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Dynamic Analysis of the Growth of Building Area and the Immigrant Population in Shanghai based on the PVAR Model

Zijing Zhou

Shanghai Maritime University, Shanghai 200000, China

Abstract

Since the reform and opening up more than 30 years ago, Shanghai has witnessed rapid development of economic and continuous acceleration of urbanization and continuous growth of building area. However, the number of migrants has decreased over the same period, which is inconsistent with previous studies that show that population affects land demand and floor space. In this paper, panel data of each district of Shanghai from 2014 to 2018 are selected and the panel vector autoregression model (PVAR model) is constructed to analyze the dynamic relationship between the building area growth of each district of Shanghai, the immigrant population and the economic growth. The results show that : (a)There is no long-term equilibrium relationship between the growth of Shanghai's floor area and the migration of foreign population. (b) The construction area growth in Shanghai can affect the regional GDP growth to a certain extent. (c) The migration of migrants into Shanghai has a certain effect on the economic growth of Shanghai.

Keywords

PVAR model,Building area, Migration of migrants, Economic growth.

1. Introduction

As for urban construction and building area growth, scholars generally hold the view that population inflow can boost urban economy. Housing and employment needs brought by population inflow can promote the growth of urban residential buildings and non-residential buildings (commercial buildings, industrial buildings, public buildings, etc.). However, by observing the growth of floor area in each district of Shanghai and the inflow of migrant population in the past five years, it can be intuitively found that when the change of population inflow was not big, the overall growth rate of floor area share in Shanghai kept an average of 4.37%. Moreover, while the number of migrants in Shanghai ranks among the top in China, the newly released Shanghai Urban Planning (2017-2035) clearly states that construction land should be strictly controlled and some regional planning should reduce the amount of construction land. Direct observation shows that the population inflow in Shanghai has no obvious influence on the construction area of Shanghai, which is inconsistent with the general economic logic. Therefore, this paper establishes the panel vector autoregression model to study whether there is a dynamic equilibrium relationship between the growth of building area and population migration in Shanghai. This paper puts forward the hypothesis that the growth of building area in Shanghai may not be explained simply by using the past theory.

2. Status Quo of Shanghai City

2.1. Construction Status in Shanghai

Shanghai is one of the municipalities directly under the Central Government in China, the core city of the world-class city cluster in the Yangtze River Delta, and an international economic, financial, trade, shipping, scientific and technological innovation center and cultural metropolis.

In the process of planning and layout of Shanghai, urban planning and architectural planning are particularly important for the sustainable development of a city. As a prosperous and open city, it attracts migrants from all over China, and the demand for housing ,industry and commerce further stimulates the growth of Shanghai's floor area.

Table 1: Changes in the proportion of total building area in Shanghai

District	Proportion of total construction area in district administrative area (%)					Average growth rate
	2014	2015	2016	2017	2018	
Shanghai	18.19	18.99	20.14	20.80	21.59	4.37%
Pudong new area	21.87	22.73	24.12	25.12	25.98	4.40%
Huangpu district	181.72	181.28	183.63	185.92	184.70	0.41%
Xuhui district	108.16	110.59	113.37	114.76	116.62	1.90%
Changning district	103.68	105.12	108.30	109.30	111.02	1.72%
Jing'an district	150.01	150.32	154.34	158.03	159.19	1.57%
Putuo district	106.07	107.79	109.52	109.89	113.04	1.60%
Hongkou district	151.02	150.17	155.03	157.45	157.24	1.01%
Yangpu district	94.06	95.80	97.89	98.32	100.02	1.55%
Minhang district	34.90	36.18	38.56	39.80	41.28	4.28%
Baoshan district	33.86	35.10	37.26	38.10	39.28	3.78%
Jiading district,	15.95	17.29	19.13	20.11	21.30	7.49%
Jinshan district	6.84	7.37	8.20	8.57	9.03	7.18%
Songjiang district	14.73	15.59	16.72	17.53	18.37	5.67%
Qingpu district	7.81	8.49	9.51	9.93	10.79	8.40%
Fengxian district	7.39	8.02	8.89	9.35	10.10	8.12%
Chongming district	1.60	2.00	2.06	2.17	2.32	9.82%

According to the data of 2018, there is still some room for growth in Shanghai's floor space. Huangpu District has the highest ratio of building area to district administrative area. It can be seen that the building density in Huangpu District is higher and the building distribution is denser than that in other districts, with more high-rise buildings. Jing 'an District and Hongkou District followed, and Xuhui District, Putuo District, Changning District and Yangpu District had more than 100% of the building area and their administrative area. These districts also had high building density and were housing intensive areas in urban planning. In addition, Compared with the above districts, Minhang District and Baoshan District have a large gap in the proportion of floor area and administrative area, whose value is only about 40%. While pudong New Area's building area ratio of 25.98% is slightly higher than the city's average of 21.59%, but it is also far lower than the building density of other districts mentioned above. In addition, the ratio of building area and administrative area of Jiading District, Songjiang District, Fengxian District, Qingpu District, Jinshan District and Chongming District is lower than the average level of the whole city, indicating that these districts have great potential in urban construction land planning and building area growth in the future.

The proportion of floor space in all districts of Shanghai is steadily increasing, and the overall average growth rate of the proportion of building space in Shanghai is also 4.37%. The average

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growth rate of Jiading District, Jinshan District, Songjiang District, Qingpu District, Fengxian District, Chongming District and Pudong New Area over the past five years is higher than the overall level of Shanghai, indicating that the building area expansion rate of the above areas is faster than that of other areas.

2.2. Migrant Population in Shanghai

Table 2: Number of migrants in All Districts of Shanghai

District	2014	2015	2016	2017	2018
Pudong new area	235.65	234.32	234.19	235.09	235.84
Huangpu district	128.60	127.26	127.04	124.59	125
Xuhui district	109.08	108.58	108.11	105.95	106.11
Changning district	60.81	59.93	60.09	57.94	57.68
Jing'an district	18.08	16.52	16.66	16.63	17.43
Putuo district	28.55	26.82	26.75	26.98	26.7
Hongkou district	17.41	16.71	16.75	17.48	17.7
Yangpu district	26.92	26.1	26.08	26.68	26.88
Minhang district	34.75	34.35	33.41	33.8	33.98
Baoshan district	18.22	15.65	15.52	15.37	15.26
Jiading district	26.75	26.09	25.92	26.86	27.33
Jinshan district	85.56	84.57	84.46	83.47	83.71
Songjiang district	91.40	90.79	90.68	89.9	90.18
Qingpu district	26.96	27.34	27.55	27	27.22
Fengxian district	72.49	72.05	72.22	70.75	71.27
Chongming district	15.19	14.57	14.77	14.19	13.92

According to the data in the above table, from 2014 to 2018, the increasing trend of resident alien population in all districts of Shanghai is not obvious, and the resident alien population in Songjiang, Fengxian, Huangpu, Xuhui, Jing 'an, Hongkou, Baoshan, Jiading and Qingpu Chongming have a trend of fluctuation in five years. Compared with other districts, the administrative area is larger, and the number of permanent resident population is larger.

According to public data, the resident population of Shanghai in 2018 was 24.2378 million, an increase of 54,500 over the previous year. Among them, there are 14.475,800 permanent residents with permanent residence and 9.762,100 permanent residents from outside, accounting for 40 percent of Shanghai's total population.

3. Empirical Analysis of PVAR Model

3.1. Panel Data Model Setting and Variable Selection

This paper aims to explore the dynamic relationship between the growth of building area and population migration in each district of Shanghai. Considering the small number of population migration in the urban districts, it is not taken as a variable in the model and only focuses on the population moving in from outside Shanghai. In order to avoid the error of omission of variables in the model, gross domestic product (GDP) of each district in Shanghai was included as a variable in the model. The above data are from Shanghai Statistical Yearbook and statistical yearbooks of various regions, covering the period of 2014-2018.

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In this paper, a panel vector autoregression model is used to analyze the dynamic relationship between the growth of building area and population migration in Shanghai. Compared with the common vector autoregression model, PVAR comprehensively considers the advantages of panel data model and time series model. The influence of the impact of one endogenous variable on other endogenous variables is analyzed. Because it introduces individual time and time effect variables, individual difference and common impact of different sections can be obtained. At the same time, PVAR reduces the length requirement of time series.

The gross product of each district in Shanghai was defined as lnGDP after taking the logarithm, and the floor area and the number of immigrants in each district in Shanghai were defined as lnFA and lnNOI respectively after taking the logarithm. The PVAR model can be expressed as:

$$y_{it} = \alpha_i + \beta_0 + \sum_{j=1}^{p} \beta_j y_{i,t-j} + y_{i,t} + u_{i,t} \tag{1}$$

Where, y_{it} is a column vector containing three variables {lnFA,lnNOI, lnGDP}, I represents each region of Shanghai, T represents year, and P represents the lag order of the model. At the same time, considering the regional heterogeneity of coastal areas, the column variable α_i, which represents the fixed effect of human representative area, is introduced into the model to represent the location, natural conditions and various regional related factors that may be missed. $y_{i,t}$ represents the time effect and is used to explain the time characteristics of the variable. β_0 is the intercept vector, β_j is the parameter matrix of the lag variable, and $u_{i,t}$ is the random disturbance term.

3.2. Determination of Optimal Lag Order

In order to estimate the PVAR model composed of three variables, namely, building area growth, population migration and GDP growth, it is necessary to determine the optimal order of the model. There are three information criterion to determine the optimal lag order, namely, Akaike Information Criterion, Bayesian Information Criterions and Hannan - Quinn Criterion. The method to judge the optimal lag order is to choose the AIC, BIC or HQIC model with the lowest value. However, if the three results are not consistent, the models used by each of the above information criteria need to be considered. BIC/HQIC tends to be simpler with fewer variables, while AIC tends to be more variable, but BIC/HQIC is generally better than AIC. According to the results in the following table, the optimal lag order of this model is order 1.

Table 3: Determination of optimal lag order

lag	AIC	BIC	HQIC
1	-8.41526*	-6.19321*	-7.57554*
2	-8.10488	-5.0818	-7.10282

3.3. Unit Root Test and Stability Analysis of Panel Data

Before the regression of PVAR model, it is necessary to check whether the variables in each region are stable. Therefore, this paper uses Stata to conduct ADF test on the panel data.

Table 4: Stability test of PVAR model

Eigenvalue		Modulus
Real	Imaginary	Modulus
0.8601824	0.0239151	0.8605148
0.8601824	0.0239151	0.8605148
0.2681246	0	0.2681246

According to the above table, the moduli of all characteristic roots are less than 1, so it can be concluded that the PVAR model is stable, which lays a foundation for impulse response and variance decomposition. The following figure makes it more intuitive to observe that all points representing characteristic roots fall within the unit circle, which also indicates that the panel data selected in this paper is stable.

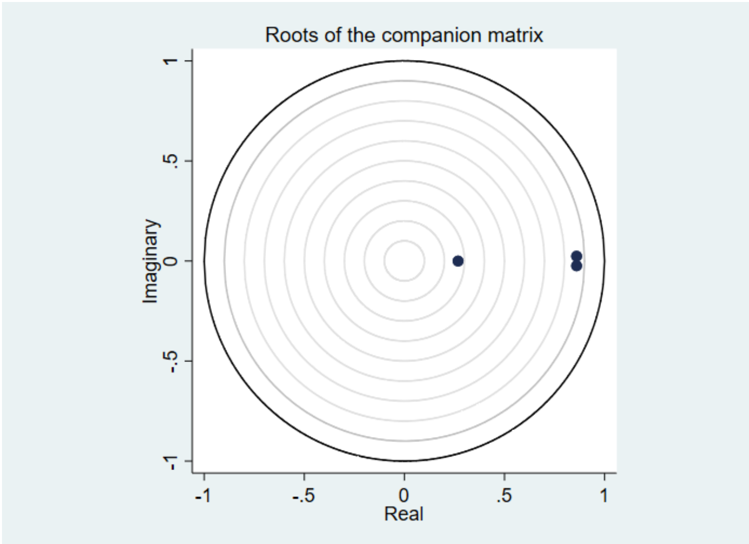

Figure 1: Stability test of PVAR model

3.4. Estimation of the PVAR Model

In this paper, the above PVAR model is estimated by sys-GMM moment with the first order of lag, so as to preliminarily judge the regression relationship among various variables. This paper uses 'Helmert conversion' to eliminate the individual effects, which ensures the lag and the transformed variables orthogonal, to make lag variables as a tool to estimate. The regression estimates are shown in the table below, where H_ * indicates the variable has been Helmert converted and Lh_* indicates the h_* lag phase. The regression results are shown in the table below.

Table 5: Estimation of the PVAR model

Lag of variables	h_lnFA	h_lnNOI	h_lnGDP
lh_lnFA	.5620659***	.4848965	.1677466
lh_lnNOI	.0007129	.2170963	-.0164959
lh_lnGDP	.0073214	.1767163	.5300583***

The relationship between variables can be preliminarily obtained from the above table. When taking the growth of building area of each district as a reaction variable, the change of the immigrant population with a lag of one period and the influence of economic growth on it are positive, but the influence coefficient is very small, and the estimated result of the coefficient is not significant. Only the growth of building area lagged behind by one stage had a significant positive effect on it, with a dynamic impact coefficient of 0.56, which was significant at 1% level. When the change of the immigrant population is taken as a response variable, the dynamic influence coefficient of the building area growth lagging behind one stage is 0.485, but the estimated result is not significant. Economic growth has a positive effect on the immigrant population, but the estimated coefficient is still not significant. When economic growth is taken

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as a response variable, the impact of immigration on economic growth is negative, but the effect is weak and the result is not significant. The building area growth has a weak and insignificant effect on the positive dynamic of economic growth. Only the change of GDP itself with a lag of one stage has a significant positive effect on it, and the dynamic influence coefficient is 0.53, which is significant at 1% level.

3.5. Impulse Response Analysis

Impulse response function can describe the dynamic action between variables directly and judge the time-delay relation between variables from the dynamic reaction. In this paper, the pulse response function is obtained by using monte Carlo method to simulate 1000 times, as shown in the figure below. On this basis, a 95% confidence interval is given. The horizontal axis of the figure below represents the number of response periods (years) of impact reaction, and the number of lag periods is 10. The vertical axis represents the response degree of endogenous variables to shocks. The middle curve represents the response function curve, and the outer two curves represent the confidence interval of twice the standard deviation.

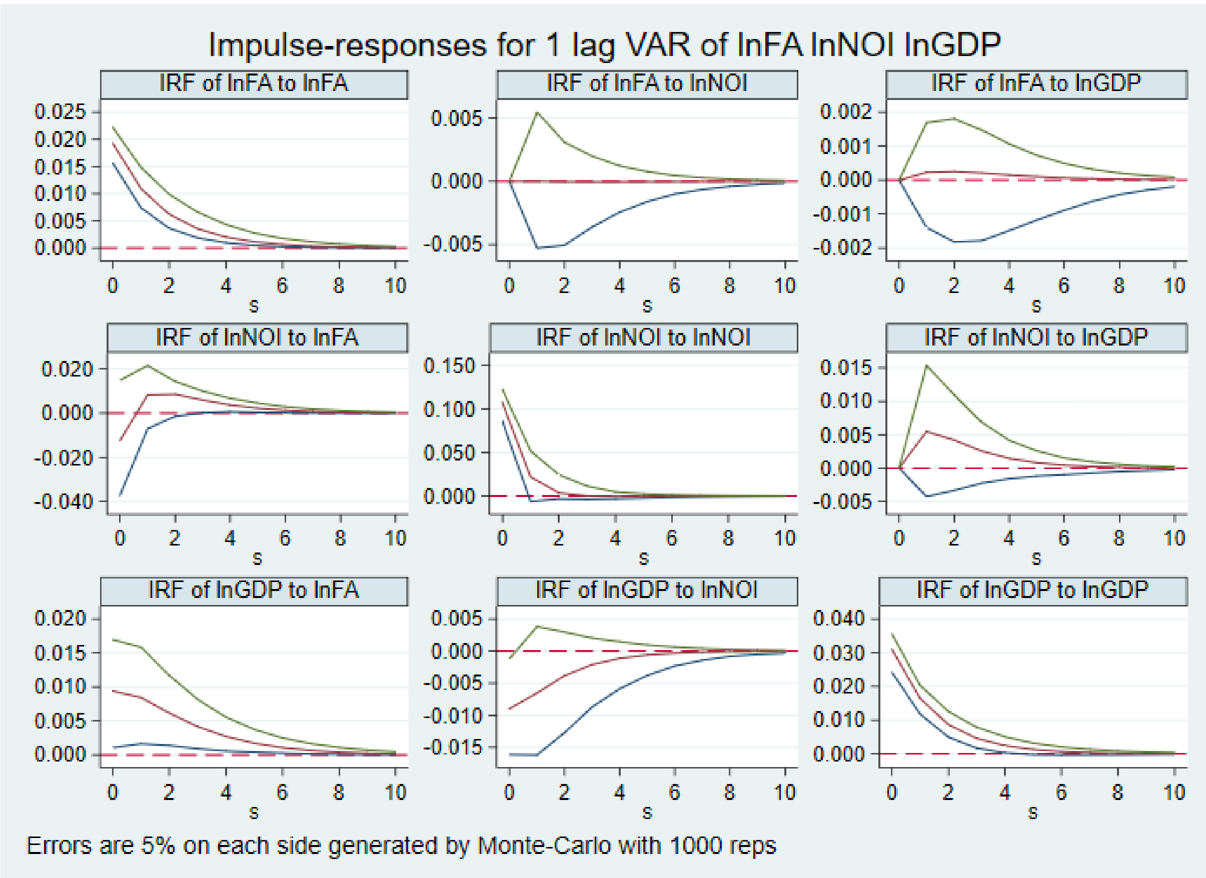

Figure 2: PVAR model impulse response function

As shown in the figure above, the impact of one standard deviation on the growth of the incoming population in each district will initially have a very weak negative impact on the growth of the building area in each district. In the second phase, the impact of the incoming migrant population will have a positive impact on the growth of the building area, and the impact will be maximized at this time. From the third phase to the tenth phase, the impact of the impact on the growth of the building area of the migrant population gradually decreases and approaches 0. It can be seen from this that there is no long-term equilibrium relationship

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between the migration of the migrants and the growth of the floor area of each district in Shanghai.

Giving a standard deviation shock to economic growth, the growth of district floor area will have a slight positive response. This positive response is maximized at the beginning, and gradually approaches 0 at the end. This shows that economic growth has a rather small impact on the growth of district floor area in the current period.

The immigrants have no correlation with the changes caused by the impact on the growth of building area in each district. Therefore, it can be concluded that the growth of building area is not the relevant reason for attracting the immigrants to settle in Shanghai.

However, the change of migrant population after being impacted by one standard deviation has a slight positive influence on the GDP growth of Shanghai districts in the initial stage. The response also tends to be 0 over the following periods. This shows that the migration of migrants has a rather small impact on the current GDP growth of Shanghai districts. Similarly, it can be observed from the impulse response graph that the impact of the growth of floor area on the GDP growth of all districts in Shanghai is the current period, and the impact is relatively slight.

To sum up, in the process of exploring the reasons affecting the growth of building area in each district of Shanghai, only the GDP growth of each district has a dynamic relationship with it.

3.6. Variance Decomposition

On the basis of impulse response, variance decomposition can further obtain the variance contribution rate of impulse response of different PVAR equations to the fluctuation of variables. The influence of endogenous variables in the above PVAR model can be described more clearly. The following table shows the variance decomposition results of the 1st, 5th and 10th prediction phases.

Table 6: Variance decomposition of PVAR model

The response variables	Forecast period	lnFA	lnNOI	lnGDP
lnFA	1	1.000	0.000	0.000
	5	1.000	0.000	0.000
	10	1.000	0.000	0.000
lnNOI	1	0.013	0.987	0.000
	5	0.028	0.968	0.005
	10	0.029	0.967	0.005
lnGDP	1	0.078	0.072	0.850
	5	0.131	0.085	0.784
	10	0.133	0.085	0.782

First of all, by comparing the three prediction periods, there is no significant difference in the impact rate of each variable. It shows that the system of PVAR model has been basically stable after 10 forecasting periods. In the process of variance decomposition, it is found that the growth and change of floor area in each district of Shanghai are mainly influenced by itself, while the number of immigrants and economic growth have no influence on it. In addition, the increase of immigrants is also mainly related to its own growth, and is affected to a certain extent by the growth of building area in all districts of Shanghai, with an influence rate of 3%. The influence of economic growth on immigrants is negligible. As for the economic growth of all districts in Shanghai, it is mainly related to their previous growth, and also affected by the growth of floor area to a certain extent, with an influence rate of 13.3% and an influence rate of 8.5% by the increase of immigrants. This shows that the growth of building area in each district can promote the economic growth of each district to a certain extent, and the migration of foreign population as labor force can also promote the GDP growth of each district.

4. Conclusion

Based on the empirical analysis above, it can be observed that there is no long-term equilibrium relationship between the growth of building area in each district and the migration of foreign population, which is consistent with the results shown by intuitive statistical data. Therefore, in the process of considering urban expansion and building planning, other important factors besides the migration of the population need to be considered. Based on the empirical results of Shanghai's 2035 plan, it is not difficult to find that the growth of floor area is subject to more constraints. For the mega cities such as Shanghai, it has reached the stage of transformation of development mode. In terms of urban planning and building construction, ecological environment requirements should be regarded as the bottom line and red line of urban development. We will make clear the total amount and structure of land used for urban construction, encourage and guide the economical and intensive use of land for all urban construction projects, increase the potential exploitation of land used for existing construction projects, and promote the appropriate mix of land use functions, so as to realize the negative growth of the total amount of land used for planned construction projects and comprehensively improve land use efficiency. Intensive control of building area growth can promote the economic development of all districts in Shanghai on the basis of protecting resources and environment.

The inflow of migrants into Shanghai can promote the GDP growth of all districts and the whole of Shanghai to a certain extent. In the process of Shanghai's development, attention should be paid to the inflow of migrants. Some problems of Shanghai's current population situation need to be concerned. Such as the talent gathering advantage of the migrant population is not obvious, so it is difficult to meet the requirements of Shanghai's economic transformation and development. At present, the population density in the central city is so high and the population in the parish new town is slow, which will lead to the imbalance of people and land, and the effect of population migration on economic development will be weakened. Therefore, Shanghai should promote the optimization of population structure, adjust population distribution with appropriate population density, and actively respond to population distribution.

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