

Ageing, Divorce and Housing Demands

—An Empirical Study from China

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Abstract

This paper examines the role of divorce in the nexus between aging and housing demands. Based on China's provincial panel data from 2005 to 2017, we construct a dynamic panel model from the perspective of family to investigate the impact of aging population on housing demands, and the moderating effect of divorce. The study shows that in the sample period, when the moderating effect of divorce is not taken into account, the aging population has a significant inhibitory effect on housing demands, and divorce rates do not increase housing demands in general, but there are instead, differences in the significance levels of the impact of the number of residential transactions and the area in which they occur. After considering the moderating effect, an aging population has an obvious promoting effect on housing demand, but since the divorce rate has a weakening role, the promoting effect will gradually decline. Based on the data from this research, this paper puts forward some suggestions to housing market.

Keywords

Ageing, Divorce, Housing Demands, Interaction Function

1. Introduction

Housing is an important part of people's life. The real estate market is not only the pillar of national economic development, but is also important to everyday life. A home provides shelter, a basic human need, as well as place of security, belonging and investment. Arguably, it is important for quality of life. Demand for housing in China has been soaring since the urban housing system was reformed in 1998. Housing prices not only exceed many people's ability to pay, but also pose a hidden danger to economic development and social stability. On the

one hand, in order to buy a house, many young people choose not to get married or not to have a child; on the other hand, some people buy a house because they see the huge profits, the real purpose of buying a house is to speculate. What's more, in order to avoid the restriction policy, some people choose "fake divorce" to buy houses for speculation. In order to control the excessively rapid growth of housing prices, the Chinese Government introduced a series of macro-level policies for example, restricting the purchase of houses and adjusting the interest rate of loans, to control housing prices, but with little effect. It is therefore important to understand the reasons behind the continued surge in housing demand and consequently prices.

At present, an analysis from the macro perspective of factors impacting on housing demand includes economic development, land finance, wealth accumulation and construction costs and other economic fundamentals. The analysis of housing demands from the perspective of population structure has always been the starting point of foreign scholars. However, there has been little research that analyzes the impact of demographic structures on the real estate market macro perspective. In particular, there is no consensus on the impact of aging on housing demand. World Bank data show that the old dependency ratio in China will continue to rise in the next 20 years, whilst the young dependency ratio will continue to decline. Chinese housing demands and the old dependency ratio show a highly positive correlation (see [Figure 1](#)). What are the reasons for this? An analysis based only on demographic is not enough. The main body of housing demands comes from the family. Marriage and divorce are therefore important factors. Domestic and foreign research on housing and family mainly focuses on family events such as marriage, divorce, cohabitation and birth of children. Data from China's National Bureau of Statistics show that, up to 2017, the divorce rate has been on the rise for 15 consecutive years, compared with four consecutive years of negative marriage rates. Young people are reluctant to get married, and middle-aged and elderly people are also choosing to leave marriage. In 2017, middle-aged and elderly people aged 45 and above accounted for 49.3 percent of the total numbers of those choosing to divorce. As families dissolve through divorces, it is inevitable that this would mean additional housing needs. [Fan Ziyang and Hu Xianmin \(2015\)](#) explored the panel data of divorce and housing price of prefecture-level cities in China from 2005 to 2012. They found that the increase of housing prices in recent years was positively correlated with the increase of divorce rate. They also found a positive correlation between housing price and divorce rate through simple regression of statistical data (see [Figure 1](#)). Current research has not yet taken divorce into account in studies on the impact of aging on housing demand, but the increasing divorce rate in China must surely be a cause for alarm. Some people even buy houses through "fake divorces". [Tang Yun and Liang Ruobing \(2016\)](#) mainly use Chinese divorce data to examine the impact of the purchase restriction on the marriage market. It is found that the policy has a significant effect on the increase in the number of divorce, but the impact on the crude divorce rate and the number of marriages is not significant,

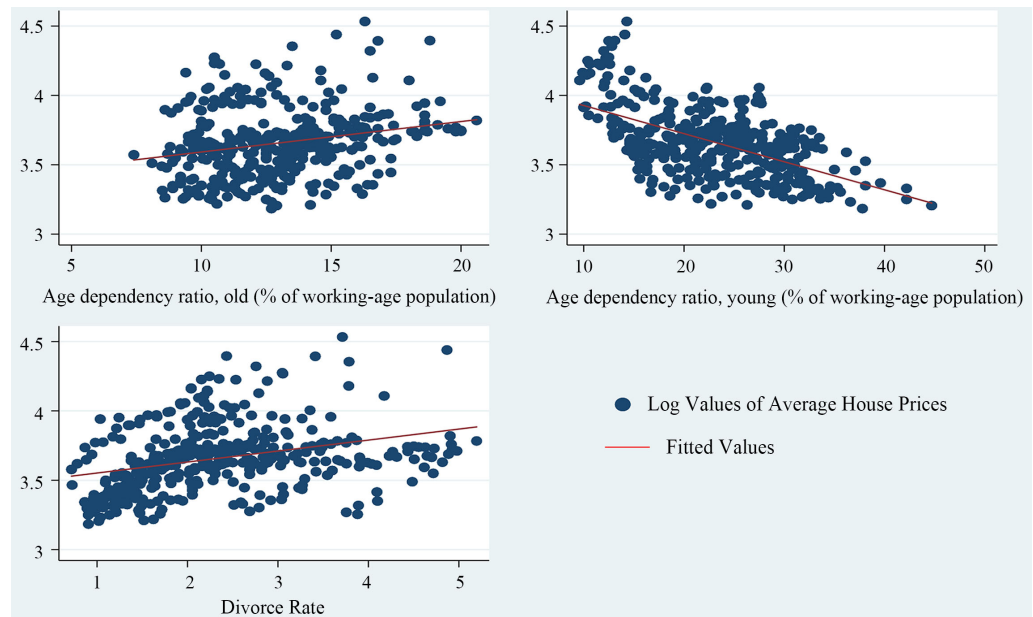


Figure 1. Average house price of 30 provinces in china, demographics changes and divorce rate. Resource: China NBS (National Bureau of Statistics).

and the latter has a significant negative correlation with the housing price. This has had a very negative effect on the stability of both housing market and marriage market. What role does divorce play in the relationship between aging and housing demand? This will be the research focus of this paper.

In the next part of this paper a review of current literature is offered followed by a model and data description. Finally, the results of the analysis and a discussion of these is presented before highlighting the ways this paper has contributed to our understanding in this area.

2. Literature Review

From the perspective of population structure as a model to analyze real estate markets supply and demand, were mostly based on Franco Modigliani work in the 50 s which focused on a Life-Cycle Hypothesis. This perspective holds that rational consumers arrange their consumption according to their lifetime income. When the individual enters old age and no longer has the ability to work, they reduce the consumption level to meet their needs at this point in their life. Based on this theory, [Mankiw and Weil \(1989\)](#) first combined the age structure of populations with housing demands. Their research explained why house prices soared in America in the 1970s, mainly because baby boomers entered the housing market, and as they got older, demand for housing was considered to probably fall. Following the research thinking of [Mankiw and Weil \(1989\)](#), many scholars have considered this issue. Most Western academics believe that aging will reduce the demand for housing, but the main points of dispute are in the following: first, aging where they question the relationship between housing demands, believing that aging cannot significantly inhibit the demand for housing.

Green and Hendershott (1996) expanded the characteristic house price model of Rosen's (1974) by connecting the per capita housing expenditure and demographic structure information, and found that the housing demand did not decline with the increase of age. This is because the education and income level of the elderly are not taken into account in the m-w model., Piet Eichholtz college, Piet Eichholtz and Thies Lindenthal (2014) improved on Green and Hendershott's (1996) work by introducing the Three Steps of Estimation strategy and found that housing demand is mainly determined by the human capital, of family, with housing demand increasing with age. Although this growth will decline after retirement, it will not be a large decline. Second, housing demands are influenced by different levels of economic development and regional differences. In Scotland, Chen et al. (2012) combined the macro-level housing price model with the micro-simulation model and concluded that population aging or more general demographic changes are not the main determinants of real housing price fluctuations. In addition, Takats (2012) used the macro panel data of 22 developed economies from 1970 to 2010 to measure all housing units and all families in the same scale, and found that the increase of the proportion of the elderly in the societies was related to the low housing price growth from the perspective of reduced family size and the improvement of education levels. Recent research by Thenuwara, Siriwardana and Hoang (2019), using data from Australia, found that macroeconomic shocks and house-price specific shocks explained the change in house price more than the change in population age structure, indicating that these factors may exceed the impact of future demographic changes on house price. In general, Western scholars' research on the effect of the population age structure on housing demand is negative in nature. However, due to the influence of economic development and education levels, income shock and regional differences, there may be a positive correlation in the short term.

Along with the thoughts of Mankiw and Weil (1989) and Modigliani's life-cycle consumption theory, domestic scholars have increasingly studied the impact of the population age structure on housing demand. Similar to Western research conclusions, Chinese scholars generally believe that aging will reduce housing demand, and the current positive impact of aging on housing demand is only a short-term effect caused by economic, social, cultural and regional differences. One is the impact of the "baby boom". Li Chao, Ni Pengfei and Wan Haiyuan (2015) believe that the reason for the continuous housing boom in China is the fact that the babies from the "baby boom" in China in the 1980s began to reach the age of marriage and childbearing so creating a housing demand. After 2025, when the demographic dividend disappears, China's current housing demands will no longer see such rapid growth. In addition Chen Yanbin and Chen Xiaoliang (2013) suggest that the level of urbanization China's aging population and family size miniaturization does not mean that aging would inhibit the growth of housing demand in the short to medium term, and any such negative effect would not appear until 2045. A "housing reform bonus" (Xu, Xu, &

He, 2012), shows, by using a fixed effect model, that the increase of the elderly dependency ratio would lead to a decline of housing prices, but this was only a “windfalls of profits” left by the era of planned economy. Once the dividend was released, it eventually leads to the decline of housing prices. Hu Mingzhi, Nong Huifu and Chen Jie (2017) also believe that the current aging inhibitory effect on the housing price is not obvious because the housing reform bonus has not disappeared completely. When the aging degree is intensified, it will inevitably curb the rise of housing prices.

Although analyzing the development trend of the real estate market from the perspective of population structure has always been a common method to evaluate the housing demand, it is clearly not enough to consider only the demographic structure without considering the family structure. After all, the primary function of housing is to provide a home for the family (Mulder & Lauster, 2010). In their research hypothesis, Mankiw and Weil (1989) first proposed that housing demand should be the sum of housing demand of all family members in a family, but did not analyze the family as a whole. The study of Horioka (1988) concluded that the smaller the family size division was, the more significant it was in pushing up the housing price. In addition to the change of people's lives and living style, divorce is an indispensable and important reason for the decrease of family size. F. M. Dieleman and R. J. Schouw (1989) found that divorce is a major factor affecting housing demand in addition to changes in income and family size. Although after divorce, one of the parties will move out of the original residence, which will generate additional housing demand, they found through their analysis of data from the Dutch real estate market, that divorce will have a serious impact on both parties. Therefore, the increase in housing demand caused by divorce may not be obvious in the short term, but will gradually emerge after 6 - 7 years. S. L. Brown and M. R. Wright (2017) did a meta-analysis of academic studies on marriage, cohabitation and divorce of the elderly in recent years and found that the grey divorce rate doubled with the elderly giving up marriage and choosing unmarried partners or to live as single people. The retreat of older people from marriage raises important questions, including the need for housing. Recently, Mikolaj, J. & Kulu, H. (2018) used the data of the British Household Panel Survey (BHPS) and applied the multi-level historical model of competitive risk events to reach a similar conclusion, finding that divorce has a long-term impact on individual housing demand. Studies abroad generally find that divorce has little impact on real estate markets in the short term, but will have a serious impact in the long term. In China, the impact of divorce on the real estate market can be considered as only starting in recent years, and it is basically centered on fake divorce, marital mismatch and other issues. For the correlation studies, Fan Ziyang and Hu Xianmin (2015), based on the marriage economics created by Beck, Landes. & Michae (1977) and using the panel data of Chinese prefecture-level cities from 2005 to 2012, confirmed that the divorce rate and housing price are correlated. For fake divorces studies, the analysis results of Tang Yun and Liang Ruobing (2016) also found that divorce

contributed 10% to the increase of housing price in the cities with purchase restrictions. For marital match studies, Li Bing, Jiang Juanjuan & Zhang Suodi (2018) find that the increased marriage matching competition caused by the long-term imbalance in gender ratio does have a significant non-linear effect on the housing market.

To sum up, we can see that there are close links between aging, divorce rate and housing demands. However, the main limitations of current literature are that first, previous studies on the relationship between aging and housing demand or divorce rate and housing demand all isolated, and the divorce rate was not taken into account as a moderating variable to comprehensively analyze the impact of aging on housing demand. In the future, China's housing demand is likely to follow the situation of "high old-age dependency ratio and high divorce rate". If we do not clarify the role of divorce rate in the relationship between aging and housing demand, it will have serious socio-economic consequences with housing and marriage problems within the aging society of the future. Second, housing demand is rarely analyzed from the perspective of the family; whilst housing demand is easily analyzed from the perspective of population, this can lead to double counting. Therefore, when selecting variables, this paper considered them from the perspective of families, such as the housing demand per household and GDP per household.

This paper focuses on the relationship between aging and housing demand. This is important because if the divorce rate continues to rise, what will the consequences be on the real estate market? Based on the theoretical models developed by Meen (1990) and Zou, Yu, & Wang (2015), this paper constructs the Spatial Dynamic Panel Model of housing demand and adopts the systematic GMM estimation method to compare and analyze the impact of aging on housing demand from the perspectives of considering and not considering divorce rate. Both of these will be explained in the next section. In order to test the robustness of the model, the spatial econometric model is also used to test the robustness of the main model, and the interaction effect diagram of the divorce rate is drawn to judge its regulating effect as a whole.

3. Model and Data Description

3.1. Theory Model

Mankiw and Weil (1989), by estimating the cross-sectional expenditure equation of the 1970 census data, directly linked the actual per capita housing expenditure with age, and modeled the family's demand for housing as an additional function of its members' housing demand.

$$D = \sum_{j=1}^N D_j, \quad (1)$$

D_j represents the housing demand of the j th family member, and N is the sum of the housing demand of all the people in a family. Mankiw and Weil (1989) believed that housing demand should be calculated based on the family, but their

paper mainly studied the change of population growth, namely the birth rate, on housing demand. Therefore, when building the dynamic equilibrium model, the model was still based on the individual housing demand and derived. This paper contends that the main demand for housing in society comes from families. Therefore, when constructing the theoretical model, in order to accurately estimate, we will take the average residential demand of each family as the research object.

Following the research of Meen (1990) and Zou, Yu, & Wang (2015), we then seek to improve the model. First, we construct the housing demand function (Zou, Yu, & Wang, 2015):

$$H_d = f\left(\frac{Y}{POP}, \mu, G, F\right) \quad (2)$$

where H_d = the transaction in the housing market; POP = the total population, μ = the cost of housing; G = the demographic structure. F = other factors would affect housing demands. Based on Equation (2), we refine the model and construct the housing demand function from the perspective of family:

$$H_d = f\left(\frac{Y}{FAM}, \mu, G, F\right) \quad (3)$$

The μ is a function of the housing price. We derive the deterministic model of the price change from the following. It is assumed that the utility function of a single family is composed of housing consumption and non-housing consumption, which are represented by H_t and C_t . Where H_t represents the housing consumption per household, and C_t represents the non-housing consumption per household in Equation (3). ν is the subjective discount rate. Dougherty and Van Order (1982) and Ermisch (1984) also used the similar models. The family utility maximization function can be expressed as (Meen, 1990):

$$\max \int_0^{\infty} e^{-\nu t} \mu(H(t), C(t)) dt \quad (4)$$

$$\text{s.t. } g(t)X(t) + S(t) + C(t) = (1 - \theta)Y(t) + (1 - \theta)iA(t) \quad (5)$$

$$\dot{H}(t) = X(t) - \delta H(t) \quad (6)$$

$$\dot{A}(t) = S(t) - \pi A(t) \quad (7)$$

In this lifetime utility maximization problem, assuming that there is no credit limit, consumers may borrow and lend money at the normal interest rate i and set the price of general commodities as 1, which can obtain the budget constraint condition Equation (4) faced by consumers' intertemporal consumption behavior. In Equation (5), where $g(t)$ = real purchase price of dwellings; $x(t)$ = new purchase of dwellings; $S(t)$ = real savings, net of real new loans; θ = marginal household tax rate; $Y(t)$ = real household income; $A(t)$ = real net non-housing assets. In Equations (6) and (7), δ is the physical depreciation rate on the housing stock, whereas π represents the constant, general rate of inflation. (\cdot) denotes the time derivative of a variable.

In order to solve the optimal control model, we use Equation (4) and the constraints of Equations (5), (6) and (7), to construct the Hamilton function as follows,

$$H_c = V(H(t)C(t)) + \lambda(g(t)X(t) + S(t) + C(t) - (1-\theta)Y(t) - (1-\theta)iA(t)) \quad (8)$$

The equation of marginal rate of substitution of housing and non-housing consumer goods (U_h/U_c) is as follows (Zou, Yu, & Wang, 2015)

$$\frac{U_h}{U_c} = p(t)[(1-\theta)i - \pi + \delta - rpe] \quad (9)$$

where rpe represents the expected yield of real estate. U_h and U_c represent the marginal utility of housing and non-housing consumer goods. When consumers achieve utility maximization, they must meet the following principles:

$$\frac{U_h}{U_c} = \frac{U_c}{1} \quad (10)$$

we make an assumption that the price of a general good is 1, then $\frac{U_h}{U_c} = \mu$,

Substitute Equation (9) into Equation (8), generates the following equation,

$$\mu = p(t)[(1-\theta)i - \pi + \delta - rpe] \quad (11)$$

Sorting out the formulas above, we generate the house price equilibrium model as follows,

$$p = f\left(DF, \frac{Y}{FAM}, \mu, G, i, \delta, \theta, \pi, rpe, F\right) \quad (12)$$

The housing demand function can be expressed as follows,

$$H_d = f\left(\frac{Y}{FAM}, p(t), G, r, \delta, \theta, \pi, rpe, F\right) \quad (13)$$

Under the condition of housing equilibrium, we can find that the Equation (13) of the demand function for average house is affected by age, demographic structure and family scale, housing price, inflation rate, interest rate and expected income and other factors affecting the demand for house.

3.2. Selection and Setting of Econometric Model

As the housing transaction volume in the real estate market will be affected by the housing sales volume in the previous year, we introduced the lagging item of housing demand when measuring the housing demand, combined with the model setting of existing literatures (Ding & Zheng, 2018), and selected the dynamic panel model for estimation. Short dynamic panel generally adopts differential GMM and system GMM for regression analysis. Since the system GMM includes the estimation of the horizontal equation and can estimate the coefficient of the variable that does not change with time, this paper adopts the estimation method of GMM for regression analysis. In order to avoid endogeneity

and ensure the effectiveness of the quantity of tools, the lag term above the second order of explained variables was selected as the instrumental variable for estimation. According to Equation (13) of demand function, this paper constructs the following econometric model:

$$\ln H_{it} = \alpha_0 + \alpha_1 \ln H_{i,t-1} + \alpha_2 Old_{it} + \alpha_3 Control_{it} + \varepsilon_{it} \quad (14)$$

$$\ln H_{it} = \rho_0 + \rho_1 \ln H_{i,t-1} + \rho_2 Young_{it} + \rho_3 Control_{it} + \tau_{it} \quad (15)$$

$$\ln H_{it} = \theta_0 + \theta_1 \ln H_{i,t-1} + \theta_2 Divorce_{it} + \theta_3 Control_{it} + \sigma_{it} \quad (16)$$

where H denotes the logarithmic of housing demands, Old denotes old dependency ratio, $Young$ denotes young dependency ratio, $Divorce$ denotes divorce ratio, ε , τ and σ are the random of every model, i involves 30 provinces in China and t ranges from 2000 to the year 2017. Control variables include average house prices, urbanization levels, unemployment, interest rates, and GDP. These three simple regression models are used to test the effects of old age dependency ratio, young age dependency ratio and divorce rate on housing demands without considering the moderating effect of divorce rate.

When examining the interaction of divorce rates, the following econometric models are constructed:

$$\begin{aligned} \ln H_{it} = & \beta_0 + \beta_1 \ln H_{i,t-1} + \beta_2 Old_{it} + \beta_3 Divorce_{i,t} \\ & + \beta_4 Old_{it} \times Divorce_{it} + \beta_5 Control_{it} + \mu_{it} \end{aligned} \quad (17)$$

$$\begin{aligned} \ln H_{it} = & \lambda_0 + \lambda_1 \ln H_{i,t-1} + \lambda_2 Young_{it} + \lambda_3 Divorce_{i,t} \\ & + \lambda_4 Young_{it} \times Divorce_{it} + \lambda_5 Control_{it} + \delta_{it} \end{aligned} \quad (18)$$

where $Old \times Divorce$ and $Young \times Divorce$ are the interaction terms to examine the moderate effect of the divorce rate in the relationship between aging and housing demands. μ, δ are various random error terms. Other variables have the same meaning as above.

3.3. Variables

3.3.1. Dependent Variables

This paper draws on the research of Ding Yang and Zheng Jianghuai (2018), using *housing transaction sets* and *residential transaction area* to measure housing demand. However, they chose the total amount, not the average amount, and therefore could not be more prepared to analyze the marginal effect of aging on housing demand. According to this theoretical analysis, it is the households rather than the individuals that affect housing demands. Therefore, this paper selects the logarithmic HU (the number of household sales per household) and the logarithm of $Area$ (the average residential transaction area per household) as the independent variable to measure the degree of change in the household housing demand. In terms of data calculation, since the statistics of the households in the China Statistical Yearbook are 1% in the year of the mantissa 5, the statistical caliber is inconsistent with other years. Therefore, when calculating the number of household sales per household, we use the number of commercial housing sales

divided by annual average population, then multiply household size. In the same way, the average transaction area per household is equal to the transaction area of the commercial housing divided by the average annual population multiply the size of the household.

3.3.2. Independent Variables

The Independent variables involved in this paper include old-age ratio (*Old*), young dependency ratio (*Young*), divorce rate (*Divorce*), interactive terms (*Ageing* \times *Divorce*, *Young* \times *Divorce*), divorce rate (*Divorce*), average house price level (*lnhp*), urbanization level (*lnup*), unemployed population (*lnunem*), interest rate (*i*) and GDP per household (*lngdp*).

1) *Old* and *Young*. The data on old dependency ratio and young dependency ratio came from the National Bureau of Statistics of China in 2005-2017. According to international practice, the population aged 0 - 14 and over 65 is the non-labor population, and the population aged 15 - 64 is the labor force. The ratio of the population over 65 years old to the population aged 15 - 64 is calculated. In the same way, the population aged 0 - 14 is divided by the population aged 15 - 64, that is, the dependency ratio of children. This method of calculating the population dependency ratio can more accurately reflect the real situation of the population burden. It is well known that the problem of aging is caused by a decrease in birth rates and an increase in life expectancy. Therefore, using the old dependency ratio and young dependency ratio as proxy variables can more fully reflect the problem of aging.

At the same time, in order to examine the role of divorce rate in the relationship between aging and housing demands, we introduce the interactive term to assess the moderate function of divorce.

2) *Divorce*. The divorce rate in this paper is the annual crude divorce rate in 30 provinces in China. The data comes from the National Bureau of Statistics of China in 2005-2017 and the China Statistical Yearbook. The crude divorce rate = the number of divorces per year \div total population.

3) Control variables: a) *lnhp*, the logarithm of average sales price of residential commercial housing. The most direct indicator reflecting the supply and demand sides is house prices, so we use the logarithm of house prices to reflect the supply and demand relationship in the real estate market. b) The logarithm of the urban population, *lnup*. The level of urbanization is considered by most scholars to be the main factor driving the rise in housing demand. In order to simplify the data, we directly select the logarithm of urbanization rate \times total population to measure the level of urbanization in China. c) The logarithm of the number of unemployed *lnunem*. The level of unemployment can reflect the degree of economic development in the region to a certain extent, which in turn affects the purchasing power of consumers, especially for large-capacity consumption. Therefore, we introduce the logarithm of unemployment rate \times total population to reflect the economic prosperity of the town. d) Interest rate *i*. In most cases, faced with high housing prices, most people will choose loans to ease

the economic burden of high housing prices. Therefore, the adjustment of interest rate levels will largely affect the trading volume of the real estate market. We use the RMB legal loan to calculate the annual benchmark interest rate by weighting the benchmark interest rate of more than five years, and then subtract the annual inflation rate of each province to obtain the interest rate i . e) GDP per household ($Ingdp$). This variable was introduced to examine the extent to which the level of economic development in the region has affected housing demand. This paper is based on the perspective of housing from the perspective of the family, and in order to ensure that the statistical caliber is consistent, the province's per capita GDP \times household size is taken in logarithm. The above control variables are derived from the 2005-2017 National Bureau of Statistics of China.

3.3.3. Data

The data in this paper is from the National Bureau of Statistics 2005-2017, China Statistical Yearbook, China Demographic Yearbook and China Population and Employment Statistics Yearbook. The reason why the 2005-2017 data was selected is that since China implemented the reform of China's urban housing system in 1998, housing was actually introduced to the market, and the welfare housing system was cancelled. The promotion of this policy in the real estate market has been highlighted since 2005. To ensure the stability of the data, the data of this stage is selected. Due to the serious lack of some data in Tibet, this study does not consider it for the time being. Finally, the provincial data of 30 provincial administrative units in Mainland China are selected for empirical analysis. **Table 1** is the statistical description of variables. In **Table 1**, all variables have 390 observations. It means the data is a balanced panel data, so that we can use it to analyze panel regression.

Table 1. Statistical description of variables.

	Variables	Obs.	Mean	Std.Dev.	Min	Max
Dependent Variables	Log of residential transactions units per household ($lnHU$)	390	-1.736	.222	-2.416	-.984
	Log of residential transactions area per household ($lnArea$)	390	.293	.207	-.251	.924
Core Independent Variables	Old Dependence (Old)	390	12.944	2.595	7.4	20.6
	Young Dependence ($Young$)	390	23.356	6.771	9.6	44.7
	Divorce Rate ($Divorce$)	390	2.318	.993	.718	5.197
Control Variables	Log of average house price ($lnhp$)	390	3.657	.242	3.184	4.533
	Log of urbanization population ($lnup$)	390	3.26	.327	2.328	3.892
	Log of unemployment ($lnunem$)	390	1.312	.305	.455	1.783
	Interest rate (i)	390	6.234	.781	4.868	7.579
	Log of GDP per household ($Ingdp$)	390	.698	.022	.627	.743

4. Results

In order to ensure the consistency of the system GMM estimation results and the validity of the instrumental variables, all the models were tested by autocorrelation and Sargan test. It was found that all the models passed the autocorrelation test, and the instrumental variables were valid. To examine the interaction effects of the divorce variable, we first examine the relationship between aging and housing demand without considering divorce factors. Then, we introduce divorce rate as moderate variables to consider the role of divorce in the relationship between aging and housing demand. Finally, we will test the robustness of the main model.

4.1. Without the Role of Divorce Rate Considered

In this section, we first study the marginal effect of aging on housing demand, but do not consider the divorce factor from the family level. The idea was to validate the assumption that the introduction of a divorce variable at the household level is critical to the impact of housing demand. To understand why it is important, you can cite Life Cycle Consumption Theory that Modigliani proposed in 1950s. The theory is that rational economic people will reduce their housing demands as they approach retirement age, because of reduced incomes, they will either reduce (down-size) or sell their homes.

4.1.1. The Regression Results of Population Structure

Table 2 Model (1), Model (2), Model (4) and Model (5) are the regression results of population structure on the number of household transactions and the average transaction area per household, respectively. From the regression results, we found that:

1) The regression results of $\ln HU_{i,t-1}$ and $\ln Area_{i,t-1}$ are significantly positive, indicating whether the number of housing transactions or housing transaction volume is affected by The influence of inertia factors will be affected by the trading volume of the real estate market in the previous year. And the more the volume in the previous year, the more it will promote the market transaction volume in the next year.

2) The regression results of *Old* are significantly negative, which verifies the important hypothesis of life cycle theory, indicating that the number of housing transactions per household and the average transaction area per household will decrease with the aging of the population.

3) The relationship between the young dependency ratio and housing demand is significantly positive, indicating that the increase of family population base can significantly increase the housing demand of families.

Control variables: 4) The coefficient of *lnhp* is significantly negative, which is in line with the assumption of demand theory, the general demand is inversely proportional to the market price. 5) The coefficient of *lnunem* is significantly negative, indicating that the more unemployed people in the working-age population, the heavier the economic burden in the family, and the demand for

housing will also be weakened. 6) The coefficient of i is negative, and the regression results is significant. The regression result confirms our hypothesis that rising interest rates will lead to increased mortgage pressures and weakened housing demand. 7) The regression results of $lngdp$ show that the significant level of GDP per household varies between the number of household transactions per household and the average transaction area per household. The regression results for the average residential transaction area are not significant, indicating that the economic level of households is not statistically significant. As mentioned earlier, this may be due to the reasons for intergenerational support, which is the result of the family's economic synergy.

Table 2. Regression results without considering the moderating effect:

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	$lnHU$	$lnHU$	$lnHU$	$lnArea$	$lnArea$	$lnArea$
$L.lnHU$	.368*** (.037)	.294*** (.040)	.373*** (.049)			
$L2.lnHU$	.148*** (.023)	.159*** (.023)	.146*** (.025)			
Old	-.007*** (.002)			-.004** (.002)		
$lnhp$	-.306*** (.070)	-.135* (.078)	-.266*** (.068)	-.189** (.085)	-.119 (.093)	-.177** (.076)
$lnunem$	-.281*** (.055)	-.224*** (.057)	-.242*** (.068)	-.364*** (.080)	-.432*** (.097)	-.267*** (.063)
i	-.053*** (.003)	-.047*** (.004)	-.050*** (.003)	-.060*** (.003)	-.059*** (.003)	-.059*** (.002)
$lnup$	.625*** (.117)	.460*** (.080)	.531*** (.104)	.604*** (.074)	.570*** (.084)	.506*** (.054)
$lngdp$	1.348 (.874)	1.261 (.789)	1.408 (1.077)	-1.525* (.799)	-1.210 (.805)	-.670 (.963)
$Young$		.008*** (.002)			.006** (.003)	
$Divorce$			-.012 (.009)			-.024*** (.008)
$L.area$				.440*** (.023)	.385*** (.023)	.445*** (.029)
$L2.area$				.217*** (.018)	.219*** (.018)	.219*** (.021)
_cons	-1.868*** (.561)	-2.402*** (.476)	-1.878*** (.721)	.832** (.328)	.374 (.335)	.385 (.478)
Obs.	330	330	330	330	330	330
Sargan Test	.8721	.8625	.8738	.8660	.9219	.8576

Standard errors are in parenthesis *** $p < .01$, ** $p < .05$, * $p < .1$.

4.1.2. The Regression Results of Divorce Rate

At the same time, in order to verify the significant impact of divorce rates on housing demand, we also included the divorce rate as an explanatory variable for regression analysis in this section (see **Table 2**: Model (3) and Model (6)). Affected by Chinese traditional culture and the “altruism” of parents, where parents usually help each other when they buy a house. Coupled with the influence of the “mother-in-law” economy effect, usually when young people get married, they gather two generations of wealth to buy new houses, we therefore have reason to believe that in the short-term, after the marital relationship ends, there will be no economic ability to purchase a second home. This assumption is also consistent with the findings of the study. From the regression results of model (3) and model (6), it can be found that the overall divorce rate has a negative impact on housing demand, but the significance level is different due to the number of sets and area. The regression result of the number of household transactions per household is not significant, but the regression result of the average residential transaction area is significant and negative. This means that the occurrence of divorce will reduce the demand for housing space for households. After a divorce, both husband and wife often continue to live in the marriage home. Due to the pressure of repaying loans, they may choose to sell the wedding home and choose to buy a smaller house or, rent a house (Feijten & van Ham, 2010).

4.2. The Role of Divorce

Next we examine the role of the divorce rate as a moderator in the relationship between aging and housing demand. The introduction of the divorce rate can reflect the stability of the current marriage market and can also indirectly reflect the size of households. This is currently the most important factor affecting family composition and disintegration. As the results of F.M. Dieleman and R.J. Schouw (1989) show, divorce will generate additional housing demand, but it also means that the size of households is smaller along with more households being generated. The number of households in a region can roughly reflect the housing demand in the region. Based on this, we assume that after the divorce rate variable is added, there is a positive correlation between housing demand and aging.

According to 2016 National Statistical Yearbook, the number of divorces over the age of 45 accounted for 47.7 percent. Moreover, the head of the household in this age group accounted for 64.8%. Based on the previous analysis, in an aging society, the elderly are more and more inclined to live alone, and the “baby boomer” generation of elderly people, just caught up with the welfare housing system, has the possibility to accumulate wealth. Daniël J. Herbers, Clara H. Mulder & Juan A. Mòdenes (2014) concluded that disruption in the partnership career is highly correlated with the likelihood of moving out of home ownership at the older age. That may increase housing demands.

If divorcing when young, divorce will have a serious impact on the economic

level of individuals, especially as relates to housing. For example, Feijten and van Ham (2007, 2010) found in their research that divorce resulted in the division of matrimonial property, which reduces the income, savings and real estate of the individual. At the same time, moving due to divorce is usually very urgent. Therefore, the party moving out of the marital home may choose to live with their parents or other relatives and friends because of their financial inability to make other choices as well as the imperative to seek alternative accommodation. (Dieleman & Schouw, 1989)—this may also increase the demand for housing.

A regression analysis is carried out next to see if the results of the model are consistent with our assumptions. First, this paper looks at the relationship between aging and the number of household transactions per household after the divorce rate adjustment variable (Table 3 Model (1), Model (2)). The regression results are as follows: 1) After the divorce rate adjustment variable is added, the marginal influence of the old-age dependency ratio on the average number of household transactions is affected by the divorce rate. The regression coefficient of the old-age dependency ratio is the opposite of that of the old one. The coefficient of old is significantly positive. This verifies that our assumptions are correct. When the influence of the old-age dependency on the number of households in the household transaction is added to the influence of the family, that is, the divorce factor, it will promote the transaction volume of the real estate market. This may be due to the intensification of the phenomenon of living alone in China. According to China's previous census data, the proportion of elderly living alone has increased year by year, reaching 41.7% in 2010. It shows that the way of living of Chinese elderly people is changing. However, we also see that the coefficient of the interaction term $Old \times Divorce$ is significantly negative, indicating that as the divorce rate increases, the positive impact of the old-age dependency ratio on the number of housing transactions weakens. When the divorce rate increases by a large margin, the promotion of the old-age dependency ratio will be offset, ultimately inhibiting the growth of a housing demand. 2) After adding the divorce rate adjustment variable, the child's dependency ratio is the same as the regression coefficient of *Young* and the unadded regression coefficient, but it is not statistically significant. The coefficient of the interaction term $Young \times Divorce$ is significantly positive. This means that after the factor of divorce rate is added, the relationship between the child dependency ratio and the number of household transactions is not statistically significant, but the divorce event has indeed promoted the relationship between the two. After the divorce, it is possible to remarry and create a new housing demand.

Finally, we look at how the relationship between aging and the average housing transaction area changes after considering the divorce factor (Table 3 Model (3), Model (4)). The estimated results are as follows: 1) The coefficient of *Old* is significantly positive, indicating that the relationship between the old-age dependency ratio and the average household transaction area is negatively positive

Table 3. Regression results considering the moderating effect.

	(1)	(2)	(3)	(4)
Variables	<i>lnHU</i>	<i>lnHU</i>	<i>lnArea</i>	<i>lnArea</i>
<i>L.lnHU</i>	.379*** (.055)	.292*** (.044)		
<i>L2.lnHU</i>	.096*** (.034)	.152*** (.026)		
<i>Old</i>	.022*** (.006)		.032*** (.007)	
<i>Divorce</i>	.144*** (.030)	-.053*** (.018)	.154*** (.032)	-.076*** (.012)
<i>Old × Divorce</i>	-.010*** (.002)		-.013*** (.002)	
<i>lnhp</i>	-.248** (.122)	-.136* (.074)	-.103 (.100)	-.172* (.103)
<i>lnunem</i>	-.264 (.170)	-.174** (.078)	-.218** (.086)	-.283*** (.101)
<i>i</i>	-.055*** (.004)	-.046*** (.004)	-.064*** (.003)	-.061*** (.005)
<i>lnup</i>	.593*** (.185)	.424*** (.114)	.430*** (.092)	.469*** (.114)
<i>lngdp</i>	1.227 (1.410)	1.170 (1.010)	-1.006 (.884)	.573 (1.105)
<i>Young</i>		.001 (.003)		-.001 (.004)
<i>Young × Divorce</i>		.002** (.001)		.003*** (.001)
<i>L.lnarea</i>			.452*** (.028)	.384*** (.037)
<i>L2.lnarea</i>			.161*** (.035)	.208*** (.023)
_cons	-2.372*** (.818)	-2.138*** (.616)	.133 (.403)	-.333 (.674)
Obs.	330	330	330	330
<i>Sargan Test</i>	.9837	.8605	.9130	.9944

Standard errors are in parenthesis *** $p < .01$, ** $p < .05$, * $p < .1$.

due to the divorce factor. However, since the coefficient of the interaction term **Old** × **Divorce** is significantly negative, this promotion will decrease as the divorce rate increases, and eventually return to negative again. The possible explanation is that as the aging and divorce rates increase, the internal members of the family may include three or even four generations in the short term, and the demand for housing area will increase. However, in the long run, with the death and remarriage of the elderly, it will return to family miniaturization, thus reducing the demand for housing area. 2) The coefficient of **Young** is negative from positive, but not statistically significant. The regression result of the interaction term **Young** × **Divorce** is significantly positive, indicating that divorce will promote families with children to increase housing demand. The regression results show that families with child-rearing burdens may choose to live in small-scale houses due to limited economic capacity in the short-term after divorce, but as the economic capacity improves, there will still be improved demand for increased housing area.

4.3. Robust Test of Divorce

4.3.1. Robust Test by Spatial Econometric Model

According to the research design of Holly et al. (2010, 2011) and Li Chao, Ni Pengfei, Wan Haiyuan (2015), in order to ensure the research results are stable, this paper introduces spatial factors to examine the impact of various explanatory variables on housing demand. In order to investigate the time and space effects of the change in the number of divorcees in the aging society on housing demand, this paper constructed a spatial dynamic panel model with both space and time effects.

$$\ln H_{it} = \rho \sum_{j=1}^n w_{ij} \ln H_{it} + \beta_0 + \beta_1 \ln H_{i,t-1} + \beta_2 Old_{it} + \beta_3 Divorce_{i,t} + \beta_4 Old_{it} \times Divorce_{it} + \beta_5 Control_{it} + \mu_{it} \quad (19)$$

$$\ln H_{it} = \eta \sum_{j=1}^n w_{ij} \ln H_{it} + \beta_0 + \beta_1 \ln H_{i,t-1} + \beta_2 Young_{it} + \beta_3 Divorce_{i,t} + \beta_4 Young_{it} \times Divorce_{it} + \beta_5 Control_{it} + \mu_{it} \quad (20)$$

Equations (18) and (19) imply important information about the spatial distance, and w_{ij} is the (i, j) element of the spatial weight matrix (used to measure the distance between provinces). The settings of other variables are the same as those of Equation (14).

Generally, before performing spatial measurement modeling, we first examine whether there is spatial dependence on the data. Whether the data has autocorrelation is the key to deciding whether to use the spatial measurement method. Methods for examining spatial autocorrelation include Moran's I, Geary's C, and Index G of Getis-Ord (Cheng, 2010). This paper uses the most popular Moran's I test to measure spatial autocorrelation. The formula is as follows:

$$\text{Moran's I} = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{S^2 \sum_{i=1}^n \sum_{j=1}^n w_{ij}} \quad (21)$$

where w_{ij} is the (i, j) element of the spatial weight matrix (used to measure the distance between provinces). $\sum_{i=1}^n \sum_{j=1}^n w_{ij}$ is the sum of all spatial weights. Moran's I is divided into Global Moran's I and Local Moran's I. Moran's I in Equation (21) refers to Global Moran's I, which is used to investigate the spatial agglomeration of the entire spatial sequence. The value of Moran's I is generally between -1 and 1 , and greater than 0 means positive autocorrelation, that is, the high value is adjacent to the high value, the low value is adjacent to the low value, and less than 0 is the negative autocorrelation, that is, high. The value is adjacent to the low value. For rigorous testing, the progressive distribution of the Moran index I must be derived. Consider the null hypothesis

$H_0 : Cov(x_i, x_j) = 0, \forall i \neq j$ (means no spatial autocorrelation). Under this null hypothesis, it can be proved that the expected value and the variance expression of Moran's I are as follows,

$$E(\text{Moran's I}) = \frac{-1}{n-1} \quad (22)$$

$$Var(\text{Moran's I}) = \frac{\text{Moran's I} - E(\text{Moran's I})}{\sqrt{\text{Moran's I}}} \quad (23)$$

The standardized Moran's I obeys the progressive standard normal distribution.

It is calculated that the Moran's I of the four models in **Table 4** are significantly positive. It shows that there is spatial autocorrelation between the number of household transactions in each province and the average transaction area per household. So we can use the spatial dynamic panel model to make the regression. The regression results are shown in **Table 4**.

It can be seen from the regression results that the spatial spillover coefficients ρ and η of the average number of household transactions and the average transaction area per household are both significantly positive. It shows that the residential transactions in the provinces show a certain positive linkage trend, and the changes in housing demand caused by the demographic structure will be transmitted between the provinces. In model (1) and model (3) in **Table 4**, the regression result of the core explanatory variable *old* is significantly positive, which is the same as the sign of the system GMM regression result in **Table 3**, indicating that the increase of the dependency ratio of the elderly will lead to the increase of the number of residential transaction sets and the residential transaction area. And the coefficient of the interaction item *Old* \times *Divorce* is significantly negative, indicating that after the addition of the space factor, the increase of the divorce rate will weaken the housing demand caused by the increase of the old-age dependency ratio, and eventually the old-age dependency ratio will still reduce the housing demand. The regression results of the child dependency ratio are not significant, similar to the regression results in **Table 3**, indicating that the promotion of the child dependency ratio indicates that cross-regional divorce may occur in the case of considering spatial factors, and such divorce may

Table 4. Regression results of spatial econometric model.

	(1)	(2)	(3)	(4)
Variables	<i>lnHU</i>	<i>lnHU</i>	<i>lnArea</i>	<i>lnArea</i>
<i>L.lnHU</i>	1.418*** (11.25)	1.543*** (13.44)	1.697*** (16.42)	1.044*** (6.77)
<i>w_lnHU</i>	.00001*** (7.33)	.00002*** (9.37)		
<i>w_lnArea</i>			.00002*** (10.30)	.00001*** (7.49)
<i>Old</i>	.025*** (2.72)		.021*** (2.31)	
<i>Divorce</i>	.221*** (4.49)	.039*** (.050)	.171*** (3.43)	.062 (1.61)
<i>Old × Divorce</i>	-.009*** (-2.58)		-.007** (-2.01)	
<i>lnhp</i>	-.037 (-.31)	-.174 (-1.48)	-.223* (-1.93)	-.101 (-.95)
<i>lnup</i>	-.409** (-2.01)	-.257 (-.50)	.345 (1.11)	-.099 (-.89)
<i>lnunem</i>	-.089 (-.74)	-.063 (-.53)	-.061 (-.51)	.005 (.04)
<i>i</i>	-.040*** (-5.93)	-.029*** (-4.35)	-.029*** (-4.30)	-.030*** (-4.12)
<i>lngdp</i>	9.972*** (7.37)	10.677*** (6.28)	12.078*** (6.33)	5.43*** (4.80)
<i>Young</i>		-.0026 (-.50)		.001 (.28)
<i>Young × Divorce</i>		.002 (1.06)		-.001 (-.71)
_cons	.416*** (6.78)	-.023*** (-3.01)	-.376*** (-5.37)	1.105*** (4.37)
Obs.	390	390	390	390
<i>Moran's I</i>	.8768	.8805	.8783	.8623

Standard errors are in parenthesis *** $p < .01$, ** $p < .05$, * $p < .1$.

It is the increase in housing demand caused by the phenomenon of “fake divorce” caused by the purchase restriction policy. The coefficient of the interactive term $Divorce \times Ageing$ is significantly positive. The regression results of the control variables were not significant except for the number of unemployed people.

By using the spatial dynamic panel model to test the robustness, we find that the regression result of the core independent variable $Old \times Divorce$ is similar to that of the previous system GMM, indicating that the regression result is robust. The effect of the old-age dependency ratio on housing demand, as the divorce rate increases, there is also a spillover effect between regions. However, the regression result of $Young \times Divorce$ is not significant, indicating that the most important target group in the real estate market is still the elderly.

4.3.2. Further Test for Robustness

To further examine the role of divorce rates in the relationship between aging and housing demand, interaction effects were mapped (Appendix: **Figures A1-A3**). This implementation represents a marginal effect, and the shaded portion represents a 95% confidence interval. As can be seen from the left side of **Figure 1** and **Figure A2**, the marginal effect of the old-age dependency ratio on housing demand varies with different values of *Divorce*. On the left side of **Figure 1**, when the value of *Divorce* is small (about less than 2‰), the marginal effect of *Old* on *lnHU* includes zero in the 95% confidence interval, indicating that the marginal effect of *Old* on *lnHU* is not significant (or no effect); but when the value of *Divorce* is large (greater than 2‰), the marginal effect of *Old* on *lnHU* does not include zero in the 95% confidence interval, indicating that the marginal effect of *Old* on *lnHU* is significant and positive. Similarly, in **Figure A2**, the critical value is also around 2‰. According to the National Bureau of Statistics, the divorce rate in China has exceeded 2‰ since 2010. According to our research results, we can infer that since 2010, due to the impact of divorce rate, the impact of China’s aging on housing demand is gradually becoming more obvious. This is also consistent with our previous regression results. From the interaction diagrams in **Figure A1** and **Figure A3**, it can also be seen that the marginal effect of the young dependency ratio on housing needs will also vary with the divorce rate. When the divorce rate is more than 3‰, the marginal effect of *Young* on *lnHU* and *lnArea* is significant and positive. Although the above regression results are positive, but not significant, it may be because the data of *Divorce* in our database is less than 3‰. Overall, we can see that the divorce rate plays an important role in regulating the relationship between aging and housing demand.

5. Conclusion

This paper explored the role of divorce rate in the relationship between aging and housing demand by constructing a dynamic panel model of housing demand and using the system GMM approach. The results show that 1) the di-

divorce rate has a reversal effect between the old-age dependency ratio and the housing demand relationship. Before considering the divorce rate, the old-age dependency ratio will curb housing demand, and after joining the divorce rate, the old-age dependency ratio will promote housing demand, which can explain why the current aging society has entered the aging society. However, we find that this positive promotion will diminish as the divorce rate increases. 2) The impact of the divorce rate between the child dependency ratio and housing needs is not obvious. The positive effect of young dependency ratio on housing demand is not obvious after joining the divorce rate. However, the interaction between divorce rates is indeed significant, indicating that this effect will gradually appear as the divorce rate increases. In general, aging will eventually curb housing demand, which has not yet appeared. It may be caused by the diminishing size of the family and the change in the lifestyle of the elderly. When the divorce rate tends to be stable, the family size miniaturization is completed, and the negative impact of aging on housing demand will gradually become prominent.

Based on these results, we found that divorce does play an important role in the relationship between aging and housing demand. When the divorce rate is higher than 2‰, the marginal impact of aging on housing demand is significant and positive. We must pay close attention to Marital Market, so as to timely adjust the real estate market policy.

In view of this, we suggest that first, under a situation where the aging population is gradually increasing, if the impact of divorce is one of the reasons for the current high demand for housing, it is necessary to reflect and adjust the current thinking and practices of the real estate market. According to the National Bureau of Statistics, China's divorce rate in 2017 has reached 3.15‰, which has reached the critical value of the divergence rate. If the middle-aged and older generation chooses to divorce in order to avoid the purchase restriction policy, it will certainly contribute to the surge in housing prices. Therefore, the future reform of China's housing system should be considered in conjunction with the marriage system to avoid the impact of "fake divorce" caused by speculation and other factors on the real estate market, and truly return the real estate market to "the house that is used to live in, not to use to speculate on", that is the basic positioning of the housing market.

Second, the positive impact of aging on housing demand is short-term, and so we must pay attention to the structural changes in the real estate market brought about by the aging population structure in the future. Although, from the current point of view, aging will promote housing demand, as the divorce rate increases, this positive effect will gradually be weakened. Since China's first Marriage Law in 1950 stipulated that individuals can freely divorce, the divorce rate has continued to rise with the liberation of social culture and thinking in this area. As the wealth of the elderly who enjoyed the "house reform dividend" is exhausted, the stimulating effect of aging on housing demand will be weakened

and return to normal. From the perspective of just-needed, the real estate market should pay more attention to the housing supply structure, such as housing within smaller areas, health care and community service functions and energy-saving emission reduction functions, which will better meet the needs of the elderly living alone in the future.

Thirdly, stabilize the marriage market and encourage birth. From the research results presented here, we find that the impact of divorce on the relationship between aging and housing demand is still very serious. Therefore, we must pay much attention on marriage market. Continued rising divorce rate in China not only affects the relationship between aging and housing demand, but also affects social harmony and stability. More and more people are reluctant to get married, which means that the entire society will have fewer and fewer births. The problem of aging and housing demand will become more and more serious. So we must spread the concept of positive marriage, actively promote the second child policy, and promote the stability of the marriage market.

In recent years, with the aging and the falling population of children in China, academic research on the relationship between housing demand and population structure is gradually strengthened. This paper only uses the macro data to analyze the relationship between the divorce rate and the aging population and the housing demand, without involving the micro level problems. The housing demand problem should focus more on the needs of micro-individuals, which will be the next focus of this study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

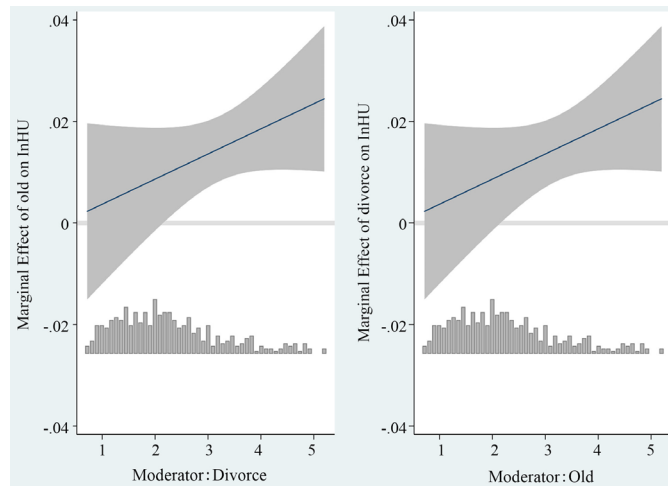
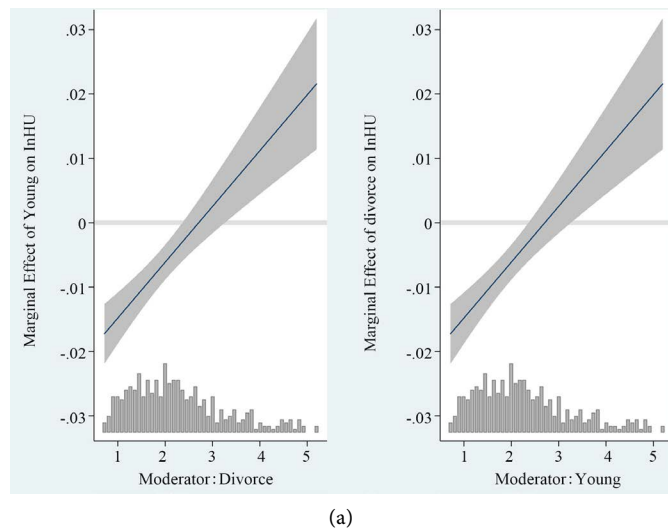
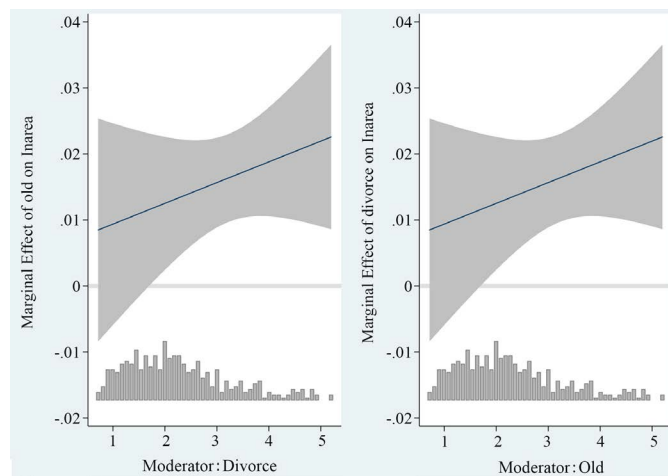


Figure A1. Divorce interaction function between old dependency and $\ln HU$.



(a)



(b)

Figure A2. (a) Divorce interaction function between young dependency and $\ln HU$; (b) Divorce interaction function between old dependency and $\ln Area$.

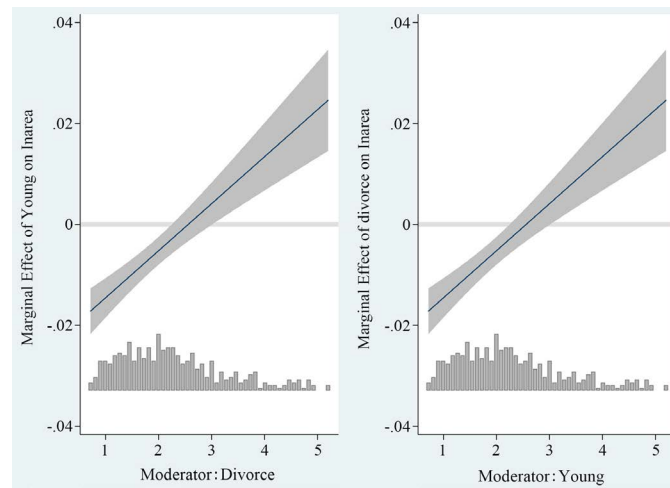


Figure A3. Divorce interaction function between young dependency and *InArea*.