Application and Verification of Municipal Administrative Areas Spatial Zoning Model in New Town Location Selection

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Abstract: As one of the three most important location-oriented policies in urban and regional development, the location selection of new towns largely determines the strategy of urban economic development and regional economic development. In the previous study, an objective model of municipal administrative areas spatial zoning model (MAA-SZ model) is constructed based on the theory of spatial equilibrium and mathematical logic deduction, which can provide guidance for the location of new towns. This paper takes a city in the south of Heilongjiang Province as an example to verify the value and superiority of the MAA spatial zoning model in the location selection of new towns. The results show that the consistency Kappa value of the model is 77.2% when the MAA-SZ model is compared with Glaeser-Gottlieb new town location selection model new towns that has been widely used, which verifies the accuracy of the model. In addition, the spatial differentiation and DEA effectiveness of the model are higher than the contrast model. The superiority of the MAA-SZ model over the contrast model mainly lies in two aspects. Firstly, the MAA-SZ model effectively reduce the influence of some factors that can not be assigned objectively while inheriting the economic relationship among the factors of the contrast model. The MAA-SZ model makes it easier to simulate and operate, and more practical. Secondly, it effectively reduce the contradiction between development, agriculture and ecology, which is often caused by the traditional site selection of new town basing on center-urban gravitation. The MAA-SZ model solve this problem by balancing the relationship among construction, agriculture and ecological land from the macro-perspective of the MAA. Therefore, the MAA-SZ model has the characteristics of high accuracy, high balance, high effective, high spatial differentiation, and high practicality. We believe the MAA-SZ model can also provide a reference for the development of urban system.

Keywords: spatial zoning, municipal administrative area, new town.

1. Introduction

From the perspective of urban economics, new town construction is an important carrier to promote the rapid development of urbanization and the sustainable growth of regional economy. With the increasingly prominent problems of environmental pollution, traffic congestion, and the decline of quality of life in urban central areas, new town construction has become an important way to solve urban space expansion and function optimization (Sun, 2016). As an important location-oriented industrial policy, the location of new towns has a significant impact on the layout of urban industries. The location of new towns largely determines the urban economy and is an important part of the strategy of regional economic development (Johnson, 2007). At present, most of the models used to solve the problem of new town location are based on the economic factors that attract consumers from the city. Their application is not practical enough, and there are great differences between the valuation of some economic factors and the actual situation (Nouri *et al.* 2013). At the same time, many new town location models focus on the city gravity and lack of balanced consideration from the perspective of the city, resulting in conflicts between the location of new town and the location of agricultural and ecological land (Sun, 2016). In order to solve the problems of new town location, it has become the primary task of regional economic development strategy to establish a highly practical and balanced MAA spatial zoning model to guide the new town location.

At present, the new town location selection models can be divided into five categories: agricultural location model, industrial location model, single-center new town location selection model based on the gravity of the central city, multi-center new town location model, and new town location model based on agglomeration economy. The core idea of agricultural location model (Johann, 1826) and industrial location model (Alfred, 1909) is from producers' version and aim to maximize the production profit. It selects the appropriate new town location through the producer input/output ratio. The new town area has little connection with the traditional central urban area and is relatively isolated. With the continuous deepening of the relationship between the new town and the traditional central city, a single-center new town location model focusing on the gravity of the central city based on the logical deduction between economic factors was developed. Developers determine the location of the new town according to their target income. Among them, the number of enterprises, population size and land area of the new town are endogenously generated by the gravity of the traditional central city. Chen Hongxia (Chen, 2008) started with the gravity of the central city, and aimed at the theoretical and practical problems of the new town formation and development, constructed a general endogenous theoretical model of the new town. And the mechanism of the new town development was also studied. With the development of multicenter city and urban diffusion, Krugman's multi-center new town location model was proposed. Based on the single-center new town location selection model and the principle of attraction and repulsion between enterprises, this model organically connects the new town and the traditional central city to clarify the inner structure of the economic spatial pattern of the city (including the new town and the traditional central city) (Krugman, 1993). Recently, the impact of agglomeration economy on new town location selection increase, so some new town location selection models based on agglomeration economic factors and balancing the central and suburban areas have been proposed. For example, Gottlieb and Glaeser (Glaeser and Gottlieb, 2008) pointed out that the agglomeration economic effect under spatial equilibrium between the central city and the new city is an important economic factor behind the new town location selection policy. At present, this model has been widely used in the location selection of new towns, and many meaningful results have been achieved (Minha, 2017, Liu, 2016).

Generally speaking, the existing five types of new town location selection models differ from each other due to the differences in urban structure and morphology, and all of them show shortcomings in the application practice of new town selection location. Firstly, the existing models are constructed by the logical relationship between economic factors. Some of the economic factors, such as consumer preferences and the number of urban products, can not be assigned in practice, which leads to the weak applicability of the models. Secondly, most of the existing models advocate that the location of new towns focus on the gravity of the central urban areas. It is lack of rational consideration to the relationship between the development of new towns and agricultural and ecological land from the perspective of MAA. Therefore, it aggravates the contradiction among construction, agriculture and ecological land. Thirdly, most of the existing models are based on different urban forms and structures, and their scope of application is limited.

In our previous study, the model of MAA spatial zoning was constructed by using the economic logic derivation and the objective derivation of the relationship between the model factors. The MAA-SZ model aim to study the suitability of MAA spatial development construction basing on the theory of spatial equilibrium. It is used to simulate and analyze the MAA spatial zoning and the results are compared with three existing models: urban structure model, UGB delimitation model and functional regionalization model. It is found that the average Kappa value is 81.3%, which verifies the correctness of the model (Zhao *et al.* 2018). Theoretically, it is possible to use the MAA-SZ model to solve the problem of new town location selection. In order to verify the application value of the model in the new town location selection, this paper take a city in southern Heilongjiang as an example and applies the new town location selection model to it. Meanwhile, we compared the spatial differentiation and DEA effectiveness of the MAA-SZ model and Glaeser-Gottlieb new town location selection model (Glaeser and Gottlieb, 2008). The results show that the model has advantages in solving the problem of urban new town location selection. Moreover, the model show many advantages than the traditional Glaeser-Gottlieb model, such as it is more balanced, more effective, as well its more spatial differentiation, easier value assignment, wider application scope and more convenient application.

2 Research Method and Research Area

Based on the practical problems existing in the existing model for the new town location selection, this paper starts with the introduction of the model and the research area.

2.1 Introduction of the Model

2.1.1 MAA Spatial Zoning Model

In the previous study, through data, personnel research and economic derivation, under the condition of the restriction of the main functional areas, the model of MAA spatial zoning was constructed, and the correctness of the model was verified by comparing with the existing spatial zoning model. The MAA-SZ model is used to solve the spatial differentiation of urban areas (including central and new towns), urban systems and village and town systems. The factors included in the model are: available land resources; population aggregation; economic development level; location advantage; traffic advantage; number of development zones; topography; natural disasters; available water resources; environmental capacity; ecosystem vulnerability. Among them, the factors contributing to D are: available land resources, population aggregation, economic development level, location advantages and transportation advantages; the second factor contributing to D is the number of development zones, topography and topography; the lowest factor contributing to D is natural disasters, available water resources, environmental capacity and ecosystem vulnerability. (Zhao *et al.* 2018) In order to reflect the superiority and practical value of the established model of MAA spatial zoning, this paper uses the model to further apply in the new town location. The MAA-SZ model is as follows: Formula 1.

$$D(r)=\left(\frac{L_1^{\,2}N_1\lambda tYe^{(\lambda t|r-y-r_0|)}}{e^{\lambda tr}-1}\right)\left(p^{x_1}\left(y+\mathrm{r}_0\right)^{x_2}J^{x_3}\right)^{(1-\mu)}\left(\frac{\sigma-1}{\sigma}\right)^{\mu}M_1(r)^{\left|\frac{\mu}{1-\sigma}\right|}$$ (Zhao *et al.* 2018)

The weight of each factor in P value is 0.15 for natural disasters, 0.15 for topography, 0.3 for available water resources, 0.2 for environmental capacity and 0.2 for ecological vulnerability. The parameters of μ、t、x1、x2、x3、σ are 0.5, 0.005, 0.45, 0.2, 0.35, 2 (Fujita et al. 1997, Fujita and Mori, 2005, Wang et al. 2009), respectively. (Zhao *et al.* 2019)

2.1.2 Glaeser-Gottlieb New Town Location Model

$$D = \theta N^{-\sigma}\left(1\text{-t}\right)WP^{-\beta}$$ (Glaeser and Gottlieb, 2008)

In which, D represents the suitability utility of MAA spatial development, N represents the population, W represents the wage rate, T represents the location advantage, P represents the preference of MAA participants to the land commodity. The values of parameters θ、σ、β are 1.9, 2 and 0.5, respectively(Fujita *et al.* 1997). What we need to explain here is that because the value of P consumer preference is difficult to determine, the p value of the MAA-SZ model (the model of MAA spatial regionalization) is adopted in the simulation, that is, the preference value of the main body of the MAA.

2.2 Introduction of Research Area

The study area is located in the south of Heilongjiang Province. The main landform is low mountains and hills. The elevation is between 100 and 850 meters. The distribution of water resources and available land resources is uneven, and the difference of natural environment is significant. In 2018, urban population accounted for more than 1/2 of the total population, urban area accounted for more than 20% of the total urban area, leading industries were secondary and tertiary industries, and its GDP accounted for more than 80% of the total GDP.

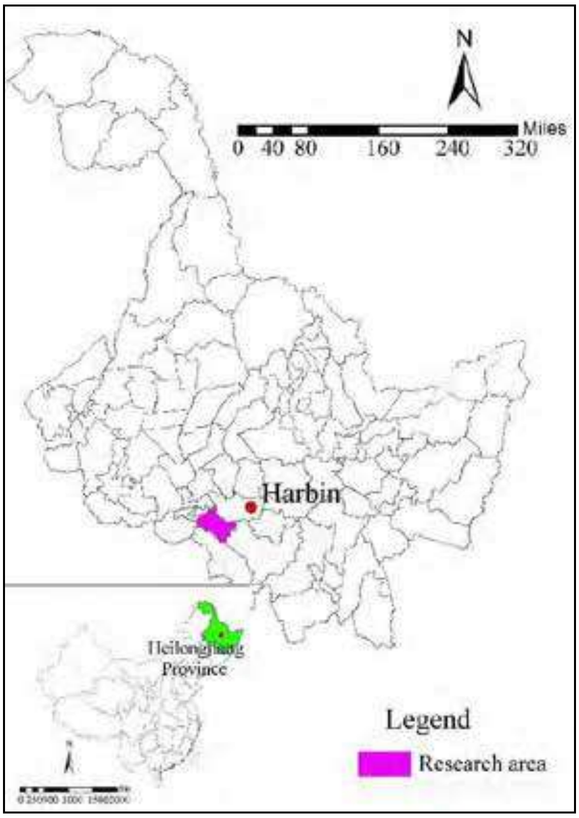


Fig. 1 Location of the research area.

3. Application and Verification of MAA Spatial Zoning Model in Location selection of New Town

Based on the current situation and research methods of the research area, the model is applied by starting with the consistency test, spatial differentiation and DEA validity of the model and the comparative model (Glaeser-Gottlieb New Town Location Model).

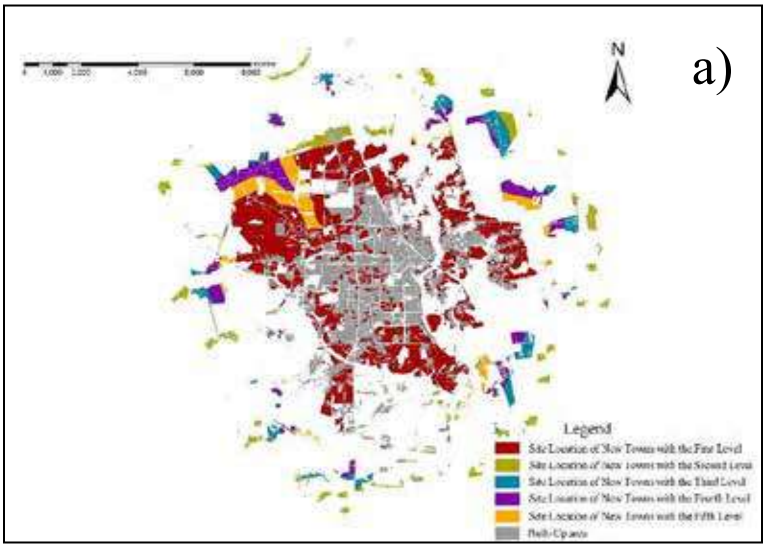
3.1 Consistency Test and Nonlinear Regression Analysis of MAA Spatial Zoning Model and Glaeser-Gottlieb New Town Location Model

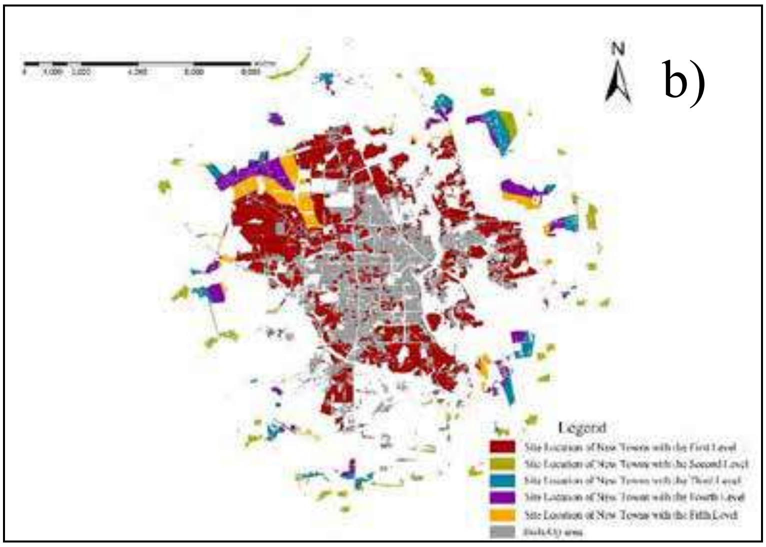
Combining the distance factor with the old city and the local policy orientation, the new town location simulated by the MAA-SZ model is compared with the new town location simulated by Glaeser-Gottlieb model, as shown in figs. 2a and 2b. The consistency kappa value is 76.1%, and the consistency test value is high. The main reasons for the difference are the determinacy of the model factors and the restriction of the main functional areas. Especially, compared with the uncertainty of consumer preference and the quantity factor of urban products in the comparative model, the MAA-SZ model can be replaced by the factor of available water resources, topography, environmental capacity, ecosystem vulnerability, natural disasters, and the number of development zones through preliminary validation and deliberation (Zhao *et al.* 2018). As a result, the MAA-SZ model has more advantages than the comparative model in delineating new cities. Because of the limited role of the main functional area, the model can balance the relationship between development, agriculture and ecological land from a macro perspective. Compared with the comparative model, it is easier to deal with the contradiction between development, agriculture and ecology when selecting the location of the new town. In conclusion, the MAA-SZ model is more balanced than the comparative model.

By comparing the consistency kappa values of the model, the comparison model generation map and the government behavior map, the kappa values of the comparison between Figure 2a and Figure 2c of government behavior are 83.8%, and that of Figure 2B and Figure 2c of government behavior is 79.7%. Compared with the government behavior, the consistency of the model is higher than that of the comparison model, which verifies that the model is more consistent with the current situation. It further illustrates that the model has a good guiding role in the location of urban new towns.

By using the MAA-SZ model and the Glaeser-Gottlieb new town location model, the multiple non-linear regression analysis and linear regression analysis show that the R_2 value of the MAA-SZ model is 0.79 while that of the comparative model is 0.73, which proves that the MAA-SZ model is more objective than the comparative model in the actual fitting process.

As can be seen from Fig. 2a, the land on both sides of the northwest and southeast of the city is more superior, and can be used as location selection for new towns. It is suggested that urban construction land be reserved in the northwest and southeast of the city in the future. And gradually adjust the future construction land and nearby agricultural land, ecological land, population transfer and other policies. This will help to adapt the development of new towns and population changes gradually.





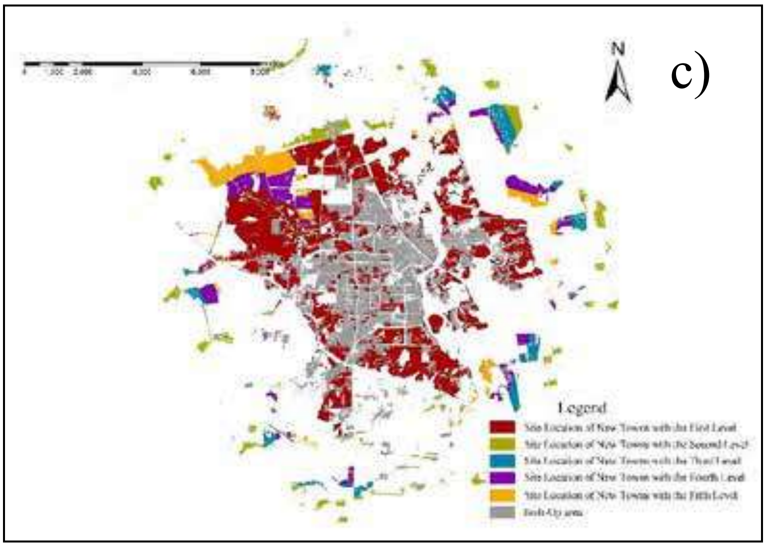


Fig. 2 Evaluation of New Town Location Selection. a) Simulation Results of the MAA-SZ model. b) Simulation Results of Glaeser-Gottlieb model. c) Government Behavior Results.

3.2 Comparison and Analysis of Spatial differentiation between MAA Spatial Zoning Model and Glaeser-Gottlieb New Town Location Model

Generally, the spatial differentiation of simulation results between two models is measured by the degree of variation of the semi-variogram of the model. Therefore, this paper tests the spatial differentiation of the two models by comparing the degree of variation of the semi-variogram of the two models. Before calculating the variation degree of the semi-variogram of the model, it is necessary to process the data with special values, analyze the spatial correlation and test the determinant coefficient of the semi-variogram and the normal distribution of the data. The processed special values are substituted into the data to test whether they belong to the normal distribution or are transformed into the normal distribution, and have good spatial correlation and the determinant coefficient of the semi-variogram. The premise of simulating the variation degree of semivariogram.

3.2.1 Special Value Processing

Geostatistical analysis requires that the data analyzed be of normal distribution, and the existence of special values will cause discontinuity of the continuous surface of variables, and then change or even conceal the original spatial structure characteristics of semi-variogram (Li *et al*. 2014). Therefore, in this section, the domain method is first used to detect and process the special values in the simulation results of 10 models. That is to say, the values in the range of 3 times standard deviation of sample average are normal values, while the values outside this range are regarded as special values, and the normal maximum is used to replace the special value (Li *et al.* 2014).

3.2.2 Semi-Variogram Fitting

Geographic statistics is based on the theory of regional variables and the main method of semi-variogram (also known as semi-variogram function). It has been applied in urban spatial regionalization, land spatial economy and ecological pattern evolution (Zhang *et al.* 2019, Xu and Hao, 2017, Jiang 2015, Yue *et al.* 2005). In this paper, semi-variogram model is used to study the spatial differentiation significance of several models. In the semi-variogram model, the nugget value represents the quantity of random variation, reflecting the variation caused by artificial and other random factors in the experimental error. The base value represents the structural variance of spatial variation, indicating the total variation in the system. The higher the base value, the higher the total heterogeneity of the system. The nugget coefficient is the ratio of nugget value to base value, which is caused by the random part. Spatial variability accounts for the proportion of total variation in the system. The nugget coefficient < 25% indicates that the variables have strong spatial correlation, 25%~50% indicates that the spatial autocorrelation is obvious, 50%~75% indicates that the variables have medium spatial autocorrelation, and > 75% shows weak spatial autocorrelation. The variation is mainly composed of random variation (Tatem *et al.* 2002).

Statistical analysis requires the data to be normal distribution, and Kolmogorov-Smirnova normal distribution test (K-S test) is used before the spatial analysis. If Pk-s > 0.05, it is considered that data obey normal distribution, otherwise data conversion is needed. The results of normal distribution test show that the significance level of the MAA-SZ model P = 0.82 > 0.05 and the comparative model P = 0.85 > 0.05, that is to say, the two sample data pass the K-S test and obey the normal distribution, so there is no need for data conversion.

Based on GS+9.0 software platform, the semi-variogram formula is fitted. The semi-variogram fitting results show that the decision coefficients of the fitting functions of the MAA-SZ model and the comparative model are greater than 0.5, which are 0.91 and 0.83, respectively. It shows that the function fitting effect of the spatial differentiation of the new town location selection land in the study area is good under the Gaussian model, and the model can explain the spatial structure adequately (Table 1).

Tab. 1 Fitting result of semi-variation function

Model	Nugget	Abutment value	Nugget coefficient	Range change (m)	Coefficient of determination	Spatial differentiation model
The MAA-SZ model	0.25	1.44	17.4%	322	0.89	Gaussian
The comparative model	0.23	1.53	15.0%	243	0.82	Gaussian

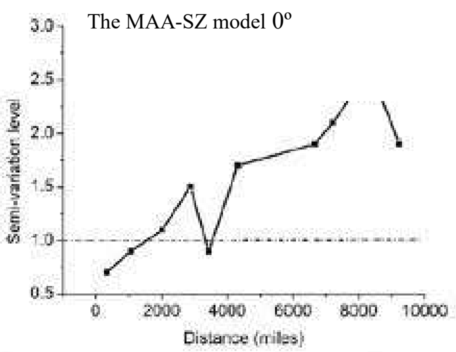
3.2.3 Anisotropy analysis of semi-variogram

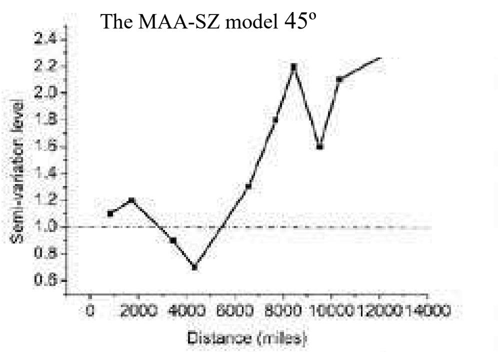
The variation degree of semi-variograms in the four directions of 0 (east-west), 45 (northeast-southwest), 90 (south-north), 135 (southeast-northwest) of the model and the comparative model is plotted in Figure 3. The dotted line in the graph indicates the variation degree of "semi-variance/sample variance=1", which can be used to measure the variation degree of elements in four directions. When the semi-variance/sample variance is greater than 1, the elements exist. When the semi-variance/sample variance is less than 1, the variation of elements is weak, even there is no variation.(Zhang *et al.* 2011)

The MAA-SZ model simulates the land evaluation of new towns site selection, which varies significantly in four directions. Wave-like fluctuation trends were observed in all four directions. Small peaks of variation appeared in the direction of 0° near 2876 miles and 8340 miles respectively, which may be caused by the high variation of population and economic factors in the two places above 0° from the annex. The U-shaped trough appears near 4321 miles and 9514 miles in the direction of 45°, which may be caused by the weak variation of economic and traffic factors between the above two locations in the direction of 45° and the appendages. In the 90° direction, the correlation factors of the model change relatively little, so the variation level presents a relatively stable low level state. The small variation peaks appeared at 1431 and 7521 miles in 135° direction, which may be caused by the high variation of population, location, economy and traffic factors between the two places above 135° direction and the accessory.

When the comparative model was used to simulate the land evaluation of new towns site selection, the similar variation trend was also found in four directions. However, compared with the model, the degree of variation is not that obvious. There was a significant variation near 9304 miles in the direction of 0°, which was mainly influenced by consumer preferences in that direction, and in a smaller range. There are some variations in the direction of 5 847 miles and 12 238 miles, which are mainly influenced by the wage rate and consumer preferences in this direction. A small peak appeared in the vicinity of 5026-977 miles in the direction of 90°, which may be affected by consumer preferences, location, wage rate and population in that direction, and show great variation in this range. There are two U-shaped troughs near 4873 miles and 11373 miles in the direction of 135°, which may be caused by the weak variation of population and location factors between the two places above 135° and the appendages.

Generally speaking, the model simulates the variation of the evaluation of new town location selection in four directions, which is more obvious than the comparative model, indicating that the model has a higher degree of spatial variation, that is, the spatial differentiation is higher than the comparative model. The high-low alternation in the semi-variogram simulated by the MAA-SZ model may be attributed to the important position of economic development level, location, population and other factors in the MAA-SZ model. The high-low alternation in the semi-variogram simulated by the comparative model may be due to population, location, economic development level, consumer preferences and other factors.





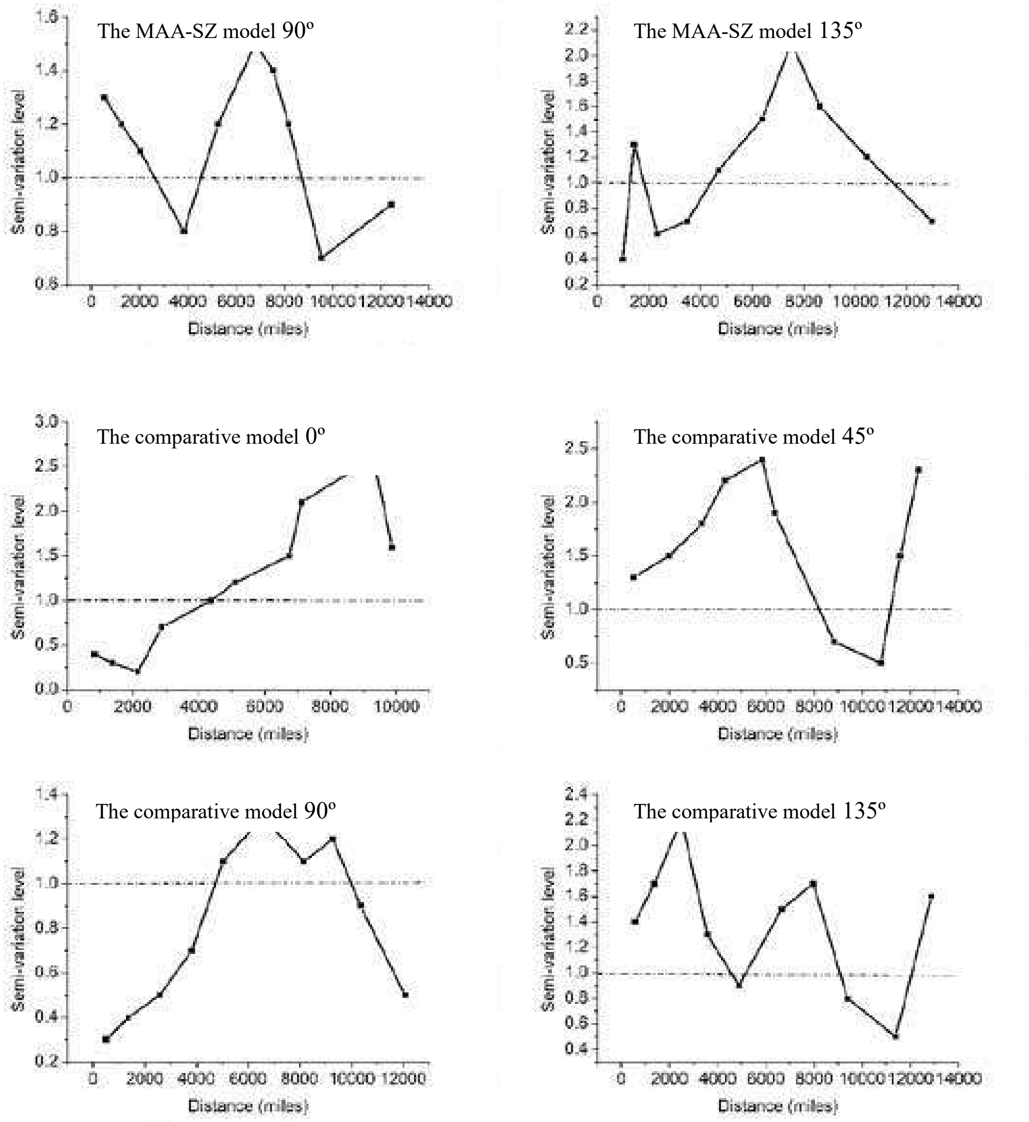


Fig. 3 The spatial differentiation of the model and the Glaeser-Gottlieb model.

3.3 Comparison and Analysis of DEA Effectiveness between MAA Spatial Zoning Model and Glaeser-Gottlieb New Town Location Model

3.3.1 DEA Model Method

DEA is a method to evaluate the relative effectiveness or benefit of the same type of decision making units (DMUs) based on the concept of relative efficiency and the multi-index input and output of the model. It is one of the commonly used methods to test the validity of the model. (Zhang *et al.* 2014) This method has been widely used in the validity test of relevant models such as urban planning and land use (Tonts *et al.* 2013, Sun *et al.* 2012). The correctness of this method has been verified in practical application. In this paper, DEA validity test method is applied to the model and the comparative model respectively, in order to verify which model is more effective. In this study, DMU refers to a block unit with a single evaluation result of the suitability utility of MAA spatial development. Among the DEA models, C2R and C2GS2 models (Li *et al.* 2017) were used more widely. Among them, C2R model reflects the comprehensive efficiency of the corresponding production state of DMU, including technology and scale efficiency; C2GS2 model reflects the technical efficiency of the corresponding production state of DMU. This paper chooses C2R model to simulate the validity of the above four models in order to reflect the synthetical effect of the model on the suitability of urban spatial development. Its construction is as follows.

In the C_2R model, assuming that the performance of n research blocks is evaluated, and that each research block has m input indices and s output indices; suppose x_{ij} (i = 1,2,3, m; J = 1,2,3, n) and y_{rj} (r = 1,2,3, s; J = 1,2,3, n) represent the total input and output of the first type of factor and the total output of r, respectively; then the input and output of each research block can be expressed by vector X_j and Y_j. According to the evaluation idea of DEA method, a linear programming model based on input reduction and output invariance is established.

$$\begin{cases} \min \theta \\ s.t. \sum_{j=1}^{n} \lambda_j x_j + s^- = \theta x_{j0} \\ \sum_{j=1}^{n} \lambda_j x_j - s^+ = \theta y_{j0} \\ \theta = \sum_{i=1}^{s} \lambda_{ij} x_{ij} \Big/ \sum_{i=1}^{m} \lambda_{ij} y_{ij} \\ \lambda_j \geq 0, j = 1,2,3 \ldots n \\ s^+ \geq 0, s^- \geq 0 \end{cases}$$

In the formula, θ is the efficiency index of the research block; λ_j (j = 1,2,3,n) represents the combination weight of the n research block (since the research block is equally important here, the weight is set equal); $\sum_{j=1}^{n} \lambda_j x_j$ and $\sum_{j=1}^{n} \lambda_j y_j$ are the input and output vectors of the block combined according to this weight; X_{j0} and Y_{j0} are the input and output vectors of the J_0 block; S-and S+ are the relaxation variables, representing pure excess and insufficient, respectively. In the C_2R model, θ, S+, S-are the important basis for evaluating the suitability efficiency of the development of MAA.

The criteria for determining the validity of the study block are: (1) DEA is effective: when θ=1, and S+=0, S-=0; (2) DEA is weak: when θ=1, at least one input or output is greater than 0; (3) DEA is ineffective: when θ<1. (Zhang *et al.* 2014)

3.3.2 Data Resource

The MAA-SZ model involves 11 input and 1 output indices while the comparative model involves 4 input and 1 output indices. The data of population, economy and wage rate come from Heilongjiang Province's 2016 Population and Economic Statistics Yearbook; the amount of available land resources and the price of land in Heilongjiang Province come from the Heilongjiang Land and Resources Department's data of 2017; the amount of available water resources in Heilongjiang Province come from Heilongjiang Taxation Bureau's data of 2017. The data about the number of undeveloped development zones in Heilongjiang Province of 2018 was provided by the Ministry of Construction. The data of natural disasters in Heilongjiang Province in 2016 was provided by Heilongjiang Seismological Bureau. Heilongjiang Elevation and Slope Data in 2016 were provided by Heilongjiang Surveying and Mapping Bureau. The Annual environmental capacity and ecosystem vulnerability data of 2016 come from Heilongjiang Forestry Bureau. The input and output evaluation system of the MAA-SZ model and the comparative model is shown in Table 2-3.

Table 2 The Suitability Evaluation System of New Town Spatial Development of the MAA-SZ model (Zhao *et al.* 2019)

First level index	Second level index	Third level index
Input index	Available Land	Area of Available Land
	Population aggregation	Population growth rate
	Economic development level	Economic growth intensity
	Location advantage	Internal location advantage
		External location advantage
	Transportation advantages	Railway stations, expressways and main roads at all levels
		Arterial airport
		Regional airports and ports
	Number of development zones	Number of undeveloped or uncompleted development zones after adjusted by the state or government
	Topography and topography	Altitude
		Slope
	Natural disaster	Risk of floods, droughts, earthquakes and forest fires
	Available water resources	Available water resources per capita
	Environmental capacity	Individual environmental capacity bearing index
	Ecosystem vulnerability	Population density
		Gdp density per capita
		Ratio of construction land
		Cod emission intensity
		Environmental quality index
		Value of ecosystem services
		Water resources per capita
		Net income per-capita
		Proportion of urban population
		Total power consumption of industrial enterprises
		Gdpcod quantity
		Sewage treatment rate
		Government investment in environmental protection
Output index	Suitability utility of urban new town spatial development	

Table 3 Glaeser-Gottlieb model of Suitability Utility Evaluation System for New Town Spatial Development (Glaeser and Gottlieb, 2008)

First level index	Second level index
Input index	Wage rate
	Location advantage
	Population size
	Consumer preferences
Output index	Suitability utility of new town spatial development

3.3.3 Operation Result Analysis

In this study, three kinds of validity of a city in the south of Heilongjiang Province were counted (Fig. 4). First, the second-level input indices of the model and the comparative model were taken as the unit; then, the land with the same evaluation result of the second-level input index of each model was merged into one block unit to ensure that each block had the reasonable evaluation result under the same model. The total research blocks of the MAA-SZ model is 1327, and the total research blocks of the comparative model is 1124. Under C_2R model, the number of DEA valid in the MAA-SZ model is 1115, accounting for 84% of the total; the number of DEA weak valid is 146, accounting for 11% of the total; and the number of DEA invalid is 66, accounting for 5% of the total. The effective number of DEA in the comparative model is 888, accounting for 79% of the total; the weak effective number of DEA is 90, accounting for 8% of the total; and the invalid number of DEA is 146, accounting for 13% of the total. Compared with Glaeser-Gottlieb New Town Location Model, the MAA-SZ model is more effective and less invalid.

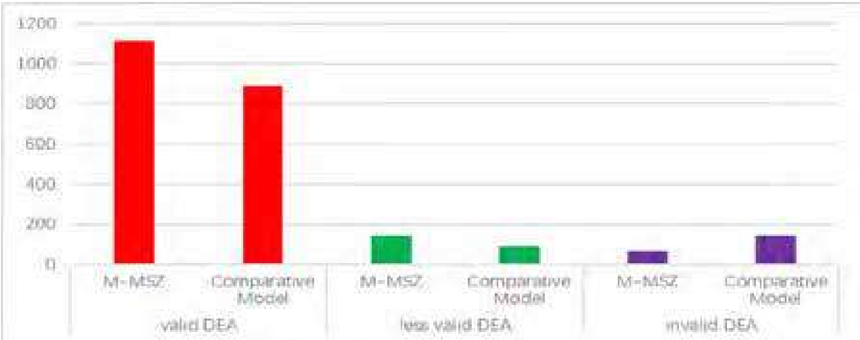


Fig.4 DEA effectiveness of the MAA-SZ model and the Glaeser-Gottlieb model.

4 Conclusions and Discussion

4.1 The kappa value, spatial differentiation and validity of the model and the comparative model

Based on the basic idea of spatial equilibrium theory, this paper applies both the MAA-SZ model and Glaeser-Gottlieb New Town Location Model to the practical application of New Town Location under the restriction of main functions. The validity, superiority and application value of the MAA-SZ model in new town location are judged by comparing the kappa value between models, spatial differentiation and DEA validity analysis.

Compared with Glaeser-Gottlieb model, the consistency kappa value of the MAA-SZ model is 76.1%, which verifies the correctness of the MAA-SZ model. At the same time, because of the determinacy of the model factors and the restriction of the main function area, the MAA-SZ model is more accurate in the new town. Because of the limited function of the main functional area, the model is more macro-balanced. Meanwhile, the consistency kappa value between the MAA-SZ model and the government behavior map is 83.8%, while that of the comparative model and the government behavior is 79.7%, which proves that the model is more consistent with the government intention.

Nonlinear regression analysis shows that the R_2 value of the MAA-SZ model is 0.79 while that of the comparative model is 0.73, which proves that the model is more objective in the process of fitting with the actual situation.

By comparing the spatial differentiation between the MAA-SZ model and Glaeser-Gottlieb new town location model, it is found that the determinant coefficient of the semi-variogram model is 0.89 for the MAA-SZ model while that of the comparative model is 0.82. And the nugget coefficient of the MAA-SZ model is 17.4% while that of the comparative model is 15.0%. From the simulated variation map, the MAA-SZ model has a higher degree of variation, which proves that the spatial differentiation of the MAA-SZ model is higher than that of the comparative model.

The DEA validity of the MAA-SZ model and Glaeser-Gottlieb new town location model were analyzed. It is found that the number of effective DEA accounts for 84% of the total, the number of weak effective DEA accounts for 11% of the total and the number of invalid DEA accounts for 5% of the total for the MAA-SZ model. For the comparative model, the number of effective DEA accounts for 79% of the total, the number of weak effective DEA accounts for 8% of the total and the number of invalid DEA accounts for 13% of the total. It proves that the MAA-SZ model is more effective than Glaeser-Gottlieb model in DEA.

4.2 The Widespread Application of the Model and Its Enlightenment to New Town Location Model

Based on the certainty of factor selection and weight assignment, it is believed that the model has greater application generalization and inheritance, as well as wide application area.

The MAA-SZ model not only enriches the equilibrium theory, but also provides new ideas for the location of new towns. The application results show that the model can effectively and reasonably divide the development, agriculture and ecological space from the macro-equilibrium point of view, and more accurately determine the location of the new town through the development time of the MAA. It promotes the balanced and rational utilization of the macro-direction of urban land. In addition, it also provides scientific basis for the future development direction of urban system.

Generally, compared with the traditional models, the MAA-SZ model show three advantages. Firstly, the MAA-SZ model maintains the objectivity of the existing new town location model, and extends the spatial regionalization equilibrium of the existing new town location model. Briefly, the traditional new town location model advocates the balance from the central city to the new town, while the idea of the MAA-SZ model is the balance of construction, agriculture and ecological land within the city area. Secondly, the MAA-SZ model widens the scope of application of existing new town location selection model. For example, different traditional new town location models were used to meet different requirements of urban structure and morphology, while there is no limitation for the MAA-SZ model. Lastly, the MAA-SZ model facilitates the application of existing new town location model. As we know, some factors of existing new town location model can not be assigned, while the MAA-SZ model reduces the factors that can not be assigned. We believe these improvements will make the model easier to operate and practice.

Acknowledgments: This research is supported by National Natural Science Foundation of China (51578176, 41501173) and Art Science Planning Project of Heilongjiang Province (2014B025). Thanks to all the experts for their constructive comments and helpful suggestions that led to significant improvements to this research.

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