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Analysis of Second-Hand Housing Price Fluctuations in Beijing and Changsha Under the Impact of the Epidemic Based on an Interrupted Time Series Regression Model

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Abstract. The arrival of the epidemic is hitting different industries, leading to an economic downturn. As one of the pillars of the national economy, the real estate industry holds indispensable significance for the stability of the national economy. There are many sectors within the real estate industry, but the secondary housing market constitutes an important part of the real estate industry and best represents it. This study aims to explore the fluctuations of the second-hand housing market in Beijing and Changsha, investigate the impact of the pandemic on the second-hand housing market from 2018 to 2022, while also considering the effects of M2, and include a dummy variable in the regression analysis. Using an interrupted time series regression model can effectively isolate mutation conditions, observe the instantaneous impact of an epidemic, and also monitor long-term fluctuations. It can also serve as research findings and provide purchase advice for homebuyers. At the same time, provide recommendations for government policy implementation, and consider using different policies for different cities' capital situations to quickly and effectively address current issues. Internationally, China provides a good example for other countries in responding to sudden public health events.

Keywords: Real Estate Fluctuations, Interrupted Time Series Models, pandemic impact

1. Introduction

As an important pillar of the national economy, the real estate industry is closely related to the stability of the financial market and concerns the basic needs of people's lives as well as the sound development of the country. The COVID-19 pandemic in 2020 had a severe impact on the national economy, financial markets, and the real estate industry. China swiftly implemented a series of policies to stimulate recovery in these sectors [1, 2].

Research on the real estate industry mainly focuses on changes in housing prices in the real estate sector following the pandemic. Zhou, based on the regression discontinuity method and the event study method, studied the impact of the first round of the epidemic on housing prices in major cities of Henan Province [3]. The study indicates that the degree of impact of the epidemic varies among different prefecture-level cities [3]. He, based on the mediation effect model, studied the impact of the COVID-19 pandemic on residential prices in Wuhan and found that the residential market in

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Wuhan continued to decline during the pandemic [4]. Based on a descriptive analysis of data, Cai studied the relevant situation of the real estate recovery after the impact of the pandemic and found that China's long-term mechanisms in the real estate market still need to be improved [5]. His research perspective focuses on the post-pandemic recovery [5]. Current research has only conducted heterogeneity analysis, and it is characterized by a concentration on selected cities and a lack of diversity, with insufficient regional breadth.

The above studies do not include a comparison between super first-tier cities and first-tier cities. The purpose of exploring the two types of cities is that super first-tier cities accumulate more capital than first-tier cities, and their resilience to external factors is higher, with a faster recovery speed than that of first-tier cities. At the same time, it does not consider whether there is consistency in the influence patterns between the two cities, because the methods used in the study make it difficult to distinguish the sudden effects of time trends. The aforementioned issues can be examined in this study.

This study employs an interrupted time series regression model, incorporating pandemic dummy variables and interaction terms to observe changes in second-hand housing prices before and after the pandemic, while also exploring the patterns of its impact and comparing the two types of cities. This article aims to provide advice to homebuyers and tenants, offer a scientific basis for the implementation of national policies, and provide coping strategies for the international community in response to the impacts of unnatural disasters.

2. Method

2.1. Data sources and description

The data for this study mainly include second-hand housing market price data and macro monetary supply data [6, 7]. The price data of the second-hand housing market comes from the changes in the sales prices of commercial residential properties in 70 large and medium-sized cities released by the National Bureau of Statistics, effectively reflecting the long-term accumulated changes in the second-hand housing market. Data from Beijing and Changsha from January 2018 to December 2022 were selected. The base period of this index is set as follows: from January 2018 to December 2020, 2015 is taken as the base year (2015=100); from January 2021 to December 2022, 2020 is taken as the base year (2020=100). As these changes have no impact on the interpretation of the data, no corresponding measures are taken. Furthermore, the macro-level money supply data is sourced from the People's Bank of China, selecting the monthly absolute amount of broad money supply for the same month (unit: 100 million yuan), in order to control for the impact of changes in housing prices caused by monetary policy in the two regions. All of the above data come from official authoritative data websites, and therefore possess strong reliability and authenticity, enhancing the scientific nature of the research.

2.2. Selection and explanation of indicators

Based on the interrupted time series regression model, the following variables are defined, as shown in Table 1.

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Table 1. Definitions of variables in the interrupted time series regression model

Indicator	Symbol representation	Explanation
Dependent variable	lnPit	The natural logarithm of the second-hand housing price in cityiin montht. Taking the logarithm allows the coefficient to be interpreted as an approximate growth rate.
Time Trend Variable	Tt	Consecutive month numbering, with T1=1 representing January 2018 and T72=60 representing December 2022, captures the natural trend of housing prices over time.
Pandemic dummy variable	Dt	Dt=0 denotes the pre-pandemic period, from January 2018 to December 2019, while Dt=1 denotes the post-pandemic period, from January 2020 to December 2022.
Interactive Item	Tt*Dt	The product of the time trend variable and the pandemic dummy variable is the key parameter that reflects whether the pandemic has altered the trend of housing prices.
Control variable	M2t	Control the impact of monetary policy on housing prices, removing the influence of nationwide monetary policy on housing prices.

2.3. Method introduction

This study employs an interrupted time series regression model, which is commonly used to analyze the effects of drugs and can assess both short-term and long-term effects. It can also effectively take dynamic factors into account. Therefore, this model can compare the levels and slope changes of variables before and after the epidemic, effectively isolating the causes of time-related effects. Establish a regression equation for each city based on this model, as follows: [8]

$$lnPit = \beta 0 + \beta 1 * Tt + \beta 2 * Dt + \beta 3 * (Tt * Dt) + \gamma * M2t + \varepsilon t \quad (1)$$

In the above content, β0 represents the initial value before the pandemic, β1 represents the monthly growth rate of housing prices before the pandemic, β2 represents the effect caused during the pandemic, β3 represents the change in the monthly growth rate of housing prices after the pandemic, γdenotes the influence coefficient of M2t, and εtis the random error term. This model uses the least squares method for estimation, while employing the t-test to determine the significance of the coefficients, that is, $p<0.05$ is significant. The F-test is used for overall significance, and $p<0.05$ is significant. By comparing the signs, magnitudes, and significance, one can assess the similarities and differences in the epidemic's impact on the two types of cities.

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3. Results

3.1. Descriptive statistics analysis

Figure 1 illustrates the trend of changes in the indexed sales prices of second-hand residential housing in Beijing and Changsha from January 2018 to December 2022, with the horizontal axis representing the year and month, and the vertical axis representing the indexed sales prices of second-hand residential housing. As shown in Figure 1, Beijing and Changsha generally display similar change trends. In December 2020, both cities experienced a decline, with the decline in Beijing being greater than that in Changsha. Subsequently, the two cities recovered at different rates: Beijing's recovery was faster and lasted longer, whereas Changsha's recovery was shorter, eventually both cities gradually stabilized.

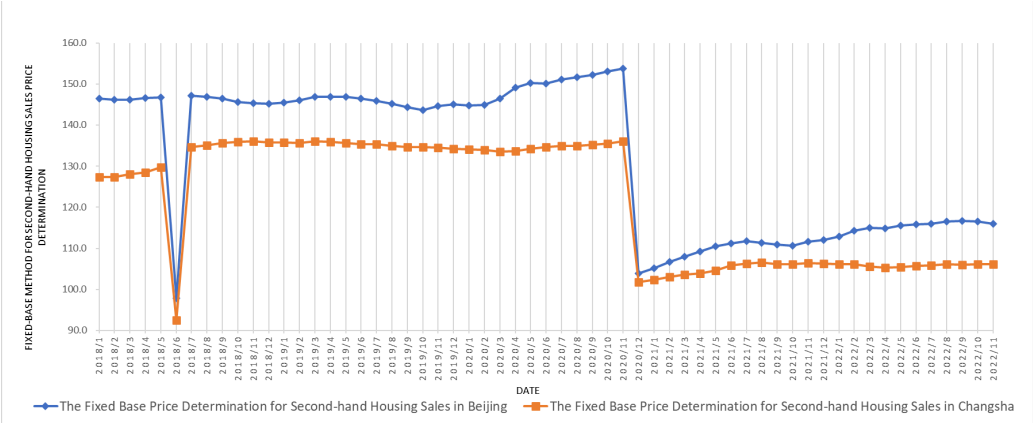

Figure 1. Fixed-base line chart of second-hand residential property sales prices in Beijing and Changsha from January 2018 to December 2022 (photo/picture credit: original)

3.2. Regression results and their analysis

The results of the regression are shown in Table 2.

Table 2. Results of interrupted time series regression analysis in Beijing and Changsha

Variable	Beijing	Changsha
β_1(T)	-0.01614 ** (0.0065)	-0.00701 (0.0048)
β_2 (D)	0.4725 *** (0.1512)	0.4245 ** (0.1603)
β_3 (T*D)	-0.02034 *** (0.0068)	-0.01932 *** (0.0060)
γ (M2)	1.508 *** (0.4120)	0.972 *** (0.3050)
R^2	0.6054	0.6813
F-test p-value	<0.001	<0.001

*Note: Figures in parentheses represent robust standard errors. * p<0.1, ** p<0.05, *** p<0.01.

Regarding the analysis of Beijing, the city was already in a declining state before the pandemic. In January 2020, the logarithm of housing prices in Beijing showed a significant positive trend. Due to the change in data metrics starting from 2020, from 2015=100 to 2020=100, it does not fully

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reflect the changes during the outbreak of the pandemic. After the pandemic, the monthly housing price growth rate in Beijing has fallen more compared to before the pandemic, with the decline accelerating noticeably.

An analysis of Changsha shows that, before the pandemic, housing prices in the city did not exhibit any clear directional changes. It showed a positive jump in January 2020, but due to changes in the data, it should not be used as a reference value for the outbreak of the epidemic. Before the pandemic, Changsha City was not significant, and after the pandemic, the monthly growth rate decreased by approximately 1.93%.

Figure 2 is the fitted line chart of Beijing, and Figure 3 is the fitted chart of Changsha. In Figures 2 and 3, the horizontal axis represents the year and month, and the vertical axis represents the fitted values. It can be seen that the fitted curve can follow the trend of the actual values, reflecting the changes in trends before and after the epidemic. During the outbreak of the epidemic, the fitted curve clearly demonstrated a steepening slope and a transition into decline, which is consistent with the results of β_3. In contrast to Figures 2 and 3, the declining trend before the epidemic in Beijing and the accelerated deterioration after the epidemic sharply contrast with the stability before the epidemic in Changsha and the abrupt deterioration afterwards, confirming the conclusion that the patterns of impact are inconsistent.

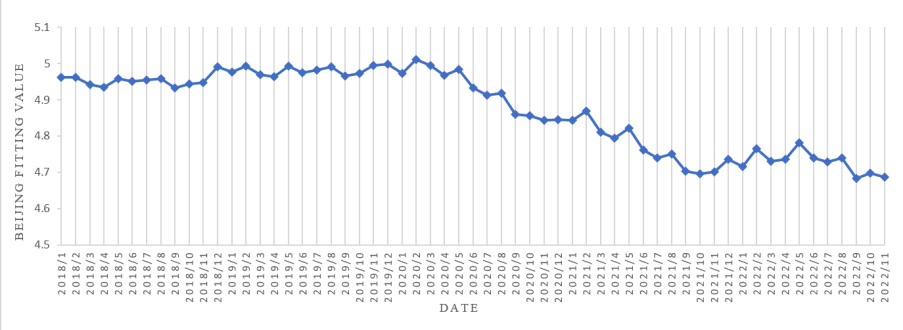

Figure 2. Line chart of fitted values in Beijing city (photo/picture credit: original)

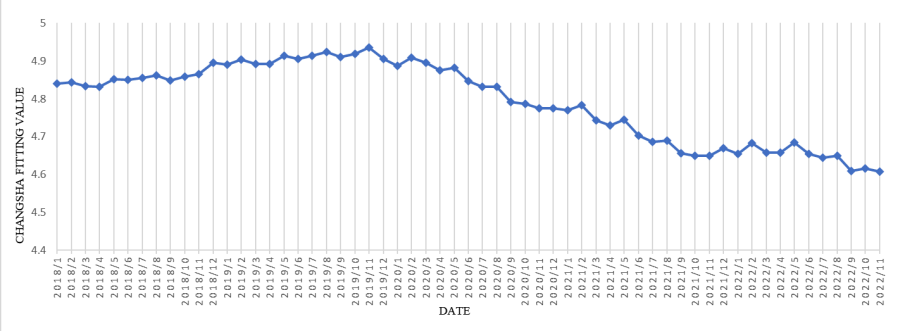

Figure 3. Line chart of fitted values in Changsha city (photo/picture credit: original)

Finally, exploring the impact of control variables, the γ in both places are significantly positive, while the increase in Changsha compared to Beijing is not high. Therefore, it can be concluded that first-tier-plus cities are more sensitive to macroeconomic changes.

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3.3. Robustness analysis

To test the reliability of the research conclusions, this paper conducts a robustness analysis, and the results are shown in Table 3.

Table 3. Results of robustness test

Model Setting	Beijing (β_3)	Changsha (β_3)
Baseline model (the intervention time 0 is January 2020)	-0.02034	-0.01932
Intervention Time 1 (February 2020)	-0.01976	-0.01884
Intervention Time 2 (March 2020)	-0.01911	-0.01821
Exclusion Time: January 2020 to March 2020	-0.01984	-0.01847

Delaying the intervention time to February or March 2020 still shows a significant negative effect in both places, close to the baseline results. After excluding extreme values from the early stage of the pandemic, it still remains negative. The conclusion does not rely on the selection of intervention timing, nor is it a short-term abnormal fluctuation, and it demonstrates considerable robustness.

3.4. Analysis of limitations

This study, along with other studies, takes into account the impact and persistence of government monetary policy on epidemic recovery, as well as the influence of financial markets, selecting them as control variables. This study still has limitations. It only considers data from 2018 to 2022, with limited coverage and not strong timeliness. In addition, it only controlled for certain factors and did not take into account other factors affecting housing prices, such as local policies, the subjective perceptions of clients, population mobility, and so on. Due to the adjustment of the statistical base period in 2021, the interpretation has been affected. Subsequent research can use microdata with a unified base period or supplementary survey data to re-estimate the immediate impact. Finally, the sample size for sub-tier 1 cities and tier 1 cities is small; future research can include more datasets [9, 10].

4. Conclusion

This study investigates the impact patterns and effects in Beijing and Changsha through an interrupted time series regression model. It was found from the regression model that Beijing was already in a declining state before the pandemic, while Changsha was relatively stable before the pandemic. After the impact of the pandemic, there was a rapid decline, with Beijing's response being significantly greater than that of Changsha, indicating that super-first-tier cities are more sensitive. Post-pandemic monetary policies have had positive effects on both locations, showing particularly strong results in Beijing, indicating that the economic capital of super first-tier cities is relatively strong and rebounds quickly. Therefore, when specifying relevant policies, the local economic capacity can be taken into consideration, and different policies can be implemented accordingly.

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