International Journal of Business and Management; Vol. 12, No. 11; 2017
ISSN 1833-3850 E-ISSN 1833-8119
Published by Canadian Center of Science and Education

Household Debt and Housing Price: An Empirical Study across 36 Countries

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Received: September 7, 2017 Accepted: October 2, 2017 Online Published: October 18, 2017

doi:10.5539/ijbm.v12n11p227 URL: https://doi.org/10.5539/ijbm.v12n11p227

Abstract

This paper investigates the effect of the change of household debt ratio (household debt to GDP) on national housing price by using unbalanced panel data in 36 countries during 1981-2015. We employ Two Stage Least Square and GMM method to analyze the fixed effect model, after controlling the demand, supply, other assets prices and endogeneity. Our findings are that household debt ratio and housing price are positively significantly related. Household debt ratio promotes the growth rate of housing prices. The findings remain robust by separating countries into two groups, European countries and non-European countries, and using nominal housing price as explanatory variable.

Keywords: housing price, household debt, household debt ratio, 2SLS, GMM, fixed effect

1. Introduction

Recently, China's household debt ratio (household debt to GDP) has reached an alarming stage after surging for years. According to the data released by the Bank for International Settlements, China's household sector (including non-profit organizations) debt to GDP ratio is about 44.4% in the end of 2016. However, in the end of 2005, China's household sector (including non-profit organizations) debt to GDP ratio was only 11.5%. It shows that Chinese household debt ratio increased by 3 times in ten years. Meanwhile, American household sector began the process of deleveraging, its ratio of household debt to GDP gradually declined to 80% in 2015 from 100% in 2008. In the past decade, Japanese household debt to GDP ratio basically remained at 60% (See Figure 1). Compared with the United States and Japan, it seems that there is still room for Chinese household sector adding leverage. However, taking into account China's immature financial system, income level and economic structure, the rapid accumulation of household debt and financial risk of its economic effects should be considered seriously.

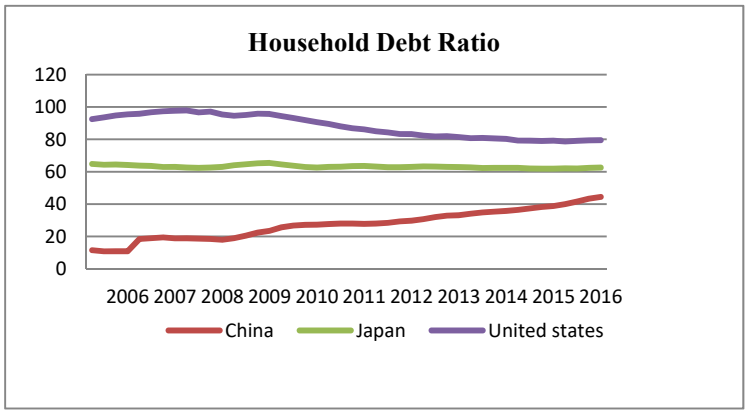

Figure 1. Household Debt to GDP ratio

Will rapid accumulation of household debt in China turn into the next round of housing price bubble? During the sharp rise in household debt in China, Chinese housing prices are also rising. According to data published by the Bank for International Settlements, the nominal housing price index in China was 77.9 in 2005 and 120.7 in 2016, increasing by 59.96 percent. At the same time, the US housing price index was facing great volatility in the deleveraging process, dropping from the peak 142.5 in 2016 to 96.9 in 2011, and then rising to 136.1 in the end of 2016. According to Figure 2, the housing price index and household debt ratio in Japan are stable, basically around 100 from 2008 to 2016.

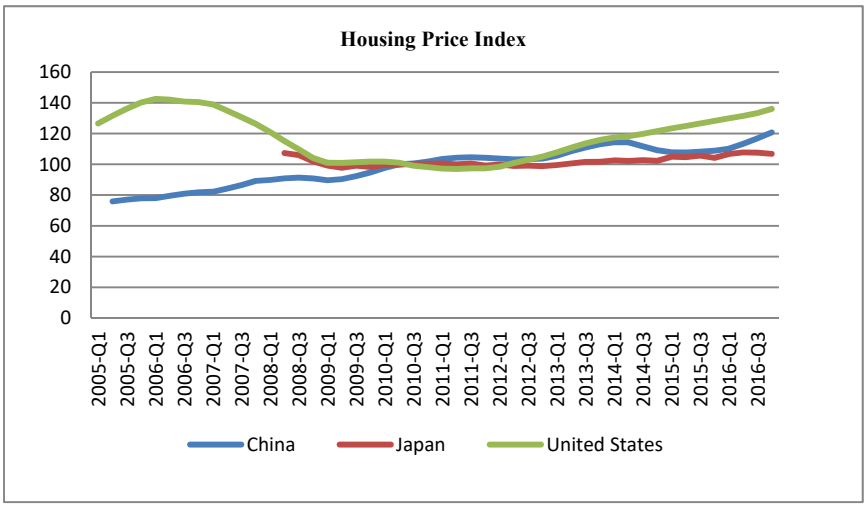

Figure 2. Housing Price Index

Generally, household debt consists of residential mortgage loans, which account for most, and consumer credit. Housing price and household debt ratio are closely related, but there is a paucity of paper researching on the impact of household debt on real estate price. The main purpose of this study is to find out the impact of household debt to GDP ratio on housing price.

Different from the existing literatures, the main contribution of this paper has the following aspects. First, the past research literatures on housing price pay more attention to how credit, currency supply, interest rates affect housing price, which neglects the effect of household debt's effect on housing price. This paper will bridge the gap. The vast majority of household debt is mortgage loans and change in household debt will inevitably have an impact on demand for housing. Household debt reveals information about credit constraints faced by families in some extent, therefore, the study on household debt and housing price is necessary and reasonable.

Secondly, unbalanced panel data among 36 countries around the world from 1981 to 2015 are employed to investigate how household debt cause an movement on housing price, after controlling the impact of demand, supply and other asset prices. Oikarinen (2009), Vlassopoulos (2009) and Kim et al. (2017) have respectively studied household debt in Finland, Greece and South Korea and only conducted time series analysis in a single country. This paper will include more control variables and cross-country panel data to reduce omitted variable bias.

Finally, the paper adopts instrumental variables and use two-stage least squares and GMM method. Gerlach and Peng (2005) study the relationship between housing price in Hong Kong and bank loans. Kim (2014) investigates the possible causes of Korea's household debt in recent years, which suggested GDP, interest rates, stock price and housing price are important reasons for the increasing in household debt. It shows that household debt and house price are likely interrelated. Endogeneity would result in a biased estimation by using OLS. This paper will treat lagged value of endogenous variables as instrumental variables and employ 2SLS and GMM for more reliable results.

The remainder of the article is structured as follows. Section 2 is literature review; Section 3 presents the data source and data description; Section 4 is the econometric model and variables; Section 5 is the empirical results; Section 6 is robustness tests; Section 7 is the conclusion.

2. Literature Review

Among the literatures on determinant of housing price, most of them are based on "Demand - Supply" analytical framework. On the demand side, literature focuses on impact of income, monetary policy, interest rates and other factors on housing prices. On the supply side, the literature mainly focuses on the impact of housing stock, land supply and land controls on housing price.

2.1 Demand Side

Many researchers believe that income level is the main factor affecting housing price. Reichert (1990) studies the influence of local and national economic factors and found that people's income trends, demographic change and employment status are major factors affecting housing prices. Lamont and Steinit (1997) analyzes the relationship between income and housing price using city-level data. They find that if the owners are facing higher leverage, the housing price will be more sensitive to income per capita. Ortalo-Magne and Rady (2006) proposes a model of the life cycle of the housing market with credit constraints and property ladder. The model identifies the main force of housing price is the affordable young families. The model also points out that credit constraints lead owners to generate capital gains or losses, and then the income changes will lead to the overreaction of the housing price, which is more significant when the housing price is going up. Claussen (2013) establishes the error correction model (ECM) to reveal that the increase in disposable income and decrease in mortgage rate are the main reasons for the upward housing price level in Sweden since mid-1990s.

Many studies on monetary policy believe that money supply will affect housing price. Lastrapes (2002) estimates the dynamic response of housing prices from the money supply shocks, and creates a dynamic equilibrium model to explain these reactions basing on the housing needs in the real estate market. It also uses monthly data to empirically study the actual monetary impact on the real estate market and finds that housing price and housing sales (new construction and existing homes) will rise in the short term in response to the money supply shocks. Goodhart and Boris (2008) establish a fixed effect panel vector autoregression model to study the relationship between monetary, credit, housing price and other economic variables in 17 industrialized countries during 1970 -2006. They find multiple interrelationship between housing price, monetary variables and macroeconomic activity. Especially when housing price is on the upward trend, housing price reacts significantly to monetary and credit shocks. Iacoviello and Neri (2010) study the origin and consequences of the housing market fluctuations by using a dynamic stochastic general equilibrium (DSGE) model. They find that monetary factors explain 20% of real estate investment and housing price fluctuations.

Most literatures studying interest rates' effect on housing price suggest that housing price are negatively influenced by high interest rates or mortgage rate. McGibany and Nourzad (2004) study the impact of mortgage rates on housing prices, they analyze the relationship of housing price and mortgage rate in short-term and long-term. The empirical results show that mortgage rate would have a long-term negative impact on housing price. In the results of granger causality test, impulse response function and variance decomposition, they show that mortgage rates have nearly no short-term impact on housing price. David (2013) proposes a theoretical model to predict the future housing price and the model suggest that price should be a function of the expected future interest rate, housing depreciation rate and rental rate. Based on intertemporal arbitrage's view, if the yield of bonds equal to the return of real estate, he believes that US housing price is a function of future corporate bond yield, and the changes in bond yields will lead to the changes of housing price in the future.

In addition, there are numerous other studies on the factors influencing housing price, including population, international demand, exchange rate and other related asset prices. Mankiw and Weil (1989) and Choi and Jung (2016) study the effects of population structure on the housing market. Aizenman and Jinjarak (2009), Favilukis et al. (2012) and Ferrero (2015) study the relationship between current account deficit, international capital flow and housing price. Benson et al. (1999) study the effects of exchange rate movements on the housing price. Ling and Naranjo (1999), Chan et al. (2011) and Lin and Lin (2011) study the relationship between the stock market, commodity markets and housing markets.

2.2 Supply Side

On the supply side, the literatures mainly focus on the impact of housing stock, land supply and land controls on housing price. Peng and Wheaton (1994) analyzes the impact of housing land supply on housing price and output. They treat Hong Kong as an example. Due to strictly land supply control by the government, it is beneficial to study whether the rise in housing price is because of the insufficiency of land supply (due to a residential land scarcity), or the increasing in investment demand (due to the expected scarcity of land and high rents). The results show that land control of the Hong Kong makes higher housing price. Higher expected rental return causes the higher housing price and encourages more capital to flow into land which decreases real estate

development. Liu Minquan and Sun Bo (2009) consider housing price in China have been rapidly rising since 2003 and local governments' "auction" revenue is the main reason. If the central government wants to curb housing bubble, it has to cut off the incentive rewards from high land price and housing price. Vries and Boelhouwer (2005) study the relationship between housing supply and housing price changes in the Netherlands. They study the impact of new housing supply on the Dutch housing price by comparing areas with a large number of construction of new residential and areas without large-scale residential projects. And they find that the more housing supply will lead to falling price, which means the relationship between housing supply and the price is negative related. Grimes and Aitken (2010) analyze the dynamic relationship between housing supply, the cost of land and housing price. The article finds that higher housing supply elasticity helps to curb rising price after demand shocks in short term. With the rise in land price, land supply will decrease and it increases the housing price. This indicates that the regional housing price is a function of regional housing supply and elasticity of land supply. Paciorek (2013) studies the close relationship between housing supply control and housing price volatility. The paper establishes a dynamic model of real estate investment structure to study the mechanisms of this relationship and finds that housing supply control increases housing price fluctuations through two channels. First, the presence of control delays the construction permits, and therefore reduces elasticity of new housing supply. Second, the area available for the construction of housing, such as steep slopes and water bodies, will have a lower rate of return than the existing housing stock and this weakens the capacity of supply to meet demand shocks.

2.3 Household Debt

The dynamic change of household debt could also cause a great impact to the housing price, even the financial system or the whole economy. However, little research has been done regarding household debt on the housing price, although Oikarinen (2009), Vlassopoulos (2009) and Kim et al. (2017) have studied the effects of the household debt on the housing price in Finland, Greece and South Korea respectively. Most literatures concern the impact of household debt on consumption, output and investment.

Campbell and Hercowitz (2004) study the impacts of relaxing restriction of household lending on macroeconomic fluctuations in the United States. They believe that relaxing household lending restrictions could help to explain the drop in the volatility of outputs and other economic variables. Debelle (2004) suggests that most of household debt growth can be regarded as a rational response to ease liquidity constraint. Sustainability of increasing debt has important macroeconomic implications. The rise in debt would cause households more sensitive to income level and interest rate fluctuation, and thus household consumption would be more sensitive to change of expected future income. Ogawa and Wan (2005) study the influence of household debt to whole economy after the burst of Japan's economic bubble. They found that household debt related to lands and housing would negatively affect consumption, and it implies household debt hinders household consumption. Yun (2011) studies the effects of US household debt on the overall economy though using simultaneous equations model. The paper finds a two-way feedback process between income and household debt. There is a long-term negative correlation between household debt and output. When the model includes investment and corporate debt as variables, the results no longer show a negative correlation between household debt and GDP. It indicates that the investment may be important channel for household debt to affect GDP. Mian et al. (2011) and Mian and Sufi (2012) explain the impact of household debt accumulation on employment and consumer when the finance system is in turbulent times based on US data. They find that the deterioration of household balance sheets play an important role in the sharp decline in employment in the United States during 2007-2009. The industry-specific supply shocks, uncertainty caused by policy changes or the credit crunch are not the main causes.

Household debt is likely to reveal the credit constraint information faced by families. Under the absence of sufficient credit constraints data, adding household debt variable into the empirical model for studying housing prices is reasonable and necessary, and the research focusing the effect of household debt on the property price is still relatively limited. The main purpose of the study is to find out the impact of household debt ratio to real estate price.

3. Data Sources and Statistical Description

According to the past literatures, we select the control variables include three parts: demand, supply and price of the relevant assets. They include growth rate of GDP per capita, growth rate of M2, growth rate of gross capital formation, growth rate of the producer price index, growth rate of consumer price index, growth rate of stock price index, rate of change of real effective exchange rate, first-order difference of interest rate of government securities and first-order difference of lending rates and so on.

This paper uses quarterly unbalanced dataset with total 1957 observations from 36 countries during 1981-2015 for regression analysis. The growth rate of real estate price, growth rate of nominal real estate prices and household debt ratio data are collected from the Bank for International Settlements. Growth rate of GDP per capita, growth rate of the producer price index, growth rate of consumer price index, changing rate of real effective exchange rate, first-order difference of government securities interest rates and lending rates come from Oxford Economics. The monetary supply growth rate in Turkey comes from International Financial Statistics of IMF. Other countries' monetary supply growth data are from Oxford Economics. For growth rate of gross fixed capital formation data, we obtained Chinese data from the National Bureau of Statistics of China, Singaporean data is obtained from the Singapore Department of Statistics, Malay and Thai data are collected from International Financial Statistics of IMF, and other countries' data are from Quarterly National Accounts of OECD (All the data above are downloaded by DataStream). The stock price index growth rate is derived from MSCI index of each country's stock market. Table 1 details the data.

Table 1. Data sources and description

Variable	Data Sources	Treatment
growth rate of nominal housing prices	Bank for International Settlements	Quarter to Quarter growth rate
growth rate of real housing prices	Bank for International Settlements	Quarter to Quarter growth rate
first-order difference of household debt ratio	Bank for International Settlements	The current quarter household debt to GDP ratio minus that in the previous quarter
growth rate of GDP per capita	Datastream -Oxford Economics	Quarter to Quarter growth rate
growth rate of monetary supply	Turkey: IMF - International Financial Statistics Other: Datastream -Oxford Economics	Quarter to Quarter growth rate
growth rate of gross fixed capital formation	China: National Bureau of Statistics of China Malaysia, Thailand: IMF - International Financial Statistics Singapore: Statistics Singapore Other: Datastream – OECD Quarterly National Accounts	Quarter to Quarter growth rate
growth rate of producer price index	Datastream -Oxford Economics	Quarter to Quarter growth rate
growth rate of consumer price index	Datastream -Oxford Economics	Quarter to Quarter growth rate
growth rate of stock price index	Datastream- MSCI Index	Value of present quarter deduct that of last quarter and minus 1
change rate of real effective exchange rate	Datastream -Oxford Economics	Value of present quarter deduct that of last quarter and minus 1
first-order difference of government securities interest rate	Datastream -Oxford Economics	Value of present quarter deduct that of last quarter
first-order difference of lending interest rate	Datastream -Oxford Economics	Value of present quarter deduct that of last quarter

Note: More detailed code and raw data can be obtained from the author.

Table 2. Descriptive statistics of variables

Variable	Symbol	Means	Standard errors	Minimum	Maximum	Observations
growth rate of real housing prices	hpr	1.75	7.26	-28.56	51.45	1957
growth rate of nominal housing prices	hpn	4.49	7.76	-24.90	65.19	1957
first-order difference of household debt ratio	houcredit	0.28	0.93	-8.80	7.60	1957
growth rate of GDP per capita	gdp	4.16	12.30	-43.33	44.27	1957
growth rate of monetary supply	m2	7.63	7.41	-25.14	74.22	1957
growth rate of gross fixed capital formation	gfcf	3.09	8.85	-32.66	73.93	1957
growth rate of producer price index	ppi	2.67	5.54	-19.72	36.89	1957
growth rate of consumer price index	cpi	2.73	3.12	-22.46	25.41	1957
growth rate of stock price index	equity	1.63	11.61	-47.46	89.55	1957
change rate of real effective exchange rate	exrate	-0.12	3.14	-26.44	26.25	1957
first-order difference of government securities interest rate	govscu	-0.07	0.66	-7.66	11.58	1957
first-order difference of lending interest rate	lendrate	-0.07	0.71	-6.19	8.39	1957
country	cntry_id	19.20	11.07	1.00	36.00	1957

Table 2 reports descriptive statistics for each variable. In the sample, the average growth rate of nominal housing price is 4.49%. which is 2.74% higher than that of real housing price. From the data, we can also see the standard

error of the growth rate of nominal housing prices is 7.76%, the minimum is -24.90% and the maximum is 65.19%. The standard error of the growth rate of real housing prices is 7.26%, the minimum is -28.56% and the maximum is 51.45%. Average change of household debt ratio is 0.28%, standard error is 0.93%, the minimum is -8.80% and the maximum is 7.60%. The above values show our sample can reflect regional differences in the global economy. In Appendix A, we also detail the list of countries under investigation, number of observations for each country and the time frame for each country.

4. Housing price, Household Debt Ratio and Other Variables

4.1 Theoretical Framework

In this paper, our analysis is based on Glindro et al. (2011) which establishes an empirical model to study the housing price. They suggest that the price is a function of the relevant macroeconomic factors and relevant institutional factors:

$$P_{it}^{*}=f(X_{it})$$

P_{it}^{*} represents housing price in country i at time t. $f(\cdot)$is the function of X_{it}. X_{it} represents macroeconomic factors and institutional variables determining the housing price. The paper suggests that factors determining prices are divided into four categories.

The first category refers to variables affecting real estate demand and it includes GDP per capita, income, et cetera. The demand for housing will increase if these variables rise. The second category is factors affecting the supply of real estate and consisting of variables such as land supply and the actual construction costs, et cetera. It is clear that these variables would have a negative impact on the housing price: price decreases when supply increases. The third category represents the price level of other assets, including stock prices and currency exchange rates, et cetera. Real estate and other assets can substitute each other at some extent and housing market would not be booming if return of other assets is too high. The fourth category is the institutional factors of the country, including the extent of free trade, level of corruption, the degree of protection of property rights, et cetera. They believe that these institutional factors also affect real estate price changes.

According to Glindro et al. (2011), we basically select the relevant explanatory variables in accordance with the above classification. However, it is very difficult to obtain institutional variables, since most of the data is likely available from mid-1990s and some countries are still short of the data. Given the problem of missing data, in order to do the analysis in a longer timeframe, we drop the institutional factors. The focus of our paper would be on the interaction of macroeconomic factors and the housing price.

In the first category, our paper selected two variables as macroeconomic factors affecting the real estate demand: growth rate of per capita GDP and growth rate of money supply. GDP per capita is a demand-side factor. In an economy, people would have a greater demand for housing, no matter quantity or quality, when their income levels increase. In general, since inflation is regarded as a monetary phenomenon, the consumer price or asset price will be driven by the money supply. Growth of money supply would be positively related to the real estate price. Growth rate of M2 would be a good index for growth rate of money supply.

In the second category, we select growth rate of gross capital formation, growth rate of producer price index (PPI), growth rate of consumer price index (CPI) and the first-order difference of lending rate in each country. We used growth rate of gross capital formation as a proxy for changes in housing supply since the housing supply data are missing for most of the countries. In the long run, gross capital formation would be highly positively correlated with changes of housing supply and thus we adopted it as a proxy for housing supply. Growth rate of PPI reflects the change of production cost. It is an indicator for production cost and has a close relationship with the housing price. Growth rate of CPI measures changes in consumer price level and it reflects the changes in the consumption cost which indicates the construction workers' salary cost. It is believed that it would have a close relationship with the housing price. First-order difference of lending rate refers to the lending rate of the present quarter minus that of the last quarter. And it is the estimate for lending cost in the country. Since real estate sector is a capital-intensive industry and real estate corporations would use leverage for financing, the increase in lending cost would shrink the housing supply.

The third category is the price level of other assets, the paper selects the following explanatory variables: growth rate of stock price index, first-order difference of the interest rate of government securities, rate of change of real effective exchange rate. Stock price index growth rate can be used as an indicator reflecting changes in the economic cycle. The stock market will decline during economic downturns and real estate price will come down as well. The stock market is an important asset pool and it is a substitute for real estate market, so they are closely related. The first-order difference of interest rate of government securities refers to the change of interest

rate. It is the indicator of risk free rate and reflects the basic return of other assets. Rate of change in the real effective exchange rate indicates changes in the exchange rate between countries. With law of one price and highly connected global financial market, real estate of similar quality should cost about the same price. Thus, we added exchange rate into the model for analysis.

The central question of this paper is whether the change of household debt ratio is a driving force of the real estate price movements. If so, how does it affect the real estate prices? Changes of household debt ratio represent the difference of household debt ratio at present and the previous period and we use it to measure the magnitude of change in household debt ratio. Mortgage loan is the main component of modern household debt and therefore we group it into the demand-side factor of housing price.

4.2 Econometric Model Design

We employ a regression model like Glindro et al. (2011) and collected a quarterly dataset with total 1957 observations from 36 countries during 1981-2015 to analyze whether household debt ratio causes housing price movements and how does it affect the price. This section will carefully investigate whether the household debt ratio causes the real estate price changes and the effects of other variables on the price.

The main variable is the change of household debt ratio. In order to analyze the quantitative effect of change of household debt ratio on housing price, we built the following model:

$$hpr_{it} = \alpha_0 + \alpha_1 houcredit_{it} + \alpha_2 gdp_{it} + \alpha_3 m2_{it} + \alpha_4 gfcf_{it} + \alpha_5 ppi_{it} + \alpha_6 cpi_{it} + \alpha_7 equity_{it} + \alpha_8 exrate\_gr_{it} + \alpha_9 govscu_{it} + \alpha_{10} lendrate_{it} + \varphi Z_i + u_i + \varepsilon_{it} \quad (1)$$

hpr_{it} represents change rate of real housing price in country i at time t, or hpn_{it} represents change rate of nominal housing price. $\mathrm{houcredit}_{it}$ represents changes of household debt ratio, which equals to the current total household debt divided by the current GDP minus that of previous one in country i at time t. gdp_{it} represents growth rate of GDP per capita. $\mathrm{m2}_{it}$ is growth rate of M2; gfcf_{it} is growth rate of gross fixed capital formation; ppi_{it} is change rate of PPI; cpi_{it} is change rate of CPI; equity_{it} is the change rate of the stock price index; exrate_{it} is the change rate of the real effective exchange rate; govscu_{it} is the first-order difference of interest rates of government securities; $\mathrm{lendrate}_{it}$ is the first-order difference of lending rates; Z_i is the time invariant variables in country i; $u_i+\varepsilon_{it}$ represents the disturbance terms.

5. Empirical Results

5.1 Stationary and Hausman Test

Before the empirical analysis, we conduct stationary test first. To ensure the robustness, we use STATA command xtfisher to conduct Phillips-Perron and augmented Dickey Fuller unit root test. Both tests show that all variables are significant at the 1% level, indicating that the selected variables are stationary (detailed test results are not listed here because of space limitations).

Using a fixed effect model or random effect model is an important issue when we analyze panel data. Random effect model assumes that the disturbance terms u_i and $\{X_i\ Z_i\}$ are uncorrelated, and the fixed effect model assumes they are correlated. Hausman test can help us to determine which model should be used. The null hypothesis for the Hausman test is u_i and $\{X_i\ Z_i\}$ are uncorrelated. If the null hypothesis is rejected, then we should use the fixed effect model, or vice versa. Table 3 shows the results of the Hausman test (detailed test results are not listed here because of space limitations). From Table 3, we can see the chi-square statistic of Hausman test is 19.12 and P-Value 0.0590. We can reject the null hypothesis at 10% confidence level. Since the Hausman test rejected the null hypothesis, we should use the fixed effect model, which can get a better estimation.

Table 3.Hausman test results (fixed effect and random effect comparison)

Hausman	chi2 (11)	19.12	P	0.0590

5.2 Endogeneity and Instrumental Variables

Modern econometric literatures believe that endogeneity is the main source of inconsistent regression estimation and there are three situations: omitted variables, reverse causality and measurement error. Due to we use unbalanced panel data, we would use fixed-effect model to mitigate the impact of omitted variables.

The relationship between the change of household debt ratio and real estate price is a typical reverse causality.

Higher housing price will induce higher amount of loans and thus higher household debt ratio and vice versa. Lots of literatures provide empirical evidence on the correlation between the housing market and mortgage lending. Kim et al. (2014) investigates the possible causes of the Korean household debt in recent years and they set housing price as explanatory variable. So there is a reverse causality between real estate prices and household debt ratio in the model. If we use ordinary least squares (OLS) or a fixed effect method to estimate the impact of the household debt ratio on real estate prices at the same period, it is possible to result in biased estimation because of endogeneity. Since we are using the panel data, a possible approach is to use first and second-order lagged change of household debt ratio as an instrumental variable. Because change of household debt ratio at current period is often associated with change of lagged household debt ratio, the lagged change of household debt ratio is determined in priori, and the reverse effect does not hold for the lagged change of household debt ratio, thus this can mitigate the endogeneity.

In addition, there is also a reverse effect of housing price on the GDP per capita and gross fixed capital formation rate. Goodhart and Hofmann (2008) believe that monetary variables and housing price can significantly affect GDP growth. Benjamin (2004), Kishor (2007) and Campbell and Cocco (2007) believe that housing price can affect consumption through the wealth effect, and thus have an impact on GDP. When real estate price rise, developers will gain more and they will build more houses, it will promote real estate investment and push gross fixed capital formation. Blackley (1999) and Glaeser (2008) have carried out research on this issue and we use a first-order lagged growth rate of GDP per capita and the growth rate of gross fixed capital formation as instrumental variables.

Firstly, we will use difference of Sargan-Hansen statistics to testify the endogeneity. The null hypothesis is that the specified variables are exogenous variables, and the statistic follows a chi-square distribution, the degree of freedom equals number of specified variables. If we reject the null hypothesis, it means that the specified variables are endogenous variables. To ensure the validity of instrumental variables, our paper was tested in two ways. First, we employ Anderson canonical correlations LR statistic proposed by Anderson (1951) to test whether there is a problem of under-identification in the use of instrumental variables, which means whether the correlation between instrumental variables and endogenous variables is strong enough. The null hypothesis of LR statistics is that canonical correlation is zero between instrumental variables matrix and endogenous variables matrix. If you reject the null hypothesis, it indicates under identification does not exist. Second, we use Hansen's J statistic to address whether there is a problem of over-identification. The null hypothesis is that instrumental variables are valid which means instrumental variables is not associated with disturbance terms. And Hansen's J statistic following chi-square distribution, the degree of freedom is the number of over-constrained. For further discussion see Hayashi (2000).

5.3 The Change of Household Debt Ratio

Before discussing the empirical results, we firstly test the multicollinearity by calculating Variance Inflation Factor (VIF). The results show that the mean value of VIF is 1.30, the maximum value of VIF is 1.57, and the minimum value of VIF is 1.06. All the VIF value are smaller than 10, this means there is no multicollinearity for our sample. More detail can be seen in Appendix B. Since we use the clustered robust standard error, we can directly make the relevant inference without considering the heteroscedasticity test.

In this part, we focus on the coefficient of change of household debt ratio. Table 2 presents mixed OLS, fixed effects, 2SLS fixed effects and GMM estimation results. In OLS estimation, the sample size is 1957, R-Squared equals 0.2355. The estimated coefficient of change of household debt ratio is 0.6866 and it is significant at 10% confidence level. It concluded that household debt ratio change has marginal effect of around 0.69 on real estate prices. That means when the household debt ratio increases by 1%, the growth rate of real estate price in the country increases by about 0.69%.

In fixed effect estimates, the sample size is 1957 and R-Squared equals 0.2699, close to 30%. It seems that the model can explain changes in house prices in the larger extent. The estimated coefficient of change of household debt ratio is 0.6029. However, it is not statistically significant. It seems that household debt ratio and change in housing prices are unrelated. To avoid the effects of endogenous, we need further analysis.

In 2SLS and GMM estimation, we use the first and second order lagged change of household debt ratio, first order lagged growth rate of GDP per capita and first order lagged growth rate of gross fixed capital formation as instrumental variables. Sargan-Hansen statistics is 6.810, which is significant at 10% confidence level and affirms the existence of endogeneity in the household debt ratio, growth rate of GDP per capita and gross fixed capital formation. Anderson LR statistic value is 432.725, which is significant at 1% level and it rejects the null hypothesis of under-identification. It means that instrumental variables are related to the instrumental variables.

Hansen's J statistic value is 2.596. It is not significant at 10% level and it cannot reject the null hypothesis that the instrumental variables are exogenous. It reveals that the instrumental variables are not correlated with disturbance terms. Thus, based on the Hansen's J statistics we conclude that the over-identifying restriction is valid.

From fixed effects 2SLS estimation result, the number of observations is 1885, R-Squared equals 0.2158. Coefficient of change of household debt ratio is 2.2794 and it is significant at 5% level. It concludes that the marginal effect of household debt ratio change on real estate price is around 2.28, that is, when the ratio of household debt rises by 1%, the growth rate of real estate price in the country increases by about 2.28%. This coefficient is much higher than the result from OLS and fixed effects regression, indicating that the higher household debt ratio, the higher the growth rate of housing price. This conclusion is not only statistically significant, but also economically very significant. Impact of change of household debt ratio on real estate price is huge.

Because there are more instrumental variables than endogenous variables, using GMM estimation will be more efficient than using 2SLS estimation. From GMM fixed effect estimation, the coefficients of change of household debt ratio is 2.0770, which is similar to 2SLS result and significant at the 5% level. That means, when the household debt ratio increases by 1%, the growth rate of real estate prices in the country increases by about 2.28%. This conclusion is consistent with the 2SLS regression results, indicating that the higher the household debt ratio, the higher growth rate of housing prices. These results illustrate the importance of the change of household debt ratio on change of real estate price. Household debt ratio is an important factor and driving force of change in real estate prices.

5.4 Control Variables

In the 2SLS estimation, the estimated coefficient of monetary supply growth rate is.1703, which is significant at 1%. The estimated coefficient of money supply growth rate in GMM estimation is 0.1640 and it is also significant at the 1% level. The results show that the money supply has a positive impact on real housing price. The estimated coefficients of gross fixed capital formation growth rate are 0.4124 in 2SLS estimation and 0.4209 in GMM estimation, and both are significant at 1% level. The results show that gross fixed capital formation has a positive effect on real estate prices. The estimated coefficient of CPI growth rate in 2SLS estimation is -0.4267 and -0.4424 in GMM estimation, which is significant at 5% and 1% level respectively. It indicates that increase of CPI has a negative impact on the changes in real estate prices. 2SLS and GMM fixed effects regression results above are very close, indicating the robustness of the regression results.

The estimated coefficient of change rate of effective real exchange rate in GMM estimation is 0.0898, which is significant at 10% level. But, the estimated coefficients of which in 2SLS is 0.0725, which is not significant.

Table 4 mixed OLS, fixed effect, 2SLS fixed effect and GMM fixed effect estimation result

	OLS	FE	2SLS_FE	GMM_FE
first-order difference of household debt ratio	0.6866 ***	0.6029	2.2794 **	2.0770 **
	[0.2071]	[0.3679]	[0.9682]	[0.9600]
growth rate of GDP per capita	0.0728 ***	0.0698 ***	0.0379	0.0330
	[0.0153]	[0.0221]	[0.0322]	[0.0321]
growth rate of monetary supply	0.2074 ***	0.2232 ***	0.1703 **	0.1640 **
	[0.0388]	[0.0707]	[0.0749]	[0.0748]
growth rate of gross fixed capital formation	0.2158 ***	0.2907 ***	0.4124 ***	0.4209 ***
	[0.0313]	[0.0607]	[0.0868]	[0.0867]
growth rate of producer price index	-0.0306	-0.0684	-0.0076	0.0104
	[0.0427]	[0.0931]	[0.0883]	[0.0876]
growth rate of consumer price index	-0.4503 ***	-0.4747 ***	-0.4267 **	-0.4424 ***
	[0.0622]	[0.1654]	[0.1658]	[0.1655]
growth rate of stock price index	0.0296 *	0.0192	0.0225	0.0178
	[0.0154]	[0.0125]	[0.0163]	[0.0160]
change rate of real effective exchange rate	0.0051	0.0245	0.0725	0.0898 *
	[0.0575]	[0.0329]	[0.0498]	[0.0486]

first-order difference of government securities interest rate	0.5400 **	0.5657 ***	0.388	.3292
	[0.2147]	[0.1944]	[0.2434]	[0.2406]
first-order difference of lending interest rate	0.8242 ***	0.7967 *	.6119	.4928
	[0.2759]	[0.4544]	[0.4524]	[0.4463]
Sargan-Hansen			6.810*	6.810*
Anderson LR			432.725***	432.725***
Hansen J			2.596	2.596
N	1957	1957	1885	1885
r2	.2355	.2687	.2158	.2232

Note: The values in parentheses are robust and clustered standard error. ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Sargan-Hansen statistic is used to test the presence of endogenous problems of the specified variable, following χ^2 (3) distribution; Aderson LR and Hansen's J statistic are used to test the 2SLS and GMM estimation to identify whether there is under-identification and over-identification problem, following χ^2 (2) and χ^2 (3) distributions. Since adopting the same instrumental variables, the Aderson LR and Hansen's J statistic in 2SLS and GMM are the same.

6. Robustness test

In order to check the reliability of empirical analysis, this paper tests the robustness in following two aspects:

First, the sample of 36 countries in this study covers the world's major economies, including 16 European countries and 20 countries from other regions. We segregate them into European and non-European countries group, and then use the 2SLS and GMM estimation. Table 5 shows the regression results. Column (1) is the 2SLS results of European countries, Column (2) presents the 2SLS results of non-European countries, Column (3) reveals the GMM regression results of European countries and Column (4) gives the GMM results of non-European countries. From Table 5, we can see that estimated coefficients of change of household debt ratio in European countries are both positive and significant at 5% level in 2SLS and GMM estimation. The result from Column (4) is not significant and it may be due to GMM estimation result is affected after the decrease in sample size. But overall, the change of household debt ratio has a positive effect on real estate price in both European and non-European countries.

Second, Column (5) and (6) from table 5 would use growth rate of nominal housing price as dependent variable, and the regression results in Table 2 use real housing price growth rate as dependent variable. The result is similar to what we obtain in Table 4, in which the coefficient of change of household debt ratio is statistically significant at 5% level for both 2SLS and GMM estimation. Coefficient obtained from 2SLS is 2.3150 and 2.1649 from GMM. The results are close to each other and it reaffirms the validity of our results.

In order to get more robust results, we also use there stage least square (3sls) and Jackknife instrumental variable method to get the relevant estimators (detailed results can be seen in Appendix C).

Table 5. Robustness test results

	(1) EU 2SLS	(2) NonEU 2SLS	(3) EU GMM	(4) NonEU GMM	(5) Nominal 2SLS	(6) Nominal GMM
first-order difference of household debt ratio	2.4048 **	4.0405 ***	2.4440 **	2.1051	2.3150 **	2.1649 **
	[1.2132]	[1.5670]	[1.1741]	[1.3309]	[0.9447]	[0.9394]
growth rate of GDP per capita	-0.0166	0.1377 ***	-0.0173	0.1136 ***	0.0402	0.0365
	[0.0481]	[0.0323]	[0.0478]	[0.0306]	[0.0325]	[0.0324]
growth rate of monetary supply	0.5826 ***	0.1967 **	0.5857 ***	0.2286 **	0.4060 ***	0.4246 ***
	[0.1209]	[0.0982]	[0.1185]	[0.0973]	[0.0892]	[0.0883]
growth rate of gross fixed capital formation	0.1859 **	0.1914 *	0.1845 **	.1402	0.2009 ***	0.1935 **
	[0.0906]	[0.1136]	[0.0899]	[0.1114]	[0.0757]	[0.0755]
growth rate of producer price index	0.0495	0.0189	0.048	0.1690 *	0.0603	0.0731
	[0.1017]	[0.1207]	[0.1011]	[0.1022]	[0.0937]	[0.0933]
growth rate of consumer price index	-0.8362 **	-0.3182 **	-0.8201 ***	-0.4971 ***	-0.0118	0.0078
	[0.3336]	[0.1482]	[0.3094]	[0.1269]	[0.1260]	[0.1253]
growth rate of stock price index	0.0146	0.0104	0.0127	0.0468 *	0.0118	0.0087

	[0.0186]	[0.0320]	[0.0115]	[0.0280]	[0.0150]	[0.0149]
change rate of real effective exchange rate	0.1974 **	-0.0715	0.2041 ***	-0.052	0.075	0.0893 *
	[0.0889]	[0.0534]	[0.0723]	[0.0527]	[0.0482]	[0.0473]
first-order difference of government securities interest rate	.5013	.3805	0.4864	.5526	0.4425 *	.3735
	[0.3343]	[0.3529]	[0.3135]	[0.3451]	[0.2411]	[0.2366]
first-order difference of lending interest rate	0.8324 **	.3734	0.8192 **	0.1292	.6697	.5501
	[0.3679]	[0.6755]	[0.3532]	[0.6674]	[0.4499]	[0.4428]
Sargan-Hansen	7.819**	0.661	7.819**	0.661	8.349**	8.349**
Anderson LR	187.612***	176.892***	187.612***	176.892***	432.725***	432.725***
Hansen J	0.017	5.475***	0.017	5.475***	2.253	2.253
N	919	966	919	966	1885	1885
r2	.2647	.1609	.2611	.2047	.2047	0.2077

Note: The values in parentheses are robust and clustered standard error. ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Sargan-Hansen statistic is used to test the presence of endogenous problems of the specified variable, following χ^2 (3) distribution; Aderson LR and Hansen's J statistic are used to test the 2SLS and GMM estimation to identify whether there is undere-identification and over-identification problem, following χ^2 (2) and χ^2 (3) distributions. Since adopting the same instrumental variables, the Aderson LR and Hansen's J statistic in 2SLS and GMM are the same.

7. Conclusions

In this paper, unbalanced quarterly panel data in 36 countries worldwide from 1981 to 2015 is used to empirically test the effect of change of household debt ratio (total household debt / GDP) on the real estate price change. We find that there is a positive correlation between the household debt ratio and housing price. Higher household debt ratio would significantly increase growth rate of real estate price. Our results are reliable and robust, because we have also controlled the impact of demand-side, supply-side, other related asset prices factors, as well as endogeneity by using 2SLS and GMM estimation. In the robustness test section, the sample countries are separated into two groups and we use growth rate of nominal housing price as the dependent variable.

The major contributions of this paper are the following. First, the change of household debt ratio is classified as demand-side factor for housing price and groups it into the model. Mortgage loans as the major part of household debt have a great impact on housing prices and it has important policy implications. Second, in order to solve the problem of endogeneity, we use lagged value of change of household debt ratio, growth rate of GDP per capita and gross fixed capital formation as instrumental variables in 2SLS and GMM estimation, which results in much more robust and reliable results.

The main deficiency of this paper is that we do not put the relevant institutional factors into our model. Due to the data insufficiency, we had to abandon institutional factors. Therefore, we plan to extend the research with institutional factors.

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Appendix A

More details about the data

Table A1. The list of countries under investigation, number of observations for each country and the time frame for each country

Country name	Starting time	Ending time	Observation for each variable
Australia	2004Q3	2015Q4	46
Austria	2001Q1	2015Q4	60
Belgium	2006Q1	2015Q4	40
Canada	1982Q3	2015Q4	134
Chile	2003Q1	2015Q3	51
China	2006Q2	2015Q4	39
Czech Republic	2009Q1	2015Q4	28
Denmark	2003Q4	2015Q4	49
Finland	2006Q1	2015Q4	40
France	1997Q1	2015Q4	76
Germany	2004Q1	2015Q4	48
Greece	2007Q1	2015Q4	36
Hungary	2008Q1	2015Q4	32
India	2010Q1	2015Q4	24
Indonesia	2003Q3	2015Q4	50
Ireland	2006Q1	2015Q4	40
Italy	1991Q1	2015Q4	100
Japan	2009Q2	2015Q4	27
Korea	1996Q2	2015Q4	79
Malaysia	2006Q2	2015Q4	39
Mexico	2006Q1	2015Q4	40
Netherlands	1996Q1	2015Q4	80

New Zealand	2006Q2	2015Q4	39
Norway	1993Q1	2015Q4	92
Poland	2011Q1	2015Q4	20
Portugal	2009Q1	2015Q4	28
Russia	2003Q2	2015Q4	51
Singapore	1999Q1	2015Q4	68
South Africa	2008Q2	2015Q4	31
Spain	2006Q4	2015Q4	37
Sweden	1999Q1	2015Q4	68
Switzerland	2000Q1	2015Q4	64
Thailand	2009Q1	2015Q4	28
Turkey	2011Q1	2015Q4	20
United Kingdom	1987Q4	2015Q4	113
United States	1981Q1	2015Q4	140

Appendix B

Variance Inflation Factor

Table A1. Variance Inflation Factor

Variables	VIF	1/VIF
growth rate of producer price index	1.57	0.638758
growth rate of GDP per capita	1.52	0.658821
growth rate of monetary supply	1.45	0.690299
growth rate of consumer price index	1.43	0.700324
growth rate of gross fixed capital formation	1.4	0.712642
change rate of real effective exchange rate	1.18	0.847284
first-order difference of lending interest rate	1.14	0.876946
first-order difference of household debt ratio	1.13	0.881986
first-order difference of government securities interest rate	1.1	0.909958
growth rate of stock price index	1.06	0.944379
Mean	1.30	

Appendix C

3SLS estimator and Jackknife IV estimator

Table A1. 3SLS estimator and Jackknife IV estimator

	hpr	hpr
	3SLS	JIVE
first-order difference of household debt ratio	2.4283***	1.8632***
	[0.3029]	[0.3967]
growth rate of GDP per capita	0.0423**	0.0518**
	[0.0178]	[0.0208]
growth rate of monetary supply	0.0043	0.2684***
	[0.0083]	[0.0422]
growth rate of gross fixed capital formation	0.3280***	0.1659***
	[0.0245]	[0.0464]
growth rate of producer price index	0.0128	0.0181
	[0.0111]	[0.0466]
growth rate of consumer price index	-0.022	-0.4254***
	[0.0136]	[0.0653]
growth rate of stock price index	0.0067*	0.0357**
	[0.0039]	[0.0157]
change rate of real effective exchange rate	0.0362*	0.0281

	[0.0209]	[0.0629]
first-order difference of government securities interest rate	0.0315	0.4066*
	[0.0547]	[0.2147]
first-order difference of lending interest rate	0.0569	0.7735***
	[0.0518]	[0.2767]
_cons	-0.0893	0.0999
	[0.1805]	[0.2924]
N	1885	1885
r2	0.1486	0.2123

Note: The values in parentheses are robust standard error. ***, ** and * denote significance at the 1%, 5% and 10% level respectively.