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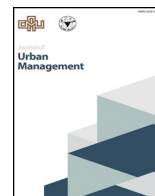
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Does the location of construction land supply play an very important role on economic growth? The case study of Tianjin Binhai New Area



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ABSTRACT

Land is not only a basic factor of production and an important space carrier, but also a key tool to control the development of urban economy. While the phenomenon of land participation in regulation exists generally in China, the theory of supporting regulation and the effect of regulation are still unclear. In the study, we intend to analyse the relationship between location of construction land supply and regional economic growth. By constructing indexes of construction land supply structure and a theoretical model based on the Solow model, we explore the relationship between the location of construction land supply and economic growth in the Tianjin Binhai New Area (TBNA). We find that the location of construction land supply significantly impacts economic growth. The circle-layers dimension has a hop about the influence of construction land supply on economic growth. The orientation dimension has superiority in some regions, especially the southwest and northwest. To realise sustainable urban development, construction land supply should focus on the lag and location difference of its economic driving effect and actively promote the redevelopment of stock construction land not only in the TBNA but also other rapidly developing cities.

1. Introduction

There are close relationship between urban economic growth and urban expansion, which occurs in most parts of the world at different temporal and spatial scales (Feng, Lichtenberg, & Ding, 2015; Jat, Garg, & Khare, 2008; Seto, Fragkias, Güneralp, & Reilly, 2011; Verburg, Eck, Nijs, Dijst, & Schot, 2004; Weilenmann, Seidl, & Schulz, 2017). Less quantity limitations exist in the market-based land management system in Western countries, which primarily maintains efficient ecological outcomes by providing economic incentives to private landholders (Moon, 2013). But in fact, the western countries also exist the phenomenon that the government regulates the urban development through the land policy (McLaughlin, 2012). For example, the United States has been adopting the land use regulations to support the land development from the early colonial period to the beginning of the 19th century (Hart,

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1996). After World War II, the most common form of land use regulation in the United States was zoning, which was used to facilitate development and support infrastructure (Fischel, 2004). By the mid-1960s, smart growth plans had been implemented throughout the United States to accommodate urban development (Bollens, 1992). While as the country experiencing the most extensive urban expansion worldwide (Seto et al., 2011), China further established the construction land supply quota (CLSQ) regime, which provides another powerful tool to guide rational urban expansion from the perspective of quantitative restrictions (Ding, 2003 ; Chien, 2015). According to the classification of land in China, construction land, including urban/rural settlements, industrial and transportation (Dang, Xu, & Tang, 2015), was used for non-agricultural production, mainly from new and stock construction land, in which the new construction land index was controlled by the government. The annual change of construction land can reflect the intensity of government regulation and control and the allocation of land index quantity and space.

The construction land supply quota sets an upper limit for conversion of agricultural to urban land and is allocated from top to bottom in a planned manner (Tan, Beckmann, Leo van den Berg, & Qu, 2009). Nevertheless, massive amounts of literature have mainly focused on sole urban land as a whole (Chen, Chang, Karacsonyi, & Zhang, 2014; Gao, Huang, He, Sun, & Zhang, 2016; Kuang, Chi, Lu, & Dou, 2014; Shafizadeh-Moghadam & Helbich, 2015; Shu, Zhang, Li, Qu, & Chen, 2014; Weilenmann et al., 2017; You & Yang, 2017).

The research addresses a neglected question in urban economic analysis: whether different locations of construction land supply will affect economic growth.

As essential productive factors and activities' spatial carrier, land resources have been generally considered an important driving force in promoting rapid growth of China's economy (Ding & Zhao, 2014; Huang and Wang, 2014; Wang & Gu, 2015). However, the shortage of urban construction land supply and the low efficiency of utilization, which has resulted from the rapid urbanisation and industrialisation, had been treated as a bottleneck of regional economic growth. (Li, Wong, & Shing William Cheung, 2015; Zhang et al., 2014). Moreover, some scholars believed that the implementation of effective land supply policy or land management policy was the key to improve the efficiency of construction land use (Hu, Jing, & Kuang, 2018; Xie, Yao, & Liu, 2015).

In the period of classical economics, William Petty and David Ricardo, as the representatives of scholars, began to discuss how the optimal allocation of land as a scarce resource could be achieved. In the period of neoclassical economics, Marshall and Solow, as the representatives of scholars, considered how technological progress can replace land scarcity and promote economic growth (Marshall, 1920; Solow, 1956; Lucas, 1993). With rapid economic growth and the development of new economic geography, more scholars have discussed land resources as production resources and space carriers on economic growth. Nicholas (1970) explained the contribution of land factors to economic growth by introducing land as a factor of production into the economic growth model. Yoshio Noguchi (2003) found that land elements are not only the important source of Japanese economic development, but also related to the future development of Japan. In fact, different levels of regional economic development will lead to the difference of land demand, and the quality and quantity of land supply will have different effects on economic development (Brock & Scott Taylor, 2010). Compared with urban economists, urban planners pay more attention to the urban spatial development model presented by land resources as a space carrier. Central Place Theory is the most classical space structure optimization theory in the early stage (Christaller, 1933). In the same period, Burgess (1967) and Hoyt (1939) put forward concentric circle model and sector mode. Ullman (1945) proposed a multi-center architecture based on functional distribution instead of the previous single-core model. In essence, these spatial structure models are the result of economic development or urban development, which is actually related to land system. Especially when the Chinese government has sufficient power over the supply of land, which requires reflection on whether the goal of sound economic development can be achieved through the supply of land.

Generally, the change in the spatial structure of construction land is not only the characteristic of economic growth but also its important driver (Gao et al., 2016; Wei, 2012; Ding & Lichtenberg, 2011; Kim, 2011; Kauko, 2015), especially under the unique land use system of China. On one hand, the sustainable development of the urban economy determines the allocation and redevelopment of urban land resources (Costello & Rowley, 2010; Murphy, 2016). On the other hand, an efficient urban spatial pattern features contributes to achieving a sound development of the urban economy (Ding, 2009)—an economy in which industrial land expansion directly stimulates economic growth (García-López, 2013), while land is used as a tool to sustain infrastructure investments and attract foreign investments, thereby indirectly triggering economic growth (Diao & Yan, 2012; Liu, Tao, Yuan, & Cao, 2008; Tao et al., 2014; Xie, 2017; Zhang, Fang, Wang, & Ma, 2013; Zheng, 2014). Much of the existing literature focuses on the impact of the spatial structure of land on economic growth (Guang, 2013; Hu et al., 2017; Karmakar, 2017; Xia, Yan, & Xu, 2014). The corresponding methods mainly used were structural equation (He, Huang, & Wang, 2014), Exploratory Spatial Data Analysis (Salvati & Carlucci, 2014), multivariate statistics (Kleemann et al., 2017; Masini et al., 2017), grey correlation model (Hu & Tan, 2017; Zhang, Uwasu, Hara, & Yabar, 2011) and the spatio-temporal land use model (Nourqolipour, 2016). The corresponding indicator primarily used is the land use type (Zhang, 2018; Salvati & Carlucci, 2014; Xie et al., 2015; Masini et al., 2017), which is used to describe the change in land structure. Because of the difference of land system, researchers pay different attention to it. These studies also show that there is a feedback mechanism between spatial structure and economic growth, that is, urban spatial structure is a result of economic development, at the same time, through active land supply regulation, economic development can be affected. The increase of different spatial locations of construction land will lead to the accumulation and diffusion of spatial activities, which will affect the spatial reorganization of labor force, capital and technology, thus promoting the evolution and upgrading of regional industrial structure, and ultimately affecting the level of regional economic growth (He, 2014; Wang and Gu, 2015). Although there is no systematic theory to support the feasibility of such a regulation in practice, it is a strong reality for countries with strong land control capacity such as China.

With the continuous development of the city, a large amount of rural land becomes urban land, which promotes the development of the urban economy, but this extends to the issue of how much change rural land into urban land will bring to economic growth if

its location is different? Is it statistically significant? In addition, how to depict the location difference is more appropriate? Current studies have acknowledged that regional economies and land use structure are highly interrelated, but they do not clearly express the direct relationship between spatial location of construction land supply and economic growth. Therefore, we are interested in addressing the following three questions: (1) What indicators are used to describe the construction land supply structure more directly and to explore the evolution of land spatial structure? (2) What is the relationship between the selected indicators and economic growth? (3) Can significant variables in the estimated model be authenticated in reality?

Tianjin is considered to have a multi-centre structure, with the urban districts and the Binhai New Area as the centres and there being great differences in the industrial layouts in different locations. Inspired by the concentric circle theory (Burgess, 1967), in this context, we use TBNA as the research object and attempt to address the above three problems and provide a new perspective for China's land supply policy innovation. We select two indexes of distance and direction to address the first question. We examine the relationship between land supply and economic growth in different distances and directions and the impacts of time on this kind of economic growth to address the second question. We explore the lag effect of construction land to solve the third problem.

The next section provides a brief introduction of the basic situation in the study area and describes the data sources and study methods in detail. Section 3 presents an application of the methods to examine the changing trend of the construction land supply space expansion and the role of construction land supply position in different space-time dimensions on urban economic growth. Sections 4 and 5 describe the main results, conclude the study and propose some suggestions for further research.

2. Materials and methods

2.1. The study area

The TBNA (38°40'N–39°00'N, 117°20'E–118°00'E) is located in the eastern coastal region of Tianjin Province, where the intersection of the economic belt around the Bohai Sea meets the Beijing–Tianjin–Hebei urban agglomeration (Fig. 1). TBNA is the first national comprehensive reform and innovation area approved by the State Council. The area is about 2270 km² with a shoreline of about 153 km and a population of about 263 million. With the continual expansion of the population and economic development, land use in the Binhai New Area has experienced constant changes. In particular, Developing TBNA became a state-level economic development strategy in 2005. Since then, China and Tianjin have formulated numerous regional development policies to promote the development of the TBNA, comprising infrastructure construction and industrial transfer. Some of the policies directly influenced land-use decisions (Li & Liu, 2017). Since the Tianjin Economic–Technological Development Area (TEDA) is the core point of TBNA and has the greatest impact on its economic development, TEDA is regarded as the central point in the calculation of the impact of construction land at different locations on economic growth.

2.2. Data acquisition and processing

2.2.1. Data acquisition

The total construction land and GDP were selected as variables with the time series data of 2000–2015 chosen for investigation. Two data sets were used, on construction land and on the economy. The construction land data was obtained by remote sensing image interpretation, for which remote sensing data from Landsat TM and ETM+ were downloaded from the data-sharing platform, Geospatial Data Cloud.¹ Multi-spectral color images with a spatial resolution of 15 m were obtained through the band fusion. The images were classified and interpreted by the working group from Chinese Academy of Sciences (CAS), the Institute of Remote Sensing and Digital Earth (RADI) into several land-use classes, including urban build-up and road, to quantify their areas. Based on the interpretation results, the area of construction land in the study area from 2000 to 2015 were calculated respectively. GDP was selected as the indicator of economic growth, and the data were obtained from the statistical yearbook of the TBNA from 2000 to 2015.

2.2.2. Data processing

The construction land data of each year were calculated in the GIS platform by drawing the construction land vector of the Binhai New Area. The dynamic information of construction land change was obtained by spatial overlay analysis. The location of construction land supply was then determined by spatial dimension analysis with TEDA as the core.

The location of construction land supply was determined by the following steps:

- (1) The construction land was divided according to an equal distance of 7 km, which was the most remarkable result after many attempts, so that the circle-layer distribution map of the Binhai New Area construction land was formed as shown in Fig. 2.
- (2) Construction land in the region was divided into the northeast, southeast, southwest and northwest directions, forming the spatial orientation structure of the Binhai New Area construction land, as shown in Fig. 3.

Figs. 2 and 3 were obtained by interpreting remote sensing images, showing the annual changes in the construction land in different circle-layers and orientations, respectively.

¹ Geospatial Data Cloud. Available online: <http://www.gscloud.cn/> (accessed on 17 April 2016).

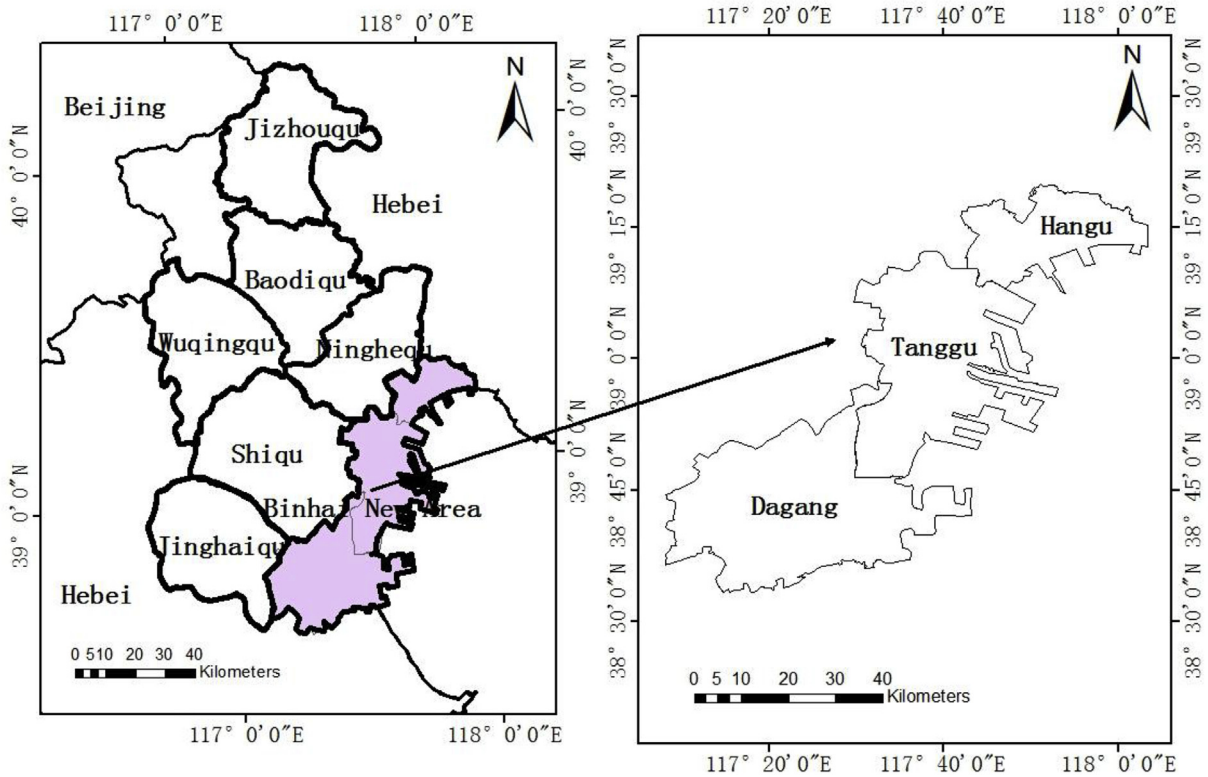


Fig. 1. Location of the Tianjin Binhai New Area.

2.3. Expansion intensity index

The expansion intensity index of construction land was introduced to compare the intensity and speed of construction land expansion in different research periods. In essence, the average annual expansion speed was standardised by the land area, so that the expansion speed of construction land can be compared in different periods (Zhou et al., 2014). The formula is shown by equation (1):

$$I_i = \frac{CLA_{i,t+\Delta t} - CLA_i}{TLA_i \times \Delta t} \times 100 \tag{1}$$

where I_i is the expansion intensity index of the spatial unit i in the period Δt . $CLA_{i,t+\Delta t}$ is the construction land area of the spatial unit i at $t + \Delta t$; CLA_i is the construction land area of the spatial unit i ; TLA_i is the total area of the space unit i ; Δt is the span of a certain research period.

2.4. Construction of theoretical model

It is because of the unique property of land that the spatial change of construction land supply in different spatial dimensions and its influence on economy are different. Based on the Solow model, the location of construction land supply was introduced and the total land supply amount R was divided into multiple dimensions to reflect the location of construction land supply. Then, the form of the economic growth model is given by equation (2):

$$Y = A \cdot e^{\lambda t} K^\alpha L^\beta (R_1^{\gamma_1} R_2^{\gamma_2} \dots R_n^{\gamma_n}) \tag{2}$$

where Y is the GDP of the study area; A is constant; K , L and R represent the investment status of the capital, labour and land production factors, respectively; λ is the rate of technological progress; while α , β and γ respectively represent the economic elasticity coefficient of each element; e is the natural constant; R_1, R_2, \dots, R_n represent the construction land supply of different spatial dimensions, which is based on the research status and the geography research unit designated by the standard of construction land supply; $\gamma_1, \gamma_2, \dots, \gamma_n$ represent the economic elasticity coefficient of the spatial dimensions; n is the natural number.

The following form was obtained by taking logs of both sides of equation (2).

$$\ln Y = \ln A + \lambda t + \alpha \ln K + \beta \ln L + \gamma_1 \ln R_1 + \gamma_2 \ln R_2 + \dots + \gamma_n \ln R_n \tag{3}$$

To determine the contribution rate of factors to economic growth over time, we made a derivative, and the resulting equation is

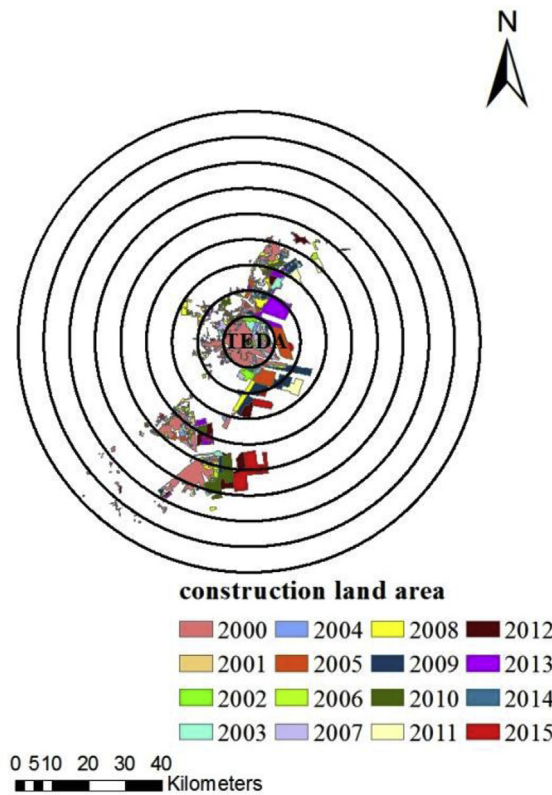


Fig. 2. Circle-layer distribution map of Binhai New Area construction land (2000–2015).

given as follows:

$$\frac{dY/dt}{Y} = \lambda + \alpha \frac{dK/dt}{K} + \beta \frac{dL/dt}{L} + \gamma_1 \frac{dR_1/dt}{R_1} + \gamma_2 \frac{dR_2/dt}{R_2} + \dots + \gamma_n \frac{dR_n/dt}{R_n} \tag{4}$$

where λ represents the influence of technological progress on the economy, while γ reflects the impact of the land that is in each spatial dimension of the economy. Since the purpose of this study is to explore the impact of the space structure on economic growth, K and L are regarded as constants, and the equation is given as follows:

$$\frac{dY/dt}{Y} = \lambda + \gamma_1 \frac{dR_1/dt}{R_1} + \gamma_2 \frac{dR_2/dt}{R_2} + \dots + \gamma_n \frac{dR_n/dt}{R_n} \tag{5}$$

It is also expressed as:

$$\ln Y = C_t + \gamma_1 \ln R_1 + \gamma_2 \ln R_2 + \dots + \gamma_n \ln R_n + u_t \tag{6}$$

Equation (6) can reflect the impact of the construction land structure on the total economy, which includes the distance scope structure and the orientation structure. If the γ_1 value is different, the difference of construction land supply in different dimensions also has different effects on the economy. The influence of construction land supply in different dimensions can be judged by γ_1 , that is, the greater the γ_1 value, the higher is the contribution rate of the construction land supply in the spatial dimension to the economy.

3. Results

3.1. The trend of space expansion for construction land supply

3.1.1. Expansion intensity of the construction land supply in each circle-layer

The expansion intensity index of construction land supply in each circle-layer from 2000 to 2015 was calculated. The results of all expansion intensities are depicted in Figs. 4 and 5 to analyse the changing trend of spatial expansion. Fig. 4 depicts the average expansion intensity of the construction land on the circle-layer, from 2000 to 2015, reflecting a general trend of the expansion of construction land supply. Fig. 5 considers 2005, 2010 and 2015 as examples to examine the fluctuation of construction land supply in different circle-layers.

As illustrated in Fig. 4, the area with the largest expansion intensity is located 14 km–21 km away from TEDA, followed by

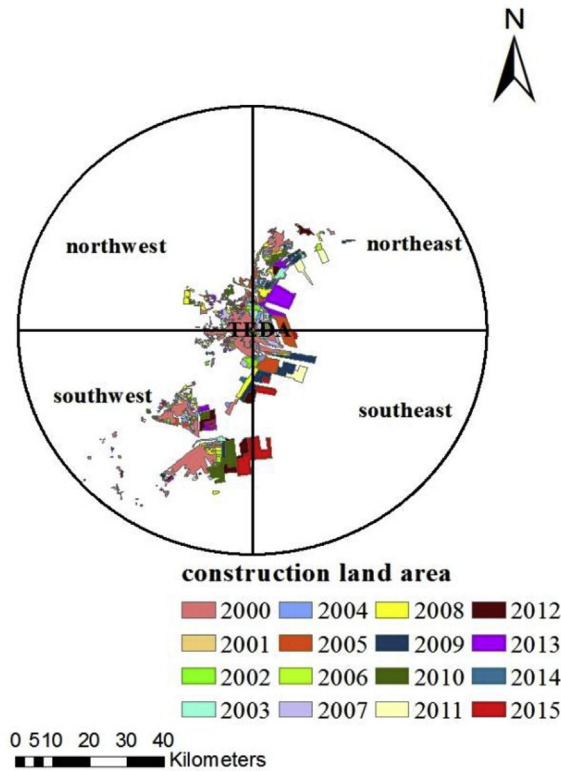


Fig. 3. Spatial orientation structure of Binhai New Area construction land (2000–2015).

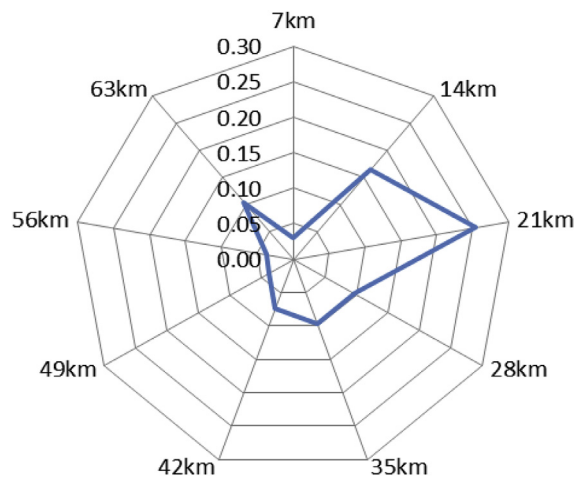


Fig. 4. Average expansion intensity of each circle-layer.

7–14 km, 21–28 km and 28–35 km. The area with smaller expansion intensity is located 0–7 km, 42–49 km and 49–56 km from TEDA. Fig. 5 depicts that as time passes, the construction land supply tends to expand from the central area to the periphery, while the expansion intensity presents a decreasing trend in the time series in the whole study.

The reasons for this situation could be determined by combining remote sensing images. First, the area near the centre is intensive. Second, the space potential of the construction land supply within the range of 14–28 km is larger than that of other areas, and the intensity of land use is increasing gradually, which may increase the supply intensity. Finally, due to the spatial spillover effect of economic growth, the region far away from the development zone is affected by the East Xinjiang bonded Port Zone, the Zhongxin Ecological City and the Binhai High-tech Zone and the intensive degree of the land is gradually improved. However, the circle-layers in the range of 42–63 km have fewer construction land quotas.

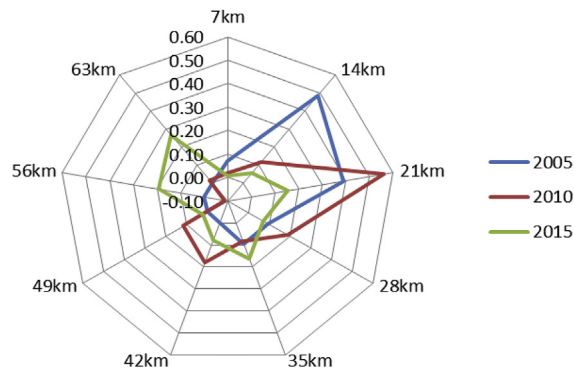


Fig. 5. Trend of expansion intensity for the construction land supply in each circle-layer.

3.1.2. Expansion intensity of construction land supply in various spatial orientations

The expansion intensity was calculated for every spatial orientation in the same way as described above. Figs. 6 and 7 depict the general trend of construction land expansion in different orientations and the fluctuation of the construction land supply, respectively.

Over the study period, the expansion intensity for the whole study area decreased monotonically. Fig. 6 illustrates that the expansion intensity of the construction land supply in various spatial orientations is in the order of southeast, northeast, northwest and southwest. The main reason for the small amount of construction land supply in the southwest is the direction of the adjacent sea area because of which urban construction and the development potential are both relatively small.

3.2. Relationship analysis between construction land supply structure and economic growth

3.2.1. Relationship analysis between construction land supply of each circle-layer and economic growth

GDP was used as the dependent variable y. The construction land supply of each circle-layer was used as the independent variable x, which was divided into x1, x2, x3, x4, x5, x6, x7, x8 and x9, according to the order of distance from near to far. For 2000 to 2015, relationship analysis was carried out between the construction land supply structure and economic growth, and the results are listed in Table 1.

Table 1 shows that the fitting degree between the construction land supply of each circle-layer and economy is very high, and the correlation coefficient reaches 0.999. However, for the ranges of only 0–7 km, 7–14 km and 21–28 km circle-layers, there is a significant relationship between the construction land supply and economy, which is reflected from the F value and the adjoint probability of the parameters. Usually, when the F-Statistic test is significant while some variable's t-Statistic test is not significant, a serious multicollinearity problem is considered to exist. In order to eliminate multiple collinearity, the stepwise regression method was used to eliminate insignificant variables, and the regression results are as follows:

$$\log(y) = -14.04 + 0.66 \log(x_1) + 0.24 \log(x_2) + 1.13 \log(x_4) + 0.44 \log(x_5)$$

$$\begin{matrix} (-7.83) & (2.90) & (3.88) & (10.26) & (3.45) \end{matrix}$$

$$R^2 = 0.998 F = 1530.875 D. W = 1.542 \tag{7}$$

Equation (7) shows that the model fitting degree is high. The supply of construction land in the circle-layers within the range of

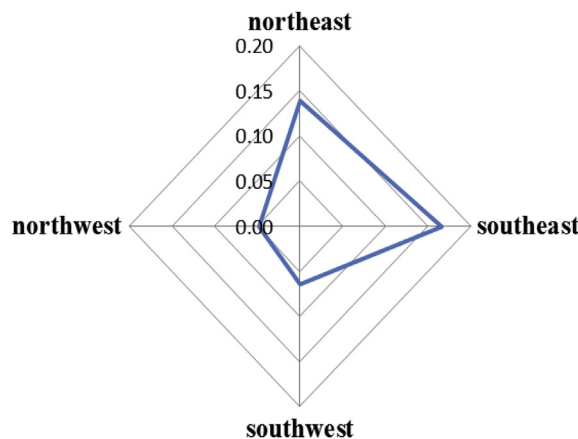


Fig. 6. Average expansion intensity of various spatial orientations.

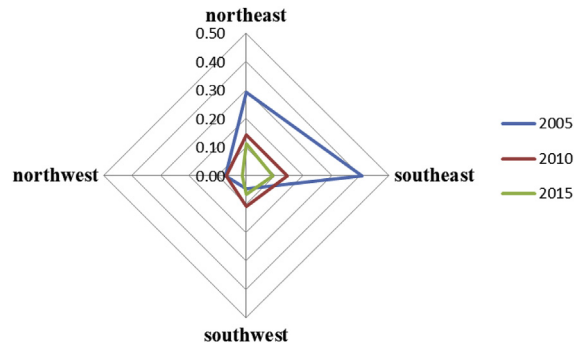


Fig. 7. Expansion intensity trend for construction land supply in various spatial orientations.

Table 1
Relationship between construction land supply of each circle-layer and economic growth (2000–2015).

	Coefficient	t-Statistic	R ²	F
constant	−14.763***	−5.916	0.999	937.429
log(x1)	0.954**	3.636		
log(x2)	0.221**	3.332		
log(x3)	0.084	0.643		
log(x4)	1.166***	4.798		
log(x5)	−0.186	−0.448		
log(x6)	1.071*	2.044		
log(x7)	−0.952	−1.702		
log(x8)	0.152	0.979		
log(x9)	−0.083	−0.969		

Note: Significant at * 10%, ** 5%, ***1%.

0–7 km, 7–14 km, 21–28 km and 28–35 km had a significant impact on the economic aggregate, while it was not significant in the other circle-layers. In the circle-layers with significant influence, the promotion degree of construction land supply to the Binhai New Area's overall economy from high to low was the circle-layers within the range of 21–28 km, 7–14 km, 28–35 km and 0–7 km.

The results showed that the Binhai New Area construction land supply presents a jumping development trend in the circle-layer layout centred on TEDA. Combined with the analysis of satellite remote sensing images, this trend was due to the following points. First, due to the agglomeration effect of the economic development in TEDA, there are obvious positive correlations between the land use and economic development in the surrounding areas of TEDA. Second, several projects with a strong advantage of backwardness had been built in some areas, such as the Yili International Ecotourism island and Yujiabao station within the range of 0–7 km, Fantawild within 7–14 km and the Binhai station within 21–28 km. The Binhai New Area's tourism area, industrial zone and central new town construction will bring forth a strong economic promotion effect through the construction land supply. Finally, the region far away from the TEDA shows an insignificant driving effect on the economic growth, indicating that the Binhai New Area is still following a single-centre development trend.

In addition, considering the periodicity of land construction, theoretically, the impact of the total supply of construction land on the economy was lagging (Wang, 2013). The lag analysis of construction land supply and economic growth was undertaken, and the lag of one, two and three years was analysed to test whether this effect is consistent with reality. Then, the most significant and good fitting results were chosen as follows:

$$\log(y) = -15.73 + 1.15 \log(x1(-1)) + 0.26 \log(x2(-1)) + 1.25 \log(x4(-1))$$

$$\begin{matrix} (-8.09) & (4.66) & (3.82) & (16.97) \end{matrix}$$

$$R^2 = 0.997F = 1424.241D. W = 1.754 \tag{8}$$

Equation (8) shows that the impact of the construction land supply of the Binhai New Area on the economy is relatively significant, when the lag period is one year, while the fitting degree does not improve from equation (7) and the scope of construction land that impacts the economy also appeared to reduce the situation. The lag analysis shows that the promotion of the economy by the construction land supply of each circle-layer is more significant in the same year, which may be because the good market expectations brought by construction land supply are better digested in the current period.

3.2.2. Relationship analysis between construction land supply of various spatial orientations and economic growth

The GDP was used as the dependent variable y, the construction land supply for each direction was used as the independent variable m. The independent variable was divided into m1, m2, m3 and m4 according to the northeast, southeast, southwest and northwest positions, respectively. To eliminate the influence of dimension, each variable was processed by logarithm. The regression results are shown in Table 2.

Table 2

The fitted relationship between construction land supply of various spatial orientations and economic growth in the Binhai New Area (2000–2015).

	Coefficient	t-Statistic	R ²	F
constant	−18.708***	−7.739	0.998	1132.989
log(m1)	0.209	1.148		
log(m2)	0.215	1.684		
log(m3)	1.483***	8.628		
log(m4)	0.906**	2.253		

Note: Significant at ** 5%, ***1%.

Table 2 shows that there may be multicollinearity between the data, which leads to uncertainty in some direction analyses. Therefore, as in the previous paper, the variables are introduced into the equation step by step by using the stepwise regression method and the multicollinearity test was performed.

$$\begin{aligned} \log(y) &= -20.53 + 0.27 \log(m2) + 1.61(m3) + 1.13(m4) \\ &(-11.11)(2.23)(12.33)(3.16) \\ R^2 &= 0.997F = 1471.301D. W = 2.150 \end{aligned} \quad (9)$$

Equation (9) indicates that the influence of construction land in the northeast of the study area (m1) on GDP is not significant, while the promotion degree of construction land in the other three directions to GDP is southwest, northwest and southeast. The causes and characteristics of the results are determined through the remote sensing images of various regions, as described next. (1) The construction land distribution in the northeast direction is more fragmented and mainly used for developing ecology and tourism, and the degree of economic development is low. (2) The construction land in the southwest direction is mainly used for industry development and there is a convenient regional network, so construction land supply has the highest promotion effect on the economy. (3) The construction land in the northwest direction is mainly used for developing real estate and industry and the transportation is convenient; therefore, the construction land use efficiency is inferior. (4) The construction land in the southeast direction is adjacent to the sea area and is mainly used for developing harbour logistics, so the development potential is small.

The substance of the impacts of construction land supply in different orientations on economic growth is examined by analysing the lag effect between this index and economic growth. The lag period was selected from one, two and three years. The study shows that the optimal delay period was one year.

$$\begin{aligned} \log(y) &= -23.359 + 1.209(m3(-1)) + 2.207(m4(-1)) \\ &(-30.447)(5.519)(8.776) \\ R^2 &= 0.993F = 835.05D. W = 2.256 \end{aligned} \quad (10)$$

The fitting degree of the analysis results shows that the lagging effect of construction land supply in the Binhai New Area is significant, which may be related to its open construction cycle. In contrast to equation (8), the goodness of fit has not improved and the effect of construction land supply on the economy has reduced. This is mainly because the location of construction land supply in the Binhai New Area is more likely to have a direct impact on the economic benefits of this year. In addition, the lag effect of each spatial orientation is also different. The lag effect in the southeast direction (m1) and the northeast direction (m2) is so small that it is not shown in the regression results. The lag effect in the southwest direction (m3) is obviously behind that of the northwest direction (m4), which may be due to the difference in the infrastructure and industrial base.

4. Discussion

The abovementioned results show that during the past 15 years, the location of construction land supply of the Binhai New Area has had a very significant impact on economic development, and the significant variables in the model have been verified in reality.

In the Binhai New Area, the supply of construction land within the range of 0–7 km, 7–14 km, 21–28 km and 28–35 km has a significant impact on economic growth. The construction land supply in the southeast region near the sea has a relatively weak role in promoting the economy, while the southwest and northwest regions near the inland area play a relatively strong role in economic growth, especially the southwest region where the industry and infrastructure are both well developed. The results show that with the increasing distance from TEDA, the influence of construction land supply structure on economic growth in the Binhai New Area shows a trend of leapfrogging development. The significant level of the location of construction land supply is mainly related to resource endowment and the industrial basis of the construction land supply area. There are main engineering in the significant circle-layers, and more developed industry and infrastructure in the significant orientations than in other orientations.

The space change trend of the expansion intensity was compared with the driving effect of the location of the construction land supply on the economy. We can see that as the supply of newly added construction land was reduced in China, the Binhai New Area should increase the supply of construction land in the southwest and northwest directions within the circle-layers of 21–28 km and 28–35 km.

Irrespective of whether from the perspective of circle-layer structure or orientation structure, the effect of construction land supply in the current period and one year's lag on economic promotion is very significant, and there are differences in different spatial dimensions. On the one hand, the current market expectation of construction land supply can be reflected rapidly in the market,

while because of the relatively fast land development speed, the supply will have an obvious driving effect on economic growth in a short time. On the other hand, it also shows that for different spatial dimension conditions, the lag effects are not exactly the same. For example, due to the relative weakness of the location infrastructure and industrial foundation, the impact of construction land supply on the economy in the southeast direction is weak in the current period, which has little effect after one year.

5. Conclusions

Our research suggests that the driving effect of construction land supply in different directions or different circles on economic growth is related to the land's location conditions and industrial basis. In the circle-layers of dimension, there is a hop about the influence of construction land supply on economic growth. In the orientation dimension, some regions have superiority, especially the southwest and northwest regions, and this significantly influences the economy. In addition, the effects are significant for the current and previous years. Thus, it can be concluded that the economic growth of the study area is obviously affected by the quantity of construction land and regional spatial structure, and this influence has a time lag effect and location difference.

According to the present situation and the existing problems of land use in the study area the Binhai New Area should actively adjust its urban development thinking and undertake various measures to redevelop the stock construction land of advantageous areas. Meanwhile, when formulating relevant plans in the region, we need to grasp the economic efficiency of the entire construction land supply based on the problem that the economic benefits of the construction land have not yet been fully highlighted.

In general, our research contributes to the formulation of urban construction land supply planning and transformation of the economic structure. However, the study has several limitations. Because of our focus on location of construction land supply by distance and direction, this study does not include many factors of the spatial effect of the construction land supply structure or the source of construction land supply (e.g. new construction land, stock of construction land) and use of land supply (e.g. residential, industrial) levels, which may also affect the economic growth of the study area.

Declaration of competing interest

No potential conflict of interest was reported by the authors.

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