ANALYZING THE UNDERLYING RELATIONSHIP BETWEEN MONETARY POLICY AND RESIDENTIAL PROPERTY PRICES IN CHINA

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Abstract. Policymakers and the public express concern regarding the volatility of housing prices due to its potential to increase consumer costs and negatively impact housing affordability. Based on empirical study, it has been seen that the expansion of the real estate sector has a significant impact on the investment in fixed assets by firms. This influence is mostly attributed to the alteration of the transmission of monetary policy. Real estate investment is considered a feasible option because of the significant and rapid appreciation in property prices. The primary objective of this study is to examine the influence of monetary policy on the housing market in China. To conduct the current study, macroeconomic data from a total of 44 time periods, ranging from the fourth quarter of 2012 to the fourth quarter of 2022, was collected. The findings of our study indicate that in the context of China, an expansion in the money supply has a greater propensity to positively influence the borrowing activities of real estate suppliers and clients, as opposed to the supply of properties themselves. The housing market can be influenced by governmental actions such as adjustments to the money supply and interest rates. While scholars have extensively examined the subject matter, the housing market in China remains relatively under-researched in terms of its susceptibility to government macroeconomic policies. Moreover, the current study offers a comprehensive overview of the prevailing challenges encountered by the residential property market in China, emphasizing the significance of macroeconomic policies within this particular context.

Keywords: real estate, interest rates, Chinese economy, property prices, VAR.

Introduction

The backdrop of the Chinese real estate market

Evergrande, the real estate corporation briefly achieved the status of being China's leading construction entity, having effectively completed over 1,300 projects across 280 distinct geographical regions.

In the wake of its declaration of bankruptcy in August 2023, Evergrande encountered an abrupt collapse, leading to the apprehension of Mr. Xu Jiayin, founder of Evergande, in China in November 2023, on charges of involvement in "unlawful activities" in connection with the company's breakdown (Al Azzam, 2019; Alazzam et al., 2023; Saleh et al., 2020). Since July 2020, the shares of Evergrande, a real estate developer with the greatest debt level on a global scale, have undergone a substantial decrease of 99%, leading to the eradication of about $47 billion in market capitalization. The decrease in value can be ascribed to the decline in the real estate market and the enforcement of governmental initiatives aimed at mitigating unsustainable obligations. The current investigation into the whereabouts of Mr. Xu is still ongoing. Given the company's current financial difficulties in fulfilling its projected debt of $300 billion, the Chinese government has taken over ownership of the prestigious stadium (Al Azzam et al., 2023; Sial et al., 2018; Wan et al., 2024).

The bankruptcy filing of Evergrande in the United States has raised apprehensions regarding the future of this prominent Chinese real estate conglomerate. Evergrande has been widely regarded as a prominent sign of

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China's economic and building industry prowess. Country Garden, a prominent participant in the Chinese real estate sector, had previously indicated financial difficulties by failing to make a bond payment of $1,000,000, which occurred nine days before the announcement above. Following its declaration of bankruptcy in 2021, Evergrande promptly initiated the process of corporate restructuring, which garnered significant global attention. Certain analysts argue that the Chinese government should intervene in order to provide market support, similar to the actions taken by European and American governments in 2011 and 2007, respectively. The onset of a significant decline in the Chinese housing market was observed in the year 2019. The annual growth rate of new construction home prices in the 70 largest housing markets in the United States had a deceleration from double-digit increases observed in the first half of 2019 to 4.6% by July 2021. However, the magnitude of the burst was truly remarkable. The real estate market in China had a significant decline in 2022, following a substantial decrease in 2021, primarily attributed to the rapid dissemination of the coronavirus throughout the nation. In an endeavor to avert the emergence of a housing bubble, the Chinese government had previously made efforts to restrain the swift expansion of the housing sector. However, it persisted in disregarding the ramifications of the global COVID-19 pandemic (Alazzam & Alshunnaq, 2023; Alazzam et al., 2020b) and the subsequent economic decline (Al-Omoush et al., 2022; Lee et al., 2022; Szopiński, 2023; Xu et al., 2022).

Housing markets have emerged as a prominent topic in the ongoing policy discussions of developed nations. Numerous towns have had notable episodes of substantial appreciation in property values during the past two decades, typically succeeded by a subsequent adjustment. Cities in China that are widely recognized and have a prominent role in business or politics exemplify locations where cyclical fluctuations fail to obscure a discernible long-term pattern of substantial inflation in property values. There is a growing concern among policymakers and the general public regarding the volatility of housing prices and its potential implications for higher user costs and diminished affordability. The topic of housing garners significant societal focus due to its fundamental importance as a primary necessity (Alshebami & Aldhyani, 2022; Alshebmi et al., 2020).

Overview of Chinese housing market

After the communist revolution in China on October 1, 1949, the Chinese government in starting in, 1950s, embarked in the housing welfare distribution system inline the ideology of socialist manifesto. But in 1990's, the Chinese government decided to open up its economy and as part of the capitalistic reforms ended the housing welfare distribution system in 1998, the housing market has seen significant growth (Campbell & Cocco, 2007). Scholars in this regard have proposed several theories, but there are two prevalent views. First, one state links it to market

reforms carried out by the Chinese government, according to which the reintegration of property rights amongst the major stakeholders of the Chinese economy, such as state-owned enterprises, individuals, and investors (Stark & Bruszt, 1998; Walder, 1994). The other theory contends that as China opened its economy to capitalistic reforms, by reallocation of land was its priority. In this context, all strata of the economy were included. The cadres and institutions carrying out this role assigned by the government gained strategic power in the form of discretionary powers (Walder, 1994). They exercised this power to reap future benefits that resembled rent-seeking behavior (Bian & Logan, 1996) and thus protected their newly gained power (Zhou, 2000). It can be compared to the alignment of interest by the political and market forces. To offer a comprehensive explanation of asset transformation within the context of housing industry reform, He and Xia (2012) amalgamate these two perspectives. The authors contend that the state had a pivotal role in instigating the privatization of public housing, asserting that the value of these assets saw fluctuations in accordance with market conditions. Furthermore, they suggest that the resultant uneven distribution of wealth favored persons employed by state-owned enterprises (Alshebami & Khandare, 2014).

In recent years, there has been a consistent increase in real estate prices attributed to growing demand and a consistent supply (Li-ping, 2006). As a consequence, the real estate market has yielded continuously elevated annual returns for investors. Following a consistent yearly growth rate of more than 18% since 2004, the housing market experienced a substantial surge of 25% in 2009. Since 2010, the real estate market has had a rapid resurgence and significant divergence, mostly due to the implementation of various supportive policies and economic stimulus measures aimed at loosening market conditions. North, Shanghai, Guangzhou, and Shenzhen represent a limited selection of first- and second-tier cities that have had significant growth and consistently achieved remarkable progress (Yang et al., 2016). Although the Chinese government passed a number of laws in 2003 intended to curb rising housing costs, the problem has not been remedied (Al Droua et al., 2020; Alazzam et al., 2020a; Koval et al., 2022). The escalation of housing expenses would necessitate the redistribution of society resources, potentially resulting in significant implications for several domains, such as economic advancement, equitable social conditions, and fiscal stability (Dai & Yin, 2017). In many economically advanced regions, the escalating housing expenses have surpassed the ability of a significant portion of the population to sustain themselves, resulting in a demographic expansion commonly referred to as "mortgage slaves". The impact of housing price escalation on individuals is dual, encompassing both economic considerations and the fundamental need for existence (Fang et al., 2023; Wen & He, 2015).

The correlation between housing expenditures and income holds significant implications for various factors,

such as urban and regional expansion, as well as the overall state of the economy. The expansion of locations with a higher long-term price elasticity in relation to income is mitigated by the concurrent increase in home prices, hence impacting regional housing affordability. The relationship between housing expenses and income is anticipated to have an impact on various economic factors, including savings, subjective financial well-being, household consumption patterns, and consumption inequality (Anundsen, 2015; Ibrahim & Law, 2014; Mian et al., 2013). Let us posit a persistent and unchanging correlation between regional income levels and housing prices. When prices diverge from this established relationship, it is possible to utilize the disparity as a means of ascertaining whether we are currently encountering situations of overpricing or underpricing. The relationship between income and property prices has a significant impact on credit and macroeconomic cycles, as highlighted by Li et al. (2022), Muellbauer and Murphy (1997, 2008). Therefore, regional policymakers and central authorities must comprehend the variations in this relationship across different regions (Estrada et al., 2023).

Role of real estate in China

The development of China's real estate market has been essential to the country's economic growth. Since China's housing market reforms were enacted in 1998, it has experienced consistent growth (Campbell & Cocco, 2007). Many companies outside of the real estate sector have decided to invest in it as a whole because of the high rates of inflation seen there. The Chinese economy has undergone a shift from a tangible to a conceptual framework. Despite the current flourishing status of the real estate market, private investment is seeing a decline as a result of the government's expansionary monetary policy. The evaluation of real estate and its relationship with the transmission of monetary policy needs a reassessment. The Chinese housing market has experienced a substantial inflow of capital as a result of multiple rounds of monetary easing (Tsai, 2017). The transmission of monetary policy is significantly impacted by the real estate sector, which has evolved into a distinct investment vehicle serving several objectives.

The residential property market positively influences the transmission of monetary policy since it facilitates the collateral impact, sometimes referred to as the crowding-in channel, hence promoting the real economy. In a study conducted by Wang et al. (2016), the authors examined the effects of certain variables on a specific phenomenon.

Similarly, Chauvin and Muellbauer (2018), McCarthy and McQuinn (2017) conducted a study to investigate the relationship between different factors and a particular outcome. Additionally, Leamer (2015) explored the impact of various variables on a specific phenomenon. Furthermore, Davis and Heathcote (2005) conducted a study to examine the effects of certain factors on a particular outcome. The presence of bubbles in the real estate market might

potentially augment the value of collateral, enabling enterprises to secure larger loan amounts from banks for innovation or investment. It, in turn, can alleviate the financial limitations faced by these firms.

The economic impact of the wealth effect on consumption is demonstrated by the observed increase in demand (Baltagi et al., 2000). Increasingly, scholarly literature suggests that the rise of the real estate sector has a notable impact on the transmission of monetary policy, leading to a reduction in corporate investment, specifically in fixed assets. Real estate has become a promising investment option due to the significant financial gains resulting from the rapid escalation of housing prices. Chang et al. (2015) have noted that microenterprises, in particular, tend to participate in speculative activities and redirect their earnings towards the real estate sector instead of productive ventures.

Moreover, enterprises lacking land ownership face the challenge of being ineligible for bank loans as a result of real estate speculation (Khushk et al., 2015; Tiwari et al., 2015; Tsai, 2015); there is a correlation between the acceleration of the financial system and the fluctuations observed in both home prices and corporate investments. The significance of the collateral channel in China is noteworthy; however, the speculative channel may exhibit a more prominent role. The hollowing-out situation in China's industrial sector has experienced a deterioration in recent years. The ongoing expansion of the real estate industry amplifies the transition from a tangible to a virtual economic landscape. When the magnitude of the crowding-out impact surpasses that of the collateral benefit, the efficacy of loose monetary policy in promoting the real economy is significantly diminished.

The remainder of the research comprises of four further parts. The first part, comprising of in-depth review of literature related to the research topic. The second part consists of model development and a description of the variables. The third part consists of results and a discussion of the results, and the fourth part consists of a conclusion and recommendations.

1. Literature review

1.1. Real estate prices and economic policy

Scholars and policymakers have conducted research on the influence of asset prices on consumer prices during the business cycle. In order to provide more clarification, it is anticipated that several linkages between asset markets and the macroeconomy would enhance the transmission of monetary policy. There are two illustrative instances of such connections in the literature. The first is the credit channel, which functions by exerting collateral effects on the external finance premium of households and businesses (Baltagi et al., 2000; Pesaran et al., 1999). The second is the wealth channel, which elucidates the influence of asset prices on consumption through investment choices (Storper, 2011). The financial crisis that occurred

in 2008–2009 demonstrated that asset prices, which consistently vary from their underlying fundamentals, can serve as a significant and independent cause of unexpected disturbances. The significance of policy is emphasized by the "lean against the wind" discourse, which examines the advantages and disadvantages of incorporating asset prices into monetary policy conduct. If the ability of monetary authorities to effectively influence asset market movements is lacking, the approach is likely to be unsuccessful (Duca et al., 2010).

Previous scholarly investigations into the relationship have yielded divergent conjectures and outcomes, necessitating a more intricate analysis of the intricate mechanisms governing the interaction between housing expenditures and household earnings. Academic studies such by Claessens et al. (2012), Lu and Dong (2016) have demonstrated that many organizations, such as central banks, employ the house price-income ratio as a metric for detecting bubbles and discerning instances of house price overvaluation. The prerequisite for utilizing the ratio as a bubble indicator is the underlying premise of price-income stability. If the price-to-income ratio remains constant throughout time, the long-term income coefficient in the regression model employed to assess house prices will be equal to 1. The presence of disparities in supply elasticities between regions questions the reliability of the assumption since these differences are anticipated to affect the correlation between housing prices and income in different regions (Su et al., 2018). The extant literature on the relationship between housing prices and income exhibits considerable divergence in terms of underlying assumptions and findings, hence underscoring the imperative for more investigation in this area. Numerous establishments, including central banks, employ the house price-income ratio as a metric for detecting potential bubbles (Abraham & Hendershott, 1996; Aizenman et al., 2019; Anundsen, 2021) and discerning instances of house price overvaluation. It is essential to assume the price-income ratio is stationary in order to use it as a credible warning of market bubbles. In the realm of examining housing prices through the application of a regression model, there exists a prevailing belief that the coefficient for long-term income is equivalent to one under the condition that the ratio of price to income remains consistent over a prolonged duration. Other variables raise skepticism regarding the accuracy of the premise. As evidenced by Saiz (2010), there exists variation in supply elasticities across different locations, which is anticipated to impact the link between housing prices and income.

In the context of this topic, previous empirical studies have presented contradictory results. The study undertaken by Ming et al. (2014) provides findings that are inconsistent with the assumption of consistent price-to-income ratios throughout all regions of the United Kingdom. The study conducted by Wang et al. (2016) investigates the concept of cointegration, specifically focusing on the enduring and reliable relationship between apartment prices and income levels in metropolitan areas of Finland. It is

crucial to recognize that the coefficient reflecting income in this correlation frequently exhibits substantial deviations from a baseline value. While the tests discussed in the articles mentioned above are constrained to pairwise comparisons and are specific to unique cities or areas, panel data tests are widely employed in the academic literature. Case (2000) conducted a study on urban locations in the United States, whereby the existence of non-stationarity in price-income ratios was recognized.

In contrast to the viewpoint described before, Gallin (2006) presents an argument that spatially dependent panel methodologies have the potential to effectively challenge the concept of non-stationary ratios in state-level data from the United States. To account for disparities in the relationship between prices and income across diverse geographical areas, several panel models incorporate the flexibility of allowing the income coefficient to differ between regions, hence departing from a homogeneous value. Foote et al. (2021) utilizes conventional pooling panel estimators in order to ascertain a stationary vector that exists between prices and aggregate personal income among metropolitan areas in the United States. This study differentiates between panels comprising cities that are subject to supply constraints and those that are not. Based on the research conducted by Gallin (2006), it has been determined that there is a lack of empirical support for the existence of cointegration between house prices and population in metropolitan regions of the United States. The finding mentioned above is supported by panel tests that take into account the cross-correlations among cities. Gimeno and Martinez-Carrascal (2010) add the consideration of spatial dependency in their regression models, hence expanding the scope of analysis beyond unit root testing.

Scholarly interest in the correlation between home prices and GDP growth has increased in the wake of the 2008 financial crisis. Under these circumstances, a substantial body of research has been dedicated to examining the impact of fluctuations in housing prices on key macroeconomic indicators such as GDP, residential development, and inflation. Caballero et al. (2008), Case and Quigley (2008), Goodhart and Hofmann (2008), and Telyukova and Wright (2008) and numerous more scholars have contributed to the existing scholarly literature by conducting case studies that examine both aggregate and household-level phenomena. The significance of the discovery made by Disney et al. (2010) that "house price shocks have a greater impact on the macroeconomy compared to stock market shocks" cannot be overstated. Case and Quigley (2008) claim that the challenges faced by the housing market have extensive economic implications, such as a decrease in consumer expenditure, a deceleration in the rates of home construction and completion, and a reduction in overall residential investment.

Additionally, these findings illustrate the correlation between decreasing property prices and their beneficial impact on household income and the financial sector, which is evidenced by a decrease in the utilization of

housing and construction services, a decline in the demand for home financing, and a rise in mortgage defaults. Multiple studies have established a strong association between housing prices and economic activity. Nyakabawo et al. (2015) demonstrated a causal relationship between real house prices and real GDP per capita by analyzing aggregated data from the United States, covering the period from 1963Q1 to 2012Q2. The findings of their study indicate a potential causal association between actual housing prices and the real gross domestic product (GDP) per person; however, the strength of this relationship is very modest compared to initial expectations. The impact of the Granger effect on real house prices extends to its influence on real GDP.

Neglecting the volatility of house prices might lead to either an overestimation or underestimation of the impact of monetary policy. There is a growing body of information derived from scholarly inquiries that indicates uncertainty has extensive implications for enterprises. It encompasses both political and economic policy uncertainty, as discussed by Berentsen et al. (2015), Eidgenössische Steuerverwaltung ESTV (2015), Jordà et al. (2015), Kuzin and Schobert (2015), Leamer (2015), and Nyakabawo et al. (2015). The prevailing consensus among scholars is that uncertainty exerts a detrimental influence on investment activities. There exists a significant discourse about the two mechanisms via which uncertainty serves as a deterrent to corporate investment.

Furthermore, the influence of uncertainty can be modified by the institutional environment within which a corporation operates. The fluctuation in Chinese housing prices may provide empirical support for identifying correlations and evaluating alternative options. During the preceding decade, China implemented a series of monetary policy adjustments, particularly evident during the years of 2009 and 2010, which coincided with the implementation of stimulus plans (Guo & Huang, 2010; Ouyang et al., 2010). Consequently, there has been a significant and fluctuating rise in housing prices, which has contributed to the overall enhancement of the economy. This study investigates the effects of different monetary policies on housing prices and analyzes the corresponding responses of diverse investment structures inside enterprises.

The potential consequences associated with the volatility of housing values should not be disregarded. Real estate is often seen as a dependable method of asset preservation due to its favorable attributes of high liquidity and low risk. There are two primary causes for this phenomenon (He & Xia, 2012). The heavy reliance of local governments on revenue generated from land sales is attributed to the existing tax distribution scheme (Zhang et al., 2021). In contrast to other countries, the Chinese government exercises stringent supervision over the allocation of land (He & Xia, 2012). There exists a robust correlation and mutual reinforcement between the costs associated with land and residential properties (Yang et al., 2016).

In contrast, local government officials possess a motivation to artificially increase the value of the real estate market in order to stimulate economic growth and enhance their political standing. A natural consequence of this situation is a high level of confidence in the future increase in housing prices (Disney & Luo, 2017). Additionally, the inconsistent implementation of government policies and the adoption of countercyclical measures by the government serve to encourage buyers' false expectations regarding future increases in house prices (Li & Wan, 2015). The government has implemented a comprehensive set of rules pertaining to the real estate sector, encompassing several aspects like limitations on sales and purchases, restrictions on property supply, and the imposition of real estate taxes. The imposition of higher transaction expenses temporarily impedes real estate transactions (Yi & Huang, 2014). The housing market has exhibited a limited decline in prices despite the implementation of new regulations (Fu, 2016). There is a prevailing belief among certain individuals that governmental intervention in the housing sector is an eventual inevitability (Su et al., 2018; Yang & Ji, 2017). In the event of an anticipated economic slump, the government may opt to relax regulations pertaining to real estate transactions, such as acquisitions and sales, with the objective of stimulating consumer expenditure. The prevailing belief among the general public that house values will not experience significant further decline is subsequently bolstered by a recent series of retaliatory recoveries resulting from the uneven execution. There exists a line of argumentation suggesting that real estate possesses the capacity to function as an endogenous reservoir of value (Davis & Heathcote, 2005; Montgomery & Takahashi, 2014). Due to the growing volatility of the current economic landscape, investors perceive real estate as a reliable and secure investment option (Leskinen et al., 2020). Despite the considerable volatility in the rate of house price growth, many firms continue to allocate substantial financial resources towards real estate investments. In this particular instance, it is imperative to elucidate the correlation between real estate prices and business investment. The presence of uncertainty over housing prices significantly influences the overall economy, thus necessitating a focused consideration of this variable.

1.2. Role of money supply and residential property market

The study conducted by Goodhart and Hofmann (2008) utilized a panel vector autoregression (VAR) analysis on a sample of seventeen industrialized nations. As a result, it can be observed that a significant portion of money created within the Euro area is comprised of net foreign assets. The limited availability of empirical data regarding the intricacies of monetary systems and credit mechanisms can be ascribed to two fundamental issues. The fundamental rationale pertains to the money multiplier framework, which has contributed to a pervasive misconception regarding the process of money creation. The second aspect pertains to the simultaneous determination of credit and

money (Wen & He, 2015). The procedure through which a financial institution obtains additional liquidity entails the concurrent deposit of monies into the recipient's bank account, coupled with the provision of a loan. Moreover, it is worth considering an alternative technique that involves moving in the other direction. The volatility of currency values can impact the magnitude of risk premiums and the conditions under which credit is extended (Schabert, 2005).

Nevertheless, there exist circumstances wherein it is deemed more logical to undertake an independent examination of the aggregate money supply and lending operations conducted by both banks and non-banks, as proposed by the Bank of England in 2008. During periods characterized by economic recessions, it is common to observe a difference between credit and money. The possibility of restricting credit expansion comes when financial institutions choose to retain liquidity buffers, notwithstanding the availability of borrowing at relatively low costs. The presence of risk aversion and the inclination towards liquidity can potentially result in an expansion of the overall money supply, accompanied by a simultaneous growth in the narrower component of the money supply (Su et al., 2018). Furthermore, it is conceivable that financial institutions can withdraw funds from a capital market that is gradually becoming more restricted in terms of accessibility. The efficacy of monetary policy may be compromised in countries with stable exchange rates due to the inflow of foreign capital, as suggested by previous research undertaken by Su et al. (2018, 2017b), and Yang and Ji (2017) claim that the introduction of foreign capital inflows exerts a favorable influence on the valuation of real estate and equities inside China. Tsai (2015) argues that a rise in the money supply will cause the housing market to deviate from its fundamental principles, leading to unpredictable price fluctuations for homes in the United States. Based on the empirical findings by Goodhart and Hofmann (2008), and Telyukova and Wright (2008), it is evident that the relationship between hot money flows and home values loses significance when accounting for the influence of the money supply. According to Su et al. (2018), and Yang and Ji (2017), the lack of a noticeable correlation between home prices and the money supply in China could suggest the existence of irrational and speculative conduct among Chinese investors. Based on the research conducted by Tsai (2017), it has been determined that demand-related disruptions mostly influence fluctuations in housing prices within China.

In contrast, the influence of the money supply is deemed to be of minimal significance. The research done by Dai and Yin (2017) presents empirical support for the proposition that M2 exerts a favorable influence on the rejuvenation of the housing market during periods of economic recession. However, when the economy is doing well, monetary policy has less of an impact on the market.

2. Choice of research model and variable selection

2.1. Variables selections

In order to accomplish the objectives of this research, an examination of macroeconomic data encompassing a total of 44 temporal intervals, spanning from the fourth quarter of 2012 to the fourth quarter of 2022, was undertaken. The variables utilized for analysis in this study were the five-year nominal loan interest rate (X1), the M2 of overall money supply (X2), and the real estate sales price index (Y). The study incorporated seasonal fluctuations and selected variables based on data accessibility. The employed processing technique was logarithmic, as indicated by references (Guo & Huang, 2010; Telyukova & Wright, 2008). Log-REP represents the log of real estate prices in the property market of China; the Log-LR represents the logarithm of the 5-year benchmark lending rate. And finally, the Log-MS2 Money supply Generalized money supply M2. The data source for the present research is the China Economic Network database, National Bureau of Statistics, and National Research Network.

2.2. Research model

Following in the footsteps of (Yin & Yan, 2021), we utilized the Augmented Dicky Fuller test, commonly known as the ADF test, to initially establish the stationarity of the data; for this purpose, the following models were considered:

$$\Delta X_t = \alpha + \beta t + \delta X_{t-1} + \sum_{i=1}^{m} \beta_i \Delta / X_{t-1} + \varepsilon_t; \quad (1)$$

$$\Delta X_t = \alpha + \delta X_{t-1} + \sum_{i=1}^{m} \beta_i \Delta X_{t-1} + \varepsilon_t; \quad (2)$$

$$\Delta X_t = \delta X_{t-1} + \sum_{i=1}^{m} \beta_i \Delta X_{t-1} + \varepsilon_t, \quad (3)$$

where, the drift term is denoted by α, and trend term is denoted by βt. In case of null hypothesis, the value of $\delta = 0$, alternative hypothesis suggests that $\delta < 0$. If the test rejects the null hypothesis, it indicates that the sequence does not possess a unit root and is instead a stationary sequence. If the null hypothesis cannot be rejected, it indicates that the sequence contains at least one unit root and is therefore nonstationary. To make the sequence stationary, differential processing is necessary.

The Augmented Dickey-Fuller (ADF) test is employed to determine whether the null hypothesis, which assumes non-stationarity, should be accepted or rejected in favor of the alternative hypothesis of stationarity. The null hypothesis is retained unless there is substantial evidence to reject it (Jalil & Rao, 2019). The ADF testing strategy involves the calculation of model coefficients through the utilization of the Ordinary Least Squares (OLS) technique (Guidolin & Pedio, 2018). The adjusted *T* (Student)-statistic, commonly known as the Dickey-Fuller statistic, is calculated

and compared to the appropriate critical value to assess the significance of the focal coefficients (Zhou, 2000). The null hypothesis is deemed to be rejected when the calculated test statistic is found to be smaller than the predetermined critical value. The critical value for each test varies based on the sample size (Kissell & Poserina, 2017).

According to Cheng et al. (2020), model 1 comprises equations that include both trend and intercept terms. In contrast, model 2 is an equation that lacks a trend term, while model 3 is an equation that solely focuses on the intercept term. In these equations, the variable *t* represents the trend term, while the variable represents the drift term. The symbol "ε" is commonly used in mathematics and computer science to represent the empty set or the empty string. The evaluation process involves assessing the alternative hypothesis H1: 0 and the null hypothesis H0: 0 throughout model 1 to model 3. If the null hypothesis is rejected, it can be concluded that the sequence does not possess a unit root and is hence considered stationary. If the null hypothesis cannot be rejected, it can be concluded that the sequence has at least one unit root. In order to achieve stationarity for this non-stationary sequence, it is necessary to employ differential processing (Sun & Wang, 2020). The equation in question, as per the AIC (Akaike Information Criterion) (Liu & Chen, 2020), is capable of computing both the intercept and trend components. In the traditional regression model, it is assumed that all variables possess stability. The application of the usual regression model is not suitable for non-stationary data.

Nevertheless, the utilization of the usual regression model approach is applicable when the associations between the variables remain constant over time. The logical importance of the cointegration test is described by Shin et al. (2014). Several unstable sequences display a long-term trend, and if there is cointegration of order (*d*, *d*), the sequence can be written as a linear combination of a long-term stable relationship and an equilibrium stable proportional relationship, suggesting that the variables will not produce spurious regression results. Furthermore, the equilibrium mechanism will cause successive adjustment regressions that converge toward the equilibrium point even if a variable undergoes disruptions from the equilibrium point throughout time (Banerjee et al., 1998; Shin et al., 2014). The study focuses on two variables, specifically single integration sequences of the first order. The primary objective is to ascertain the presence or absence of a cointegration relationship between these variables. In this study, the cointegration test is conducted using the widely adopted Johansen technique (Kenny, 1999; Price, 2011).

To gain insight into the residual term's time-series correlation, the VAR model's lag-order posterior component is built to take advantage of the small sample size. Degree of freedom decreases when sample loss grows with an increase in the number of model lag periods. It's worth noting, though, that the lag order's inability to eliminate sequence correlation completely may mean that the current model has certain shortcomings (Beltratti & Morana, 2010). In general, the principle of selecting the minimal Akaike Information Criterion (AIC) and Schwarz Criterion (S.C.) values is employed to determine the optimal lag order. When the lag order at which the Akaike Information Criterion (AIC) and Schwarz Criterion do not minimize simultaneously, the likelihood ratio (L.R.) test is utilized to make trade-offs.

In order to evaluate the dynamics of many time series, analysts frequently turn to vector autoregressive (VAR) models. The influence of unpredicted factors on a system of variables. Therefore, the following research is based on the VAR model framework proposed by Sims (1980) to investigate the dynamic interplay and influence among monetary policy variables, namely real estate prices, interest rates, and generalized money supply in China. This approach allows for the assessment of impulse response and variance decomposition between these variables (Shi & Fan, 2017).

The equation presented below is the theoretical model that has been derived:

$$Y_t = \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \beta_1 X_1 + \ldots + \beta_r X_r + \varepsilon_t. \quad (4)$$

After reorganization, the model takes the following shape.

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-1} + \sum_{s=0}^{r} \beta_s X_{t-s} + \varepsilon_t, \quad (5)$$

where, the vector Y_t denotes the set of endogenous variables in an m-dimensional space, while X_t represents the set of exogenous variables in a d-dimensional space. The parameters *i* and *s* (where *i* ranges from 1 to *p* and *s* ranges from 1 to *r*) correspond to the matrix that is to be estimated. The variables α_i and β_s indicate the order of lag periods for the endogenous and exogenous variables, respectively. Finally, the symbol *t* stands for the fraction of errors that arise due to chance. X_t in this study stands for the logarithm of the money supply and interest rate, whereas *Y* is the processed property price. The index of real estate transactions is defined as a non-stationary sequence of first order.

Consequently, the conventional VAR model incorporates the first-order difference into the model. This finding suggests that the stationary sequence is exclusively composed of the variable or the first-order difference of the variable, indicating stability in the model. The results of pulse response analysis and variance decomposition support this conclusion.

3. Results of the study and discussion of results

3.1. Results of ADF test

In this section, the results of the present study are provided in detail below, along with their explanation in Table 1.

Upon comparing the ADF value stated in Table 1 regarding the variable LOG-REP to the 5% critical value and

Table 1. The ADF test results

Variables	ADF	Critical value 10%	Critical value 5%	Critical value 1%	Conclusion
LOG-REP	−5.0023	−2.8971	−3.7015	−4.2015	Stationary
LOG-LR	−3.0021	−2.9997	−2.9908	−4.0012	Non-stationary
LOG-MS2	−1.7500	−2.9982	−3.6002	−3.9981	Non-stationary
D (LOG-LR)	−6.996	−3.0122	−3.4210	−4.2221	Stationary
D (LOG-MS2)	−3.0231	−3.1030	−3.0061	−4.3564	Stationary

the *p*-value, the test results suggest that the stability of the logarithmic distribution of the housing price index can be inferred (Yang & Dong, 2017). At a significant level of 10%, the empirical evidence regarding the relationship between money supply (LOG-MS2) and interest rate (LOG-LR) is inconclusive. This observation indicates the presence of a unit root in the dataset, as the behavior of the two variables aligns with that of a non-stationary sequence. Based on the observation that the D (LOG-LR) ADF value is significantly lower than the 5% critical threshold, it can be inferred that the log of the interest rate index (LOG-LR) exhibits a first-order single sequence in relation to the logarithmic transformation of the first-order difference of the loan interest rate and the logarithmic transformation of the money supply. Nevertheless, the estimated outcome of the test equation, which includes the intercept component and has a *p*-value of 0.1, indicates a negative relationship for the aggregate money supply M2. This finding further supports the validity of the equation. The stability of the disparity between the money supply index D (LOG-MS2) and its first-order single-sequence nature has been established (Su et al., 2018, 2017a). It is supported by a statistically significant *p*-value of 0.0096, which is below the conventional threshold of 0.05.

3.2. Model stationarity and testing

The characteristic roots of the VAR model are seen to be located within the unit circle, as evidenced by the data presented in Table 5 and Figure 1. Furthermore, the absolute values of each characteristic root are found to be less than 1, indicating that the model is stable, and its characteristic
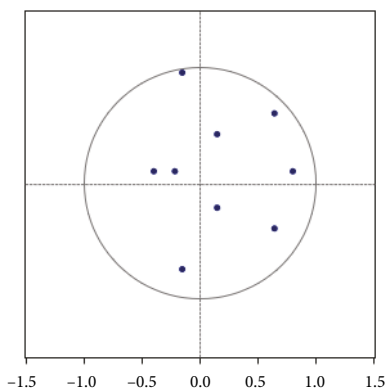
roots possess stability as well. Consequently, the examination of the pulse response function for this vector autoregressive (VAR) model, considering a standard deviation, can proceed (Dai & Yin, 2017).

The pulse response function is a measure of the reaction of the shock residual to changes in the endogenous variable as indicated by Figure 2. The utilization of a pulse response in this study serves as a valuable approach for examining the relationship between the money supply, real estate values, and domestic loan interest rates (Su et al., 2017b). The pulse function serves as an illustration of the dynamic impact exerted on the response element.

The study focuses on the initial property price as the dependent variable, with the independent variables being two specific characteristics of monetary policy. Figure 3 depicts the correlation between the number of forecast periods and the response of property values to the positive influence of one unit of the standard deviation of the money supply and interest rate. The continuous blue line visually represents this relationship. The pulse response image is represented by a red dotted line, which corresponds to a 95% confidence interval. Two standard deviations determine this interval as depicted in Table 2.
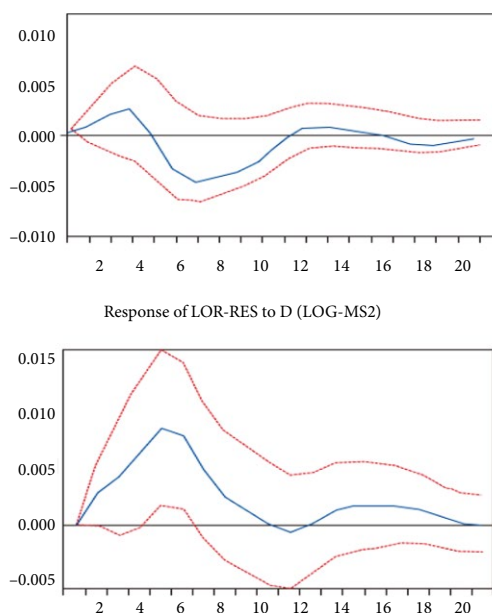

Response of LOR-RES to D (LOG-MS2)

Figure 2. Housing market sensitivity to changes in interest rates and money supply

Figure 1. Inverse roots of A.R. characteristic polynomial

Based on the results shown in Table 3, we can assume that interest rates have a short-term positive effect on property prices. In this case, four important issues come up. The highest value is thought to be around 0.025. Second, there is a downward trend in the fifth period. Third, there is a strong negative effect during the seventh period, with a maximum value of about –0.050. After that, there is a stead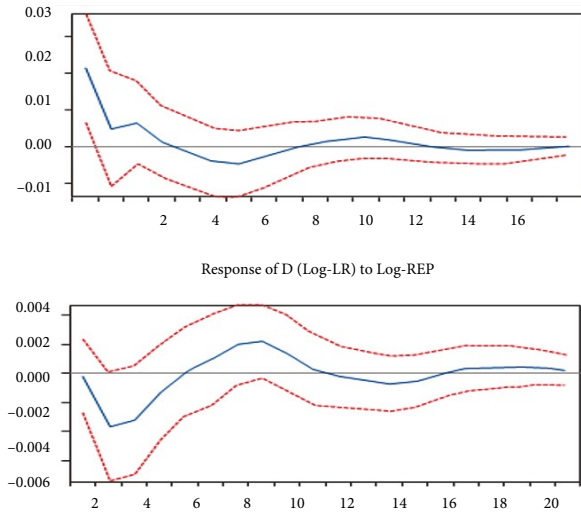y process of stabilization. There is still a clear negative effect of the 5-year loan interest rate on housing prices, even though changes to interest rate policy take time to take effect. The details of which can be found in Table 4. According to Bong and Min (2011), it is possible to argue that short-term increases in interest rates will force real estate developers to pass on the higher costs of materials and capital to their customers, which will cause housing prices to rise.

Real estate developers who are working on projects over the medium to long term recognize the importance of capital recovery more than other people. Another thing is that people who live in a certain area have more freedom to make long-lasting changes to their way of life. More and more people are becoming aware of the effects of changing home prices, which highlights how important interest rate policy is. When you look at the money supply, it's clear that even a small increase in interest rates can have a big effect on the values of homes. The graphical representation shows the big rise in property values that happened in the first four years. The most important effect of monetary policy can be seen in the sixth period, when it has a magnitude of 0.01. The line that shows the level of no effect is outside the confidence interval, which means there was a big effect. The same pattern will keep happening until issue #10. It is expected that Phase 12 will have a small positive effect on property prices after a long period of stabilization.

Response of D (Log-LR) to Log-REP

Figure 3. Effects of money supply and interest rates

Table 2. Calculation of optimal lag-period

Lag	LogL	LR	FPE	AIC	SC	HQ
1	294.6172	NA	1.11E-10	−15.0012	−15.0001	−15.1132
2	312.5401	30.3309	8.16E-11	−15.1101	−15.1001	−15.0032
3	**331.3453***	**28.9310525***	**4.41E-11***	**−16.6421***	**−15.6512***	**−15.0141***
4	336.1178	6.6079	6.10E-11	−14.2261	−13.6003	−13.9861
5	341.3844	6.4820	8.01E-11	−15.0023	−13.0209	−13.8901
6	350.9832	10.3373	8.00E-11	−15.0013	−13.0231	−13.9987
7	362.2690	10.4176	9.21E-11	−14.3341	−13.1823	−13.8856
8	372.9311	8.2016	1.02E-10	−14.5621	−13.0001	−15.1123

Table 3. Results of consolidation test (Johansen's)

Results of trace test				
Hypothetical cointegration relationship	Value of characteristic	Trace test	Critical value 5%	*p*-value
None∗	0.425624	40.491406	30.5598032	0.0028717
At most 1	0.23875968	15.742345	15.89136432	0.0539466
At most 2	0.07517648	3.5135005	3.939811632	0.0658435
Table for characteristic root statistic maximum values				
Hypothetical cointegration relationship	Characteristic value	Trace test	Critical value 5%	*p*-value
None∗	0.425624	24.749061	21.67256896	0.0187685
At most 1	0.23875968	12.228844	14.62977376	0.1164056
At most 2	0.07517648	3.5135005	3.93973984	0.0658435

Table 4. Results of the VAR model

Roots	The module of plural roots
0.917186943	0.91722285
0.8451-0.5001i	0.91331528
0.8451-0.5001i	0.91331528
0.0919-0.9011i	0.908246
0.0919-0.9011i	0.908246
0.2458-0.3015i	0.4034302
0.2458+0.3015i	0.4034302
−0.4211	0.34967471
−0.1521	0.15640841

Table 5. Breakdown of variance of Chinese real estate prices

	Standard Error	LOG-REP	D (LOG-LR)	D (LOG-MS2)
1	0.0101	100	0	0
2	0.0171072	86.662046	0.1061181	2.3318361
3	0.0227205	84.013816	0.6521229	4.4340615
4	0.025839	79.115454	1.3472811	8.637354
5	0.027621	71.857635	1.183248	16.059117
6	0.0290466	65.394143	2.6375382	21.068319
7	0.0301158	62.278227	5.0236362	21.798226
8	0.0308286	61.005255	6.7895091	21.305236
9	0.0312741	60.100445	8.1135351	20.886109
10	0.0313632	59.588565	8.8118118	20.699623
11	0.0314523	59.606385	8.8511049	20.64251
12	0.0316305	59.892753	8.779914	20.427333
13	0.0318087	60.114255	8.6962491	20.289496
14	0.0319869	60.14544	8.6232762	20.331284
15	0.0319869	60.033085	8.5846959	20.48213
16	0.032076	59.839204	8.5802409	20.680556
17	0.0321802	59.655087	8.6613219	20.783555
18	0.0322301	59.558138	8.7751026	20.766804
19	0.0322533	59.51962	8.8399674	20.740431
20	0.0322542	59.498485	8.8694595	20.732055

A statistical method for assigning the variance of an endogenous variable is variance decomposition. To determine the effect of structural components on variable fluctuations and to evaluate the impact of several factors as described in the scholarly literature (Bolt et al., 2019; Boug et al., 2021). Thus, variance decomposition, as shown in Table 5 helps explain real estate price index variables.

The dominant perspective suggests that the expansion of the money supply will exert a more substantial influence on the overall availability of borrowing funds for real estate suppliers and consumers compared to the growth in the supply of property by providers. The government

can exert control on housing prices through the implementation of two policy instruments: the manipulation of the money supply and the adjustment of the lending benchmark interest rate. Furthermore, the influence of real estate prices serves as a significant aspect, while the two constituents of monetary policy can be identified as the responsive elements. Figure 3 illustrates a positive correlation between real estate prices and interest rates throughout the initial four time periods, followed by a steady attenuation of this correlation in subsequent periods. Following a series of ten periods characterized by fluctuations, the values of real estate eventually reach a condition of stability, subsequent to exerting both positive and negative influences on the money supply. The relationship between interest rates, money markets, and the residential property market is evident.

Conclusions and recommendations

The results of the co-integration test indicate the presence of a durable and consistent long-term association among broad money supply, interest rates, and real estate prices. In order to provide a reasonable and stable real estate market, the government must exercise responsible regulation over real estate prices through the manipulation of the money supply and interest rates. Nevertheless, the impact of monetary policy on housing prices is constrained and contingent upon the particular monetary policy in question. Hence, instead of overly depending on monetary policy modifications, it is advisable to choose judicious monetary measures.

The analysis of pulse response and variance decomposition offers valuable insights into the factors contributing to fluctuations in housing prices and the degree to which different monetary policy variables impact the dynamics of real estate markets. The impact of interest rate policies on real estate values exhibits a delayed response. The utilization of interest rates as a means to influence housing rates is accompanied by a delay period ranging from five to seven periods. Nevertheless, the interest rate associated with the 5-year loan continues to exert a detrimental influence on the value of properties in the medium and long run. Over time, the regulatory influence becomes increasingly evident. It is widely acknowledged that a singular increment in an interest rate can promptly affect the money supply and exert a favorable, progressively increasing influence on the valuation of real estate. From a mechanical standpoint, it is apparent that the money supply exerts a dual influence on property prices, wherein the positive impact surpasses the negative impact by a substantial degree. The values in the initial column correspond to the standard error that arises after each prediction stage of the LOG-REP method, as calculated through the process of variance decomposition. The final three columns depict the proportional contributions of each variable to the anticipated standard deviation of property prices for each concern.

Phase 11 demonstrates a discernible trend wherein the influence of real estate prices is shown to be reducing and reaching a state of stability, estimated to be about 67%. However, when we move from Phase 0 to Phase 10, there is a noticeable improvement in the explanatory power of the interest rate when considering its relationship with the standard deviation of the house price projection. Over time, it attained a state of equilibrium at around 10%. In a similar vein, the explanatory capability of the money supply demonstrated a slight augmentation prior to attaining a state of equilibrium at 23% during the sixteenth era. Therefore, one could contend that the monetary supply policy has a greater influence on housing prices in comparison to interest rates.

Therefore, an expansionary monetary policy, which aims to increase the money supply in circulation, may have a direct and positive effect on property prices. Manipulating the money supply has a larger impact on home prices than changing interest rates does in the short term. Although there are other elements related to monetary policy that influence fluctuations in housing prices, it can be argued that the money supply has a more significant and enduring effect on home prices compared to interest rates. Hence, it can be argued that the money supply exerts a more significant influence on house prices in comparison to interest rates.

Recommendations

Hence, the governmental choice to adopt an expansionary monetary policy or augment the money supply might lead to a swift escalation in property values. In the short run, the manipulation of the money supply exerts a more substantial influence on property values compared to the adjustment of interest rates. Although there are other elements related to monetary policy that influence changes in housing prices, it can be argued that the money supply has a more significant long-term effect on home prices compared to interest rates. Hence, it can be argued that the money supply exerts a more significant influence on house prices in comparison to interest rates. The central bank can improve results by controlling the money supply via regulation of the property market.

Limitations

– The major limitations of the research relate to the context of the study, as the present study was conducted solely in the Chinese context.
– Besides this, we only concentrated on the analyzed economic and financial data related to residential housing and ignored the greater property market.
– Another limitation of the research is the fact that we conducted the research in a generalized context of China and ignored the regional context of the housing market.

The future direction of research

In the future, researchers can opt for cross-sectional data to analyze the relationship between monetary policy and its impact on the housing market in different countries.

Along with this, researchers can also analyze the relationship across different geographical regions of China.

The same analysis can be conducted by adding other macroeconomic variables, such as fiscal policy, the impact of FDI, and geopolitical developments such as the Indo-China conflict, the Ukraine war, etc.

Author contributions

All authors contributed to conceptualization, formal analysis, investigation, methodology, writing and editing of the original draft, and read and agreed to the published version of the manuscript.

Disclosure statement

The authors declare no conflicts of interest.

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