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Housing Purchase Restriction and Birth Rates: An Unintended Consequence of Governmental Intervention

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ABSTRACT
Ever since the late 20th Century, housing prices has been rising in an unstoppable trend in China, making it harder for first-time purchasers lacking sufficient savings to obtain their first home. In 2010, a housing purchase restriction was implemented by central government as a proposed solution by curbing speculative demand. Rapidly rising housing prices have effects beyond those on first-time buyers. Indeed, many studies show that increasing housing prices are associated with decreases in fertility. Based on prior research, our study focuses on the relationship between the housing purchse restriction policy and the birth rates. Our results reveal both economic and societal implications to real estate market in China, providing basic guidelines and market insights for policymakers in their decision-making. We use a difference in difference (DiD) methodology to compare the birth rates before and after the national policy implementation in 2010 across cities to determine the effect of such regulation. While theory suggests that housing purchase restrictions should raise the birth rates, our empirical study suggests a more complicated relationship: the housing purchase restriction reduces the birth rates immediately after its implementation, and increases the birth rates gradually over time.

Keywords: *Housing purchase restriction, birth rates, housing prices*

1. INTRODUCTION

Roughly twenty years after China decided to reform and open special economic zones for better industrial development, its housing market started to thrive, ultimately leading to episodes of speculative activities in real estate market. As more and more people detected a profit in the housing market, buying and selling houses for higher profit expanded. Over time the central government in China made enormous efforts to regulate the rapidly rising housing prices by restraining lending, implementing land administration, and house purchase restrictions [1]. For example, in May 2010, a housing purchase restriction (HPR) policy was first implemented in Beijing, soon spread to other first-tier cities. First-tier cities are classified as the four cities in China with the highest GDP per capita, and unlike second-tier, third-tier and fourth-tier cities, there is seldom a change in the composition of first-tier cities. The initial purpose of the HPR policy was to restrain the widespread speculation via housing purchases, however, after a few years following enactment, several third-tier cities encountered economic crisis. Hohhot, the capital of Inner Mongolia, for instance, was the first city to stop the policy of house purchase restriction in 2014 due to extremely low housing transaction volume [2], soon after Hohhot, about 36 third-tier cities began abandoning house purchase restriction for better economic development.

It is also suggested by the literatures that there is a relationship between housing prices and fertility, but widespread empirical evidences are inconsistent. Pan and Xu argue that limited and expensive housing reduces people's income available for raising children and lowers their willingness to have a child [3], theoretical models proposed by Becker, Liu and Clark also reveal that an increase in housing prices might affect family fertility decisions through price (substitution), and wealth (income) effects [4-6]. Using Hong Kong as an example, Eddie et al. find out that an average increase of

1% in housing prices is accompanied by an average fertility decline of 0.52% [7]. However, for home-owning families, an increase in housing prices might also contribute to an increase in a couple's willingness to give birth by boosting family's wealth, therefore increasing household's demand for children [8, 9].

In addition to these studies focusing on the impact of housing prices on fertility, much research has examined the impacts of China's HPR on housing prices. For example, Cao et al. find that purchase restrictions are associated with an 18% decline in housing prices and a 60% decline in sales volume in the four quarters following the introduction of the HPR policy in restricted versus unrestricted areas [10].

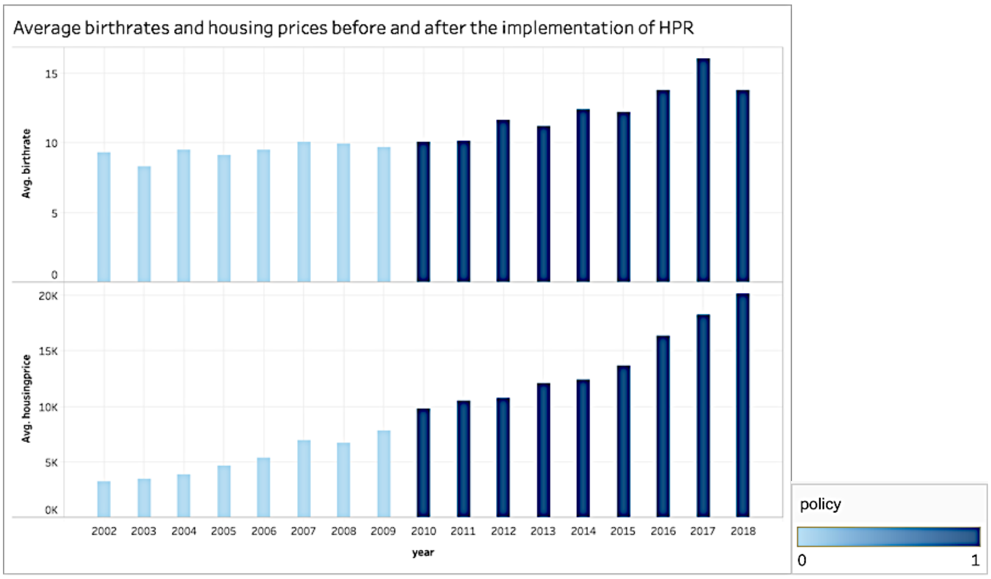

Fig 1. Average birth rates and housing prices before and after the implementation of HPR

In general, two contradictory perceptions regarding the relationship between HPR policy and housing prices persist: one view considers HPR a successful policy in curbing the housing prices and the other considers HPR an unsuccessful policy that fails to reduce rising housing prices [1, 11-15].

To the best of our knowledge, no studies have examined whether the HPR affected birth rates directly, even if that was an unintended consequence. Our research attempts to fill this gap by studying these links empirically. Specifically, we use difference in difference (DiD) analysis to examine the influence of HPR on birth rates from 2000 to 2018 using panel data consisting of average housing prices and birth rates from nineteen cities. The visualization for the impact of HPR policy in birth rates and housing prices is displayed in Fig 1.

The paper is organized as follows: Section 2 provides a literature review and Section 3 introduces the methodology we use to examine the effectiveness of house purchase restriction on housing prices and housing prices influence on the birth rates and discusses our findings. The final section summarizes our conclusion, discusses some limitations of our research and provides directions for future studies in related fields.

2. LITERATURE REVIEW

Ever since the economic structure of China was changed from command economy to market economy in the end of 20th century, the housing prices in China has been on a rapid upward trend accompanied by greater international integration outside and domestic urbanization inside. During the period from 1998 to 2018, the proportion of value-added from the real estate and construction industries to the GDP increased from approximately 4%-6.65% and from approximately 11% to about 26%, respectively [15]. Such a rapid and dramatic progression of real estate market and construction industries gradually reshaped people's consideration about housing from a necessity for living to an investment with great potential return. Driven by speculative mindset, more and more savvy and wealthy investors intentionally participated in the creation of so-called housing bubbles by generating large amounts of demands in the market—according to Dreger and Zhang, overheated investments and growing housing prices bubbles caused by a rapid rise in housing prices are two particularly serious issues faced by China's real estate market [16]. Studies by Zhi et al. reveal that 10 out of 35 major cities being examined had exhibited significant bubble characteristics [17]. Furthermore, similar research by Shih, Li and Qin also shows that most of the provinces in China have housing prices bubbles and affordability problems, and that bubbles are most severe in Beijing and Shanghai [18]. Media reports demonstrate that approximately up to 30% of new apartments being purchased and left vacant [19]. It is under this circumstance that central government proposed and implemented the housing purchase restriction in 2010 with an aim to control the housing prices at a rational level, so that it would be easier and less expensive for non-house owner to acquire their first housing.

Notably, this policy was not implemented uniformly across the cities as housing prices in some small cities are already so low that it becomes needless for government to introduce such restriction in those areas. Despite of some minor differences across cities, in general the restriction prohibits resident households with registered *hukou* from owning more than two houses and households without *hukou* from owning more than one house [12]. The implementation of housing purchase restriction soon aroused a myriad of fierce debates concerning its effectiveness to reduce the speculative demand and restrain housing prices increases.

On the one hand, Li et al. find that convergence of growth rate to unity is possible for cities with housing purchase restriction, indicating that housing purchase restriction have been successful curbing housing prices growth compared to cities without restrictions [1], Sun et al. discover that the implementation of HPR policy in Beijing results in 17-24% decrease in resale price and 50-75% reduction in sales transaction volume [11]. A counterfactual analysis done by Du and Zhang demonstrates that purchase restriction effectively reduced the annual growth rate of housing prices in Beijing [12]. On the contrary, different results are found by Somerville et al. showing that there are no relative changes post-policy introduction in housing prices between restricted and unrestricted areas [13]. Studies by Zhang and Wang show that the HPR policy can restrain the investment demand, but it's difficult to reduce housing prices in cities with high house prices already [14]. Chen et al. conclude that HPR policy is only effective against the price of new housing in the short term, but it could not control the rise of second-hand housing prices [20]. Finally, Li et al. conduct a case study focusing on a suburb of Beijing, and find that the HPR policy did not significantly reduce the price of existing houses in the study area; instead, the policy had a significantly positive effect on prices of houses that are within 1000 m from Beijing [15].

In addition to its own nature as a potentially lucrative investment, the prices of housings are found to be significantly correlated with an essential measurement of population growth—the birth rates. Based on an econometric study done by Liu et al., having housing property right, meaning that being a possessor rather than a renter of the house, has a significantly positive impact on fertility outcomes in China, and such result is consistent with most research findings for other countries [21]. In other words, public policies facilitating the purchase of housing by first-home buyer should contribute positively to China's fertility rate [21]. Ge and Zhang discover that house prices are significantly associated with fertility using provincial level house prices with China Family Panel Studies (CFPS) data [22].

A more detailed and specific study by Liu et al. using national representative data collected through population census and household surveys reveals that 1% increase in house price results in a decrease of 6.4‰ in the likelihood of women delivering births within 12 months prior to the census, and it also emphasizes that the negative correlation between house price and fertility response is significant for renter families and families with self-built houses, while the correlation becomes insignificant for house-owning families [23]. In Pan and Xu's paper, they also find out that urban fertility rate is strongly correlated with housing prices in a way that the fertility rate is higher in cities where housing is more spacious or housing prices is cheaper [3].

Nevertheless, consistent results are not found across all scholarly works: based on US data, Lovenheim and Mumford's work reveals that a $100,000 increase in housing wealth among homeowners would result in a 16-18% increase in the probability of childbirth [24]. Moreover, Dettling and Kearney find that a $10,000 increase in housing prices would lead to 6% increase in fertility rates among homeowners and a 2.4% decrease among non-owners [8].

Despite rich literatures investigating the correlation between HPR and housing prices and that between housing prices and fertility outcome separately, no study has examined the relationship between HPR and fertility outcome directly via the housing prices link. Our research aims to serve as a bridge and fill the gap between the policy and the birth rates by determining whether HPR significantly affected the birth rates as one of its unintended consequences.

3. EMPIRICAL RESULTS AND POSSIBLE MECHANISM

3.1 Housing purchase restriction and housing prices: data results

In this section, we investigate the impact of Housing purchase restriction (HPR) on change of housing prices, housing prices on change of birth rates and whether HPR would influence birth rates. By utilizing regression model, Difference in differences (DID) and interaction term, we are able to observe the effectiveness of HPR and its impact on change of birth rates and housing prices.

3.1.1 Basic results

By using random number generator, we first selected 10 first & second tier cities and 10 third, fourth & below tier cities, in which the Housing purchase restriction (HPR) are implemented, then compared to those cities that did not have HPR enaction. However, due to the limited information of housing prices, we only had access to housing prices in 8 cities among our sample, they are: Hangzhou, Shenzhen, Guangzhou, Xiamen, Shenyang, Hefei, Chengdu and Dalian. Despite of insufficient data, we were still able to collected data, which are predominantly adopted from Perspective Database(https://d.qianzhan.com) and China National Knowledge Infrastructure (https://www.cnki.net). Including data of housing prices (RMB) in cities who have and have not enforced HPR, our study aimed to investigate the impact of HPR on housing prices during the period 2000 to 2018. Our research ran a regression line to observe the impact of HPR on housing prices in different tier cities from 2000 to 2018. The dependent variable in this study is the change of housing prices, the independent variable is housing purchase restriction.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.90227734							
R Square	0.814104397							
Adjusted R Square	0.808428196							
Standard Error	0.302361042							
Observations	136							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	4	52.44860569	13.11215142	143.4241512	7.44934E-47			
Residual	131	11.97630818	0.0914222					
Total	135	64.42491387						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	8.641119133	0.08575797	100.7617033	5.3714E-126	8.471469412	8.81076885	8.47146941	8.81076885
policy	0.444223878	0.182915242	2.428577704	0.01651518	0.082373897	0.80607386	0.0823739	0.80607386
city	-0.144512866	0.011315578	-12.77114351	9.17386E-25	-0.166897777	-0.122128	-0.1668978	-0.122128
year	0.129880744	0.016495147	7.873876025	1.14812E-12	0.097249408	0.16251208	0.09724941	0.16251208
year*policy	-0.051979471	0.021507041	-2.416858345	0.017032403	-0.094525527	-0.0094334	-0.0945255	-0.0094334

Fig 2. Results from the regression analysis between *policy* and *lnhousingprice*

Based on R Square and adjusted R Square from Fig. 2, in 136 data we obtained, it suggests a fairly strong relationship between the change of housing prices and HPR policy. In the 136 data we studied, about 81% of change in housing prices could be explained by our independent variable, enactment of HPR, for a linear regression model. Plus, the adjusted R Square also indicates that there's no salient difference with R Square, which is also around 81%.

Moreover, if we narrow down to find the individual influence of independent variable, the implementation of HPR, in the range of city, year and policy in year, we would be able to detect that the year actually has the most statistically significant effect on the change of housing prices, given that the absolute value of *t Stat* is 12.8, which is much greater than 2, as well as *P-value*, is bigger than 0.05. Thus, after one year, HPR could result in 13% increase in change of housing prices. However, the result does not seem to match the principle of HPR, which arouses arguments claiming HPR is actually ineffective in regulating housing prices. Ever since HPR has been enforced in Shanghai in 2011, then reinforced in 2016 by Central Government, housing prices in Shanghai still seems to endure fluctuation due to the speculative activities. As Huan Yang concludes in the paper, housing prices in Shanghai has increased by 19.8% compared to the same time in 2016 [2]. Comparing to the year as independent variable, influence of city does not have statistical significance on change of housing prices, since the absolute value of *t Stat* and *P-value* are neither the largest according to regression model. Moreover, by adding interaction terms as year and policy for predicting the long-term effect of HPR on change of housing prices, our study discovered a statistical significance of the year on changing of housing prices. Evidence in absolute value of *t Stat* and *P-value* both support this claim, therefore, as we concluded, after every single year, the HPR would restrain change of housing prices by reducing 5.2%. Thus, we are able to determine that HPR actually results in long-term effect in change of housing prices. In addition, employing interaction term enables us to predict after how many years in the future can the housing prices rebound, and keep balance.

3.1.2 Robustness test

Regression Statistics	
Multiple R	0.905499555
R Square	0.819929444
Adjusted R Square	0.813003653
Standard Error	0.29872846
Observations	136

ANOVA

	df	SS	MS	F	Significance F
Regression	5	52.8238838	10.56477676	118.3878475	1.21546E-46
Residual	130	11.60103007	0.089238693		
Total	135	64.42491387			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	8.780499798	0.10862037	80.83658491	5.1232E-113	8.565607385	8.99539221	8.565607385	8.99539221
policy	0.444223878	0.180717688	2.458109567	0.015283405	0.086695545	0.80175221	0.086695545	0.80175221
firsttier	-0.125892213	0.061390172	-2.050690016	0.042306548	-0.247345327	-0.004439099	-0.247345327	-0.004439099
city	-0.158001317	0.012971041	-12.18108194	3.04019E-23	-0.183662971	-0.132339663	-0.183662971	-0.132339663
year*policy	-0.051979471	0.021248654	-2.4462477	0.015772062	-0.094017391	-0.00994155	-0.094017391	-0.00994155
year	0.129880744	0.016296974	7.96962352	7.07032E-13	0.097639131	0.162122357	0.097639131	0.162122357

Fig 3. Robustness test for regression between *policy* and *lnhousingprice*

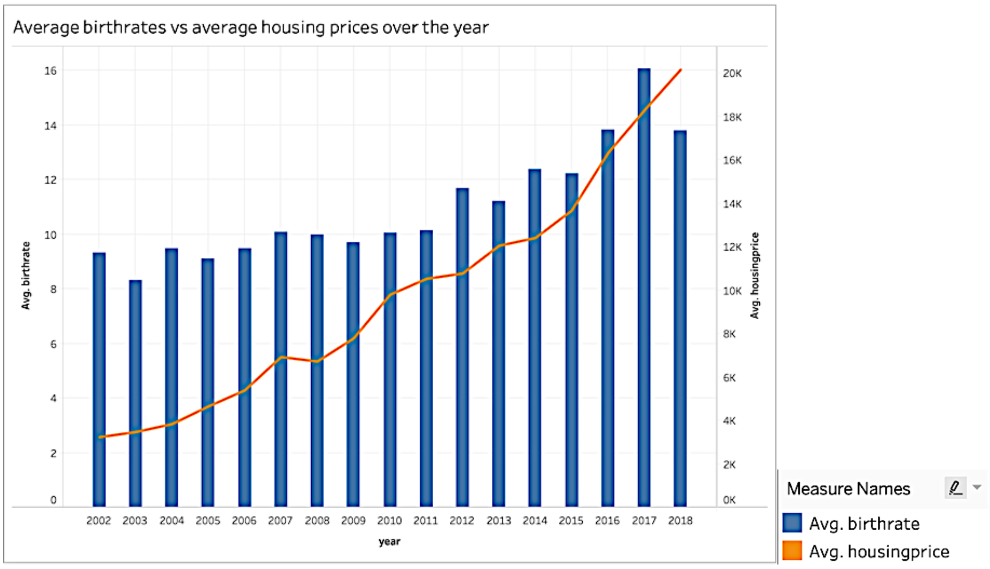

Fig 4. Average birthrates vs average housing prices over the year

Then we conducted the robustness test in Fig 3. and included two dummy variables as first tier cities and second tier cities, in order to make our research more representative, the criteria for ranking of 337 cities in China in 2019 was from YICAI (https://www.yicai.com/news/100200192.html), a professional and reputable economic news website. As introducing tiers of city as dummy variables, we are able to witness the impact of HPR on change of housing prices is varied by tiers. Moreover, adjusted R Square shows that about 81% of change in housing prices can be explained by regression model. The value for variable *firsttier* indicates a statistical significance of city tiers on change in housing prices, since the absolute value for *t Stat* is greater than 2 and the P-value is smaller than 0.05. Being a first-tier city shows a statistically significant impact on change in housing prices, which means that every year after the enforcement of HPR, housing prices in first tier cities would drop roughly 13%, as the coefficient for variable *firsttier* is -0.13.

3.2 Housing prices and birth rates: data results

In this section, we focused on finding the impact of changing in housing prices on change of birth rates. By adopting data from Anjuke (https://anjuke.com), a professional platform of China real estate market information, we are able to run regression model to testify the impact of housing prices on birth rates. In light of inadequate resource in housing prices, we only include 8 cities, covering first and second tier cities in our study. Average birth rates and average housing prices are compared to each other over the year in Fig 4. The dependent variable in this study is *lnbirthrate*, and the independent variable is *lnhousingprice*. Employing a regression model in the study, we are able to minimize the effect of confounding variables like educational level, social status, occupation, etc., and control the independent variable, catch the most effective factor, as well as the least effective one. Thus, we could make conclusion and prediction based on results. The independent variable in our study is change of housing prices, while the dependent variable is change in birth rates.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.722219755
R Square	0.521601374
Adjusted R Square	0.506993782
Standard Error	0.230788718
Observations	136

ANOVA

	df	SS	MS	F	Significance F
Regression	4	7.607627635	1.90190691	35.70755449	3.7355E-20
Residual	131	6.977509623	0.05326343		
Total	135	14.58513726			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	1.111267515	0.740252258	1.50120111	0.135710053	-0.353128032	2.57566306	-0.353128	2.57566306
city	-0.021017445	0.012772818	-1.6454822	0.102267737	-0.046285126	0.00425024	-0.0462851	0.00425024
year	-0.172045484	0.054608034	-3.1505526	0.002019548	-0.280073202	-0.0640178	-0.2800732	-0.0640178
year*housingprice	0.019059839	0.006153281	3.09750857	0.002388107	0.006887183	0.0312325	0.00688718	0.0312325
lnhousingprice	0.144462034	0.08538802	1.69183023	0.093055764	-0.024455839	0.31337991	-0.0244558	0.31337991

Fig 5. Results from the regression analysis between the *lnhousingprice* and the *lnbirthrate*

3.2.1 *Basic results*

According to Fig 5., the adjusted R Square as 0.51 shows that around 51% of the change in birth rates could be explained by the model overall. When we shift focus to the separate factors that would affect dependent variable, *lnbirthrate*, including *city*, *year*, *year*housingprice* and *lnhousingprice*, *lnhousingprice* does not have a statistically significant impact on *lnbirthrate*. *P-value* for *lnhousingprice* is greater than 0.05, and the absolute value of *t Stat* is less than 2, indicating a weak correlation between *lnhousingprice* and *lnbirthrate*. This result does not meet our expectation that soaring housing prices would curb the birth rates significantly, as studies by Liu, Xing and Zhang indicate that the increasing housing prices leads to lower reproductive probability among women, especially for those who have been married for 3-5 years and aged 30 or under [23]. However, it's reasonable that housing prices could be one of the factors that result in rising birth rates, as the urbanization has been promoted in China ever since 1993. During the progress of urbanization, more people who used to live in rural areas migrated to urban regions, which would largely stimulate housing demands, and leads to ascending housing prices. Meanwhile, as more people live in urban areas, the probability for women to give birth would potentially increase.

In order to further analyze the long-term impact of housing prices on birth rates, we add interaction term, as year and housing prices show. A statistically significant impact of year and housing prices is observed on the change of birth rates. The absolute value of *P-value* is smaller than 0.05; therefore, the interaction term *year*housingprice* has a relatively strong correlation with *lnbirthrate*. We conclude that when housing prices increase by one unit every year, birth rates would correspondingly increase by 2%.

3.2.2 Robustness test

Regression Statistics	
Multiple R	0.739198875
R Square	0.546414977
Adjusted R Square	0.528969399
Standard Error	0.225586412
Observations	136

ANOVA

	df	SS	MS	F	Significance F
Regression	5	7.969537441	1.593907488	31.32111664	8.04269E-21
Residual	130	6.615599816	0.050889229		
Total	135	14.58513726			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	1.451974478	0.734758582	1.976124557	0.05025796	-0.001657504	2.90560646	-0.001657504	2.90560646
firsttier	-0.12566219	0.047121313	-2.666780302	0.008631413	-0.218886072	-0.032438307	-0.218886072	-0.032438307
city	-0.038772439	0.01414919	-2.740258599	0.007002749	-0.066764918	-0.010779959	-0.066764918	-0.010779959
year	-0.16212773	0.053506493	-3.030057098	0.002950754	-0.267983928	-0.056271532	-0.267983928	-0.056271532
year*housingprice	0.01829138	0.006021476	3.03769056	0.002881911	0.006378611	0.03020415	0.006378611	0.03020415
lnhousingprice	0.121549173	0.083904328	1.448663918	0.149839222	-0.044445506	0.287543852	-0.044445506	0.287543852

Fig 6. Robustness test for regression between *lnhousingprice* and the *lnbirthrate*

Our hypothesis is that change in housing prices would significantly affect change of birth rates. In order to avoid making arbitrary and easily replaced assumptions, we added first and second tier cities as dummy variables, then test the robustness of Fig 6. Moreover, as R Square and Adjusted R Square show, approximately 52% of changes in birth rates can be explained by the regression model in general. The value for variable *firsttier* indicates a statistical significance of city tiers on change in housing prices, since the absolute value for *t Stat* is greater than 2 and the P-value is smaller than 0.05. Being a first-tier city shows a statistically significant impact on change in birth rates, which means that every year after the enforcement of HPR, birth rates in first tier cities would drop roughly 13%, as the coefficient for variable *firsttier* is -0.13.

3.3 Housing purchase restriction and birth rates: data results

In this final section, we investigated whether and how housing purchase restriction affected the birth rates using the data we gathered from National Bureau of Statistics (http://www.stats.gov.cn) and Bureau of Statistics at city level. We constructed a panel data consisting of birth rates information from 19 cities in China from year 2000-2018, and among these 19 cities, 9 cities have implemented and is still implementing HPR up to the point this paper is being written, and the other 10 cities have never implemented such policy at all. The comparison of average birth rates between cities with HPR policy and cities without HPR policy is shown in Fig 7. We took policy as our independent variable and birth rates as our dependent variable while controlling for both the year and the city. Since HPR was first implemented back in 2010 and roughly all cities adopted HPR around that year despite the difference in the

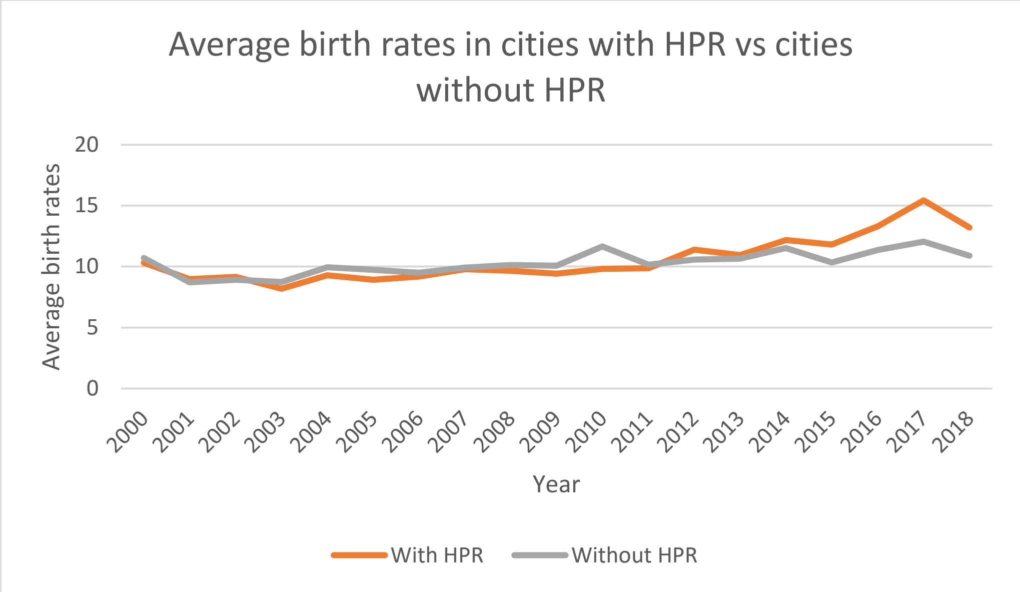

Fig 7. Average birth rates in cities with HPR vs cities without HPR

exact time and data of the implementation across cities, we decided to assign the value 0 to years before 2010 and value 1 to years after 2010 to simulate the enactment of HPR.

3.3.1 Basic results

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.482390233							
R Square	0.232700337							
Adjusted R Square	0.224078992							
Standard Error	2.715170498							
Observations	361							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	4	795.9324569	198.9831142	26.99118869	1.41693E-19			
Residual	356	2624.485697	7.372150833					
Total	360	3420.418153						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	10.37819648	0.384167349	27.01478015	3.20878E-88	9.622673768	11.1337192	9.62267377	11.1337192
Year	0.155495523	0.031416401	4.949501434	1.15043E-06	0.093710458	0.21728059	0.09371046	0.21728059
City	-0.150577867	0.027497268	-5.476102905	8.22953E-08	-0.204655368	-0.0965004	-0.2046554	-0.0965004
Policy	-5.447714361	1.688622593	-3.226129025	0.001371072	-8.768643976	-2.1267847	-8.768644	-2.1267847
year*policy	0.426522996	0.120992237	3.525209598	0.000478401	0.188573613	0.66447238	0.18857361	0.66447238

Fig 8. Results from the regression analysis between the *policy* and the *birthrate*

Based on Fig 8., the overall model we are using to explain the change in birth rates is not appropriate enough as the R Square is only 0.23 and the adjusted R Square is only 0.22, indicating that roughly only 22% of changes in birth rates could be attributed to this model as a whole. When we looked at the effect of each independent variable separately, we are able to find that among *year*, *city*, *policy* and interaction term *year*policy*, the absolute values for all of their *t Stat* are larger than 2 and *P-values* are smaller than 0.05, indicating that all independent variables in this model have statistically significant impact on birth rates. On average, one unit of increase in year will result in 0.15 unit of increase in birth rates. Due to the reason that we label the city with numbers from 1-19 randomly, it is unlikely and ambiguous that the coefficient for city variable as -0.15 means anything meaningful. To our surprise, the coefficients for independent variable *policy* and interaction term *year*policy* are in different signs even though both variables are statistically significant. For policy as an independent variable, its coefficient as large as -5.45 indicates that once the policy was implemented, the birth rates immediately dropped roughly 5.45 unit. The coefficient for interaction term *year*policy* implies that the birth rates went up 0.43 unit every year when the policy is in effect. To sum up, our regression suggests that the birth rates went down for 5.45 unit immediately once the policy was implemented, but it rebounded 0.43 unit year by year as long as the policy is in effect.

3.3.2 Robustness test

Regression Statistics	
Multiple R	0.592633783
R Square	0.351214801
Adjusted R Square	0.336469683
Standard Error	0.22046196
Observations	361

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	8	9.261511438	1.15768893	23.81905642	3.57473E-29
Residual	352	17.10842344	0.048603476		
Total	360	26.36993488			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.226632615	0.094070373	23.66986056	8.78808E-75	2.041621944	2.411643285	2.041621944	2.411643285
Year	0.014535652	0.00261998	5.548000851	5.68891E-08	0.009382868	0.019688436	0.009382868	0.019688436
firsttier	0.17987274	0.079046623	2.275527193	0.023474838	0.024409673	0.335335806	0.024409673	0.335335806
secondtier	0.067498629	0.070439304	0.958252361	0.338593219	-0.071036197	0.206033456	-0.071036197	0.206033456
thirdtier	0.260765746	0.054824073	4.7564096	2.87957E-06	0.152941804	0.368589687	0.152941804	0.368589687
fourthtier	0.523078648	0.067339187	7.767819503	8.82128E-14	0.390640903	0.655516393	0.390640903	0.655516393
City	-0.027348585	0.005756233	-4.751125584	2.95119E-06	-0.038669519	-0.016027651	-0.038669519	-0.016027651
Policy	-0.363941947	0.137279418	-2.651103519	0.00838548	-0.633932979	-0.093950916	-0.633932979	-0.093950916
year*policy	0.027842526	0.009842293	2.828865744	0.004938943	0.00848543	0.047199622	0.00848543	0.047199622

Fig 9. Robustness test for regression analysis between the *policy* and the *birthrate*

Next, we test the robustness of the results we obtain from Fig 8. by creating a new Fig 9. with five new dummy variables as *firsttier*, *secondtier*, *thirdtier*, *fourthtier* and *fifthtier* on top of the original independent variables in Fig 8. By creating these five dummy variables, we are able to categorize our cities into different tiers based on Ranking of Cities' Business Attractiveness 2019 (https://www.yicai.com/news/100200192.html), and cities of different tiers are significantly different in five dimensions—future prosperity, density of business resource, efficiency of transportation system, variation in people's lifestyle and dynamics of people. With tier of cities, we can not only determine whether the addition of the tier of city as a controlled variable would affect the original result, but also find out whether there is a difference in change of birth rates across tier of cities. Fig 9. shows us that such difference exists. Despite of that the adjusted R Square indicates only 34% of the change in birth rates can be attributed to the model overall, it suggests that model in Fig 9. is more appropriate in explaining the change in birth rates than model in Fig 8. Our results regarding the significant relationship between HPR and birth rates from Fig 8. is proved to be robust under the impact of tier of cities as the absolute value of *t Stat* for both *policy* and *year*policy* are still larger than 2 and the *P-value* for both are still smaller than 0.05. Additional things that we can find from Fig 9. are that all the absolute value of *t Stat* for tier of city as dummy variables are larger than 2 except for *secondtier*, illustrating that being a second-tier city would not affect the local birth rates significantly. According to coefficients for *firsttier*, *thirdtier* and *fourthtier* as 0.18, 0.26 and 0.52 respectively, being a first-tier city would increase birth rates by 18%, being a third-tier city would increase birth rates by 26% unit while being a fourth-tier city would increase birth rates by 52%.

4. CONCLUSIONS

Declining fertility rates is one of the most critical issues faced by Chinese government these days, and yet soaring housing prices expedite such decrease and worsen the condition by making the nation more vulnerable to the threat of an aging society. Liu et al. point out such relationship between housing prices and fertility outcome as the increased cost of housing is one economic factor depressing China's fertility rate [23]. Dettling and Kearney also state in their paper that high house price may significantly contribute to the declining fertility rate because housing cost is recognized as a major cost for raising a child [8]. Therefore, a policy that was designed to target soaring housing prices might also help to raise the birth rates as an unintended consequence if the policy is found to be effective. We conducted this research to directly investigate the relationship between HPR and birth rates to determine whether such correlation is held valid via the link of housing prices. We found that 1) HPR policy immediately increases the housing prices after its implementation, and reduces the housing prices gradually since then 2) High housing prices do not lead to a reduction in birth rates; instead, they result in an increase in birth rates 3) HPR policy significantly reduces the birth rates right after its implementation but raises the birth rates gradually over time. Our analysis suggests that in the short run HPR fails to curb the house price as its main target right after its implementation, and it significantly reduces the birth rates as an unintended consequence; however, in the long run, HPR policy seems to be successful both curbing housing prices and raising birth rates.

Our first conclusion is supported by Zhou's paper that focuses on the interaction between housing market sentiment and intervention effectiveness in China. Zhou argues that tightening policies cannot reduce optimism, and high sentiment negatively impacts the effect of the policies [25]. This could be why HPR policy is not effective against high housing prices initially as the impact of the policy is partially offset by investors' optimism toward housing market.

Our second conclusion also conforms to previous studies by Lovenheim, Mumford, Dettling, and Kearney regarding the positive relationship between housing prices and birth rates [24, 8]. One reason for such correlation is proposed by Simon and Tamura in their paper as they conclude that an increase in the price of housings relative to other goods contributes to offsetting any possible negative effects of housing prices on fertility, and in China, there is a dramatic difference between the rapid rise of housing prices and slow growth of households' non-housing consumption demand [26, 27].

Our third conclusion contradicts to the combination of our first and second conclusion, however. We argue that this could be due to some unknown factors that can affect housing prices and birth rates simultaneously in different directions, thus distorting the relationship chain of policy, housing prices and birth rates.

Two main implications arise from our findings. First, as government designs new policy and regulation, it should take into account of the possible connections between different issues as sometimes the policy itself can be the stone for people to kill two birds. Second, the assumption about the direct relationship between two variables based on their separate correlations with the third variable should not be made during the decision-making. The government should not combine two separate correlations arbitrarily and conveniently to obtain the direct relationship as the actual direct relationship might be different from the combined one.

Certain limitations do exist for our research as we are unable to gather enough data of housing prices for all of our cities when we are dong regression analysis between HPR and housing prices, and between housing prices and birth rates. Therefore, the first and second regression are done using data from only 9 cities while the last regression is done using the data from all 19 cities. Besides, using city-level data allows us to collect more samples for comparisons by classifying them into different tiers, but the standards and qualifications of each tier are changing slightly every year, and thus the cities that belong to these tiers are different year by year. This makes it hard for us to distinguish heterogeneity between cities. Additionally, these differences in characteristics of cities will lead to greater differences in the impacts of the HPR policy on the birth rates in different cities. We highly suggest that researchers in the future replicate our results with data from more cities to draw a more accurate and unbiased result, and study whether there is a differential impact of the policy on birth rates in different cities by using micro-level data.

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