust LM test reject the null hypothesis at a significant level of 1%. Up to this point, a non-spatial model on the basis of (robust) LM tests is rejected in favor of the spatial lag model and the spatial error model.

After rejecting the non-spatial model and choosing the preliminarily spatial econometric model, a more complex model, i.e., the SDM model with three models nested (SLM, SLX and SEM) is considered.

Table 5. The summary of Wald test and LR test.

Test	Statistics	*p*
Wald test for spatial lag	45.4976	0.000
LR test for spatial lag	44.446	0.000
Wald test for spatial error	29.1318	0.000
LR test for spatial error	40.7479	0.000

Note: *p* denotes *p*-value.

Then, the null hypotheses $H_0 : \boldsymbol{\theta} = \boldsymbol{0}$ and $H_0 : \boldsymbol{\theta} + \delta\boldsymbol{\beta} = \boldsymbol{0}$ are tested to determine whether the SDM can be simplified to the SLM or SEM. Table 5 shows that both the Wald test and LR test reject the null hypothesis that the SDM can be simplified to be SLM or SEM at a significance level of 1%. Thus, both tests show that it is safe to conclude that the SDM model best describes the data. The Hausman's specification test is used to test the random effects model against the fixed effects model. The results (statistics=55.3271, df=8, *p*=0.0000) indicate that the random effects model must be rejected. Therefore, the model is extended, finally, into a spatial Durbin model with spatial and time-period fixed effects.

4.5 Spatial panel model results

The spatial panel data from 2007 to 2016 are used together with a MLE approach to estimate the SDM of the economic growth and financial development of 174 counties in the BTH region. Table 6 shows the estimation results of the ordinary least square (OLS), SLM, SEM, and SDM panel models.

Table 6. The estimation results of the spatial panel model of economic growth and financial development in the BTH region.

Variable	OLS	SLM	SEM	SDM
CREDIT	0.17441*** (0.00000)	0.16295*** (0.00000)	0.18844*** (0.00000)	0.16376*** (0.00000)
BRANCH	0.01109 (0.55937)	-0.01711 (0.37435)	-0.01755 (0.38197)	-0.02600 (0.19486)
GOV	0.30841*** (0.00000)	0.29367*** (0.00000)	0.30197*** (0.00000)	0.30125*** (0.00000)
EDU	0.00218 (0.94445)	-0.00486 (0.87814)	0.01100 (0.73413)	0.00092 (0.97637)
FAI	0.13258*** (0.00000)	0.11991*** (0.00000)	0.12342*** (0.00000)	0.12505*** (0.00000)
W×PCGDP	-	0.30264*** (0.00000)	-	0.38361*** (0.00000)
W×CREDIT	-	-	-	-0.28324*** (0.00000)
W×BRANCH	-	-	-	0.06907** (0.02268)
W×u	-	-	0.38831*** (0.00000)	-
R^2	0.9863	0.9875	0.9863	0.9880
Log-L	1350.100	1409.317	1411.166	1431.540

Notes: The *p*-values are given in the parentheses. *** Statistical significance at 1% level. ** Statistical significance at 5% level. * Statistical significance at 10% level. The “-“ symbol denotes that the corresponding spatial panel model does not produce the value for this variable.

Table 6 shows that the log-likelihood value (Log-L) of the spatial panel model is significantly larger than the Log-L of the traditional OLS panel estimation model, which verifies that the spatial panel model can better explain the relationship between regional financial development and economic growth. The estimation results in Table 6 also indicate that the SDM has the highest goodness of fit (R^2 = 0.9880) and the biggest log-likelihood value (1431.540), when compared with SLM and SEM. The SDM model is thus better able to capture the spatial dependence. This is consistent with the statistical test results in Table 5. In addition, the coefficient estimation results of the three models of OLS, SLM, and SEM are basically consistent with the coefficient estimation results of the SDM model in direction, which verifies the robustness of the estimation results of the SDM, which means the estimated results do not show directional deviations as the model changes. Next, the SDM estimation results are used in the following analysis.

(1) The two measures of regional financial development of the BTH region have

different effects on economic growth. From the perspective of *CREDIT*, there is a significant correlation between regional credit amount and economic growth, and the credit amount positively drive economic growth with an estimated coefficient of 0.16376 (p = 0.00000). From the perspective of *BRANCH*, the estimated coefficient of the number of bank branches is very small, and the statistical results are not significant, indicating that the residents and local businesses in the BTH region are convenient to access the banks. Increasing or reducing the number of bank branches has little impact on regional economic growth. It can be concluded that increasing the regional credit amount is more obvious than increasing the number of bank branches to promote regional economic growth in the BTH region.

(2) The estimation results of the spatial lag term are analyzed and it is found that the estimated coefficients of the spatial lag term of the explanatory variable and the explanatory variable are statistically significant. It confirms the rationality of the spatial effect introduced in our model. Specifically, for W×*PCGDP*, there is a significant positive spatial interaction between the explained variables in the neighboring areas (W×*PCGDP*=0.38361, p=0.00000), which means the economic growth of a county can drive economic growth with its neighboring counties. Similarly, the improvement of economic growth in the neighboring counties will also promote the growth of the local economy, and the two will change in the same direction. For W×*CREDIT*, the estimated coefficient is -0.28324 with p=0.00000. It shows that the increase of credit amount of one county will bring a significant positive effect on its economic growth, but the increase in the credit supply in neighboring counties will, to a certain extent, inhibits its economic growth. This is partly due to the fact that under the short-term limited constraints of overall financial resources. Once an area forms a financial agglomeration area, it will inevitably produce a more significant competitive advantage, plunder the credit resources in the neighboring areas, and weaken the ability of finance serving real economy in the neighboring areas. For W×*BRANCH*, the significantly positive estimated coefficient (0.06907 with p=0.02268) indicates that the increase in the number of bank branches in neighboring areas will contribute to local economic growth. It means that the ease of providing financial services in the neighboring areas will have a certain degree of impact on the economic growth of this area.

(3) For the control variables, government expenditure (*GOV*) played a significant role in

promoting economic growth in the BTH region with an estimated coefficient of 0.30125 and *p*=0.00000. The estimated coefficient value is bigger than other control variables, indicating that the government's fiscal expenditures can significantly expand domestic demand and stimulate regional economic growth. The impact of human capital (*EDU*) on economic growth is not statistically significant. It indicates that the benefits of enrollment rate in school of 6- to 18-year-olds for the regional economic growth are tiny because of the high enrollment rate in the BTH region [28]. One way to foster regional economic growth is to attract talented and skilled immigrants for local authorities. A stimulating intellectual environment creates the capacity to innovate and, in turn, to create regional success. The fixed asset investment (*FAI*) and economic growth are significantly positively correlated. Hence, as one of the three engines, i.e, investment, consumption and export, *FAI* is still promoting economic growth in the BTH region.

5. Conclusions and policy implications

The Beijing–Tianjin–Hebei (BTH) integration project in China is ambitious which offers great potential with its promotion of sustainable and inclusive development [29]. For the policy purposes, it is important to understand whether regional financial development efforts at regional level in the BTH region adds up to the economic growth. This paper employs the spatial econometrics to study the impact of regional financial development on economic growth in the BTH region. The results show that the *CREDIT* (denoted as regional financial development depth) in the BTH region played a significant role in promoting economic growth, and the *BRANCH* (denoted as regional financial intermediaries accessibility) has no impact on economic growth. There is a significant spatial spillover effect of regional financial development on economic growth. Specifically, the spatial spillover effect of the *CREDIT* has a depressing effect on local economic growth, while the spatial spillover effect of the *BRANCH* has promoted local economic growth. In addition, there is a significant positive spatial spillover effect on economic growth in the BTH region, and economic growth in neighboring areas is closely related. Using our results in Section 4, two policy implications are suggested for fostering the local economy in the BTH region.

First, reasonably construct the regional structure in the BTH region and revitalize the economic vitality of the entire region. Fig. 3 (a) shows that Beijing and Tianjin urban areas function as regional growth centers. However, the economic development level in the south of the BTH region is mostly below the regional average. The unbalanced development status presents the “high-high concentration, and low-low contiguity”. Therefore, the south of BTH region needs an economic growth pole, like Beijing or Tianjin urban areas, to drive economic growth in the neighboring areas. Shijiazhuang city, the capital of Hebei province, will be a good choice. In addition, China’s Central Government issued a decision on the establishment of Xiong’an New District in Baoding, Hebei province, which aimed to build multi-core axis-layer regional network structure in the BTH region, and push forward the coordinated development of Beijing, Tianjin and Hebei.

Second, continue to deepen regional financial development and enhance the radiation effects of financial agglomeration areas. The financial development in the BTH region is reflected in the obvious polarization effect. Beijing functions as national financial center and Tianjin functions as regional financial center, which attract the financial resources of the BTH region to agglomerate in these two metropolitan areas. But Beijing and Tianjin weaken the financial industry development in the peripheral counties. Therefore, it is necessary to enhance radiation effect to the BTH region for Beijing and Tianjin. One possible solution is to build a hierarchical financial partnership among Beijing, Tianjin and local core cities in Hebei, strengthen inter-city cooperation and perform differentiated competition.

Moreover, in this paper the spatio-temporal characteristics of regional financial development and economic growth are analyzed, and then the global Moran’s I and local Getis-Ord Gi* statistics are applied to detect the presence of spatial autocorrelation. Finally, a spatial Durbin Model is developed to unveil the impact of regional financial development on economic growth in the BTH region. The methods utilized in this study set the pace for other researchers in this field to better investigate the role of regional financial development on economic growth in other regions. However, due to spatial heterogeneity and economic disparity of the counties in the BTH regions, our future research will apply geographically weighted regression (GWR) to identify the variability of regression coefficients within the BTH region and reveal the impact of regional financial development on economic growth.

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