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„The effect of traditional preference on housing price in
China 's 13 new first tier cities “

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Chen Xie

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Zusammenfassung

Das traditionelle Konzept der männlichen Präferenz gegenüber Frauen existiert seit Tausenden von Jahren in China und hat die demografische Struktur Chinas beeinflusst, was auch Auswirkungen auf die Hauspreise in China hat. In dieser Arbeit wird diskutiert, ob der Anteil der Männer an der Bevölkerung Auswirkungen auf die Hauspreise hat. Dazu wurden Panel-Datenregression, Granger-Kausalitätstests und Impulsantwortfunktionen basierend auf Daten zu Hauspreisen, dem Anteil der Männer und dem BRP usw. in Chinas 13 neuen erstklassigen Städten von 2002 bis 2012 verwendet. Die Ergebnisse zeigen, dass der Anteil der Männer eine signifikante Beziehung zu den Hauspreisen hat und dass der Anteil der Männer und die Hauspreise eine beidseitige Granger-Kausalität aufweisen. Wenn der Anteil der Männer einen Schock erleidet, werden die Hauspreise beeinflusst, jedoch mit Verzögerung.

Schlüsselwörter

Traditionelle Präferenz, Anteil der Männer, Hauspreis, Panel-Daten

Abstract

The traditional concept of male preference over female has existed in China for thousands of years, and this concept has influenced the demographic structure of China, which also has an impact on the house prices in China. This paper discusses whether the proportion of males in population has an impact on house prices using panel data regression, granger causality test and impulse response function based on the data of house prices, the proportion of males and GRP, etc. in China's 13 new first- tier cities from 2002 to 2012. The results indicate that the proportion of males has a significant relationship with house prices, and the proportion of males and house prices have two-way granger causality, and house prices are affected when the proportion of males is shocked, but the effect has a lag.

Keywords

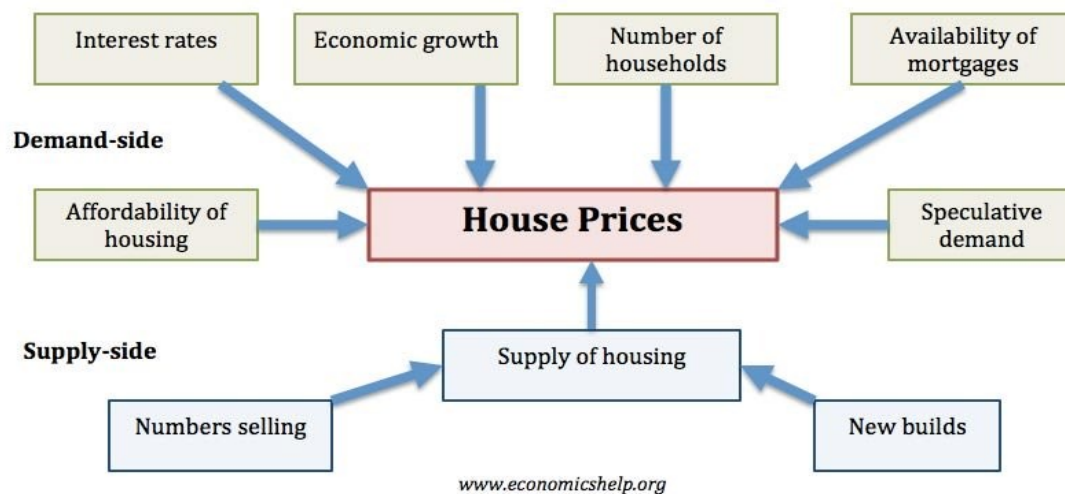
traditional preference, the proportion of males, housing price, panel data

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1. Introduction

The housing market is affected by the population fluctuations, economic state, interest rates, and real income. In addition to these demand-side considerations, available supply will also impact home prices. With times of high demand and low supply, rents, property prices, and the risk of homelessness will rise. (Pettinger, 2019).



In general, unemployment, consumer confidence, the interest rate, economic growth, the availability of mortgages, supply, etc. are the primary elements that influence the housing market (Pettinger, 2019). All the aforementioned research points are shared by the majority of economists. On the other hand, the traditional gender preference may be an additional unique factor in China that has the potential to also influence the price of housing.

1.1 Background

In China, in contrast to western countries, there is a particular traditional preference known as the patriarchal tradition. To put it another way, there is a preference for male offspring over female. This patriarchal custom has been practiced for probably thousands of years at this point. Since the beginning of recorded history, China has

been a male-dominated society that adheres to the belief that men are superior to women and that the relationship with the father's lineage is the only proper lineage. Prior to 1983, the population policy of China encouraged childbirth, which meant that families were encouraged to have many children (Kane & Choi, 1999). The Chinese government, however, started implementing birth-control policies in 1983. This meant that each family was only allowed to have one child, despite the fact that there were some very stringent conditions that could be met to make an exception. These regulations have made life very difficult for families that would rather have a son than a daughter. Therefore, in order to have a son, they typically have two options: first, they can go to the hospital for an examination while they are pregnant and choose abortion if the child is not a boy; second, they can accept the penalty from the government and the risk of losing their belongings and jobs in order to have a second child. The Chinese government started enforcing its "two-child policy" in October 2015 in response to the falling birthrate and the rising proportion of elderly people in the population (Buckley, 2015). In the time following the enactment of the two-child policy, which restricts couples to having no more than two children, there has been a notable trend of families, particularly those with a first-born daughter, opting to have additional children. On the other hand, most families whose first babies are boys do not want to have a second child. However, over the past 20 years, the proportion of males in the Chinese population has been on a downward trend.

Diagram 1 shows the proportion of males' situation in China from 2003 to 2021. The line is trending downward from overall. The continued decline in the proportion of males is an important manifestation of the trend toward a balanced gender structure. On the one hand, this is due to the change in traditional fertility concepts, such as the weakening of the "son preference" mentality and the pressure to buy a house for the

son's marriage, which has raised the cost of raising a boy. On the other hand, social progress has contributed to the continued improvement of women's status. Despite persistent challenges, the status of women has improved due to advancements in social and cultural norms. Notably, the number of women pursuing higher education has surpassed that of men, and the gap in the average educational attainment between genders is closing. Furthermore, initiatives aimed at enhancing female employment opportunities and ensuring their protection have yielded positive results. Additionally, there has been a reduction in the incidence of non-medical fetal sex determination, indicating progress in the fight against gender-based discrimination.

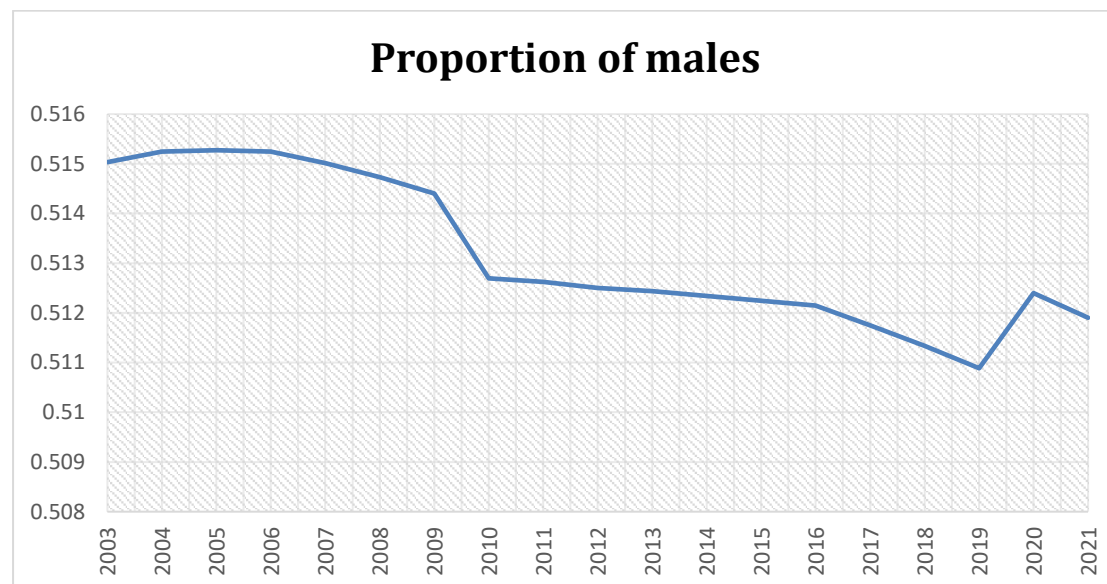


Diagram 1 Proportion of males in China

Another one of life's unavoidable facts is that owning a home is almost always considered a prerequisite for marriage. When a couple has reached the point where they are ready to get married, the man's family is responsible for getting the house ready. According to a report that was published in 2020 by two housing agencies in China that are very well-known, 80.9% of people believe that purchasing a wedding home prior to getting married is the best option, and the 64.1% of people who

purchase wedding homes believe that they need to prioritize purchasing a home when they get married. The survey also revealed that 47.1% of respondents believe that the wedding house is purchased with the man making a down payment and the couple paying the mortgage jointly.

In this way, the house, which is both a valuable asset and a very important piece of real estate, has evolved into the most significant "gift" that a family can give to their son in the family which is "son preferred". Even when their son will be attending kindergarten, the parents may already want to consider purchasing a home. Therefore, the importance of the house for men cannot be ignored, families with sons typically have a higher demand for houses. Because of this, the influence of the proportion of males in population on house prices has developed into an intriguing topic that can be discussed.

1.2 The Region selected for the study

To determine whether the percentage of males in China's population is a factor influencing home prices, it is crucial to select an appropriate sample area. China is a massive nation. It has a large population and a national territory area of 9.6 million km². China contains not only numerous modern cities, but also numerous small, impoverished villages. The primary occupation in the village is farming. As the primary component of the labor force, men play a crucial role. Therefore, the less developed a region is, the greater the demand for men. Therefore, when selecting sample areas, neither rural areas dominated by manual labor nor "first-tier cities" such as Shanghai and Beijing, which introduce large numbers of foreign talent, can be chosen. Using these criteria, I determined to use the "new first-tier city" as the research subjects.

The "new first-tier cities" in China are cities that are gaining importance as major centers of economic and cultural activity. These cities are classified based on five criteria, which include factors such as the availability of business resources, the vibrancy of urban life, the diversity of lifestyles, and future potential for growth and development. The cities that are considered "new first-tier" can be categorized as either major municipalities with significant political, economic, and middle-class population resources, regional central cities with strong educational and cultural offerings and the ability to impact neighboring provinces, or provincial capitals and coastal cities with strong economic foundations and unique urban characteristics.

Based on 170 brands' business data, 19 Internet companies' user behavior data and city big data, 15 new first-tier cities were selected after ranking 337 cities above prefecture level in China. These 15 new first-tier cities are: Chengdu, Chongqing, Hangzhou, Xi'an, Wuhan, Suzhou, Zhengzhou, Nanjing, Tianjin, Changsha, Dongguan, Ningbo, Foshan, Hefei and Qingdao. Dongguan and Foshan are excluded from the research because the number of migrant worker populations in these two cities exceeds 50% of the total local population.

1.3 Structure

Chapter 2 is devoted to the literature review, Chapter 3 to the data and methodology, Chapter 4 to the discussion of the results, and Chapter 5 to the conclusion. STATA is used to conduct all tests and estimation.

2. Literature Review

Typically, research on the factors influencing housing prices focuses on the following points:

1. Economic growth and income. When the economy grows rapidly, the residents' income increases proportionally, and their purchasing power increases, residential prices will rise; conversely, it will cause residential prices to fall, so there is a direct relationship between income and housing prices, with higher income levels generally associated with higher housing prices.

Özmen, Kalafatçılar, and Yılmaz (2019) examined the effect of "income distribution on house prices" and discovered that income inequality is correlated with changes in house prices. The change in housing prices and changes in household income have an inverse relationship. According to the supply and demand theory of economics, higher housing prices will increase supply if all other factors remain constant. However, in the short term, the quantity of available housing remains approximately constant regardless of changes in demand, indicating that the housing supply is inflexible, so demand determines housing prices. Then, residents' income is the primary factor influencing housing demand, as it determines their purchasing power. Consequently, income influences housing prices directly or indirectly via supply and demand (Duan, 2020). The relationship between income and housing prices is complex, with a bi-directional Granger causal connection in which higher housing prices not only reflect higher income levels but can also cause a reduction in disposable income. (Zhang & Chen, 2019).

2. Interest rate. The rise or fall of interest rates influences the financing practices

and sales outcomes. When interest rates rise, the expense associated with providing capital also increases and a decrease in the marginal efficiency of a real estate firm's capital, while the real estate's market price, which is determined by supply and demand, will increase if demand in the real estate market remains unchanged. Real estate investors and the broader market demand for housing will be impacted by fluctuations in interest rates, which will influence not only the perceived cost of buying property but also the expected investment returns based on potential house price changes. Theoretically, then, investment-driven "demand in the real estate market" will decline as a result of an increase in interest rates (Xu & Sun, 2019).

Jacobsen and Naug (2005) found that housing prices are highly responsive to fluctuations in interest rates, with increases in interest rates often leading to a decrease in housing prices. These changes can occur quickly and have a significant impact on the market.

Miles and Monro (2021) researched on the association between the risk-free real interest rate and house prices in the United Kingdom. Their findings indicate that the increase in UK house prices from 1985 to 2018 can be attributed to a marked decrease in real risk-free interest rates during that period.

3. Unemployment. A higher unemployment rate may cause a decline in housing prices or rentals, whereas a lower unemployment rate may cause an increase. A higher unemployment rate shows many jobless individuals in the area, which may also imply an economic recession or sluggish economic growth in the region. Investors view cities with higher rates of unemployment as having less demand for housing, and this perception can impact the prices of homes

in those areas.

Agnew & Lyons (2018) examined whether there is a correlation between foreign direct investment (FDI) employment and house prices in Ireland by using two spatially granular data sets. Studies show that there is indeed a positive correlation between the two, that is, the increase of FDI employment will lead to the rise of housing rental and sales prices. It can also be said that if 1,000 new jobs are created, rents in the neighborhood will increase by 0.5 to 1 percent and sales prices will rise by at least 2 percent over the next 1-2 years. In the post-crisis period, there is a higher significance and a larger employment coefficient, and employment destruction over employment creation will lead to different degrees of employment effect. The findings suggest that households are more willing to pay extra to gain better access to the labor market.

4. Construction cost. In most markets, the main determinant of the price of a new home is comprised of building expenditures (Gyourko & Saiz, 2006). In general, the cost of building a home comprises material and labour costs. The financial cost of construction can rise due to a combination of rising building material prices and increased labor costs. (Adam & Füss, 2009). The primary contributors to the rise in building expenses are: 1. the rising cost of structural materials, such as lumber and metal items, etc. 2. the lack of skilled labour in the building business. There are challenges attracting competent people, resulting in a rise in labour costs (YellowBrickRoad, 2022).

The rise in building costs will diminish the profitability of real estate firms and discourage the development of new homes, resulting in a decrease in the housing supply. Reduced housing supply will increase the purchase and rental

prices of homes, thereby moving the rise in building costs to purchasers and renters.

5. Population. Population and housing are interrelated, as an increase in the population, especially the increase in the number of households, causes a rise in housing demand (Mulder, 2010). Then, as the population expands, the real estate demand also increases, leading to a surge in real estate costs; conversely, a decrease in population leads to a reduction in real estate demand and a corresponding decrease in real estate prices. In metropolitan areas, particularly as the foreign and mobile population grows, the demand for real estate will inevitably increase, causing the price of urban properties to rise.

Moreover, the population density is an important indicator to represent the number of people in a particular area. Population density influences real estate prices in two ways: on the one hand, demand for real estate in places with high population density typically exceeds supply, and the relative shortage of supply enables housing prices to stay high and increase as population density rises (Miles, 2012).

On the other side, a high population density, particularly when a large number of low-income earners move into a particular region, may result in a worsening of the living environment, which may cause real estate values to decrease. The housing market in numerous first-tier cities in China is being greatly influenced by a population surge. In certain rural or isolated places with a significant population loss, relative housing costs are lower.

Under normal circumstances, a discussion of the impact on housing prices would include the factors listed above. Then, in China, the price of a home is affected by the country's situation as well as traditional beliefs for two additional reasons:

1. Educational facilities. There is a concept - "school district house" in China. According to the applicable regulations of 'nearby schooling' in the obligatory education phase, all school-aged children in the district are eligible to be interviewed to attend school if they reside in a "school district house". The rise of 'school district house' reflects the deficiencies of the existing education system, namely in the very unequal allocation of educational facilities in a city, resulting in a few so-called "excellent" primary and secondary schools, which also highlights the injustice of education. To put it in another way, not every kid in compulsory education period can get the rights to a great school.

Wen et al. (2014) created an econometrics model to examine if housing costs and educational facilities are related. And they discovered that educational institutions had a capitalization impact that is good for house prices.

2. The traditional preference. This is the subject of the present paper. The traditional preference in this context refers to the Chinese concept of favouring sons over daughters. No research has been conducted on the effect of such traditional preferences on home prices yet. In contrast to Western countries, "buying a house only for the son" and "the wedding house to be bought by the man" are extremely common issues in China.

There are a range of techniques to studying the variables that influence home prices. Chow and Niu (2015) examined the residential demand and supply in China's urban housing market since commercialization. The theoretical framework employs a widely used model that incorporates simultaneous equations to analyze the supply and demand of urban consumers. "Two-stage least squares (2SLS)" was used to estimate

its parameters. Housing demand was determined by relative prices and real income, whereas housing supply is described by construction costs and relative prices. The findings suggest that the rapid growth in urban house prices can be sufficiently accounted for by the principles of supply and demand, with demand being driven by income levels and supply being influenced by building costs.

When examining the economic determinants of reasonably priced housing in Malaysia, Olanrewaju et al. (2016) used a questionnaire sampling method. Thirteen cost determinants of affordable housing were identified after administering a cross-sectional questionnaire to 71 homeowners to determine how they evaluated the performance of their homes and their affordability in terms of housing costs and used a Likert scale from 1 to 5 to measure the importance level. All poll questions were phrased in a favorable manner. Mode and Average Relative Index were used to rank these elements. According to their analysis of these indices, thirteen cost determinants are crucial to household decisions regarding affordable housing.

Nocera and Roma (2017) examined the heterogeneous impact of house demand shocks on the overall economy, along with the part played by housing prices in the conveyance of monetary policy across several nations in the Eurozone. They employed a Bayesian random search variable selection method in a structural VAR model and developed a novel identification framework. By examining the dissimilarities between the channels of housing prices and monetary policy transmission, as well as their effects on the actual and nominal convergence process in the Eurozone, they found that the impact of the wealth of house on consumption was relatively strong in Ireland and Spain, and that housing prices played a crucial part in providing credit. The effect of monetary policy on housing prices varies significantly and is highly impactful.

Utilizing the panel data technique for the sample of 24 nations, Savva (2018) explored how changes in important macroeconomic factors impact home price increase. The primary purpose of the research was to determine the short-term factors that influence housing price variations in various countries. Population, stock returns, economic growth, and inflation seem to be important contributors to the increase in the home price index. Also, building costs and home prices are associated. Unemployment and interest rates have a negative effect on house values.

Oikarinen and Engblom (2016) compared standard panel data models to study disparities in the dynamics of house prices. Comparing panel models that account for regional variations with those that do not, they discovered that regional differences in the Finnish market are often little. In particular cities, though, the disparities are fairly dramatic. The long-run coefficients of income also vary obviously between areas, particularly in cities with constrained supply. Their results imply that the utilization of panel models that presume identical home price dynamic across areas may result in erroneous conclusions.

Wen et al. (2014) explored whether educational amenities influence housing prices in empirical research of Hangzhou, a city of China. Utilizing housing price and educational facility data for 660 areas in Hangzhou, they created a hedonic pricing model to quantify the influence of different educational amenities on housing costs. The findings suggest that spatial econometric models may successfully reduce the spatial dependency of housing prices, but conventional hedonic pricing models overestimate the capitalization rate of educational institutions. Educational institutions have a positive capitalization influence on housing values, indicating that they have an important impact on the Chinese housing market.

Xu and Tang (2014) used cointegration approaches and error correction models to

investigate whether factors in the UK economy cause housing prices to rise or fall. The researchers use the Engle Granger (EG) method with two stages. Cointegration implies a long-term equilibrium link between two or more economic variables; this is consistent with the home investment theory's prediction of a relation between variables in the rental and investment markets. Since short-run divergence may make arbitrage lucrative, and since doing so involves knowing where the housing market is in relation to its long-run equilibrium trajectory, the research employs an error correction model. With the research on the data of 41 years, the results of the cointegration analysis indicated that factors such as construction costs, interest rates, GRP, credit, and unemployment all positively affect home values, whereas factors such as disposable income and money supply adversely affected home prices. According to the error correction model, rising building costs are a major factor in rising home prices. Interest rates are the most crucial factor in the near run, followed by rising disposable income, construction costs, and credit.

To analyze how changes in monetary policy affect home values throughout the United States, Fischer et al. (2019) utilized a Bayesian FAVAR model. By using Bayesian estimation and inference, they may address the uncertainty around latent components and model parameters while concurrently estimating model parameters. In addition, they use an extraneous tool in the form of high-frequency contingencies surrounding policy announcements in order to spot monetary policy shocks. Based on their findings, they conclude that differences in regulatory environments and supply elasticity contribute to regional differences in housing.

In a comprehensive study of house price forecasting, Yu et al. (2018) developed various forecasting models to more accurately predict housing prices and their future trends. They proposed two distinct models of prediction. The first type is a deep

learning-based "Convolution Neural Network (CNN) forecasting model" and "Long Short-Term Memory (LSTM) neural network forecasting model" based on multiple characteristic factors of real estate and a logistic regression model was implemented to compare these three models. A time-series model is another type of predictive model. On the basis of deep learning, an "LSTM-1 model" based solely on time-series is proposed, followed by the implementation and comparison of an LSTM model and an Auto-Regressive and Moving Average (ARMA) model. Important for the evaluation and forecasting housing prices in the real estate industry is the preliminary analysis of real estate data crawled by web crawlers to analyze statistics and obtain the necessary characteristic factors to construct the best prediction model.

3. Data and Methodology

3.1 Data Source

The research subjects in the paper are the 13 new first-tier cities in China. They are Chengdu, Chongqing, Hangzhou, Xi'an, Wuhan, Suzhou, Zhengzhou, Nanjing, Tianjin, Changsha, Ningbo, Hefei and Qingdao. And among them, Chengdu, Hangzhou, Xi'an, Wuhan, Zhengzhou, Nanjing, Changsha, Hefei and Qingdao are the provincial capital cities. Chongqing and Tianjin are the municipalities. The paper will examine five variables: annual average housing price, annual GRP (Gross Regional Product), annual per capita disposable income, the proportion of males, and lending interest rate. From 1978 to 2020, the Statistical Yearbook for each city provides information on the city's annual GRP, annual disposable income per capita, and male population/ratio. Unfortunately, the National Bureau of Statistics of China's average annual housing price data are only available from 2002 to 2020, and the average annual housing price data from 1978 to 2001 are unavailable from any other source.

Due to limitations, the research data in this paper can only be selected for the 19 years between 2002 and 2020. The World Bank provides lending interest rate data.

3.2 Data Description

Variable	Mean	Standard Deviation	Min	Max
annual GRP (Million CNY)	708061.6	497292.5	64456	2500279
per capital annual disposable income (CNY)	28329.66	15920.85	7000	70966.4
proportion of males	0.506	0.009	0.487	0.526
lending interest rate (%)	5.372	0.853	4.35	7.47
average housing price (CNY/m2)	7515.468	5013.127	1277	27448

Table 1 Data Description

Based on the descriptive statistics of the 19-year sample, it can be determined that: the difference in annual GRP between 2002 and 2020 is very large. The GRP is an important indicator of the extent of economic advancement, and the data indicate that over the past 19 years, the economic development level of the regions has increased obviously, the living standard of the population has improved, and the market has become more prosperous. In addition, the per capita annual disposable income and average housing prices have also changed a lot in those 19 years. The increase in disposable income per capita does not only result in an increase in consumption, but also a shift in the composition of consumption. The rising housing prices are evidence that basic expenditures, such as food, account for a smaller share of total consumption expenditures, while expenditures for enjoyment and development will increase. The dispersion of the proportion of males is not large, indicating that the society has remained stable over the past 19 years and that people's preference for having sons or

daughters has not shifted. The maximum and minimum values of the lending interest rates are different, but their standard deviation is less than 1, indicating that the fluctuation of the lending interest rates in these years is relatively small.

3.3 Correlation Analysis

variables	annual GRP	per capital annual disposable income	proportion of males	lending interest rate	average housing price
annual GRP	1.0000				
per capital annual disposable income	0.7820	1.0000			
proportion of males	-0.4905	-0.6561	1.0000		
lending interest rate	-0.5589	-0.5668	0.2856	1.0000	
average housing price	0.7358	0.9132	-0.6109	-0.4871	1.0000

Table 2 Correlation Coefficient of Main Variables

In a panel data multiple regression model, it is a crucial assumption that there is no exact linear connection between the explanatory variables, meaning that no explanatory variable can have a linear combination with the other explanatory variables. If there is only significant but not perfect correlation between explanatory variables, this assumption is not violated, but estimates will be inaccurate. In the sample data, there is a higher correlation between per capita yearly disposable income and annual GRP. GRP reflects the new value created by the entire society in terms of population, and in terms of distribution, it includes the income of the state, the income of enterprises, and the income of workers; therefore, per capita income is a component of GRP. When per capita income changes, GRP changes in approximately the same direction. So, the Pearson correlation test was used to screen the model's

explanatory variables, and the results are shown in Table 2.

According to the Table 2's statistics, the correlation coefficient between per capita yearly disposable income and annual GRP is 0.7820, showing a good association between these two variables. Disposable income is an important factor that affects consumer spending, which is a major component of GRP. When disposable income increases, consumers tend to spend more, which can lead to increased economic growth and higher GRP. To reduce the possibility of inaccuracy of the regression, the average annual disposable income was omitted.

3.4 Unit-Root Tests

Stationarity of variables affects the econometric analysis and must be determined prior to conducting the analysis. The objective of unit-root tests is to determine the absence of random or deterministic trends, which would otherwise result in a "spurious regression" problem. In other words, sometimes data appear strongly correlated due to the fact that they both exhibit an upward or decreasing trend over time, but they are not really connected. As a result, in this study, after choosing the model, LLC tests were run on all variables to ascertain the stationarity in order to avoid spurious regression.

Levin–Lin–Chu unit-root test for unit root		
Variables	Stationarity	p-value
Δ HP	first order integrated	0.0000
Δ lnGRP	first order integrated	0.0000
IR	Stationary	0.0000
Δ MR	first order integrated	0.0000

Table 3 Unit-Root Tests

The LLC test for HP, ln GRP, and MR determined that these three variables contain a unit-root. To eliminate the random walk trend in the series, a "first order difference" was conducted on the data. This is because, in practice, it is difficult to determine whether a time-series truly contains a random trend, and the fact that the null hypothesis is not rejected by the LLC test does not imply that it is true; rather, it indicates that we lack sufficient evidence to conclude that it is false. Therefore, the fact that the LLC test cannot reject the null hypothesis of a unit root does not indicate that the series has a unit root. In this case, the primary objective of applying first-order differencing to the three sets of data is to remove the fluctuations. The first-order differencing or multi-order differencing of the data allows the processed variables to be regarded as "already stationary data" because economic data are frequently unstable. According to Table 3, the p-values for all variables following the LLC test are less than the critical value of 0.05, indicating that all variables are stationary at the 5% level.

3.5 Model Selection

Before conducting the regression analysis, the model first needs to be screened to determine the type of effect model applicable to the panel data. This paper first screens the mixed and individual models using the F-test, and then screens the random-effects and fixed-effects models using the Hausman test. After determining the type of effect model, this paper examines the disturbance terms to determine the setting of the error terms in the regression analysis. These include the Modified Wald test for groupwise heteroskedasticity, the Wooldridge test for autocorrelation, and Breusch-Pagan LM test for cross-sectional dependence.

	p-value
F-test	0.0000
Hausman test	0.0417
Modified Wald test	0.0000
Wooldridge test	0.0718
Breusch-Pagan LM test	0.0000

Table 4 Model Selection Tests

From the result in Table 4, the p-value of F-test is smaller than 0.05, it rejects the null, the individual effect is significant. And the p-value of Hausman test is 0.0417, which is smaller than the critical value 0.05, the null is rejected at 5% level, and the fixed effects model should be selected. After examining the heteroskedasticity with Modified Wald test, the p-value is much smaller than the critical value, it indicates heteroskedasticity. The result of Wooldridge test shows that the p-value is smaller than 0.1, it can reject the null, so there is first-order autocorrelation. The last test is about the cross-sectional dependence. The p-value of Breusch-Pagan LM test is smaller than 0.1, it rejects the null, and indicates there exists cross-sectional dependence.

According to the results above, it is suggested that a dynamic panel model may be more appropriate than a static panel model. A dynamic panel model allows for the inclusion of lagged dependent variables and time-varying explanatory variables, which may help to capture the dynamic nature of the data and account for the presence of individual and time-specific effects. And the dynamic panel model can also help to address the issues related to heteroskedasticity and autocorrelation. Furthermore, the generalized method of moments (GMM) estimator is better to be used in this research, as it can address the presence of these issues by using moment conditions to estimate the parameters of the model. GMM estimation is less affected

by violations of assumptions like heteroskedasticity and autocorrelation in comparison to OLS or FE models, making it more unbiased.

3.6 Model Specification

After analyzing the data and testing the model, it was determined that the model with logarithmic form for GRP had greater explanatory power for the same variables. The housing price is the response variable, along with the annual GRP, the proportion of males, and lending interest rate. In this paper, the dynamic panel data regression model is constructed as follows.

$$HP_{i,t} = \beta_0 + \beta_1 HP_{i,t-1} + \beta_2 \ln GRP_{i,t} + \beta_3 MR_{i,t} + \beta_4 IR_{i,t} + \varepsilon_{i,t}$$

Where HP is the housing price; GRP is the annual Gross Regional Product; MR is the proportion of males; IR is the lending interest rate; β_0 , β_1 , β_2 , β_3 and β_4 are the coefficients that need to be estimated; ε is the error term.

4. Results and Discussion

4.1 Regression Analysis

Regression analysis necessitates that the variables be stationary, an assumption that can be derived from the chapter 3.5 results. And the chapter 3.6 has the results that: heteroskedasticity is present; there is first-order autocorrelation; and there exists cross-sectional dependence. And the data is short panel data, which has T=19, N=13. The study does a Generalized Method of Moments (GMM) regression to assess the link between the response variable HP and each of the other explanatory factors, with the following results:

Regression Result		
HP	Coefficient	p-value
HP (lag 1)	0.912***	0.000
lnGRP	413.503**	0.048
IR	-166.381**	0.026
MR	-58149.44*	0.095
Constant	26215.58	0.165
Wald	6651.53	0.000

Table 5 Panel Data Regression

Notes: *, **, and *** denote statistical significance at 10%, 5%, and 1% levels, respectively.

As shown in Table 5, the Wald joint significance test of the estimated coefficients of the panel model has the p-value of 0, therefore it rejects the null hypothesis that the coefficients of the explanatory variables are all zero. GRP has a positive relationship, and the lending interest rate and the proportion of males has a negative relationship with house prices, according to the regression results. This coefficient is significant at 5% significance level, indicating that GRP has a high explanatory power on house prices. This outcome is consistent with the fundamental relationship between GRP and housing prices, and the increase in GRP partially reflects the improvement in people's living standards. According to the theory of supply and demand, when supply remains unchanged and demand increases, the housing market price will rise. The coefficient of lending interest rate is -166.381 and indicates a negative effect on house prices, its p-value is 0.026, which means it is also significant at the 5% significance level. When the lending interest rate decreases, consumers become less stressed about repayment, demand for loans to buy homes rises, and the increase in demand shifts the demand curve to the right, driving home price growth. The coefficient of the effect of the proportion of males on house prices is -58149.44, the p-value is 0.095, which is smaller than the critical value 0.1, its t-test rejects the null at the 10% significance

level, indicating that the proportion of males has an explanatory power and significant effect on house prices, and the effect of the proportion of males on housing price is negative.

From the above regression results, it is evident that, in China's new first-tier cities, the proportion of males influences the house price. But from 2002 to 2020, the proportion of male has presented an effect which may opposite of the expected, that is, a higher proportion of males leads to a decline in house prices.

4.2 Robustness Tests

Robustness Tests										
	Equation 1		Equation 2		Equation 3		Equation 4		Equation 5	
HP	coefficient	p	coefficient	p	coefficient	p	coefficient	p	coefficient	p
HP(L.1)	0.915	0	0.915	0	0.94	0	0.939	0	0.808	0
MR	-75140.48	0.039	-74850.63	0.041	-90108.27	0.007	-89652.92	0.007	-59925.7	0.056
lnGRP	426.35	0.087	431.28	0.083						
P	12.805	0.829					37.967	0.468		
MP			21.052	0.856	71.608	0.484				
IR					-162.689	0.039	-161.92	0.04	-62.392	0.419
DI									0.052	0
cons.	33599.87	0.095	33408.97	0.101	47289.66	0.005	47041.11	0.005	31230.72	0.051
Wald	6763.17		6763.67		6471.59		6473.69		7370.64	
p-value	0		0		0		0		0	

Table 6 Robustness Tests

After executing the model regression, it is necessary to confirm the regression results' robustness, i.e., to assess the robustness of the explanatory power of the evaluation methods as well as indicators, to determine whether they continue to provide a more stable and consistent explanation of the analysis results when specific parameters are altered. The variable replacement approach, the changing sample size method, the split-sample regression method, the supplemental variable method, etc. are often used approaches for robustness testing. In order to verify the reliability of the regression findings, the method of substitution of explanatory variables is used in this research.

As shown in Table 6, the explanatory variable MR was retained in the regression model, while the original lnGRP and RI were replaced with different explanatory variables in 5 new equations. First, all p-values of Wald are 0, indicating that the model is reliable, and all coefficients are non-zero. In Equation 1, replacing the lending interest rate with population (P), the coefficient of the effect of the proportion of males on house price is -75140.48 with a p-value less than 0.05, which can reject the null at the 5% significance level. The significance of lnGRP remains unchanged, as the p-value is smaller than 0.1, indicating that it remains significant at the 10% level. Equation 2 replaces population (P) with male population (MP), based on equation 1. As a result, the coefficient of the effect of the proportion of males on house price is -74850.63, the p-value is 0.041, it is less than 0.05, and it rejects the null at 5% significance level. The p-value of lnGRP still rejected the null at 10% significance level. Equation 3, replacing lnGRP with lending interest rate based on equation 2, yielded a coefficient of the proportion of males on house prices of -90108.27 and a p-value of 0.007, it can reject the null at 1% significance level. Equation 4, based on equation 3, replaced the male population (MP) with population (P). The result shows that the p-value of the proportion of males is also 0.007, it rejects the null at 1% significance level. Equation 5 replaced the population (P) with per capita annual disposable income (DI). The p-value of the proportion of males here is also smaller than 0.1, indicates it rejects the null at 10% significance level. Despite the substitution of other explanatory variables, the effect of the proportion of males on house prices is negative across all these equations. In addition, the p-value of the proportion of males in all five equations is less than 0.1, it rejects the null at 10% significance level, the results coincide with the original regression model, and indicate that the proportion of males has a significant impact on house prices. Therefore, the

results of the robustness test are not obviously different from the previous empirical results, indicating that this paper's empirical results are robust.

4.3 Granger Causality Test

The granger causality test is utilized in this paper to determine whether the proportion of males is one of the causes of the change in home prices, and whether the home prices may also impact on the proportion of males. In order to test the granger causality in panel data model, the Dumitrescu & Hurlin (2012) Granger non-causality test has been used.

Dumitrescu & Hurlin (2012) Granger non-causality test		
effect	HP	
cause	MR	
Lag (BIC)	1	
	coefficient	p-value
W-bar	2.2189	
Z-bar	3.1075	0.0019
Z-bar tilde	2.0859	0.037

Table 7 Granger Causality Tests 1

The first part of granger causality test is, set HP as the effect, MR as the cause, to examine the granger cause of MR to HP. W-bar indicates the average Wald statistic, Z-bar is the standardized statistic and Z-bar tilde is the approximated standardized statistic. The null hypothesis here is MR does not granger cause HP. After the lag length selection by the Bayes information criterion (BIC), the optimal number of lags is 1 which is shown in Table 7. The p-value of Z-bar and Z-bar tilde are 0.0019 and 0.037 respectively, they are both smaller than the critical value 0.05, so they can reject the null at 5% significance level. With this result, it can be concluded that the

proportion of males does granger cause housing price for at least one city with lag 1. Table 8 shows the result of second part granger causality test. In the second part, the MR is the effect, and the HP is the cause. Similarly, the optimal lag length is provided by BIC, with the number of 2. The Z-bar has the p-value of 0.0002, the Z-bar tilde has the p-value of 0.0419, which are both smaller than the 0.05 critical value. The null can be rejected at 5% level. This indicates that the housing price does granger cause the proportion of males for at least one city with lag 2.

Dumitrescu & Hurlin (2012) Granger non-causality test		
effect	MR	
cause	HP	
Lag (BIC)	2	
	coefficient	p-value
W-bar	4.0584	
Z-bar	3.7109	0.0002
Z-bar tilde	2.0343	0.0419

Table 8 Granger Causality Tests 2

According to the findings presented above, the change in the proportion of males may be responsible for the changes in house prices, but this effect has a lag, and similarly, the proportion of males can also have the reaction to the changes of house prices, but the lag length is different. That is, the change in house price during the current period is affected by the shift in the proportion of males with a lag of one period. And the change in the proportion of males during the current period is affected by the variation in the house price with a lag of two periods. This phenomenon is in line with the lagging nature of real estate market regulation, as it requires a procedure of various duration and a certain time lag from demand and supply imbalance to price adjustments to making decisions to reaching demand and supply equilibrium. To put it

another way, despite the fact that the market is timely and sensitive, it is unable to accurately reflect the long-term trend of supply and demand and instead will engage in a process that can be described as an ex-post adjustment.

4.4 Impulse Response

Impulse response functions are often used in macroeconomic modelling to represent the reaction of the economy to exogenous impulses, also known as shocks, over time and are frequently modelled in vector autoregressions' context. Variations in tax rates, government expenditures, and other fiscal policies' instruments, variations in productivity or other technical entities, and variations in preferences are examples of exogenous shocks. The impulse response function may characterize the dependent variable's response at the moment of the shock and subsequent time points. This paper examines the impulse response function in order to discuss the dynamic impact on house prices when the variable the proportion of males is exposed to exogenous shocks.

In chapter 3.5, the unit-root has been tested and the results shows that the MR and HP are both first-order integrated variables; before the impulse function is established, it is needed to set the PVAR model with the first differences of MR and HP. In chapter 4.3, the lag of the effect of the proportion of males is discussed, and it is determined that the change in house price is correlated with the change in the proportion of males with a lag of 1. Therefore, in this section, the PVAR models are estimated with lag1 and lag 2, and the impulse response functions are estimated based on the results.

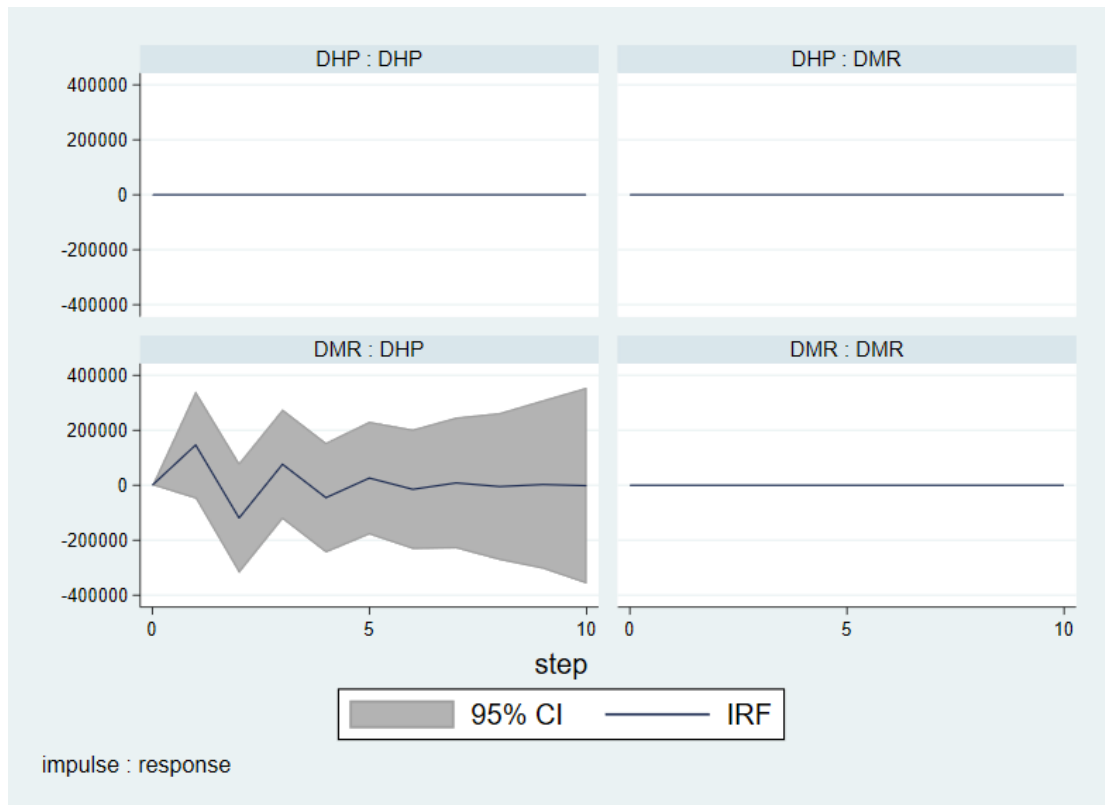


Diagram 2 Impulse Response with 95% confidence interval

Diagram 2 plots the impulse response with lag 1. The horizontal coordinate is scaled in units of time estimated by the PVAR model, which are annual units in this case. The left lower panel of the graphs generated by the impulse response function indicates the existence of an impulse response, which depicts the effect of a one-unit standard deviation shock in DMR on DHP. As can be seen from the diagram 2, the fluctuations brought by shocks are relatively large in the first five steps.

The results of the impulse response function show the reaction of house price after the proportion of males is shocked by external factors. First, it is certain that the reaction of house price is strong, because the proportion of males also reflects to some extent the change of marriage rate and the number of households, and especially in China, marriage is the main reason for buying a house. So, the change in the proportion of males also affects the amount of demand for housing. Second, the response time of house price to the proportion of males is still relatively long. This may be due to the

fact that housing is a high-value real estate, and its price adjustment takes a longer time.

5. Conclusion

The rate of economic growth, prices, wages and employment levels, the saving rate, etc., have been studied and accepted by the majority of academics as factors influencing home prices. However, the impact of the traditional concept of "male preference over female" as represented by the influence of the proportion of males on Chinese housing prices has been overlooked. Using dynamic panel data regression, the granger causality test, and the impulse response function, this paper examines the influence of the proportion of males on house prices in China's new first-tier cities over a 19-year period, from 2002 to 2020. The results show that, firstly, the effect of the proportion of males on house prices in 13 new first-tier cities is significant but negative. This may be a phenomenon unique to China. With China's rapid economic development, the population size in the new first-tier cities are increasing and demand for real estate is strong, but due to limited land resources, some local governments have imposed restrictions on real estate development and ownership, making it more difficult for people to purchase homes and keeping prices up. At the same time, due to several historical, cultural and social factors, the proportion of males in China has declined, which means that household demand has a more significant impact on the real estate market. In this case, the combination of household demand and market demand may lead to higher home prices. Second, according to the results of the granger causality test, the proportion of males and house price are two-way granger causes, and the proportion of males granger influences house prices at lag 1. This indicates that the proportion of males with lag 1

will contain information regarding the current period's predicted home price. In other words, if you want to predict the price of a home, you can use the proportion of males with lag 1 as a predictor. Although this is not a typical causal relationship, not simply "because the proportion of males has increased, house prices have increased," this result demonstrates that the proportion of males is correlated with house prices and can be used to predict house prices in 13 new first-tier cities. However, it does not specify how the home price will be affected. This is because of the constraints of this paper. The main limitations of this paper are as follows: first, initial limitations exist in the sample data. There is no way to obtain the average housing price prior to 2002, so this paper only contains information for the 19-year period between 2002 and 2020. Changes in population structure, viewed from a macro perspective, will have an effect on housing prices in the long term, but in the short term, the effect will be minimal. Therefore, it would be more convincing if the sample data covered at least twenty or twenty-five years. Second, the model does not discuss policy factors. House prices and the proportion of males in the population can be affected by policy factors. For instance, the implementation of the two- and three-child policies will have a direct impact on the composition of the population and the proportion of males within the total population. Housing prices are also affected by policies and regulations such as land use planning, real estate taxation, and purchase restrictions. Prior to 2010, there were no restrictions on the purchase of homes by individuals in China. People could purchase as many properties for personal use or as investments as they desired. Since April 2010, however, the Chinese government has established a purchase limitation policy, limiting local households and households with talent residency (non-resident of the city which has a high education degree or special skills) permits in each city to only own two houses, and limiting external families and foreigners to only own one

house. In addition, the time between acquisitions must be at least two years, and corporations are forbidden from owning homes. This policy has curbed speculation and excessive investment, thereby cooling the previously hot property market and bringing home prices under control.

The findings of this paper's analysis suggest that, in China's new first-tier cities, traditional perceptions influence demographics, and demographics influence house prices. The practical implication of this result is that it can provide relevant information to policymakers and guidance to real estate developers, who can adjust investment locations and market positioning based on the ratio of male residents and demographic composition of investment locations. In addition, Bayesian networks can be used in the modelling of future studies to determine the impact of the proportion of males or other factors on house prices. The advantages of Bayesian network models are that they can learn and investigate problems with causal or dependent relationships in depth and have a better ability to deal with missing data, while combining Bayesian probability can effectively avoid the issue of overfitting the data. This methodology may be utilized in future research.

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