VAR dynamic analysis of the impact of population structure on urban residential land price: the case of Zhengzhou

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Abstract

Based on the vector autoregression model, this paper focuses on Zhengzhou and uses the 1994–2013 population structural variables and relevant data on commercial and residential land price to analyze the dynamic relationship between population structure and residential land price through impulse response function and variance decomposition. Results show a co-integration between Zhengzhou residential land price and three variables, namely, urbanization rate, per capita disposable income, and household size. The short-term variation in land price is mainly caused by the residential land price itself, and the three population substructural variables show long-term effects on the land price with a certain time lag. Among these variables, per capita disposable income has the shortest positive effect on residential land price, whereas urbanization rate has the longest and most remarkable positive effect.

Keywords: population, land price, VAR model, Zhengzhou

1 Introduction

All sectors of society have expressed great concern about the increasing land price in large and medium-sized cities of China. In recent years, scholars have attempted to explain the increase from different angles, such as economic growth, social policy, monetary supply, speculative demand and motivation, and housing price. Population is an intrinsic factor that influences housing demand and is less vulnerable to business cycles than other factors, and thus it is more likely to influence housing and land price. However, the influence of population structure on the variation of residential land price has not been studied enough.

Foreign scholars have studied the relationship between population structural variable and housing price and arrived at varied findings. For instance, David [1] examined the Dutch commercial housing price from the aspect of household disposable income and found that disposable income is positively related to and significantly affects housing price. Wolfgang Maennig [2] studied the relationship between the population fluctuation of 98 major German cities and housing price and suggested that population decline in large cities exerts a more significant effect on housing price than population growth. Vansteenkiste and Hiebert [3] studied seven European countries using the vector autoregression (VAR) model to determine the relationship between real per capita income and housing price and found that real per capita income contributes to the rise of real housing price. Ramesh Kumar Jain [4] examined relevant data on major Indian cities and found that the deepening urbanization and urban population accretion promote local economic development and increase regional housing price. Bischoff and Oliver [5] studied the regional difference in the relationship between housing price and income in Germany and found a positive interactive effect between income and housing price. Based on these studies, population development is the most important factor that causes the disparity between housing price and income in all regions.

Most of the literature published by Chinese scholars about the relationship between population and housing price focus on the influence on housing price caused by four factors: population age structure, per capita disposable income, urbanization, and population migration. The consistently drawn conclusion is that per capita disposable income, which signifies a lower correlation index than other influencing factors, is not the primary factor affecting housing price; rather, the ongoing process of urbanization improves urban housing demand and subsequently leads to the fluctuation of housing price. Ha Jiming [6] showed that urbanization and changes in population structure promote economic growth and affect housing price, and that population structure directly affects housing price. Wu Tao [7] demonstrated that gross domestic product and per capita disposable income indirectly affect housing price by influencing CPI. Kuang Weida [8] showed that cities with a higher population growth rate exhibit more volatile housing prices than cities with a relatively small population. Xue Liwei et al. [9] analyzed the data on Beijing, Wuhan, and Xi'an and found a positive correlation between population structural

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variables and housing price income. Guo Jian[10] analyzed the influence of the urbanization of the Jiangsu population on commercial housing price and concluded that the extent of population aggregation is the primary factor that affects urban housing price. Conversely, Xun Fang [11] studied Jiangxi and found that level of urbanization could significantly influence housing price. He Fan [12] examined the dependency ratio of population and housing price data of 19 countries and found a negative correlation between dependency ratio of population and housing price fluctuation in most countries; however, the proportionate rise in the aging population of China, rather than a price fall, causes an active demand for commercial housing. Du Benfeng and Zhang Yu [13] used the grey relational degree to study the correlation between the Chinese comprehensive demographic factor and home sales price index and found that population is highly correlated with home sales price index.

The literature review shows that foreign scholars have conducted extensive research about the influence of population structure on housing price fluctuation. Their studies, although recent, have covered a wide range of concerns about theoretical exploration and used the econometrical approach for a quantitative analysis of the correlation between population structure and price fluctuation. By contrast, Chinese scholars have used foreign research methods and the true state of China to focus on typical Chinese regions and found that population structural variables affect the volatility of housing price. Studies involving the correlation between population structure and urban residential land price are rarely conducted. This paper benefits from the method used to study the influence of population structure on the volatility of housing price. It analyzes the dynamic influence of Zhengzhou's population structural variables on residential land price. The findings provide reference for similar research on other regions and contribute to the government's decision making in the development of diverse regulatory policies for local residential land price.

2 Data resource and research method

This paper takes the urban residential land price indexes and population structural variables of Zhengzhou as analysis data. Without affecting the results, price indexes lower data heteroscedasticity while increasing sequence stationarity. The data selected covered the period of 1994–2013 and were taken from the China Urban Land Price Dynamic Monitoring Network, Henan Statistical Network, and Zhengzhou Statistical Network.

This study mainly discusses the extent of influence of Zhengzhou's population structural variables on the fluctuation of residential land price. Analysis software Eviews 6.0 was used for building the VAR model. Co-integration analysis, impulse response function, variance decomposition, and other approaches were used to analyze the correlative mechanism between Zhengzhou population structural variables and land prices.

The AR model is a simultaneous form of the autoregression model. If y_{1t} is related to y_{2t} and the two autoregression models are built separately, the relationship between these two variables will not be captured:

$$y_{1t} = f\left(y_{1,t-1}, y_{1,t-2}, \ldots\right), \tag{1}$$

$$y_{2t} = f\left(y_{2,t-1}, y_{2,t-2}, \ldots\right). \tag{2}$$

Once the simultaneous form is taken, the relationship between the two variables can be determined. Taking the VAR model of one-period lagged variables y_{1t} and y_{2t} as an example, the VAR model can be expressed as:

$$y_{1t} = c_1 + \pi_{11.1} y_{1,t-1} + \pi_{12.1} y_{2,t-1} + u_{1t}, \tag{3}$$

$$y_{2t} = c_2 + \pi_{21.1} y_{1,t-1} + \pi_{22.1} y_{2,t-1} + u_{2t}. \tag{4}$$

3 Empirical analysis

3.1 VARIABLE SCLECTION

Based on demography, population structure generally covers the natural population structure, the socio-economic structural features of the population, and the regional structure of the population. This approach is adopted in this study on population structural variables. By selecting the variables according to the three aspects, this study attempts to discuss Zhengzhou's residential land price from the perspective of population structure.

On the basis of the literature review, this study tentatively selects seven population structural variables: sex ratio (*XB*), labor resource structure (*LP*), dependency ratio (*FY*), household size (*JG*), employment structure (JY), per capita disposable income (*SR*), and urbanization rate (*CZ*).

3.2 DATA STATIONARY TEST

Stationarity was the first variable to be tested. Time series stationarity indicates that statistical laws on time series do not change with time; i.e., the features of the stochastic process during which the variable time series data are generated are time-invariant. Logarithm operation was conducted on these time series variables to reduce heteroscedasticity. The ADF approach was adopted for the unit root test of the same variables. The results indicate that variables do not form a stationary series, that urbanization rate is the only stationary series after the first-order difference, and that the rest of the variables are stationary series after the second-order difference (Table1).

TABLE 1 Unit root test on the time series of land price and population structure variable in Zhengzhou City

Variate	Test Type (c,t,n)	ADF statistical magnitude	5% critical value	Inspection results	Variate	Test Type (c,t,n)	ADF statistical magnitude	5% critical value	Inspection results
ln *CZ*	c, 0, 0	–0.69	–3.25	Non-stationary	D^2 ln *CZ*	c, 0, 1	–3.45	–3.32	stationary
ln *FY*	c, 0, 0	–2.48	–3.25	Non-stationary	D^2 ln *FY*	c, 0, 1	–3.84	–3.52	stationary
ln *JY*	c, 0, 0	–1.94	–3.25	Non-stationary	D^2 ln *JY*	c, 0, 1	–3.58	–3.52	stationary
ln *LP*	c, 0, 0	–2.46	–3.25	Non-stationary	D^2 ln *LP*	c, 0, 1	–3.89	–3.52	stationary
ln *SR*	c, 0, 0	3.33	–3.25	Non-stationary	D^2 ln *SR*	c, 0, 1	–6.61	–3.52	stationary
ln *XB*	c, 0, 0	–3.08	–3.25	Non-stationary	D^2 ln *XB*	c, 0, 1	–7.23	–3.52	stationary
ln *JG*	c, 0, 0	–0.74	–3.25	Non-stationary	D^2 ln *JG*	c, 0, 1	–4.06	–3.40	stationary
ln *HF*	c, 0, 0	–0.31	–3.25	Non-stationary	D^2 ln *HF*	c, 0, 1	–3.88	–3.52	stationary

Notes: (c, t, n) are the constant term, trend term, and lag order, respectively, in the unit root test.

3.3 JOHANSEN CO-INTEGRATION RELATIONSHIP TEST

The Johansen test is used to determine the existence of several non-zero characteristic roots for the vector matrix of co-integration test, which suggests a co-integration among various time series. The test was conducted with Trace Statistic and Max-Eigen Statistic. The data generation test proved that the system shows no linear trend and that the co-integration equation is a random walk with drift. The Trace Statistic and Max-Eigen Statistic approaches used by the Johansen co-integration relationship test indicate that, below the level of 5%, no non-zero characteristic root exists between Zhengzhou residential land price and dependency ratio, labor resource, employment proportion, and sex ratio, thus indicating the absence of co-integration. Moreover, no non-zero characteristic root exists between Zhengzhou residential land price and urbanization rate, per capita disposable income, and household size, thus indicating a co-integration relationship. Table 2 shows the results of the co-integration relationship test.

TABLE 2 Johansen test between land price and population structure variables in Zhengzhou City

	Original hypothesis co-integration equation	Eigenvalue	Trace Test	Trace Test C.V.	Maximum Eigenvalue	Maximum Eigenvalue C.V.
ln *HP* and ln *CZ*	None*	0.98	35.11	15.49	34.50	14.26
	At most 1	0.07	0.62	3.84	0.62	3.84
ln *HP* and ln *SR*	None*	0.87	21.89	15.49	16.54	14.26
	At most 1	0.49	5.34	3.84	5.34	3.84
ln *HP* and ln *SR*	None*	0.83	16.62	15.49	14.21	14.26
	At most 1	0.26	2.40	3.84	2.39	3.84

Notes: "*" is that refused to the original assumption under the 0.05% significant level

3.4 VAR MODEL ESTIMATION

The co-integration relationship test suggests a long-term equilibrium relationship between Zhengzhou residential land price and urbanization rate, per capita disposable income, and household size. The VAR model, which is used to analyze the correlation between variables, is an unstructured equation model based on data statistics and is completely built on endogenous variables.

Lagged orders, which significantly influenced the test results, need to be set to build the VAR model. Low orders disregard some important variables, whereas high orders lower the freedom of the model, lead to a considerable standard deviation of parameter estimation, and reduce accuracy. This study determines the lag period according to the lag length criteria. As shown in Table 3, the smallest lag periods of the five evaluation indexes are represented by "*". According to the minimum AIC and SC criteria, the optimal lag period is set to 2 and a VAR (2) model is determined for building.

TABLE 3 Criteria to determine VAR lag length and appropriate lag order number

Lag	LogL	LR	FPE	AIC	SC	HQ
0	–321.67	NA	6.10e+10	36.18	36.38	36.21
1	–211.70	15.72	15637203	27.52	29.30	27.76
2	–227.42	136.14*	10850357*	27.49*	28.48*	27.62*

Eviews 6.0 was used to build the four-variable VAR model of Zhengzhou urbanization rate, per capita disposable income, household size, and residential land price. The model estimation results are as follows:

$$\begin{bmatrix} \ln CZ \\ \ln DJ \\ \ln JG \\ \ln SR \end{bmatrix} = \begin{bmatrix} -4.52 \\ 124.14 \\ 6.24 \\ 188339.77 \end{bmatrix} + \begin{bmatrix} 1.06 & -0.06 & 4.12 & -6.11 \\ 2.54 & 1.55 & -60.67 & 5.43 \\ 0.05 & 0.02 & -0.32 & 1.42 \\ 17274.21 & -1278.27 & 84524.99 & -0.54 \end{bmatrix} \begin{bmatrix} \ln CZ(-1) \\ \ln DJ(-1) \\ \ln JG(-1) \\ \ln SR(-1) \end{bmatrix} + \begin{bmatrix} 0.09 & 0.04 & -4.06 & -3.45 \\ -2.96 & -0.40 & 31.04 & 6.59 \\ -0.12 & -0.01 & 0.36 & 1.80 \\ -15478.00 & 1274.89 & 150190.05 & -0.22 \end{bmatrix} \begin{bmatrix} \ln CZ(-2) \\ \ln DJ(-2) \\ \ln JG(-2) \\ \ln SR(-2) \end{bmatrix}.$$

The stationary test for the model, all characteristic roots in the model shown in Figure1 are in the unit cycle; therefore, the VAR model has a stable system. After the test for the residuals of the VAR (2) model, the model residuals were found to follow a normal distribution and to have no autocorrelation or heteroscedasticity. Estimation results also suggest that the joint parameter survey is significant. The model determination coefficient *R* is between 0.955 and 0.996; therefore, the statistical property of VAR (2) is favorable.

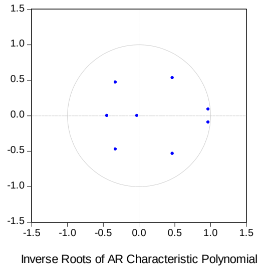

FIGURE 1 Stability of the VAR model of Zhengzhou residential land price and population structural variables (AR characteristic polynomial root diagram)

3.5 IMPULSE RESPONSE ANALYSIS AND CONTRIBUTION ANALYSIS

The conduct of impulse response analysis and variance decomposition for the VAR model was necessary to study the change rule of the long-term equilibrium relationship within a certain period after the influence.

3.5.1 Impulse response analysis

Impulse response analysis is usually carried out on the basis of the graph observation of the impulse response function, which describes the response of error change. The random disturbance term is assumed to be affected by a standard deviation, and the variables would be affected both in the current and later years; i.e., the change in each endogenous variable can influence itself and all other endogenous variables. Figure 2 shows the disturbance when one standard deviation is given. The response route, which revealed the influence of variables on land price within 10 predictive periods, was observed. The full line denotes the change orbit of land price after the effects, and the dotted line indicates the resulting value of land price plus or minus the double standard deviation, thus showing the maximum range of possible effects, i.e., the upper and lower limits to be reached.

As shown in Figure 3, when a random disturbance of one standard deviation is observed from the household size against the residential land price, a strong influence appears immediately. The current impulse curve falls gradually after going up by approximately five grades; at the eighth period approaching zero, the influence gradually disappears. This trend shows that the development of land price is stable and that short-term variations of household size can cause fluctuations in residential land price. However, the fluctuation range reduces with time. Land price increases immediately when a positive effect of one standard deviation is exerted on itself, but the increase range shrinks gradually and immediately, and the price begins to fall by the second period until the final recovery. When a positive effect of one standard deviation from the urbanization rate is exerted on the residential land price, the effect is gradually seen. The price begins to gradually decline after reaching the second grade by the second predictive period, falls to first grade by the third predictive period, begins to gradually increase by the fourth predictive period, and remains at the third grade. No significant response is shown in land price when a disturbance of one standard deviation from the per capita disposable income is exerted on the residential land price. Based on the effect of population structural variables, the per capita disposable income has the shortest positive effect on residential land price. Given the high price of residential land, income increases may have no significant influence on the increasing land price. By contrast, the positive effect of urbanization rate on residential land price is the longest and strongest. Therefore, new housing demands caused by urbanization can actively promote the residential land price market of Zhengzhou and significantly improve the land price of this region.

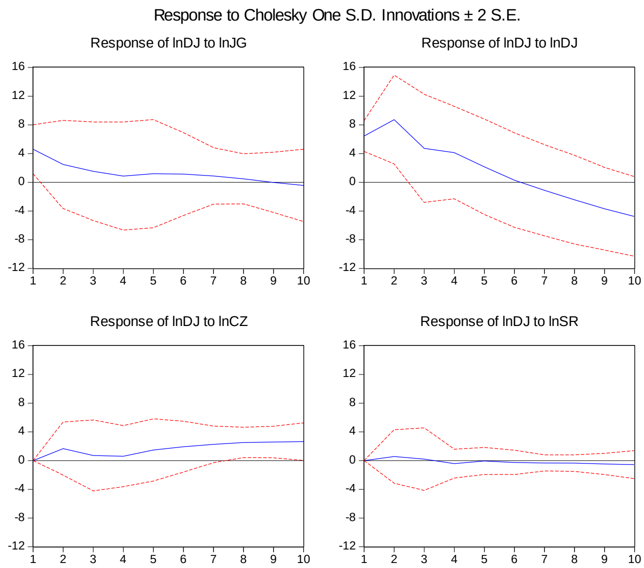

FIGURE 2 Impulse response analysis of Zhengzhou residential land price

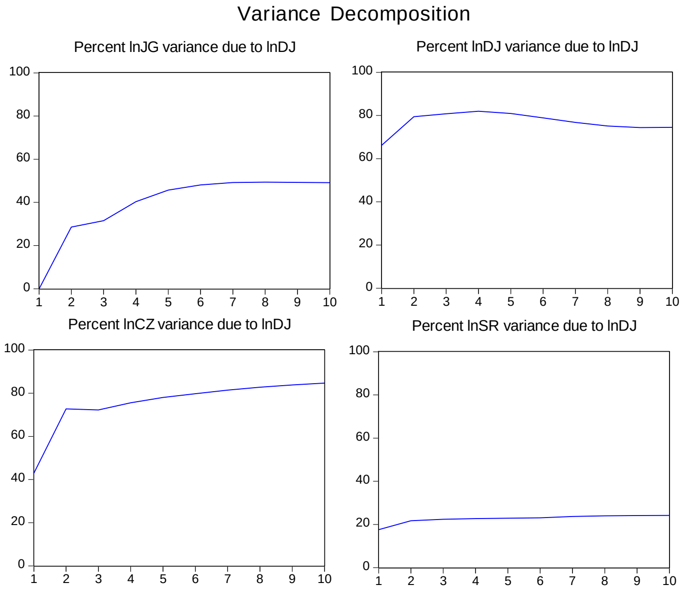

FIGURE 3 Variance decomposition of population structural variables against residential land price in Zhengzhou

3.5.2 Contribution analysis

Variance decomposition means that interactions between variables can be expressed by percentages of predication error variances after a variable in the system suffers one unit of effect. Variance decomposition reflects the relative importance of random information. That is, the variation of each endogenous variable in the system is decomposed into all constituent parts relevant to random disturbance terms to determine the relative importance of innovation to the endogenous variables of the model. Variance decomposition analysis was conducted to study the influence of the Zhengzhou population structural variables on the fluctuation of residential land price.

In Figure 3, the horizontal axis represents the periods after various effects, and the vertical axis represents the contribution of the four variables (including land price itself) to the increase in land price. As shown in Figures 3 and Table 4, land price has an effect on itself. The contribution rate reaches 66.22% by the first predictive period and increases gradually. It reaches approximately 80.91% by the fifth period, declines, and then tends to stabilize until it is maintained at 75%. Household size (lnJG) has no contribution to Zhengzhou land price by the first period. However, the contribution rate increases to 28.58% by the second predictive period, escalates, reaches 48.09% by the sixth predictive period, and then stabilizes. The contribution rate of urbanization rate (InCZ) to Zhengzhou residential land price is only 42.99% by the first predictive period and increases fast thereafter. It reaches 72.75% by the second predictive period and escalates until the 10th predictive period when the contribution rate reaches 84.66%. The contribution rate of per capita disposable income to Zhengzhou residential land price is maintained at a low level all the time at around 23.00%.

TABLE 4 Variance decomposition of population structural variables against residential land price in Zhengzhou

Period	Percent LNDJ variance due to LNDJ (%)	Percent LNSR variance due to LNDJ (%)	Percent LNCZ variance due to LNDJ (%)	Percent LNJG variance due to LNDJ (%)
1	66.22	17.58	42.99	0.00
2	79.47	21.70	72.75	28.58
3	80.81	22.38	72.26	31.52
4	81.97	22.69	75.59	40.34
5	80.91	22.89	78.01	45.66
6	78.92	23.07	79.79	48.09
7	76.83	23.66	81.39	49.19
8	75.15	23.97	82.76	49.38
9	74.42	24.09	83.82	49.26
10	74.53	24.17	84.66	49.15

The contribution analysis shows that different population structural variables have varied effects on the fluctuation of residential land price. Among all the variables, urbanization rate causes the greatest effect, followed by household size. Per capita disposable income causes the smallest effect. In the short term, land price fluctuation is mainly caused by its own influence. Nevertheless, as the predictive period progresses, the effect of population structural variables on Zhengzhou residential land price becomes stronger and gradually becomes the leading influencing factor. This result suggests that the effect of population structure factors on land price is long standing and stable.

4 Results and discussion

4.1 RESULTS ANALYSIS

This study examines the correlation between the 1994–2013 land prices of Zhengzhou and its population structural variables. Co-integration test, impulse response function, variance decomposition, and other approaches are used to analyze the influence of population structural variables on land price. The findings are as follows:

1) Co-integration test results show that no co-integration relationship exists between Zhengzhou land price and the population structural variables of dependency ratio, labor resource, employment proportion, and sex ratio. However, urbanization rate, per capita disposable income, and household size show significant effects on Zhengzhou land price.
2) The positive effect of Zhengzhou's per capita disposable income on residential land price is the shortest. As income increase may have no significant effect on the increase in residential land price, it is not the primary influential factor on land price. The positive effect of urbanization rate on residential land price is the longest and strongest. Therefore, new housing demands caused by urbanization can actively promote the residential land price market of Zhengzhou and significantly improve the land price of this region.
3) Different population structural variables exert various effects on residential land price fluctuation. Among all the variables, urbanization rate causes the greatest influence, followed by household size. Per capita disposable income causes the smallest effect.
4) In the short term, land price fluctuation is mainly caused by its own influence. Nevertheless, as the predictive period progresses, the effect of population structural variables on Zhengzhou residential land price becomes stronger and gradually becomes the leading influencing factor. This finding suggests that the effect of population structure factors on land price is long-standing and stable.

4.2 DISCUSSION

Through a correlation study between Zhengzhou population structural variables and urban residential land price, this paper examines the impact degree of population structural variables on residential price. Two policy suggestions are suggested:

1) Taking measures to increase resident income should be continued. The empirical tests conducted by this study show that per capita disposable income is not significantly related to residential price. Income growth does not necessarily mean that it can remarkably promote commercial residential land price. The real estate market shows a trend of excessive speculation. Therefore, the basic solution to the housing problem is to increase resident income.
2) Conducting rational control over urbanization should be maintained. Data analysis shows that the increase in and the concentration of urban population are principal factors that increase the price of Zhengzhou commercial residential land. Urbanization, an inevitable process in urban development, greatly influences the development prospect of the real estate market. However, excessively rapid growth can accelerate the increase in urban residential land price, and it will be further promoted under the market force. Therefore, the government should conduct rational control over it. fluctuation in Tianjin caused by a land price fluctuation in Beijing is lower than that in Beijing caused by a land price fluctuation in Tianjin city. This is consistent with the quantitative analysis on the land price fluctuation of the two cities.

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