An Empirical Study on the Interaction between Housing Prices, Interest Rates and Macroeconomics in China

Yuqi Xin

University of Nottingham Ningbo China, Ningbo, China

xinyuqi_0624@163.com

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Abstract: This paper examines the interaction between housing prices, interest rates and macroeconomics in China, and studies the monthly time series data of the National Bureau of Statistics of China from 1998 to 2022 through vector autoregression. There are two main conclusions that can be obtained about housing prices. First, housing prices are the Granger reason for the growth of money supply. Rising housing prices will cause a reverse change in the growth rate of money supply, with the impact reaching its maximum in 1-8 months. Second, the rise in housing prices is the Granger factor of interest rates. The reason is that rising house prices will cause interest rates to change in the same direction with the impact growing gradually over time. This result reflects the fact that the Chinese government usually adopts control policies to reduce M2 growth when housing prices grow too fast, and also takes measures to moderately raise interest rates, both of which are manifestations of the government's tightening monetary policy. In other words, the government in China will tighten the monetary policy to cool down the property market when the price growth is excessively high.

1. Introduction

In China, real estate is closely related to the national economy. The economic development of real estate will prompt changes in macroeconomic factors from multiple perspectives. Since the reform of real estate market in 1998, real estate prices have gradually developed from the growth stage to a boom, and met the bubble period. The economic structure driven by real estate has also laid hidden risks for sustainable economic growth, with rising house prices giving rise to speculative demand for real estate and forcing the basic housing needs of the general public, which is not conducive to the stability of social livelihood and fair distribution of wealth. What's more, the single financing structure of the real estate industry, with credit facilities secured by commercial properties and real estate projects, also undermines financial stability, causing credit risk and loss of collateral value, or even financial crisis, once housing prices fall.

In August 2020, , the Ministry of Housing and Urban-Rural Development of the People’s Republic of China (short as MOHURD) and the People’s Bank of China(short as PBOC) jointly issued a real estate market regulation policy called "Three Red Lines", proposing that the asset-liability ratio of real estate companies should not exceed 70%, the net debt ratio should not exceed 100%, and cash-to-short-term debt ratio should be greater than after excluding pre-receipts, which emphasizes the stabilization of the market and the promotion of resolution and prevention of financial risks [1]. This indicates that the corporate financial problems in the real estate industry have been taken seriously by the government in China, and the relationship between the real estate market and the macro economy has become a concern of all walks of life. Therefore, in this paper, the study will examine the interaction between housing prices, interest rates and macroeconomics in China through a vector autoregressive model [2].

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2. Literature Review

2.1 Relevant International Studies

Real estate economic research has an early history of development, and previous scholars agree that there is a positive causal link between real estate investment and economic development. Wacher and Plollakowski (1990) obtained from quarterly data for Montgomery County from 1982 to 1987 that stronger state land supply policy constraints result in faster real estate price growth. Green (1997) studied with quarterly data for the United States from 1959-1992 and found that real estate investment is a unidirectional Granger cause of economic growth, which suggests that real estate is a unidirectional driver of economic development. Peng and Gerlach (2005) conducted a time series analysis of Hong Kong real estate prices and macroeconomic variables, and found that real estate prices significantly affected credit supply, while credit expansion did not significantly contribute to real estate prices. Allen (2012) investigated the correlations between the U.S. real estate market and the money supply and obtained the result that both are positively related in most cases. Jansen (2013) also examined the relationship between the Norwegian real estate market and credit through a vector autoregressive model and found that the two show a two-way interaction on the long-term [3].

2.2 Relevant Studies in China

Because the "visible hand" of the government in China has a greater influence in the real estate economy, and the real estate market is closely related to China's economy, the research in this field has been a quite popular. Cui Guangcan (2009) used provincial panel data to investigate the interaction between real estate prices and macroeconomics from 1995 to 2006, and found that interest rates and inflation rates significantly affected real estate prices, and real estate prices significantly contributed to total social investment and consumption [4]. Using a panel vector autoregressive model, Li Ying and Hu Ridong (2001) have found that there is a two-way interaction between real estate prices and regional GDP. Ma Yaming and Wang Hongshan (2018) examined the relationship between shadow banking, real estate market, and macroeconomic volatility through a Bayesian model, and obtained through variance decomposition analysis that interest rate shocks significantly cause house price changes and shadow banking growth in scale [5]. Hu Chengchun and Chen Xun (2019) analyzed the monthly data from 2003 to 2017 through a GVAR model, and found that the uncertainty of economic policy has differential effects on the real estate market and macro economy in different regions. Using a real economic cycle (RBC) model of the banking sector, Yang and Liu et al. (2021) have found that when a fall in house prices makes the economy tend to go down, the tightening of the regulation of financial sector leverage at this time leads to an acceleration of the economic decline.

2.3 International Research on the Real Estate Economics

After reviewing the literature, it can be found that international research on the real estate economics is earlier than that of China. However, there are not many international researches on this topic in recent years. Recent relevant research in China, in contrast, can be described as "quite abundant", with current scholars paying more attention to national policies, real estate market and macroeconomics. In earlier studies, more scholars focused on the relationship between real estate prices and variables such as interest rates, economic growth, and financial markets, but in recent years, the number of such interactive studies is quite limited. Therefore, this paper attempts to study the interaction between housing prices, interest rates and macroeconomics in China from the perspective of the Covid-19 epidemic era, and enrich the literature on real estate economic research [6].

3. An Empirical Model of the Interaction between House prices, Interest rates and Macroeconomics in China

3.1 Research Design

3.1.1 Model Introduction

In this paper, the vector autoregression model (VAR) will be used to examine the relationship between different influencing factors on the competitiveness of financial services trade. VAR is an econometric model specially designed to analyze the long-term dynamic relationship of multiple groups of time series. It can be combined with impulse response graphs and Granger causality test to examine in depth whether there is a significant relationship between real estate prices and various influencing factors [7].

$$Y_t = \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{i=1}^{p} \alpha_i X_{1t-i} + \ldots\ldots + \sum_{i=1}^{p} \alpha_i X_{nt-i} + C + \varepsilon_t$$

The above equation presents the VAR with P-order lagged terms. The model assumes that both Y and X are endogenous variables, Y represents financial services trade, X represents the influencing factors, t represents different periods, ε represents the random error at period t, and C represents the constant term. The VAR model helps to analyze the multi-order lag coefficient relationship between interest rates, macroeconomic factors and real estate prices.

3.1.2 Variable Setting

In this study, following the findings of Huang Zhonghua et al. (2008), all the variables are presented in the table below. The data are obtained from the National Bureau of Statistics of China, the data span is from 1998 to 2022, and the data structure is a monthly time series. Among them, the variables of the model include housing price level, economic development, interest rate, inflation rate, and money supply. To eliminate the seasonal difference of each data, the X12 method is adopted to smooth the data in this paper, and the missing data are filled by linear interpolation method [8].

Table 1: Variable Settings

Variable Name	Calculation Method	Code
House price level	Natural logarithm of national real estate sales prices of China	HP
Economic development	Year-on-year growth rate of monthly GDP	GDP
Interest rate	30-day weighted average interest rate provided by the PBOC	I
Price Index	Consumer Price Index (previous year=100)-100	CPI
Currency supply	Year-on-year growth rate of M2 money supply	GM2

3.2 Descriptive Statistical Analysis

All variables used in this paper are from the table below, which presents the descriptive statistical results of house price level, economic development, interest rate, price index, and money supply. The mean house price level (HP) is 8.435 and the median is 8.517. The mean of economic development is 8.302 and the median is 7.900 [9]. The mean interest rate is 3.280 and the median is 3.020. The mean 14.569, and the median is 14 price index is 1.936 and the median is 1.800. The mean value of the growth rate of M2 money supply is.030. It is found that the mean and median of all variables in the following table are close to each other, and there are no significant outliers in the maximum and minimum values. Therefore, an econometric model can be used to examine the interaction between housing prices, interest rates and the macroeconomics in China.

Table 2: Descriptive Statistical Analysis

	GDP	GM2	CPI	I	HP
Mean	8.302	14.569	1.936	3.280	8.435
Median	7.900	14.030	1.800	3.020	8.517
Maximum	18.300	29.740	8.740	7.590	9.308
Minimum	-6.800	8.000	-2.200	1.040	7.517
Std. Dev.	2.687	4.435	2.092	1.144	0.538
Skewness	-1.233	0.865	0.597	0.842	-0.140
Kurtosis	13.438	4.297	3.545	3.735	1.671

The figure 1 below shows a time series diagram of housing prices, interest rates, and macroeconomic variables. It can be seen that the real estate price level has shown a steady growth trend in recent years, while the GDP growth rate was in a stable growth stage from 1998 to 2007, and the GDP growth rate began to slow down after 2008. The year-on-year growth rate of M2 was relatively stable from 1998 to 2009, but gradually decreased from 2010 to 2022, indicating monetary tightening. In addition, the inflation rate was in a relatively large fluctuation trend from 1998 to 2022, which increased significantly from 1998 to 2008, but began to decline from 2008 to 2022. Different to the other three factors, the interest rates have been on an overall downward trend from 1998 to 2022.

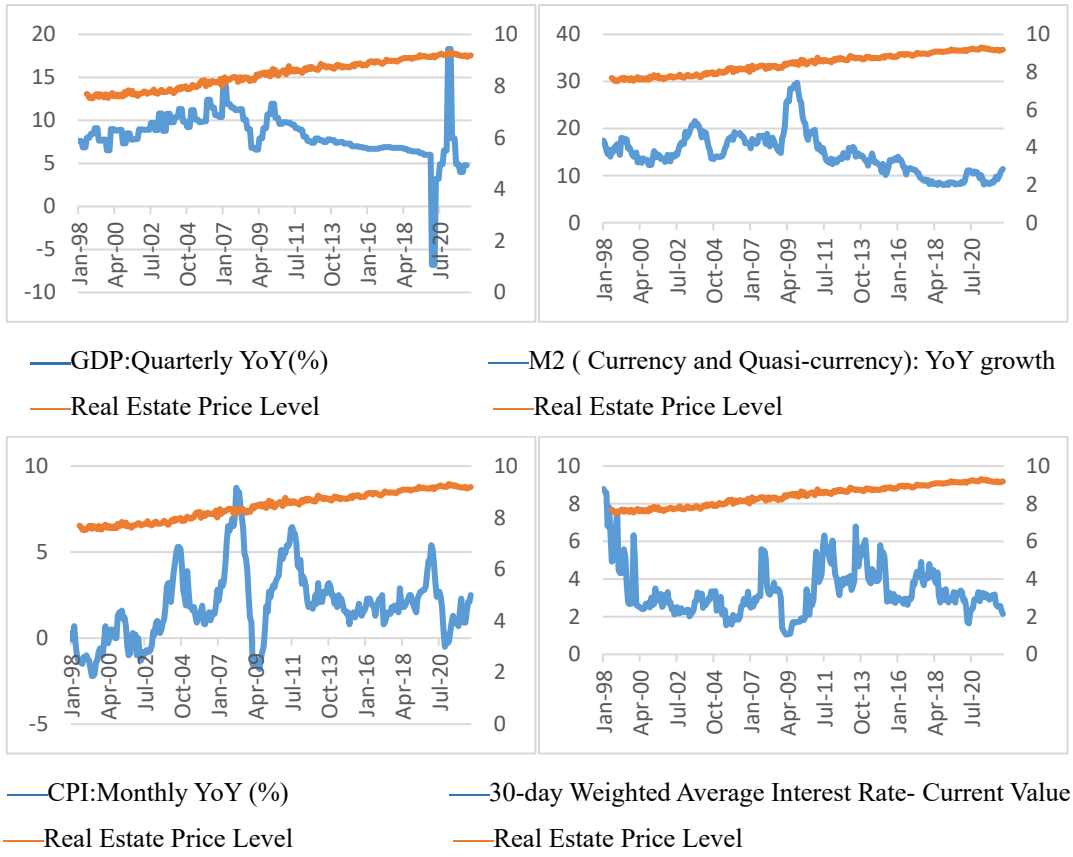

Figure 1: Time series diagram of housing prices, interest rates and macroeconomics in China

3.3 Stationarity Test

Before testing the VAR model, the stationarity test should be used to test whether there is a unit root in housing prices, interest rates and macroeconomic variables. If the time series are in growth or decline, pseudo-regression results will appear. Generally speaking, ADF statistics can be used to test the stationarity of house prices, interest rates and macroeconomic variables. It can be found that the ADF statistic of house prices (HP) is -1.003, which fails the 10% significance level, but passes the 1% significance level after the first-order difference, suggesting that the house price series is a

first-order single integral. Similarly, there are also economic development (GDP) and money supply (GM2), which are also first-order unitary sequences. Moreover, the ADF statistics of the interest rate (I) and inflation rate (CPI) series pass the 1% and 5% significance levels, which indicates that both series are stationary series. Overall, the series studied in this paper are partly stationary and the other is first-order single integral, so the VAR model can be adopted to examine the interaction. (See Table 3)

Table 3: Stationarity Analysis

Variable	Original sequence		Difference term	
	Statistics	P value	Statistics	P value
HP	-1.003	0.753	-6.216	0.000
GDP	-2.025	0.276	-9.930	0.000
I	-5.504	0.000	-15.518	0.000
CPI	-3.031	0.033	-7.082	0.000
GM2	-1.308	0.627	-7.615	0.000

3.4 Correlation Analysis

In the multiple regression, the problem of over correlation coefficients between independent variables should be avoided, otherwise it may result in pseudo-regression of housing prices, interest rates and macroeconomic variables. In correlation analysis, it can be seen that the absolute values of all correlation coefficients are below 0.6, indicating that the multicollinearity of the model can be ignored. (See Table 4)

Table 4: Correlation Coefficient Analysis

Variable	D(GDP)	D(GM2)	CPI	I	D(HP)
D(GDP)	1.000	0.073	-0.106	-0.076	0.065
D(GM2)	0.073	1.000	-0.171	-0.196	0.045
CPI	-0.106	-0.171	1.000	0.253	-0.004
I	-0.076	-0.196	0.253	1.000	-0.047
D(HP)	0.065	0.045	-0.004	-0.047	1.000

3.5 VAR Modl Analysis

3.5.1 Rank Test

Table 5: Optimal Lag Order Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1476.57	NA	0.034	10.814	10.880	10.841
1	-962.253	1006.108	0.001	7.243	7.638*	7.402
2	-913.899	92.826	0.001	7.072	7.798	7.363
3	-867.899	86.628	0.001	6.919	7.974	7.342*
4	-839.193	53.012	0.001	6.892	8.277	7.448
5	-812.445	48.420	0.0007*	6.879*	8.593	7.567
6	-793.892	32.908	0.001	6.926	8.970	7.747
7	-782.019	20.625	0.001	7.022	9.396	7.975
8	-754.717	46.434	0.001	7.005	9.708	8.090
9	-735.659	31.716	0.001	7.049	10.082	8.266
10	-711.629	39.116*	0.001	7.056	10.418	8.405

In this paper, a VAR model of housing prices, interest rates and macroeconomic variables is to be constructed. It is to prepare to construct the optimal lag order of the VAR(p) model, which generally adopts the AIC Akaike statistic to determine the optimal p-order of the model, and can be obtained by the comparative analysis of the lag order coefficients of Eviews. According to the results of AIC and FPE statistics, it is considered that lag 5th order is optimal, because the AIC statistic is 6.879,

which is the smallest in the 0-10th order, indicating that VAR(5) can control the smallest error. (See Table 5)

3.5.2 VAR Model Analysis

From the VAR(5) model of housing prices, interest rates and macroeconomic variables, the adjusted R squares of the five groups of empirical models are 0.328, 0.097, 0.201, 0.924, and 0.736, respectively, indicating that the inflation rate and interest rate models explain interest rates very well. The housing price model also works well, which explains 32.8%, while the economic development and inflation rate models are in poor performance. In the inverse AR root test in Figure 2, all points are within the unit circle, indicating that the model residuals are stable and acceptable. (See Table 6 and Figure 2)

Table 6: VAR Analysis

Variable	D(HP)	D(GDP)	D(GM2)	CPI	I
D(HP(-1))	-0.507	-1.727	1.851	0.242	-1.350
Standard Deviation	0.062	1.506	0.897	0.606	0.598
t-Statistic	-8.202	-1.147	2.062	0.399	-2.259
D(HP(-2))	-0.474	-0.872	0.665	-0.410	0.155
Standard Deviation	0.068	1.652	0.985	0.665	0.656
t-Statistic	-6.988	-0.528	0.675	-0.616	0.236
D(HP(-3))	-0.142	-1.802	-0.960	-0.083	-0.709
Standard Deviation	0.074	1.794	1.069	0.722	0.712
t-Statistic	-1.925	-1.004	-0.898	-0.115	-0.996
D(HP(-4))	-0.369	0.732	-1.519	-0.061	1.264
Standard Deviation	0.067	1.635	0.974	0.658	0.649
t-Statistic	-5.498	0.447	-1.559	-0.092	1.948
D(HP(-5))	-0.270	-0.884	-1.641	0.417	0.729
Standard Deviation	0.063	1.531	0.913	0.617	0.608
t-Statistic	-4.294	-0.577	-1.799	0.677	1.199
D(GDP(-1))	0.004	-0.014	-0.021	0.015	0.017
Standard Deviation	0.003	0.063	0.038	0.025	0.025
t-Statistic	1.662	-0.215	-0.558	0.573	0.666
D(GDP(-2))	0.001	-0.027	-0.118	0.048	0.047
Standard Deviation	0.003	0.063	0.037	0.025	0.025
t-Statistic	0.577	-0.427	-3.145	1.907	1.869
D(GDP(-3))	0.001	-0.354	-0.078	0.025	0.041
Standard Deviation	0.002	0.060	0.036	0.024	0.024
t-Statistic	0.278	-5.871	-2.184	1.014	1.704
D(GDP(-4))	0.003	-0.024	-0.019	0.040	0.027
Standard Deviation	0.003	0.065	0.039	0.026	0.026
t-Statistic	0.975	-0.364	-0.479	1.541	1.051
D(GDP(-5))	0.001	-0.009	-0.001	-0.009	0.006
Standard Deviation	0.003	0.064	0.038	0.026	0.025
t-Statistic	0.211	-0.149	-0.025	-0.344	0.242
D(GM2(-1))	0.005	-0.015	-0.154	0.046	0.032
Standard Deviation	0.004	0.105	0.062	0.042	0.042
t-Statistic	1.191	-0.140	-2.466	1.086	0.772
D(GM2(-2))	0.004	-0.042	0.028	-0.071	0.045
Standard Deviation	0.004	0.103	0.061	0.042	0.041
t-Statistic	0.892	-0.403	0.453	-1.714	1.101
D(GM2(-3))	0.004	0.003	0.224	0.047	-0.019
Standard Deviation	0.004	0.099	0.059	0.040	0.039
t-Statistic	0.871	0.034	3.781	1.186	-0.472
D(GM2(-4))	0.003	0.178	0.145	-0.102	-0.034

Standard Deviation	0.004	0.099	0.059	0.040	0.039
t-Statistic	0.755	1.789	2.456	-2.548	-0.858
D(GM2(-5))	0.003	-0.035	-0.077	0.070	-0.006
Standard Deviation	0.004	0.100	0.060	0.040	0.040
t-Statistic	0.683	-0.354	-1.296	1.742	-0.155
CPI(-1)	-0.004	0.130	-0.343	1.079	0.101
Standard Deviation	0.006	0.157	0.094	0.063	0.062
t-Statistic	-0.631	0.830	-3.664	17.071	1.617
CPI(-2)	0.007	-0.401	0.256	-0.025	0.040
Standard Deviation	0.009	0.230	0.137	0.092	0.091
t-Statistic	0.764	-1.744	1.870	-0.272	0.442
CPI(-3)	-0.002	-0.020	0.123	-0.044	-0.108
Standard Deviation	0.009	0.228	0.136	0.092	0.091
t-Statistic	-0.218	-0.088	0.904	-0.482	-1.189
CPI(-4)	0.003	0.012	-0.257	0.008	0.139
Standard Deviation	0.009	0.225	0.134	0.091	0.089
t-Statistic	0.350	0.055	-1.915	0.092	1.557
CPI(-5)	-0.004	0.253	0.204	-0.071	-0.142
Standard Deviation	0.006	0.158	0.094	0.064	0.063
t-Statistic	-0.546	1.603	2.166	-1.121	-2.264
I(-1)	-0.005	0.023	-0.172	-0.064	0.737
Standard Deviation	0.006	0.151	0.090	0.061	0.060
t-Statistic	-0.787	0.155	-1.919	-1.050	12.316
I(-2)	0.005	0.007	-0.097	0.166	-0.030
Standard Deviation	0.007	0.182	0.109	0.073	0.072
t-Statistic	0.715	0.037	-0.896	2.268	-0.415
I(-3)	-0.003	-0.019	-0.092	-0.065	0.159
Standard Deviation	0.007	0.179	0.107	0.072	0.071
t-Statistic	-0.388	-0.108	-0.864	-0.894	2.233
I(-4)	-0.003	-0.010	0.239	-0.020	-0.147
Standard Deviation	0.007	0.180	0.107	0.072	0.071
t-Statistic	-0.453	-0.055	2.237	-0.270	-2.060
I(-5)	0.004	-0.088	0.059	-0.033	0.167
Standard Deviation	0.006	0.146	0.087	0.059	0.058
t-Statistic	0.747	-0.603	0.674	-0.555	2.885
C	0.019	0.354	0.225	0.161	0.294
Standard Deviation	0.013	0.311	0.185	0.125	0.123
t-Statistic	1.459	1.138	1.216	1.283	2.378
R-squared	0.388	0.178	0.273	0.931	0.760
Adj. R-squared	0.328	0.097	0.201	0.924	0.736
Sum sq. resids	0.846	502.457	178.433	81.433	79.171
S.E. equation	0.058	1.409	0.840	0.567	0.559
F-statistic	6.419	2.198	3.800	136.566	32.047
Log likelihood	412.987	-477.952	-333.527	-224.100	-220.170
Akaike AIC	-2.774	3.613	2.577	1.793	1.765
Schwarz SC	-2.436	3.951	2.916	2.131	2.103
Mean dependent	0.006	-0.013	-0.020	2.005	3.229
S.D. dependent	0.071	1.483	0.940	2.061	1.089

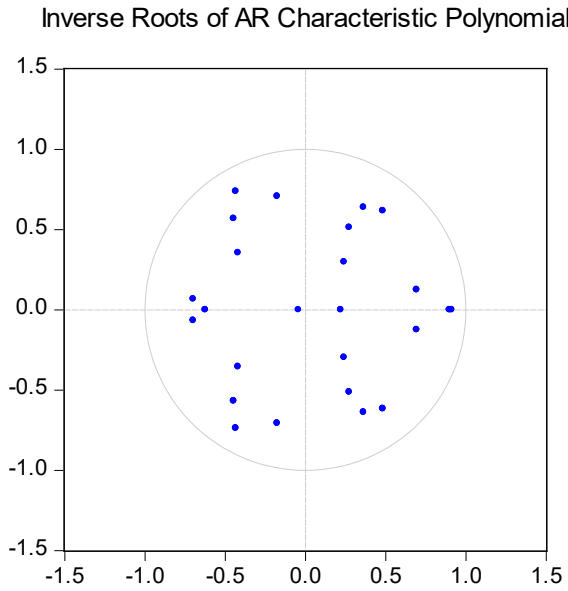

Figure 2: Inverse AR root test

3.5.3 Granger Causality Test

The purpose of Granger causality test is to examine the causal relationship between housing prices, interest rates and macroeconomic variables. The principle is the ability to explain future changes in target variables from historical data. The Granger causality test statistic can be judged by the P-value. There are five findings can be drawn from the following table of Granger causality test. First, no factor is the Granger cause of housing prices. Second, the inflation rate is the the Granger reasons for economic development, with the test P value of 0.068, which passed the 10% significance level. Third, housing prices, economic development, inflation and interest rates are all Granger reasons for the growth of money supply. Fourth, the growth rate of money supply is the Granger cause of the inflation rate, passing the 1% level of significance. Fifth, the house price and inflation rate are the Granger cause of the interest rate, and their P values are 0.006 and 0.005, respectively. (See Table 7)

Table 7: Granger Causality Test

Dependent variable: Housing Price				Dependent Variable: Economic Development			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
D(GDP)	3.314	5	0.652	D(HP)	2.819	5	0.728
D(GM2)	4.669	5	0.458	D(GM2)	3.744	5	0.587
CPI	1.175	5	0.947	CPI	10.272	5	0.068
I	1.552	5	0.907	I	1.435	5	0.921
All	13.195	20	0.869	All	21.498	20	0.368
Dependent variable: M2 year-on-year growth rate				Dependent variable: Inflation Rate			
Excluded	Chi-sq	df	Prob.	Excluded	Chi-sq	df	Prob.
D(HP)	11.124	5	0.049	D(HP)	1.185	5	0.946
D(GDP)	15.808	5	0.007	D(GDP)	7.956	5	0.159
CPI	21.029	5	0.001	D(GM2)	15.474	5	0.009
I	18.197	5	0.003	I	6.062	5	0.300
All	66.393	20	0.000	All	30.270	20	0.066
		Dependent Variable: Interest Rate					
		D(HP)	16.170	5	0.006		
		D(GDP)	7.417	5	0.191		
		D(GM2)	2.369	5	0.796		
		CPI	16.549	5	0.005		
		All	42.103	20	0.003		

3.5.4 Impulse Response Analysis Diagram

The purpose of the impulse response diagram is to examine the long-term dynamic relationship of the two groups of variables, and to visualize the dynamic time-series changes of the variables through a graphical method. In this paper, this method is used to describe the relationship between housing prices and other variables: First, in the curve of housing prices impacting the YoY growth rate of M2, it can be obtained that when housing prices have a positive standard deviation shock, the YoY growth rate of M2 will respond reversely in 1-8 periods, and will gradually narrow from the minimum value within 8-20 periods, which indicates that rising house prices will slow down the growth rate of money supply after 1-8 months.

Secondly, in the curve of housing prices impacting interest rates, it can be seen that when there is a positive standard deviation shock to housing prices, the curve will begin to grow steadily over time, reflecting that interest rates will rise in the long run and will continue to rise. (See figure 3)

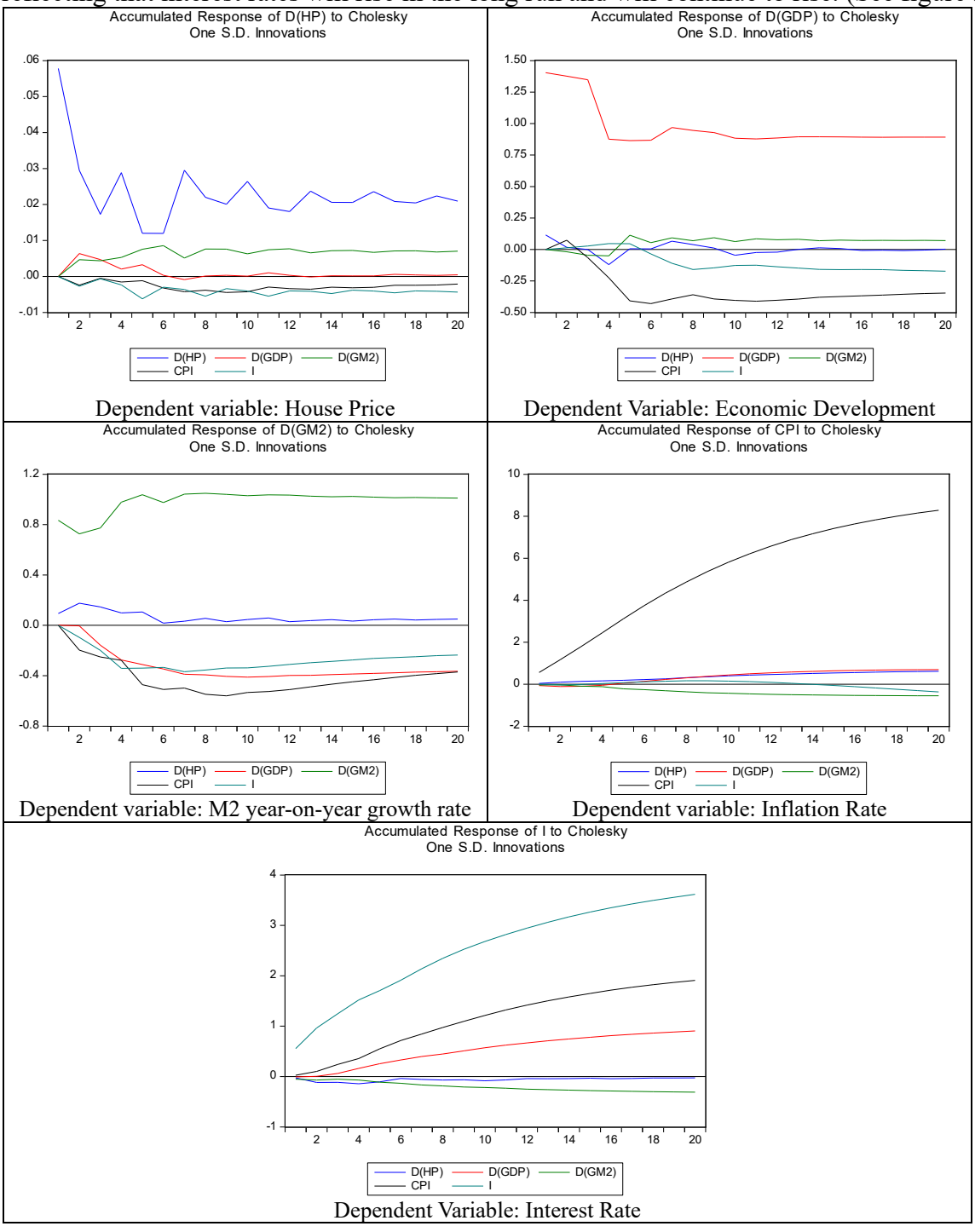

Figure 3: Impulse Response Plot Analysis

4. Research Conclusions and Recommendations

4.1 Research Conclusions

In the empirical research of this paper, the interactive relationship between housing prices, interest rates and the macro economy in China is investigated, and the monthly time series data from 1998 to 2022 is studied through VAR model. There are two main conclusions that can be obtained about housing prices. First of all, housing prices are the Granger reason for the growth rate of money supply. Rising housing prices will cause a reverse change in the growth rate of money supply, and the impact will be the strongest in 1-8 months. Secondly, rising house prices are the Granger cause of interest rates. The rise in house prices causes interest rates to change in the same direction, and the impact will gradually increase over time. This result reflects the fact that the government usually takes control policies to reduce the growth rate of M2 when house prices are growing too fast, and also takes measures to moderately raise interest rates, both of which are manifestations of the government's tightening monetary policy. In other words, when housing prices grow too fast, the Chinese government will cool down the property market by tightening monetary policy.

In addition, the study did not find the impact of housing price growth on other macroeconomic variables, nor did it find that other macroeconomic variables affected housing price growth. It suggests that in the long run, housing prices have no direct relationship with China's macroeconomics, but will prompt the government to change the monetary policy, which may also be determined by China's national conditions, because the government will take active measures to ensure people's livelihood and housing needs, and take the initiative to prevent economic development from being overly dependent on real estate.

4.2 Policy Suggestions

First, rising real estate prices will make the Chinese government change its monetary policy guidelines, but monetary policy has not had a significant impact on housing prices. In the future, the Chinese government should make appropriate use of different monetary policy tools at different stages of the real estate market. This requires the Chinese government to unblock the transmission channels of monetary policy to the real estate market and the real economy, so that the government can respond faster to the real estate market and the macro economy.

Second, as the real estate industry enters a downward cycle, many real estate companies have serious debt problems, and the model results reflect that monetary policy may be loosened. However, China's financial market is currently at a high level of financial risk, and has been actively deleveraging for many years, which requires reducing the proportion of credit to GDP in various places around China and actively guiding enterprises to strengthen direct financing.

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