Forecast of the Demand of State-Owned Construction Land of 2021-2035 Based on Multiple Linear Regression Model

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Abstract—Providing a reasonable amount of construction land to match the economic development and urban population expansion is an important responsibility faced by the land administration department. There are relatively few studies that provide long-term holistic quantitative analysis and future exploration of the construction land supply at the national level. In this paper, the screening of indicators is achieved through stepwise regression, and then a mathematical model based on linear regression is constructed. After verification, this model can accurately fit the relationship between the supply of state-owned construction land, the increase of urban population and the GDP growth from 2001 to 2020 in China, and can be used to forecast the scale of state-owned construction land demand from 2021 to 2035. The prediction results reveal that the total state-owned construction land demand from 2021 to 2035 is 8.41 million hectares. By 2035, the annual demand for construction land will be approximately 388,000 hectares, which is 60% of the 2020 supply. The forecast results can be a reference for the state-owned construction land supply plan for the next 15 years.

Keywords - state-owned construction land supply, multiple linear regression model, forecast model, China

1 INTRODUCTION

State-owned construction land is an important carrier of economic development and urban residents' lives, and its supply scale can reflect the macro trend of the national economy and market players' expectations for social and economic development and urban expansion [1]. In the past two decades, China was going through a rapid urbanization process, and a large amount of construction land was supplied to fulfill the requirement of the urban population expansion and economic growth. To study and analyze the changes in the scale of construction land supply at the national level in the past 20 years, as well as the correlation between the

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construction land supply, economic development and urban population changes is of great significance to formulate the plan of construction land supply at the national level every year.

At present, the relevant research on the supply of state-owned construction land mainly focus on the analytical study of the comparison of temporal and spatial characteristics of one type of state-owned construction land in different cities or regions of China, and most studies are concentrated in cities and provinces with a higher level of economic development. Yu et al. revealed the spatial agglomeration and diffusion of commercial land in Beijng [2], Wu revealed the spatial-temporal changes of residential land in Beijing [3], Chen revealed the characteristics and mechanism of construction land expansion in Nanjing [4]. There are also many pieces of research studying the influencing factors of the scale of land supply, but most qualitative studies are focused on the scale of a medium and small area, and very few quantitative studies use mathematical models. Gao et al. studied the urban public service facilities of Guangzhou City during the economic system transformation [5], Zhang et al. revealed the evolution pattern and mechanism of public service facilities land in Changchun [6]. There are relatively few studies that provide a macro perspective, long-term holistic quantitative analysis and future exploration of the construction land supply at the national level.

In this paper, we first revealed the spatial-temporal characteristics from 2001 to 2020 at the national level. Then a multiple linear regression model was built to simulate the coupling relationship among the supply of state-owned construction land, the increase of urban population and the GDP growth in the past 20 years. The reliability and accuracy of this model were verified. Actually, the state-owned construction land supply scale in the past years reflected the actual transaction scale, i.e. the demand of the market, therefore we can use this model to predict the future demand of the state-owned construction land. Hence, this model was used to predict the demand for nationwide construction land from 2021 to 2035 based on the GDP growth and urban population growth predicted by relevant government agencies. The prediction results could provide a reference for the future nationwide plan of construction land supply from 2021 to 2035. The prediction results show that the total state-owned construction land demand from 2021-2035 is 8.41 million hectares, with an average annual demand of 561,000 hectares. The average annual demand is fluctuating and decreasing year by year, with an average annual decrease of 3.9% per year. By 2035, the annual demand for construction land will be approximately 388,000 hectares, which is 60% of the 2020 supply.

2 MATERIALS AND METHODS

2.1 Data Sources and Processing

In order to build a proper model for the state-owned construction land supply scale, several variables from 2000 to 2020 are chosen, including the state-owned construction land supply, GDP, GDP index, GDP growth rate, permanent residential population, permanent residence population growth rate, urban population and urban population growth rate. All the parameters are the yearly values of the country. The national urban population data, the GDP, GDP index and GDP growth rate data from 2001 to 2020 is obtained from the National Bureau of Statistics of China. The state-owned construction land supply scale data from 2001 to 2019 is from China Land and Resources Statistical Yearbook, and the state-owned construction land supply data of 2020 is from China Statistical Report on Natural Resources (Fast Annual Report).

2.2 Research Methods

In order to reduce the volatility of each indicator, natural logarithmic transformation (ln) is performed on each indicator before modeling. As there are several independent variable indicators, the screening of indicators is achieved through stepwise regression.

Since multiple col-linearity occurs a lot between macroeconomic data, usually in modelling econometrics, we pay most attention to the significance of independent variables and the overall fitting effect of the model [6]. Many attempts are made by analyzing the correlation between many variables and the supply of construction land.

Finally, four independent variables including GDP, urban population, urban population growth, and GDP index are selected. The following multiple linear regression model is established:

$$\ln y = -171.7 + 6.6\ln(gdp) + 18.8\ln(cp) + 0.9\ln(deltcp) - 15.2\ln(gdpix) \quad (1)$$

where y is the demand of state-owned construction land of the year, *gdp* is the Gross Domestic Product of the year, *cp* is the urban population of the year, *deltcp* is the urban population growth rate of the year, and *gdpix* is the GDP index of the year.

The respective variables are tested to be significant at the 5% significance level, except that ln(deltcp) is significant at the 10% significance level. The coefficient of determination R^2 of the model reaches 0.89, and the fitting effect is at a good level.

The rationality of the model selection is further tested and explained. If we tried to exclude the multi-col-linearity in the model, then only ln(gdp) remain in the model, and the coefficient of determination is only 0.81, which is no better than the overall fitting effect of equation (1) and with only one parameter. Therefore, from the perspective of selecting effective independent variables and achieving the accuracy of prediction, equation (1) remains the best choice.

2.3 Model Accuracy Verification

To verify the accuracy of the state-owned construction land demand scale model built in section II.B, the predicted demand of the state-owned construction land was compared with the actual supplied scale from 2001 to 2020 in Table 1 in column 6 and column 7, and the absolute value of error rate was calculated in column 8. As shown in Table 1 column 8, average error rate of the model is 12%, indicating that the model has a good fitting effect. Therefore, the model is verified and can be used to predict future demand for construction land.

Table 1 Comparison of prediction and actual value of state-owned construction land supply from 2001 to 2020

Year	Urban population (ten thousand people)	Urban population growth (ten thousand people)	GDP (index) growth rate	GDP (trillion yuan)	Supply of construction land (ten thousand hectares)	Forecast value of construction land demand (ten thousand hectares)	Absolute value of error rate
2001	48064	2158	8.30%	11.1	17.9	18.7	4.50%
2002	50212	2148	9.10%	12.2	23.5	20.8	11.80%
2003	52376	2164	10.00%	13.7	28.6	24.1	16.00%
2004	54283	1907	10.10%	16.2	25.8	28.7	11.10%
2005	56212	1929	11.40%	18.7	24.4	28.4	16.30%

2006	58288	2076	12.70%	21.9	30.7	27.6	9.90%
2007	60633	2345	14.20%	27	34.2	33.7	1.50%
2008	62403	1770	9.70%	31.9	23.4	33.5	43.00%
2009	64512	2109	9.40%	34.9	36.2	33.3	7.90%
2010	66978	2466	10.60%	41.2	43.3	50.4	16.40%
2011	69079	2101	9.60%	48.8	59.3	59.5	0.30%
2012	71182	2103	7.90%	53.9	71.1	63.6	10.60%
2013	73111	1929	7.80%	59.3	75.1	58.9	21.50%
2014	74916	1805	7.40%	64.4	64.8	50.8	21.60%
2015	77116	2200	7.00%	68.9	54	58.1	7.50%
2016	79298	2182	6.80%	74.6	53.1	60.4	13.80%
2017	81347	2049	6.90%	83.2	62	68.1	9.90%
2018	83137	1790	6.80%	91.9	64.3	65.1	1.30%
2019	84843	1706	5.90%	98.7	62.4	60.5	3.00%
2020	90199	5356	2.30%	101.6	65.6	449.9	abnormal

3 RESULTS AND ANALYSES

3.1 The spatial-temporal characteristics of the state-owned construction land supply from 2001 to 2020 in China

1) From 2001 to 2020, the supply of state-owned construction land across the country showed an overall growth trend, but the growth rate declined in the past five years.

From 2001 to 2020, the total supply of state-owned construction land is 9.20 million hectares, with an annual average of 46 million hectares (Figure 1). During the Tenth Five-Year Plan (2001-2005), Eleventh Five-Year Plan (2006-2010), Twelfth Five-Year Plan (2011-2015) and Thirteenth Five-Year Plan (2016-2020) period, the supply of construction land were 240.5, 335.4, 648.7 and 614.8 thousand hectares per year. The largest increase in supply happened in 2011, and the largest decline happened in 2008. The peak supply appeared in 2013, at 766,000 hectares, but it's still at a very high supply level in the recent five years.

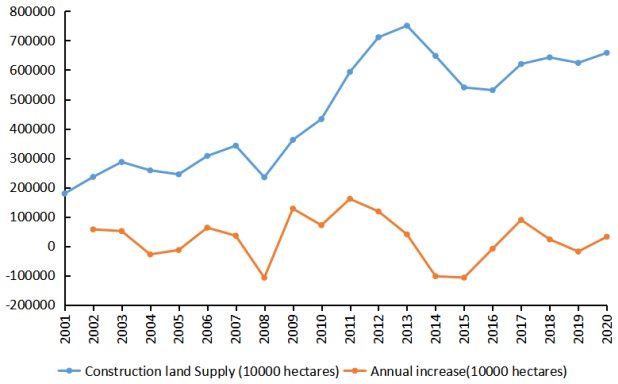

Figure 1 the state-owned construction land supply scale and annual increase from 2001 to 2020

2) The growth rate of construction land supply, GDP and urban population showed a trend of

rising at first and declining afterwards. After the "Twelfth Five-Year Plan (2011- 2015)", the growth rate of construction land supply declined faster than population and GDP.

From year 2001 to 2020, China's GDP grows from 11.1 trillion yuan to 101.6 trillion yuan, with an average annual GDP growth rate of 8.7% (Table 2, Figure 2) (calculated at constant GDP prices); the total population increase from 1.28 billion to 1.40 billion, with an average annual growth rate 0.5%; the urban population increase from 4.81 billion to 9.02 billion, with an average annual growth rate 3.4%; the annual supply of state-owned construction land is 460,000 hectares, with an average annual growth rate of 9%.

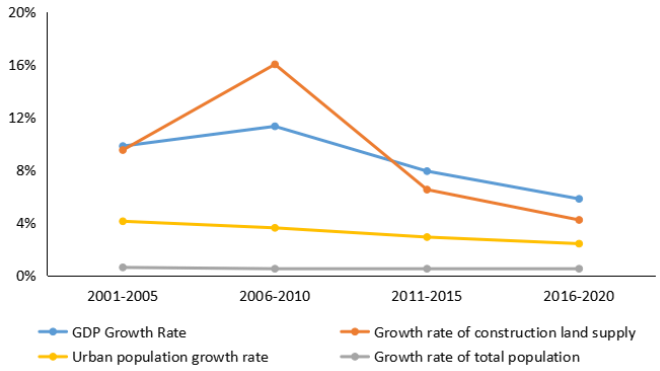

Figure 2 Growth rate of population, urban population, GDP, and construction land supply from 2001 to 2020 in five year average

From the point of GDP turnover point of view, the GDP of 2008 doubled the GDP of 2001, and the state-owned construction land supply scale was 2.086 million hectares from 2001 to 2008. Then, the GDP of the country doubled again from 2009 to 2017, and the state-owned construction land supply was 5.189 million hectares, which is two times more than the scale from 2001 to 2008.

Table 2 Growth rate of GDP, population and construction land supply from 2001 to 2020

	GDP Growth Rate	**Growth rate of construction land supply**	**Growth rate of total population**	**Urban population growth rate**
2001-2005	9.80%	9.50%	0.60%	4.10%
2006-2010	11.30%	16%	0.50%	3.60%
2011-2015	7.90%	6.50%	0.50%	2.90%
2016-2020	5.80%	4.20%	0.50%	2.40%
2001-2020 Average	8.7%	9.0%	0.5%	3.4%

3) From the perspective of spatial distribution, the supply of construction land is mainly concentrated in provincial capital cities and key cities of the four major urban agglomerations, and the center of land supply has generally moved westward.

From the perspective of urban agglomerations, the construction land supply of 19 urban agglomerations [8] from 2001 to 2020 accounted for 77.6% of the country's total (Figure 3). Among them, Yangtze River Delta (14.8%), the middle reaches of the Yangtze River (9.9%), Central Plains (7.9%), and Shandong Peninsula (7.7%)) and other urban agglomerations account for a relatively high proportion.

From the perspective of single cities, Chongqing (208,000 hectares), Shanghai (123,000 hectares), Tianjin (121,000 hectares), Hangzhou (103,000 hectares), Chengdu (102,000 hectares), and Suzhou (98,000 hectares) have the largest land supply than other cities.

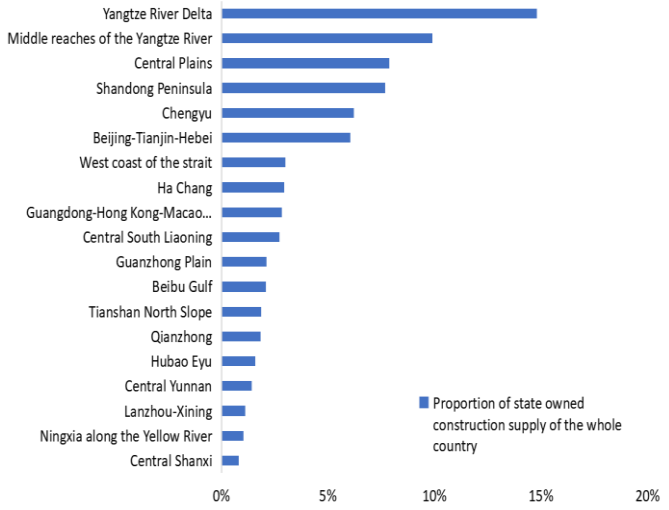

Figure 3 The proportion of the state-owned construction land supply in 19 urban agglomerations from 2001 to 2020

3.2 Forecast of the scale of state-owned construction land demand from 2021 to 2035

In order to use the above regression model built in session II. B to predict the annual construction land supply area from 2021 to 2035, it is necessary to obtain the values of GDP, GDP index, total urban population, and urban population growth from 2021 to 2035. The method of obtaining these values is as follows:

The GDP and GDP growth rate: according to the 'Recommendations of the Central Committee of the Communist Party of China on Formulating the Fourteenth Five-Year Plan for National Economic and Social Development and the 2035 Long-Term Goals', to double the total economic output by 2035, the average GDP (change price) annual growth rate needs to reach 4.73% [9]. Calculated by linear regression, the average annual growth rate of GDP (index) is 3.84%. And hence GDP index of 2021-2035 can be calculated (Table 3).

The urban population and urban population growth rate: according to the forecast results of China's Population and Development Research Center on China's population development trends from 2020 to 2050 [10], urban population (the urbanization rate) will reach 0.94 billion people (66.2%), 1.01 billion people (71.1%), and 1.06 billion people (75.5%) in 2025, 2030 and 2035, respectively.

Substituting the above four independent variable values into the state-owned construction land demand scale model, the value of the state-owned construction land supply from 2021 to 2035 is predicted, as shown in TABLE 3.

According to the forecast results (Table 3), the total state-owned construction land that needs to be supplied from 2021 to 2035 is 8.41 million hectares, and the average annual demand is 561,000 hectares. The average annual demand shows a fluctuating downward trend, with an average annual decrease of 3.9%. In year 2035, the annual demand for construction land is about 388,000 hectares, which is 60% of the 2020 supply.

Table 3 Predicted value of the state-owned construction land demand from 2021 to 2035

Year	Urban population (ten thousand people)	Urban population growth (ten thousand people)	GDP (index) growth rate	GDP (trillion yuan)	Forecast value of annual demand for construction land (ten thousand hectares)
2021	90903	704	3.80%	106.4	**65.7**
2022	91608	705	3.80%	111.4	**58.1**
2023	92313	705	3.80%	116.6	**51.3**
2024	93019	706	3.80%	122.1	**45.3**
2025	94004	985	3.80%	127.8	**56.7**
2026	95325	1321	3.80%	133.8	**73**
2027	96645	1321	3.80%	140.1	**72.2**
2028	97966	1321	3.80%	146.7	**71.2**
2029	99286	1321	3.80%	153.6	**70**
2030	100253	966	3.80%	160.8	**48.6**
2031	101210	957	3.80%	168.4	**44**
2032	102521	1311	3.80%	176.3	**56.7**
2033	103611	1090	3.80%	184.6	**44.8**
2034	104771	1159	3.80%	193.3	**44.6**
2035	105851	1080	3.80%	202.3	**38.8**

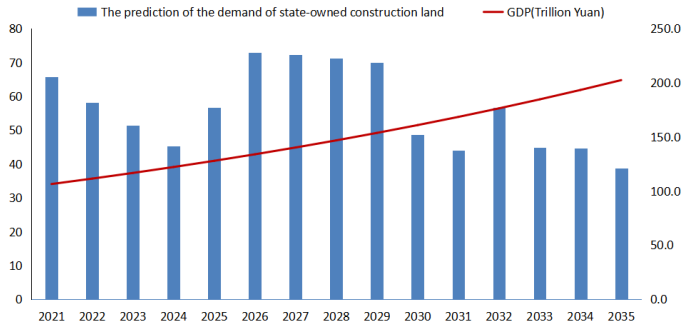

Figure 4 The prediction of the demand of state-owned construction land and the GDP values from 2021 to 2035

4 CONCLUSIONS AND DISCUSSIONS

The supply of state-owned construction land across the country has shown an overall growth trend, and has declined after reaching its peak in 2013, but it is still at a high level. The growth rate of construction land supply, GDP and urban population showed a trend of at first rising and then falling. After the "Twelfth Five-Year Plan (2011- 2015)", the growth rate of construction land supply is faster than population and GDP. From the perspective of urban agglomerations, the construction land supply of 19 urban agglomerations from 2001 to 2020 accounted for 77.6% of the country's total.

A multiple linear regression model was built to simulate the coupling relationship among the supply of state-owned construction land, the increase of urban population and the GDP growth in the past 20 years. The reliability and accuracy of this model were verified.

The state-owned construction land supply demand from 2021 to 2035 is predicted with this model. According to the prediction results of the model, in the next 15 years, the total demand for construction land across the country will be about 8.41 million hectares, and the annual demand will fluctuate and decline, with an average annual decline of 3.9%. Taking into account the increasingly stringent requirements for the conservation and intensive use of land resources in the context of ecological civilization and high-quality development, in the future, it is necessary to increase the potential of stock land, digest unused and idle land, and reduce the supply of new construction land.

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