THE IMPACT OF HOUISNG PRICES ON BIRTH RATES IN CHINA

by

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ABSTRACT

This report attempts to investigate the relationship between birth rates and housing prices in China. The empirical literature suggested mixed results in terms of relationships between housing prices and birth rates. First, we set up a theoretical model suggesting that the relationship between birth rates and housing prices depends on other consumption expenditures (except for housing expenditure) and family wealth. Then we use a number of estimation methods to estimate the relationship between birth rates and housing prices in China from 30 provinces from 2002 to 2018. The results show that while there is a negative relationship between housing prices and birth rates in China from 2002 and 2018 in our Difference GMM model, the static model shows a positive relationship. We provide some possible explanations for these findings and conclude by presenting some policy recommendations for increasing birth rates in China.

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1. Introduction

Following the development of their economies and the growth of urbanization, more and more countries and regions have encountered periods of low birth rates. However, an overly low birth rate is often accompanied by social problems, such as a sharp reduction in the working population and an aging population, which is not conducive to the sustainable development of a country in the long run. Since China’s reform and opening up, beginning in 1978, its economy has developed rapidly. The massive demographic dividend represented by its abundant labor force is one of the important explanations for this remarkable economic achievement. Currently, due to rapid changes in the nation’s demographic structure over the past two generations, this dividend is gradually disappearing, and China is entering a stage of structural labor shortages (Wang, 2014). Over the next 20 years, the percentage of people in China aged 60 years or over is expected to more than double, from 12.4% of the total population (168 million people) in 2010 to 28% (402 million) in 2040 (UN DESA, 2013a), which is significantly higher than the 10% United Nations standard for a traditional aging society (World Health Organization, 2015).

Different countries have different mechanisms for dealing with declining birth rates. Compared with the natural decline in fertility levels in European countries, the series of rapid changes in fertility levels in China reflects significant intervention by the state. Appendix A provides a summary of China's population policy since 1949. Below in Table 1 we briefly describe fertility policy shifts in China.

Table 1: Fertility Policy Shifts

Policy	Time
Encouragement of fertility	1949-1953
Advocacy of Family Planning	1954-1977
Strict Fertility Planning (One-Child Policy)	1978-2001
Selective Two-child Policy	2002-2015
Universal Two-child Policy	2016-Current

(see Appendix A for details on sources)

While state population policies have played a major role in changing China's birth rates over the past 60 years, there are many other factors that influence people's decision to have children. According to Becker's "New Family Economics" (1960), among many factors influencing people's decision to have children, family budget constraints are a major determinant. For families, housing and children are the two biggest expense items. The higher the expenditure for housing, the less likely it is that people will have children (Li, 2019). However, housing can also be seen as a family asset. When housing prices increase, the equity effect may dominate price effect (Dettling & Kearney, 2014).

In the case of China, since the government began its housing reform in 1998, housing prices have been rising rapidly, especially in big cities such as Beijing and Shanghai. From 2003 to 2013, real housing prices grew by 13.1 percent annually in China's first-tier cities, higher than the annual growth rate of household income (Fang et al. 2015). Meanwhile, the birth rate dropped to 1.048% nationwide in 2019, its lowest point since 1949 (National Statistics Bureau). Given that China's housing reform, beginning in 1998, resulted in sharp increases in housing prices from 2002 to 2018, the question that arises is how significant a role housing prices play in birth rates.

The objective of this report is to investigate the relationship between housing prices and birth rates in China by using data from 30 provinces (including autonomous regions and municipalities, except Tibet) from 2002 to 2018. The existing empirical literature on the relationship of housing prices and birth rates showed a mixed result. Some empirical studies found a positive relationship between birth rates and housing prices, and others a negative relationship.

We estimate this relationship using both static and dynamic panel data models and a number of estimation methods, including Feasible Generalized Least Square (FGLS) estimation of a Fixed Effect (FE) static model and Difference Generalized Moment Method (GMM) with a dynamic model to estimate the relationship between birth rates and housing prices in China from 30 provinces (including autonomous regions and municipalities, except Tibet) from 2002 to 2018. The results show that while there is a negative relationship between housing prices and birth rates in China from 2002 and 2018 in our Difference GMM model, the static model shows a positive relationship. We provide some possible explanations for these findings and conclude by presenting some policy recommendations for increasing birth rates in China.

The rest of this report is organized as follows: Section 2 reviews the literature on the determinants of fertility rates. Section 3 presents a theoretical model (developed in Liu, Zhang & Hu, 2016) based on new family economics. Section 4 explains the data and estimation methods. Section 5 presents our empirical results. Finally, Section 6 concludes and provides some policy recommendations.

2. Literature Review

Robinson (1997) examined the economic theory of fertility over time. In his view, children, like other commodities, can be considered as a special type of capital goods. In fact, his theoretical model is actually nothing more than a special application of consumer demand theory, based on a simple intuitive microeconomic model. Given that every household is rational, its members tend to maximize its utility using internal and external resources and various tools of household technology. In essence, the desire to produce children stems from the demand for child-services, which can be summed up as (1) consumption utility (emotional and psychological and other non-economic benefits); (2) labour productivity utility; (3) an old-age security utility. The total child-services figure equals the number of children times the average quality per child. The quality of child-service is related to income, whereas the quantity is not, which means that the key factor in declining fertility in modern societies is the shift towards demand for high-quality children, who require increased external inputs (especially health and education) and internal inputs (time-consuming within the household).

As women's labour force participation and real wages increase over time, the cost of input for time-intensive child-service has risen rapidly. In modern societies, alternative sources of consumption, which can replace some of the consumption utility formerly brought by children, have emerged. All the services provided by children can be found in other markets at a price. For example, the expansion of insurance and social security programs has weakened the former reliance of households on children for old-age security. Given that children are a 'no-money-back' purchase, that child-services are different from child to child, and that there is some possibility of death before the household receives any services from them, the uncertainty and risk related to investment in children remain higher than is the case of other comparable household assets.

Real estate has been a steady and lucrative investment in China in the past twenty years, one that has to some extent squeezed out people's desire to have children, since people tend to invest in high return and low-cost assets. Moreover, the higher the rate of increase of housing prices, the greater is the motivation for households to devote their resources to purchasing housing rather than investing in child-rearing. From a purely economic point of view, people believe that they can gain easier profits from purchasing housing and then reselling it at a higher price, rather than by spending years raising a child who might not end up returning economic rewards. As high housing prices increasingly burden households economically, they tend to reduce investment in children--thus the decline of the birth rates.

The transition towards raising "quality" children in China means that parents tend to invest a lot of external resources in each child, in order to better their children's future. Given the inadequate protections provided by housing rental law in China, people who want children tend to own a house instead of renting one. Family household ownership represents an important external resource for their children. On those grounds as well, high housing prices can further hold down the birth rates.

The phenomenon of birth rate decline has aroused the attention of academics for a long time. Scholars have explored many factors affecting birth rates, and from multiple angles. Becker (1960), the founder of the field of "new family economics", pointed out that reductions in infant mortality, the popularization of contraceptive knowledge and the increase in the cost of raising children are three important factors affecting birth rates. After investigation, he found that the number of children in urban white households in the United States decreased by 56% on average from 1870 to 1940, but that the decline in infant mortality could explain only 14% to 25% of that decline. Since then, Freedman (1995) has also put forward three essential explanatory variables affecting fertility rate, namely the decline in infant mortality, family planning programs, and broad social and economic development. Among them, economic development will have a negative effect on the fertility rate. The higher the degree of economic development, the faster the fertility rate will decrease.

Bar & Leukhina (2010); Jones, Schoonbroodt, & Tertilt (2008); Schultz (2007); Wigniolle (2002) have also verified this from an empirical point of view across different countries. Peng (2014) used a panel data set from 1980 to 2011 in 27 regions of China to confirm the long-term, negative relationship between birth rates and economic development. He pointed out that economic development in cities and rural areas had different effects on birth rates: increasing urban income levels increased birth rates but rising rural income levels reduced birth rates. In addition, Happel et al. (1984) found that changes in the unemployment rate significantly affected total family income, and thus affected the decision-making process over reproduction. Wang (2005) argued that for China, policy implementation effect was also an important reason for large differences in fertility levels in different regions.

However, the factors affecting birth rates are very complex, and existing empirical studies have not reached consensus on them. Recently, some studies have shown that among the factors leading to shifts in fertility, rising housing prices play an important role. Using a provincial-level panel data set from 2000 to 2015 from China, and fixed-effect/ random-effect estimations, Jin and Liu (2019), by including the square of housing price-to-income ratios, found that housing price-to-income ratios had a positive impact on birth rates at first, and then trended negatively. That is, when the housing price-to-income ratio is low, an increase in housing price-to-income ratio will increase fertility rates; conversely, when the housing price-to-income ratio is already high, an increase in housing price-to-income ratio will bring a decrease in fertility. Li (2019) attempted to explore the causal effect of housing prices on birth rates by using a city-level panel data set from 2005-2012 in China. By using different GMM methods, the author found that both current and lagged housing prices had a significantly negative effect on birth rates. Li then revealed that it was not housing prices levels generally that cause such shifts, but high rates of growth in housing prices that discouraged births. To test the exogenous shock of a housing purchase restriction policy, Li set up a difference-in-difference model (DID) and found that such a policy had a positive effect on birth rates.

Chen and Peng Yin (2016) used a time-series data set for 1990 to 2013 for China to estimate a Vector Auto Regression (VAR model) relating birth rates to housing prices to earnings ratios and child dependency rates. By analyzing the impulse response function and variance decomposition, they found that the strong positive response to the housing price-to-income ratio lasted for a long time, nearly as long as 20 years, indicating that the decline in birth rates was associated with a decline in housing prices. Perhaps, the most relevant study to this report was Liu, Zhang and Hu (2016). The authors used a panel data set of 29 provinces in China from 1999-2013 to examine the effect of housing prices on birth rates. Running regressions by gradually adding control variables, they found that housing prices had a significant negative effect on birth rates. In particular, a 1% increase in housing prices per year was associated with a decline in birth rates of about 0.1%. Using a time series data set on Hong Kong and an Autoregressive Distributed Lag model (ARDL) to explore the relationship between birth rates, house prices, and elder dependency, Hui et al. (2012) found that a 1% increase in housing prices and elder dependency led to decreases of 0.52% and 1.65% in birth rates respectively.

Dettling and Kearney (2014) studied separately the impact of housing prices on fertility rates for those who did not have a house themselves, and that for those who did have a house. They began their empirical investigation with a set of ordinary least square (OLS) regressions. To address the possibility that other local factors could be biasing their OLS estimates, they implemented an instrumental variable (IV) strategy that exploited exogenous variations in housing prices movements induced by variation across Metropolitan Statistical Areas in their housing supply elasticity. In their view, increases in short-term housing prices increase the cost of raising children, and as a result would reduce the fertility rate proportionately among those who do not own a house. In the case of those who already own a house, however, rising housing prices to a certain extent led to the appreciation of family wealth, which has a positive overall effect on fertility. Using an US sample, they showed that for every $10,000 increase in housing prices, the fertility rate for homeowners increased by 5%, while the fertility rate of those without houses decreased by 2.4%.

Lindert (1978), Easterlin and Crimmins (1985) argued that families with more members would subjectively choose housing at lower prices. They emphasized that personal preferences have an impact on birth rates, and they attribute the difference in birth rates between urban and rural areas to personal preferences. Clark, Yi and Zhang (2020) found that there is an approximately 0.94-percentage-point decrease in the probability of having a child under two with a 1 percent increase in housing prices by using the date in 35 large cities from 2013 to 2017 in China. By conducting a panel threshold model, Su et al. (2020) found that housing prices had a negative impact on marriage when the price was above the threshold value. Homeownership is an extremely central aspect of marriage decisions in China, and marriage without housing is considered unacceptable to many.

Some scholars also discussed the effects of fertility policies on birth rates in China. In discussing the declining birth rates in China, Zhang (2017) pointed out that official family planning policy played a certain role in the reduction of the fertility rate in China around 1979, but it had little effect on the fertility rate after the 1990s. Jin and Liu (2019) found that the selective two-child policy (2004-2015) did not have a significant impact on the birth rates in China.

In sum, a lot of research has been done on the determinants of birth rates, especially for China. Population growth and increasing housing prices are two major issues in China. However, empirical studies of the impact of housing prices on birth rates to date have produced mixed results. Do changes in housing prices explain changes in birth rates in China? According to the literature reviewed, China's family planning policy and selective two-child policy had little effect on birth rates after 2000. Although it might be interesting to see how effective the universal second child policy is, the time since implementation of that policy has been short. Due to these considerations, we decided not to include fertility policy in our models. This report contributes to the literature by using an updated panel data set of 30 Chinese provinces/cities from 2002 to 2018 and advanced estimation methods to estimate the relationship between housing prices on birth rates in China.

3. Theoretical Model

Based on the theory of new family economics, Liu et al. (2016) developed a family utility model to derive the relationship between housing prices and birth rates as follows.

Suppose there is a representative family whose initial assets are K. Family consumption is divided into two stages: the first stage is to buy a house and raise children; the second stage is for the children to grow up as the family's new labor force and to increase family income.

Assuming that the labor process produces negative utility (The more hours you work, the less leisure you have), and the representative household utility level depends on consumption and labor supply, the utility function and constraint conditions of the first stage households are as follows:

$$\begin{cases} U_1 = lnC_1 + \beta \ln(1 - L_1) \\ C_1 \le WL_1 + K_1 \end{cases} \quad (1)$$

Where C_1 is the consumption of the representative household in the first stage, and L_1 is the labor supply of the representative household; β (β> 1) reflects the consumer's evaluation coefficient for the negative effect of labor process. With respect to budget constraints, assuming that household consumption depends on wage income and part of the initial assets, in the household consumption constraints, W represents the wage rate, and K_1 represents the initial assets that the household can use for consumption in the first stage.

At the same time, we assume that household consumption consists of two aspects: housing consumption and other consumption (including food, transportation, etc.), as follows:

$$C_1 = aHP + (1 + BR)E \tag{2}$$

Where HP represents the housing prices (assuming that the average housing area of the family is a, this value does not affect our analysis); E represents other consumption expenditures of the family of two, and BR represents the birth rates.

Then, in the first stage, to maximize the utility of the representative household under equation (1), the optimal consumption and labour supply are:

$$\begin{cases} C_1 = \frac{W+K_1}{1+\beta} \\ L_1 = \frac{W-\beta K_1}{(1+\beta)W} \end{cases} \tag{3}$$

The utility function of the second stage is similar to equation (1), the only difference is that the family in this stage faces a new constraint:

$$\begin{cases} U_2 = lnC_2 + \beta \ln{(1 - L_2)} \\ C_2 \leq (1 + BR)WL_2 + K_2 \end{cases} \tag{4}$$

Where K_2 in equation (4) means the initial assets that the family can be used for the second stage of consumption, which satisfies:

$$K_1 + K_2 = K \tag{5}$$

According to equation (4), to optimize the utility of the representative household the optimal consumption and labour supply are:

$$\begin{cases} C_2 = \frac{(1+BR)W+K_2}{1+\beta} \\ L_2 = \frac{(1+BR)W-\beta K_2}{(1+BR)(1+\beta)W} \end{cases} \tag{6}$$

Substituting the equations (3) and (6) into the utility functions in the two stages, we have:

$$\begin{cases} U_1 = ln\frac{W+K_1}{1+\beta} + \beta\ln\frac{\beta W+\beta K_1}{(1+\beta)W} \\ U_2 = ln\frac{(1+BR)W+K_2}{1+\beta} + \beta\ln\frac{\beta(1+BR)W+\beta K_2}{(1+\beta)(1+BR)W} \end{cases} \quad (7)$$

At the same time, the representative household must decide the distribution of initial assets in the two stages at the beginning, so that the sum of the two stages' utility is the largest. That is, under constraint (5), we can obtain $({K_1}^* + {K_2}^*)$ by optimizing $U_1 + U_2$:

$$\begin{cases} {K_1}^* = \frac{K+BRW}{2} \\ {K_2}^* = \frac{K-BRW}{2} \end{cases} \quad (8)$$

Combining equations (2), (3), (8), housing prices and birth rates satisfy the following equation:

$$aHP + (1 + BR)E = \frac{W+\frac{K}{2}+\frac{W}{2}BR}{1+\beta} \quad (9)$$

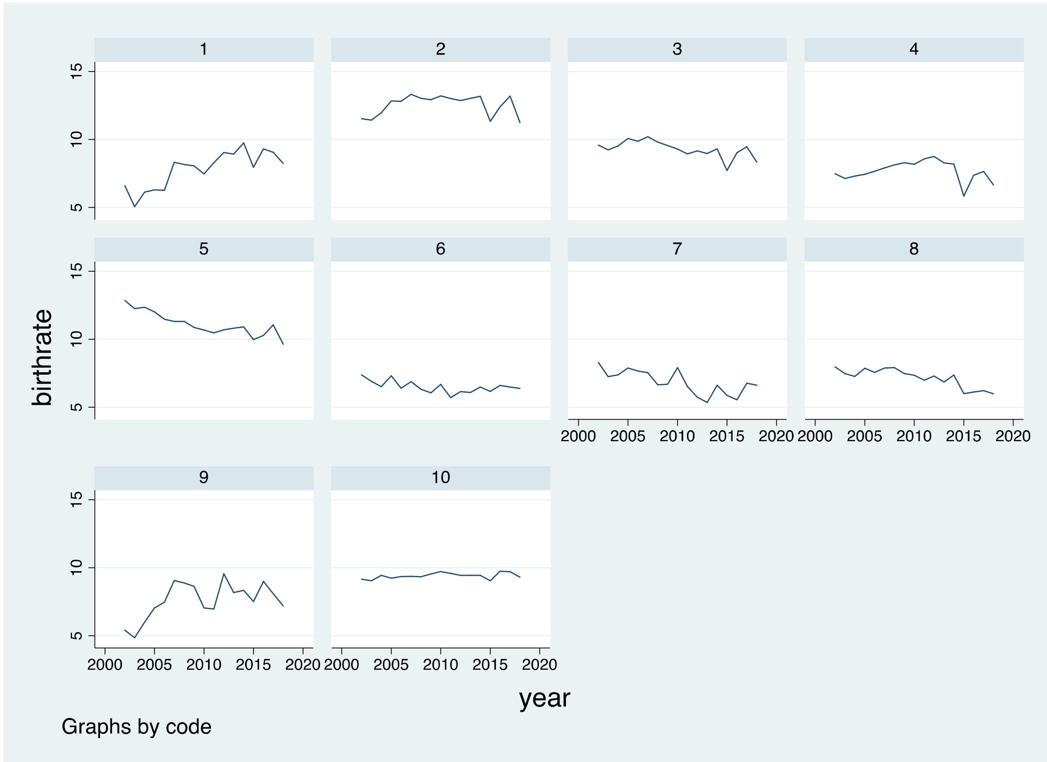
That is:

$$aHP + \left[E - \frac{W}{2(1+\beta)}\right]BR = \frac{W+\frac{K}{2}}{1+\beta} \quad (10)$$

Equation (10) shows that If $E - \frac{W}{2(1+\beta)}$>0, that is E>$\frac{W}{2(1+\beta)}$, there is a negative relationship between HP and BR. That is, other things being equal, the higher the housing prices, the lower the birth rates. If $E - \frac{W}{2(1+\beta)}$<0, that is E<$\frac{W}{2(1+\beta)}$, there is a positive relationship between HP and BR. That is, other things being equal, the higher the housing prices, the higher the birth rates.

4. Methods and Data

According to the data analyzed here, the liberalized fertility policy did not achieve its desired effect. In 2015, the national birth rate was only 1.207%, and in 2018, the national birth rate dropped to 1.094%, showing no rebound trend in population growth. Figure 1 shows the birth rate changes in 30 provinces (except Tibet) from 2002 to 2018. From Figure 1(see Provinces/Cities' Code in Appendix B1), we can see obvious decline trends in most provinces in 2015. In November 2013, the selective two-child policy changed to one that permitted any couple to have a second child, as long as at least one parent was an only child. Thus, in 2014, the birth rates increased slightly in some provinces. However, the birth rate dropped in many provinces in 2015, which may indicate that people's interest in having children was exhausted in 2014. Next, on January 1,2016, a universal two-child policy was implemented, permitting all couples to have a second child. Therefore, birth rates rebounded in 2016 in most provinces. After this new one-time release of fertility willingness, birth rates declined continuously in 2017 and 2018.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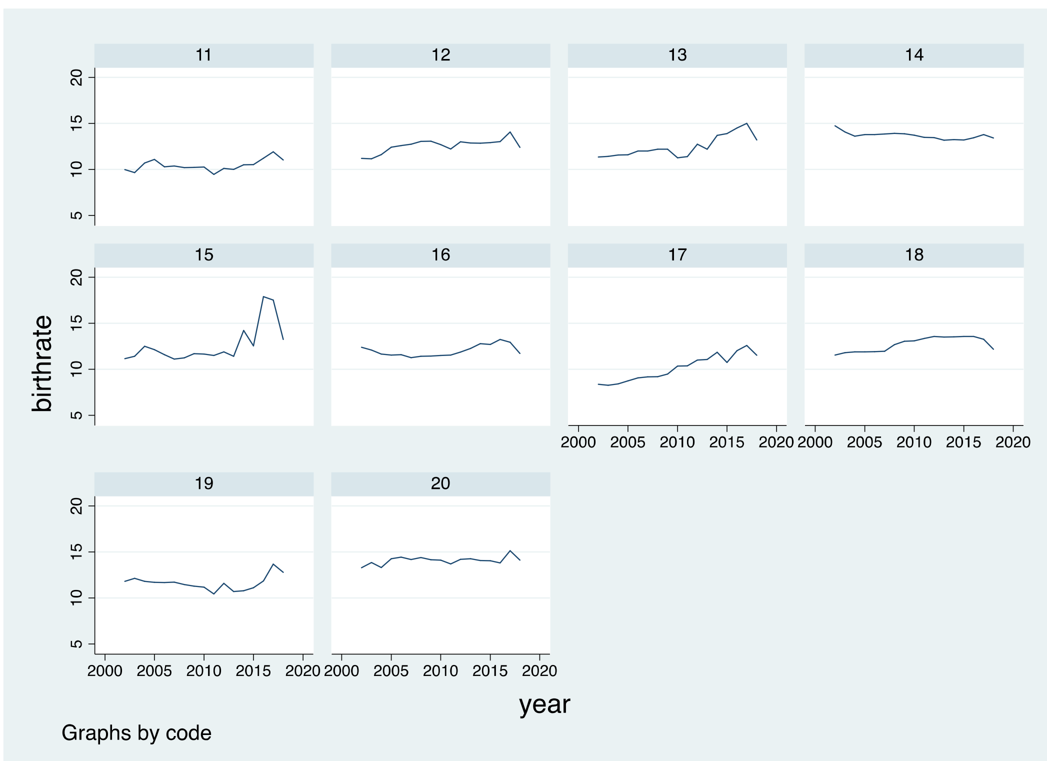
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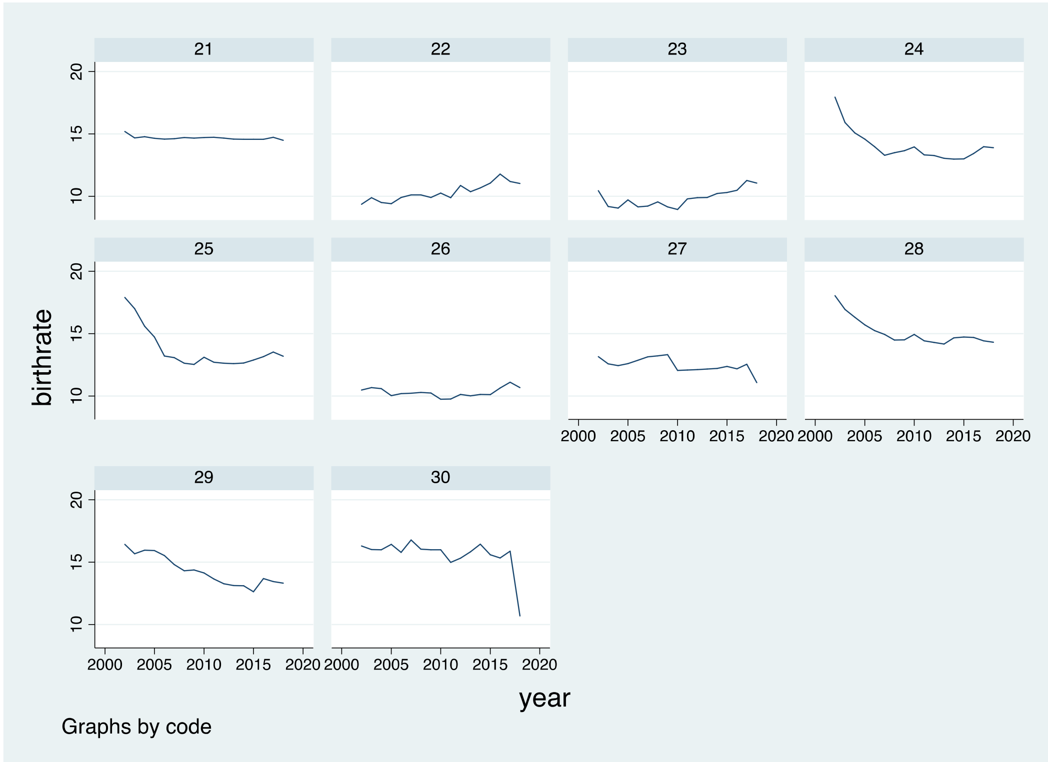
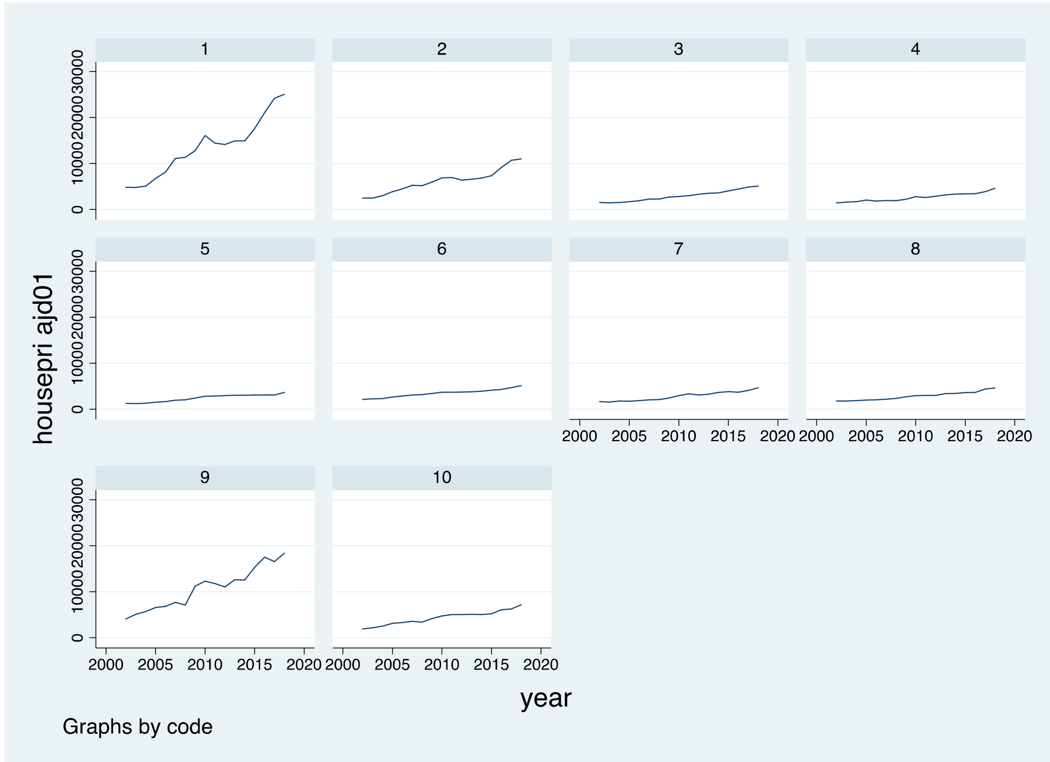


Fig.1. Birth rates in 30 Chinese Cities/Provinces from 2002 to 2018 [1]

Figure 2 illustrates the trends in housing prices indicated as housepri adj001 on the vertical axis (transformed to the same price level in 2001) in 30 cities/provinces (except Tibet) from 2002 to 2018 (Code 1 represents Beijing and Code 9 represents Shanghai). All these cities/provinces showed an upward trend.

[1] Please see Provinces/Cities' Code in Appendix B1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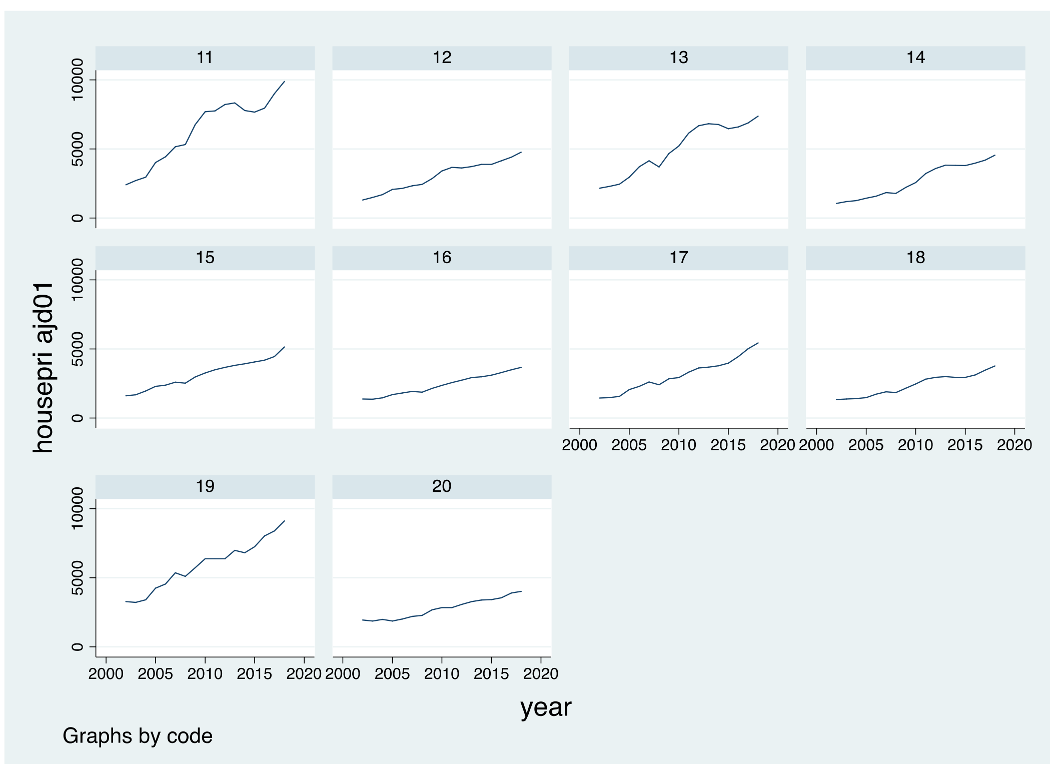
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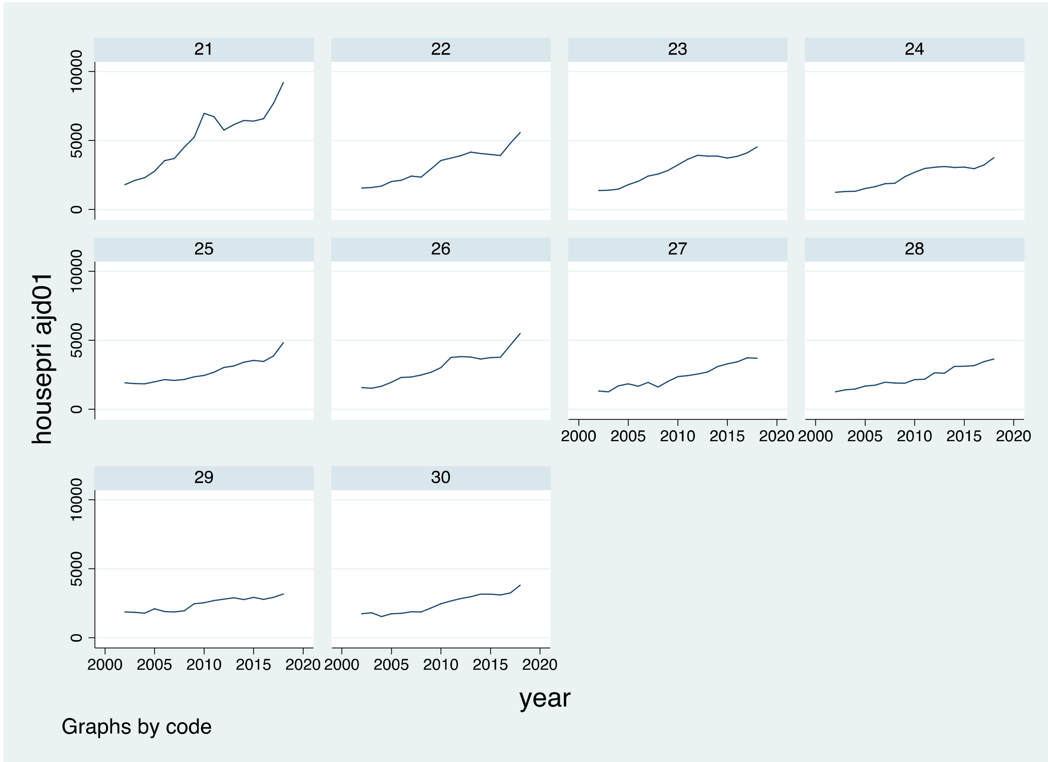


Fig.2. Housing Prices in 30 Chinese Cities/Provinces from 2002 to 2018

As previously noted, according to the microeconomic theory of fertility, children, like other commodities, can be considered as a special type of capital goods. In modern societies, insurance and social security can replace the function of children in parents' old-age security issues; women's labor force participation and real wage increase decrease their willingness of having children (Robinson, 1997). Birth rates also depends on other factors such as social and economic development (Becker, 1960) housing prices (Jing and Liu, 2019) and urbanization (Clark and Cummins, 2009).

Based on the literature review, this section first explains model specification, then variables and data sources.

4.1. Model specification

Following the existing literature and data availability, we choose the following model to examine the determinants of birth rates in our study:

$$BR_{i,t} = \beta_0 + \beta_1 LnHP_{i,t-1} + \beta_2 LnGDPP_{i,t} + \beta_3 ED_{i,t} + \beta_4 UR_{i,t} + \beta_5 LnSSEP_{i,t} + \varepsilon_{i,t} \quad (11)$$

In Equation (11), $BR_{i,t}$ denotes birth rates; $HP_{i,t-1}$ is the housing prices in the ith province in year t-1; $GDPP_{i,t}$ stands for GDP per capita; $ED_{i,t}$ is women's education level; $UR_{i,t}$ is urbanization rate and $SSEP_{i,t}$ *is* social security per capita. β_0 is constant term and $\varepsilon_{i,t}$ is error term.

Most empirical studies include current housing prices or current housing and lagged housing prices. We follow Liu *et al.* (2016) by including lagged housing prices only in our study for two reasons: (1) There exists a multicollinearity problem when we include both current and lagged housing prices in our model. To alleviate this multicollinearity problem, we decided to keep only lagged housing prices. VIF multicollinearity test tells us that there is no multicollinearity in our new model. (see Appendix B2); (2) Lagged housing prices have a greater effect on current birth rates due to the typical 9-month pregnancy period.

Several studies (e.g., Li *et al.*, 2019) used static models to analyze the impact of housing prices on birth rates. However, inertia in population size is a general phenomenon and can be produced by any demographic transition or perturbation (Koons, Holmes & Grand 2007). That is, the birth rates of a certain area over a given year is greatly affected by its past birth rates. At the same time, the problem of missing important explanatory variables can be alleviated by introducing the lagged dependent variable. Therefore, in this study, we estimate both static and dynamic models to conduct our empirical analysis. The dynamic model is as follows:

$$BR_{i,t} = \beta_0 + \beta_1 BR_{i,t-1} + \beta_2 LnHP_{i,t-1} + \beta_3 LnGDPP_{i,t} + \beta_4 ED_{i,t} + \beta_5 UR_{i,t} + \beta_6 LnSSEP_{i,t} + \varepsilon_{i,t} \qquad (12)$$

The newly added variable $BR_{i,t-1}$ is the birth rates in the year t-1. Other variables have the same meaning as Equation (11).

We find that there is a negative relationship between birth rates and lagged one housing prices after producing correlation matrix (see Appendix B3).

Not only our static model but also our dynamic model may face the endogeneity problem. It is possible that there still might be an endogeneity problem because of omitted variables which can both influence the birth rates and the housing prices. For example, the culture of people having their own home and getting married in China is a factor that affects both birth rates and housing prices. It is necessary to select the appropriate variable as an instrument. Binkaia and Rudaib (2013) and Clark, Yi and Zhang (2020) used land sales as the instrument variable to solve the endogeneity problem of housing prices, because land sales have a very strong influence on the housing market but do not have an obvious relationship to birth rates.

However, due to lack of land sales data, we decided to use internal instrument variables in our study. Anderson et al. (1982) proposed a method to provide an instrumental variable for differential dependent variable $y_{i,t-1} - y_{i,t-2}$. This instrumental variable is $y_{i,t-2}$. Since the differential variable itself contains $y_{i,t-2}$, there is a high degree of correlation between instrumental variable and endogenous variables. Given that there is no autocorrelation in the error term, there is no correlation between instrumental variable and the difference of error term. Arellano and Bond (1991) argued that $y_{i,t-2}$ is not the only instrumental variable. $y_{i,t-3}$ and $y_{i,t-4}$ can also be used as instrumental variables. They proposed first order difference General Method of Moments (GMM) which uses more instrumental variable to solve this problem.

4.2. Variables

Our dependent variable is *Birth rates* (*BR*). Common indicators reflecting fertility levels are birth rates (BR) and total fertility rate (TFR). Following Liu, Wang & Hu (2016), we use the birth rates as our indicator since the total fertility rate focuses on reflecting women's fertility behavior but cannot properly reflect the changes in fertility caused by macro factors such as housing prices and it is difficult to obtain panel data of each province for total fertility rate (Liu et al., 2016).

Independent variables are measured as follows.

Logarithmic housing prices (*LnHP*). We use average sales price (yuan/square meter) of residential housing to represent our housing prices (*HP*) which is converted into the price level in 2001. Housing prices as our variable of interest has different impact in different studies. Liu, Zhang and Hu (2016) and Hui et al. (2012) argued that housing prices would have a negative effect; However, Chen and Yin (2005) and Dettling and Kearney (2014) came tp the opposite conclusions. To further examine the impact of housing prices on birth rates in China, we conducted our empirical analysis.

Logarithmic GDP per capita (*LnGDPP*). GDP per capita is gross domestic gross divided by population. This variable indicates the development of the economy across a spectrum of years for each province. The value is also converted into the price level in 2001. Bar & Leukhina (2010); Jones, Schoonbroodt, & Tertilt (2008) verified that increases in income would reduce the fertility level. However, Peng (2014) found that increasing urban income levels would increase the birth rates but rising rural income levels would reduce the birth rates. It is hard to predict the impact of economic development on the whole (rural and urban) birth rates.

Education (ED). This measures women's education level. It is calculated by the number of women over 6 years old with a high school education or above/ population over the age of 6. Becker, Cinnirella & Woessmann (2013) argues that women's higher education is consistently associated with lower fertility. The higher the women's education level, the higher the women's participation in labor force. Having children for educated women may squeeze the time for work and thereby increase the opportunity cost of raising children. Martin (1995) find that in some of the less developed countries, education might have a positive impact on fertility by conducting the empirical analysis.

Urbanization rate (UR). Urbanization rate (UR) is the proportion of urban population in the total population (including agricultural and non-agricultural). In 2000, China's urbanization rate was 36%. According to the sixth national census (November 1, 2010), the population living in cities accounted for 49.68%. On the one hand, this indicator reflects the level of economic development. On the other hand, due to the large difference between rural and urban fertility rates, this indicator can control the difference between urban and rural areas to some extent. Clark & Cummins (2009) shows that urban women exhibit fertility rates that are, on average, 11% lower than those of rural women in Coastal Ghana; Liu, Zhang &Hu (2016) found there is an inverse relationship between urbanization rate and birth rates in China. The same result is expected in our study.

Logarithmic social security expenditure per capita (*LnSSEP*). Social security expenditure per capita represents the social welfare situation of different regions. Social security expenditure in this report includes five insurance categories: basic medical, basic pension, maternity, work injury, and unemployment. After summing up the five insurances' expenditure, we carried out a per capita treatment. Robinson (1997) argued one of the demands for child-services is old-age security utility. As the increase of social security expenditure per capita, people tend to be less dependent on children when they are old. Liu, Zhang &Hu (2016) found that the increase of social security expenditure per capita will decrease the birth rates.

4.3. Data Sources

Since panel data has both a cross-sectional dimension and a time dimension, the sample size of panel data is usually larger, which can improve the accuracy of estimation. At the same time, missing variable bias is a common problem. It occurs when a variable (such as the culture of people having their own home and getting married) not observed by the researcher is correlated both with the treatment (housing prices) and with the outcome (birth rates) (Becker, 2016). If we can find a variable as instrument, one which can only have an effect on housing prices and not directly affect birth rates, the instrumental variable method would reduce the missing variable bias. Although it can be addressed by the instrumental variable method, effective instrumental variables are often difficult to find. Missing variables are usually caused by unobservable individual differences or "heterogeneity". If this individual difference is time invariant, panel data provides a way to solve the problem of missing variables.

Considering that China started housing market reform in 1998 and that there is missing data from the first few years, this study is based on the period 2002-2018, for which we collected data. Based on the data availability of each province, we eliminated Tibet because of missing data. The 30 provinces (including autonomous regions and municipalities) are Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.

The data regarding GDP per capita, housing prices and birth rates are from the CEInet Statistics database. Social security expenditures per capita are calculated based on the data from the China Labor Statistics Yearbook; the data on urbanization rates are from China Statistics Yearbook; the data on women's educational levels are calculated based on the China Population and Employment Statistical Yearbook. Due to the missing data on women's education levels in the year 2010, we conducted the method of linear interpolation to fill in the missing data.

4.4. Unit root tests of panel data

With our panel data set, we first need to test the stationarity of the variables before fitting the model. Non-stationary time series may appear in the following three situations: deterministic trends, structural changes, and random trends. Non-stationary time series will cause the traditional t-test to fail and lead to spurious regression. Spurious regression may be good at the level of goodness of fit, significance level and other indicators, but because the residual series is a non-stationary series, it shows that this regression relationship cannot truly reflect the equilibrium between the dependent variable and the explanatory variable, but just a numerical coincidence. To avoid spurious regression and validate the estimation result, we need to test the stationarity of each variable. The most used method to test the stationarity of the panel data is panel unit root tests.

In this study, Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS) are used to perform a unit root tests on all variables. The results in Table 3 show that all variables are stationary except UR, *LnGDPP* and *LnSSEP*. After first order differencing, both are stationary. Thus, we replaced them by their first differences in the regressions,

Table 3：Unit root test for variables

Variables	LLC	IPS
BR	-3.892***	-2.565***
LnHP	-7.243***	-3.210***
LnGDPP	0.065	6.654
ED	-5.538***	-4.777***
UR	-0.705	-1.95**
LnSSEP	-0.267	1.775
DUR	-10.822***	-10.589***
DLnGDPP	-5.176***	-6.980***
DLnSSEP	-3.826***	-9.952***

Note: *, **, *** indicated it is significant at the level of 10%, 5% and 1%.

5. Results

5.1.Descriptive Statistics and Graphical Result

Table 4: Descriptive Statistics

VARIABLES	N	Mean	SD	MIN	MAX
BR	510	11.29	2.768	4.850	18.05
HP	510	3,934	3,083	1,061	25,061
GDPP	510	27,369	18,559	3,290	102,915
SSEP	510	1,376	1,507	92.36	10,467
UR	510	51.66	14.54	24.29	89.60
ED	510	11.56	5.066	2.745	34.53

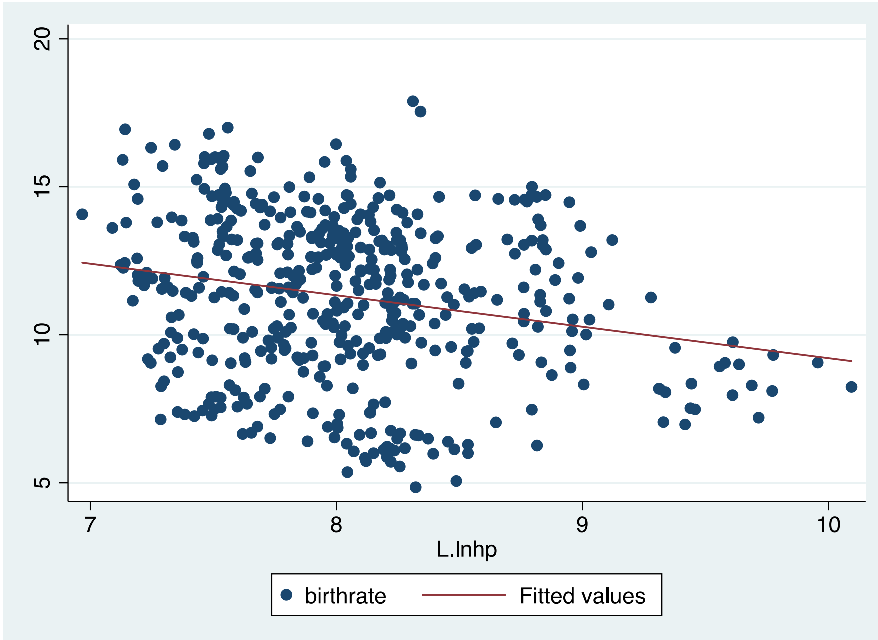


Fig.3. Lagged one lnHP and birth rates

Figure 3 briefly describes the relationship between housing prices (lagged by one period) and the birth rates. As is shown in Figure 3, it indicates there exists a negative relationship between lagged one housing prices and birth rates in China.

5.2. Results of the Static Panel Model

We first estimate the static model by using Pooled Ordinary Least Square (POLS), Fixed Effect (FE), Least Square Dummy Variable (LSDV) and Random Effect (RE). POLS is still unbiased and consistent if errors are serially correlated but POLS will not be efficient anymore (Wooldridge, 2015). Considering each province is unique, we believe that there exists a province-specific idiosyncratic effect. To examine the individual effect, we run an FE model without robust standard error. The F test shows that FE is significantly better than Pooled OLS, and each individual should be allowed to have its own interception. However, since cluster robust standard errors are not used, this F test is not effective because ordinary standard errors are only about half of cluster robust standard errors. Therefore, we further run LSDV and found that most of the individual dummy variables are significant, that is, we believe that there are individual effects, and FE is better than Pooled OLS.

To determine whether FE or RE is more appropriate, we conducted a Hausman test (see Appendix Table B7). The null hypothesis was rejected, so FE is better than RE. After conducting heteroskedasticity, autocorrelation and cross-sectional correlation tests (see Appendix Table B4-B6), we found that all three problems exist. Therefore, we used Feasible Generalized Least Squares (FGLS) estimation method to run our regression and use its results as our main estimation results. The results of all regressions are reported in Table 5.

Table 5: Regression results of the static panel data model

Variable	OLS	FE	LSDV	RE	FGLS
L.LnHP	0.843** (1.013)	0.364 (0.222)	0.364 (0.021)	0.419* (0.221)	**0.605*** (0.160)**
ED	-0.273*** (0.107)	0.009 (0.032)	0.009 (0.050)	-0.009 (0.031)	**-0.001 (0.012)**
DUR	0.011 (0.012)	-0.004 (0.010)	-0.004 (0.007)	-0.004* (0.010)	**-0.009* (0.003)**
DLnGDPP	-0.475 (1.457)	1.488* (0.902)	1.489 (0.903)	1.292 (0.907)	**-0.103 (0.319)**
DLnSSEP	0.109 (0.121)	-0.505** (0.536)	-0.505 (0.336)	-0.492 (0.540)	**0.085 (0.107)**
Constant	7.843*** (2.557)	8.182*** (1.528)	4.213 (2.851)	7.962*** (1.586)	**2.323* (1.456)**
Obs	480	480	480	480	**480**

Note: *, **, *** indicates significance at the level of 10%, 5% and 1% respectively.

Table 5 shows that the lagged housing prices is significant at the 1% level of significance in FGLS. It is shown that there was a positive relationship between lagged housing prices and birth rates which is contrary to our graphical result in Fig.3. This finding is in contrast with that of Liu *et al.* (2016). Dettling & Kearney (2014) showed that when the homeownership rate reached 30%, the net effect became positive. It is also argued that for current homeowners, an increase in housing prices will increase home equity, leading to a positive effect on birth rates. Hence, a positive home equity effect may outweigh any negative price effect among current homeowners. However, our static model may face serious endogeneity problems. Liu et al. (2016) included lagged one birth rates to alleviate the endogeneity. As explained above, to deal with this problem, we set up our GMM model by including lagged birth rates and internal instruments. The other reason is, according to the home ownership rate rating by country, China is the ninth highest-ranked country in the world with respect to homeownership, with a homeownership rate of 89.68% in 2018 (source: Peking University Institute of Social Sciences). This might explain the positive relationship between lagged housing prices and the birth rates. People who hold real estate tend to have children more than those who do not hold home equity or have little home equity.

The results of FGLS show a significant inverse relationship between urbanization rate and birth rates, which is consistent with the literature (Guo et al., 2012). Specifically, birth rates decreased by 0.009% as the growth rate of urbanization rate increased by 1%. However, this does not seem to be economically significant.

5.3. Results of the Dynamic Panel Model

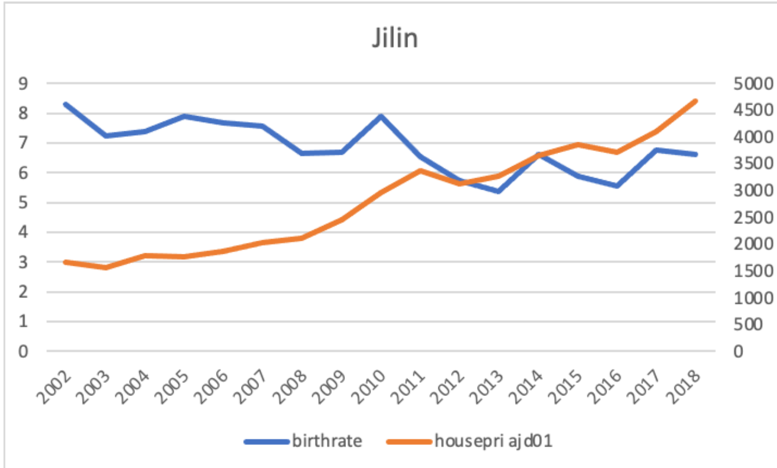
As explained above, lagged birth rates are included in this model to transform it into a dynamic model. Although the introduced lagged birth rates can help alleviate the problem of missing variable bias, there may still exist endogeneity problems due to possible reverse causality (Dettling and Kearney, 2014) since fertility rates could affect housing prices. To overcome this problem, Dettling and Kearney (2014) used an instrumental variable—housing supply elasticity for housing prices. Due to lack of data on housing supply elasticity for China, we decided to use Difference Generalised Method of Moments (GMM) in this report. The prerequisite for establishment of the difference GMM is that there is no autocorrelation in the disturbance term. Besides, in case there are too many instrumental variables generated by GMM method which will result in overidentification problem, we conducted overidentification tests by using Sargan test method. This model passed the test of no autocorrelation in the disturbance term and Sargan test (see AppendixB8-B9). The results of difference GMM is shown in Table 6.

Table 6: Regression results of dynamic panel data model

Variable	Difference GMM
L.LnBR	-0.124*** (0.040)
L.LnHP	-0.600*** (0.191)
ED	0.087*** (0.014)
DUR	-0.005* (0.002)
DLnGDPP	0.229* (0.137)
DLnSSEP	0.015 (0.124)
Constant	16.433*** (1.595)
Obs	450

Note: *, ***indicated it is significant at the significance level of 10% and 1%.

Our Difference GMM results show that the lagged birth rates had a significant and negative impact on the current birth rates in difference GMM model. At the same time, the lagged housing prices had a negative relationship with birth rates, which is statistically significant at the 1% level. This negative relationship is consistent with our graphical analysis but is against our static model. This finding is also consistent with Liu *et al.* (2016), who also included lagged birth rates in their model. We feel more confident with our difference GMM model because it alleviates the endogeneity problem by including lagged birth rates and internal instruments. Figure 4 shows some representative provinces in birth rates and housing prices, and the right scale represents birth rates, and the left scale represents housing prices adjusted to the 2001 price level. The results from the difference GMM showed that if lagged housing prices increased by 1%, other variables being constant, birth rates decreased by 0.6%. Meanwhile, the results also show that the higher the women's education level, the higher the birth rates. Martin (1995) indicates that in some less developed countries, women's education might have a positive impact on fertility. From the result of difference GMM the growth of urbanization rate is statistically significant negative to the birth rates at the 10% level of significance, which is consistent with the findings of Guo et al. (2012). The growth of GDP per capita has a positive effect on birth rates at 10% significant level. (Here we use the growth of GDP per capita, which is different from the absolute value of GDP per capita that some other researchers used. Thus, our conclusions may differ.) As an indicator of economic development, with higher growth of GDP per capita, people are more likely to have children. Our result shows that, as the growth of GDP per capita increases by 1%, birth rates increase by 0.229%. In the household theory of fertility, there are two effects in consumption of child- service. One is income effect, that is, higher income allows for larger family size; the other is substitution effect, that is, higher price (cost) of children implies smaller family size. Here we tend to believe that the income effect dominates the substitution effect.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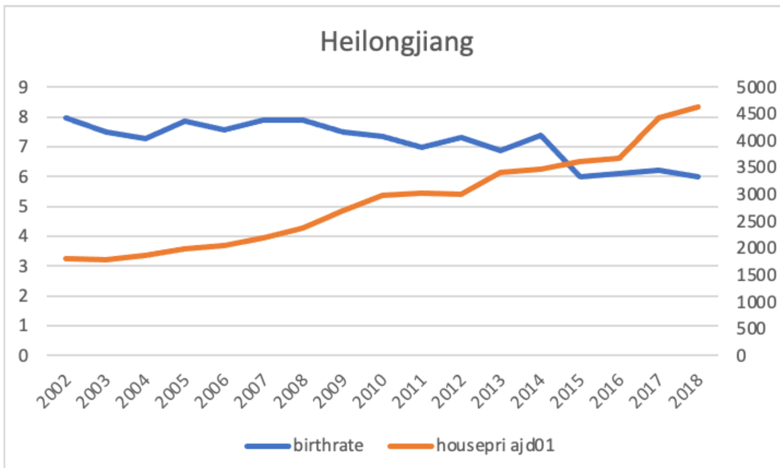
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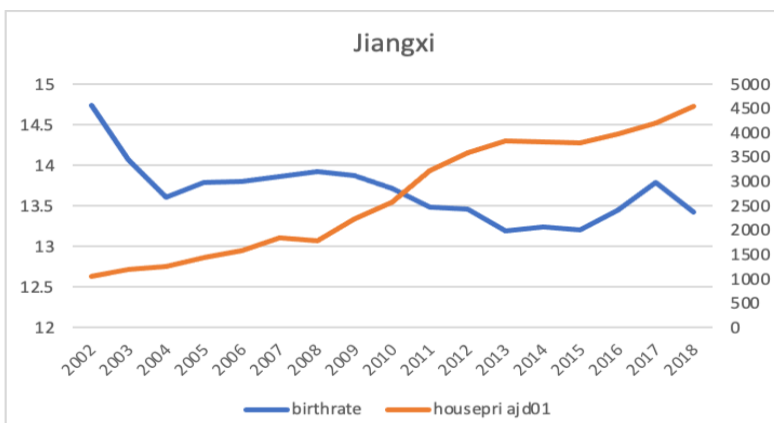
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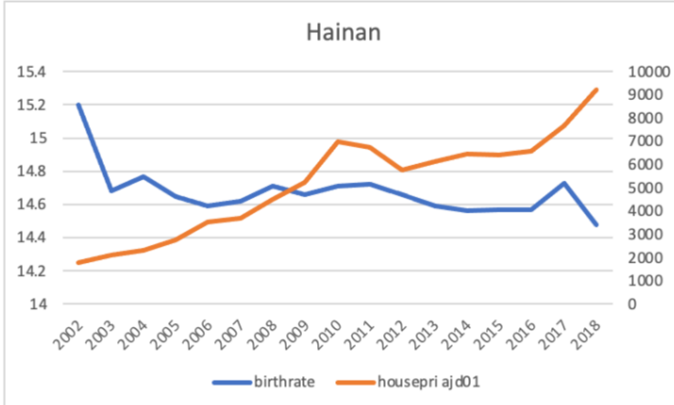

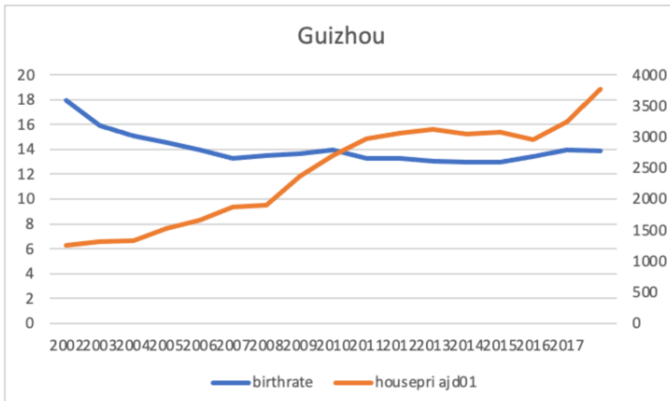

Fig.4 Birth rates and Housing Price in Representative Provinces

6. Conclusions and Policy Recommendations

This report attempted to investigate the relationship between birth rates and housing prices in China. The theoretical literature suggested that family size depends on the net effect of income effect and substitution effect. The results from empirical studies have shown mixed results in terms of relationships between birth rates and housing prices. First, we followed the existing literature by setting up a theoretical model which suggests that the relationship between birth rates and housing prices depends on other consumption expenditures (except housing) and family wealth. Then we estimated both static and dynamic panel data models by using a number of estimation methods, including Feasible Generalized Least Square (FGLS) estimation of a Fixed Effect (FE) static model and

Difference Generalized Moment Method (GMM) with a dynamic model to estimate the relationship between birth rates and housing prices in China from 30 provinces (including autonomous regions and municipalities, except Tibet) from 2002 to 2018. The results show that there is a negative relationship between housing prices and birth rates in China from 2002 and 2018 in our Difference GMM model.

Our findings also show that the higher the rate of growth of urbanization, the lower the birth rates. Because consumption levels in urban area are greater than those in rural areas, people who have just entered the city may face greater economic pressure. Since children are an expensive commodity, at least in the short term, increases in housing prices will push the new migrants to put off having children, resulting in lower birth rates. As is shown in our Difference GMM model, the growth rate of GDP per capita has a positive effect on birth rates. In terms of rapid increase in GDP, positive economic development will overcome the additional price impact of having children.

As for policy recommendations based on the findings of this report, given the negative relationship between housing prices and birth rates, it is necessary to introduce more policies and administrative measures to regulate and control skyrocketing housing prices. Perhaps the most urgent need for the government is to reduce the cost of "first homes". At present, excessively high housing prices have increased the pre-purchase savings rate of the “first home” people, while at the same time increasing their post-purchase debt-asset ratio, which puts them under tremendous financial pressure. At the same time, the "first home" groups are mainly composed of young people, who are the main contributors to rises in birth rates. It can be seen from this that reducing the cost of a "first home" is very important for increasing birth rates. In terms of specific measures, we believe that, on the one hand, the government should introduce preferential policies for the "first home" group, such as preferential housing loans for their first homes. On the other hand, officials should develop plans for discouraging speculative housing demand so as to reduce overall housing prices. The government can increase the minimum down payment percentage for second homes, levy real estate taxes, etc.

Second, the government should develop new models to promote sustainable economic growth. After 40 years of high-speed economic growth in China, the growth rate of GDP has been slowing down in recent years. The government should seek ways to promote new economic growth, for example, by subsidising high-tech companies and accelerating the construction of Industry 4.0. As for individuals and companies, they should improve their innovation skills and invest more in R&D.

Finally, like most empirical studies, this report has several limitations. First, because of data limitations, we cannot include housing price elasticity or land sales as an external instrumental variable for housing prices, while the instrumental variables used in the GMM model are internal only. For future studies, we intend to find some reasonable external instruments to improve our results. Second, we did not use a measure to distinguish between homeowners and non-homeowners, due to the lack of available data. The statistics may differ between homeowners and non-homeowners. Third, the huge differences between rural and urban areas should be taken more into account and we need to separate them into two different groups if data are available, since people who live in rural areas spend much less on housing than those in urban area. Fourth, cultural values such as the tradition of people having their own home and getting married are difficult to quantify.

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Appendix A

Fertility Policy Shifts

Since the founding of the People’s Republic of China in1949, China's fertility policy has mainly undergone four phases of change: the encouragement of fertility phase from 1949 to 1953, the advocacy of family planning phase from 1954 to 1977, the strict fertility phase from 1978 to 2001, and the gradual liberalization of the one-child policy from 2002 to the present (Wang, 2019).

1949-1953 is the stage of encouragement of fertility. The government was focused on developing industrial and agricultural production. It was difficult to put forward a clear population policy and birth policy through social practice. Mao Zedong once pointed out in “The Bankruptcy of the Idealist Conception of History” that “The large population of China is a great good thing”. The concept of “many people is power” is deeply rooted in the hearts of the Chinese people. In addition, the government had vigorously promoted the Soviet Union’s policies and practices to encourage population growth. In such circumstances, there were no policies to restrict population growth and impose birth control. On the contrary, in practice, an informal policy to encourage population growth was implemented.

The serious economic and social consequences of population growth, and their effect on the economy, led to the stage of advocacy of family planning in the period from 1954-1977. Between 1950 and 1970, the population increased from 540 million to more than 800 million (Hesketh, Lu, & Xing, 2005). In the process, the Chinese government gradually recognized the problems that the high birth rate would bring, and gradually formulated relevant policies to promote birth control. In 1971, the government released a birth policy which was “Not less than one, three is too many, two are just right”. In December 1973, the government introduced the mostly voluntary later-longer-fewer policy, which encouraged later childbearing, longer spacing between children, and fewer children. This policy led to a large fall in the total fertility rate, from an estimated 5.9 births per woman in 1970 to 2.9 births per woman by 1979 (Zeng & Hesketh, 2016).

1978-2001 was the stage of strict implementation of family planning policy. In March 1978, “The state promotes and strictly implements family planning” was first written into the Constitution and put into practice throughout the country; in October 1978, the government clearly stated that “the best number of children for a couple is one, and the maximum number is two." In September 1980, the Central Planning Committee (CPC) issued a fertility policy, transforming the "two are just right" in the 1970s into a policy of strictly controlling the birth of the second child, under the one-child policy. In April 1984, the CPC proposed that rural areas could appropriately relax conditions for giving birth to a second child, but that it was strictly forbidden to exceed the planned second child through multiple births. The one-child policy was strictly enforced for urban residents, who in 1980 accounted for about 20% of the population, then nearly half by 2010 (China Statistics Yearbook). Beginning in 1984, rural couples in most provinces were allowed to have a second child if their first was a girl, the so-called 1.5-child policy. In the six northwestern provinces, all rural couples were allowed a second child, irrespective of the sex of the first child. Two or more children were allowed for ethnic minorities, who account for around 9% of the total population (Hesketh, Lu, & Xing, 2005). These variations created a substantial difference in total fertility rates between rural and urban regions.

Since 2002, the family planning policy has been gradually liberalized. In 2002, the government launched a selective two-child policy, which started to permit couples who were both only children to have two children. In November 2013, the selective two-child policy changed to permitting any couple to have a maximum of two children, as long as at least one member of the couples was an only child. However, by May 2015, only 1.45 million (13.2%) of the 11 million eligible couples applied for permission to have a second child (Lancet, 2016). On January 1, 2016, China began implementing a universal two-child policy, by which all couples could have a second child.

Appendix B

Table B1: Provinces/Cities' Code

Code	Provinces	Code	Provinces	Code	Provinces
Code1	Beijing	Code11	Zhejiang	Code21	Hainan
Code2	Tianjin	Code 12	Anhui	Code22	Chongqing
Code3	Hebei	Code13	Fujian	Code23	Chongqing
Code4	Shanxi	Code14	Jiangxi	Code24	Guizhou
Code5	Inner Mongolia	Code15	Shandong	Code25	Yunnan
Code6	Liaoning	Code16	Henan	Code26	Shaanxi
Code7	Jilin	Code17	Hubei	Code27	Gansu
Code8	Heilongjiang	Code18	Hunan	Code28	Qinghai
Code9	Shanghai	Code19	Guangdong	Code29	Ningxia
Code10	Jiangsu	Code20	Guangxi	Code30	Xinjiang

Table B2: VIF Multicollinearity Test

Variable	VIF	1/VIF
L.LnHP	2.80	0.357
ED	2.68	0.373
DUR	1.01	0.992
DLnGDPP	1.25	0.798
DLnSSEP	1.03	0.973
Mean VIF	1.75	

Table B3: Correlation Matrix

Code	BR	L.LnHP	ED	DUR	DLnGDPP	DLnSSEP
BR	1.000					
L.LnHP	-0.217	1.000				
ED	-0.362	0.786	1.000			
DUR	0.026	-0.046	-0.038	1.000		
DLnGDPP	0.101	-0.442	-0.390	0.048	1.000	
DLnSSEP	0.037	-0.026	-0.110	0.070	0.046	1.000

Table B4: Test of Heteroskedasticity

Modified Wald test for groupwise heteroskedasticity
H0: sigma(i)^2 = sigma^2 for all i
chi2 (30) = 88.12
Prob>chi2 = 0.0000

Table B5: Test of Autocorrelation

Wooldridge test for autocorrelation in panel data	
H0: no first-order autocorrelation	
F (1, 29) =	23.786
Prob > F =	0.0000

Table B6: Test of Cross-sectional Correlation

Frees' test of cross-sectional independence = 4.207	
Critical values from Frees' Q distribution	
alpha = 0.10:	0.1612
alpha = 0.05:	0.2116
alpha = 0.01:	0.3125

Table B7: Hausman Test

Hausman Test
Test: Ho: difference in coefficients not systematic
chi2(6) = (b-B)'[(V_b-V_B) ^(-1)](b-B)= 13.80
Prob>chi2 = 0.0319
(V_b-V_B is not positive definite)

Table B8: Arellano-Bond Test for Difference GMM

Arellano-Bond test for zero autocorrelation in first-differenced errors		
Order	z	Prob > z
1	-1.7859	0.0741
2	-0.9729	0.3306
H0: no autocorrelation		

Table B9: Sargan Test for Difference GMM

Sargan test of overidentifying restrictions
H0: overidentifying restrictions are valid
chi2(28) = 28.06036
Prob > chi2 = 0.4613

Curriculum Vitae

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Conference Presentations: N/A