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Role of Government Public Housing Loans in House-Price Dynamics in Japanese Prefectures

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Abstract

This paper explores the relationship between homeowner borrowing patterns from the government public housing loan corporation (GHLC) and house-price dynamics by estimating serial correlation and mean reversion coefficients from a panel data of 46 prefectures for 1980 to 2004 in Japan. Our principal finding is that in prefectures where a greater fraction of homeowners are highly leveraged from GHLC –i.e. have high GHLC loan-to-value ratios (= low non-GHLC loan-to-value ratio) – housing prices react less sensitively to prefecture–specific shocks. That is to say, the fitted values for mean reversion and serial correlation in all prefectures with high GHLC loan–to-value ratio lie in the convergent non-oscillatory ranges. In contrast, the fitted values for mean reversion and serial correlation in all prefectures with high non-GHLC loan-to-value ratio (= low GHLC loan-to-value ratio) (ex. Tokyo, Osaka) lie in the convergent, but oscillatory ranges. Real user costs (we used in the estimation) which capture the cost of homeownership consist of the weighted average of real mortgage rates, the effective property tax rate and the expected rate of real house price inflation. The weighted average of real mortgage rates consist of the multiplication of the GHLC borrowing interest rate by the share of GHLC loans and the multiplication of the non-GHLC interest rate by the share of non-GHLC loans. We assume the non-GHLC loan interest rate is equal to the individual's opportunity cost of capital. This finding suggests the GHLC's low subsidized interest rate policy has contributed to stabilize movements of real estate prices in Japan.

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Key Words: House price dynamics, Loan to Value ratio, Panel data, Serial correlation, Mean reversion, GHLC, Japan

JEL classification number: E31, R10, R31, R21, G20

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1. Introduction

Japan has seen a rise and fall in land and housing prices that rival that of any country in any period in modern history[1]. Asset prices began increasing in 1983, and then skyrocketed beginning in 1986. The rise in land prices spread from Tokyo to major cities such as Osaka and Nagoya and then later to other urban areas. Figure 1 graphically presents real house price changes from 1980 to 2004 in high GHLC loan-to value ratio prefectures and other prefectures. Figure 2 presents prefecture average GHLC loan-to-value ratios throughout Japan.

Housing prices are much higher, due in large part to the much higher price of land compared to almost all other countries. The affordability problem is still serious in Japan.

The present Japanese housing finance systems involve an unusual combination of private and public sector lending.

Government subsidized lending has played an important role in the Japanese housing finance system. The government-run GHLC is the largest single mortgage lender in the world and accounts for some 25 to 35 percent of housing loans in Japan. The GHLC was established in 1950 as a special public corporation that provides long-term capital at a low rate of interest for the construction and purchase of housing. About 79.7 % of public loans were allocated to construction and purchase of new owner-occupied housing, 6.0% to the purchase of second-hand owner-occupied housing and 6.1% to construct rental housing. The GHLC obtains funds from the Fiscal Loan and Investment Program, which mainly obtains funds from postal savings deposits.

[1] See, Seko (2001) for details.

Housing loans offered by the GHLC were provided at subsidized rates, but have been phased out recently.

Unlike other advanced industrial nations, Japan has no major private-sector institutions that specialize in housing finance, like the savings and loan associations in the United States and building societies in the United Kingdom. Moreover, until recently there has been no active secondary mortgage market.

In financing housing purchases, Japanese consumers typically self-finance about 40 percent of the purchase price, of which about 25-30 percent is from personal savings. About 40 percent of the purchase price is financed by government subsidized loans (mainly GHLC loans). For instance, if an individual acquires a newly-built wooden house in a large metropolitan region, the loan recipient can normally borrow a total of 15.7 million yen from the GHLC, consisting of 8 million yen for the house and 7.7 million yen for the land. This amount of money corresponds to 30-40 percent of the cost of the house and the lot, and the borrower must add funds on hand plus bank loans towards purchase of the house. The GHLC places limits on the amount and cost of its loans. The size of a GHLC loan is specified according to the floor space of the house. The interest rate is also calculated according to the size of the house. The repayment period is typically 25-30 years.

The purpose of this paper is to explore the relationship between homeowner borrowing patterns from the government public housing loan corporation (GHLC) and house-price dynamics by estimating serial correlation and mean reversion coefficients from a panel data of 46 prefectures for 1980 to 2004 in Japan and to identify whether the GHLC's low subsidized interest rate policy has contributed to stabilize movements of real estate prices in Japan or not. Although there are several studies about house-price

dynamics[2] and homeowner borrowing patterns such as Stein(1995) and Lamont and Stein(1999), they do not take into consideration a combination of private and public sector lending. This is the first empirical study of the relationship between homeowner borrowing patterns from the government public housing loan corporation (GHLC) and house-price dynamics from a panel data of 46 prefectures in Japan.

In this study, prefectures, analogous to states in the United States, are units of observation. The data encompasses 46 of 47 prefectures and spans 24 years from 1980 to 2004 in Japan. The panel data includes all Japanese prefectures for which annual data on the prices of single-family detached owner occupied housing, annual household income, population, construction costs, ratio of residential and nonresidential land area, assessment values for property tax purpose, total floor space of the average house and a local consumer price index are available.

The organization of the remainder of this paper is as follows: Section 2 presents the model; Section 3 presents a hypothesis and an overview of the data ; Section 4 presents empirical results, and Section 5 offers some concluding remarks.

2. Model

We assume in each area there exists a fundamental value of houses P^*_{jt} in each prefecture j at time t which is determined by economic conditions reflecting both demand and supply factors of housing stock and flow markets.

[2] Seslen, Wheaton and Pollakowski(2005) analyzed the house price movements at the Zip code level in the U.S. and Seko and Konno(2005) analyzed the house price movements across metropolitan areas from panel data in Japan.

$$\log(P^*_{jt}) = \mathbf{p}(\mathbf{X_{jt}}) \qquad (1)$$

where $\mathbf{X_{jt}}$ is a vector of exogenous explanatory variables which can be derived from a standard dynamic urban asset market model such as the real user cost of capital, the size of a prefecture and the real construction cost of converting land from agricultural use to new residential use. It is a long-run equilibrium steady state price. (See, for example, Capozza and Helsley(1990), DiPasquale and Wheaton(1996)[3]).

We assume, following Capozza, Hendershott and Mack(2004), that short-run dynamics in real house prices in each area are explained by:

$$\Delta \log(P_{jt}) = \delta \Delta \log(P_{j,t-1}) + \eta \left((\log(P^*_{j,t-1}) - \log(P_{j,t-1}) \right) + \lambda \Delta \log(P^*_{jt}) + \varepsilon_{jt} \qquad (2)$$

where $\log(P_{jt})$ is the log of actual real house price levels in prefecture j at time t, Δ is the difference operator and ε_{jt} is a random error. δ is the serial correlation coefficient while η is the mean reversion coefficient. That is to say, η $(0 < \eta < 1)$ is the rate of adjustment to fundamental value and λ is the adjustment coefficient to fundamentals.

We further assume, following Capozza, Hendershott and Mack (2004), that in each area the serial correlation coefficient δ and the mean reversion coefficient η may vary among prefectures, because the dynamic response of prefectures to shocks to their local economy may differ. In this case, short-run dynamics in real house prices in

[3] Himmelberg, Mayer and Sinai(2005) explains how to assess the state of house prices in a way that is grounded in economic theory. Leung(2004) surveys the research efforts focused on interplay between the housing markets and macroeconomy.

each area are explained by :

$$\Delta \log(P_{jt}) = \delta_{jt} \Delta \log(P_{j,t-1}) + \eta_{jt} \quad ((\log(P^{*}_{j,t-1}) - \log(P_{j,t-1})) + \lambda \Delta \log(P^{*}_{jt}) + \mu_{jt} \qquad (3)$$

where $\delta_{jt} = \delta + \sum_i \delta^i (Y^i_{jt} - Y^{i*})$ and $\eta_{jt} = \eta + \sum_i \eta^i (Y^i_{jt} - Y^{i*})$.

Here Y^i_{jt}, which may include a subset of $\mathbf{X_{jt}}$ (i.e., i-th component of $\mathbf{X_{jt}}$) , are independent variables, and Y^{i*} is the mean value. μ_{jt} represents random error.

3. Hypothesis and Data

3.1 Hypothesis

In each area variation among prefectures of the serial correlation coefficient δ and mean reversion coefficient η in equation (3) are assumed to reflect variation in information costs, construction costs and real user costs among prefectures.

As for information costs, as higher real income growth stimulates higher housing transactions volume and lower search costs, it is expected to cause faster mean reversion. (See Wheaton(1990) and DiPasquale and Wheaton (1996).)

As for construction costs, as higher real construction costs dampen the builders' response to shocks, it is expected to cause lower mean reversion.

It is expected that higher population growth correlates with more serial correlation as it may reflect backwards-looking expectations of market participants as Case and Shiller (1988, 1989) and Shiller (1990) suggest. It means buyers in booming housing markets have greater anticipated price appreciation. Higher real user cost may also

correlate with more serial correlation, because buyers in a booming market (and thus higher real user cost market) may wish to buy houses as an investment and purchase them before a rapid increase in real user cost. Strong market conditions should correlate with more serial correlation.

3-2 Data

We split the 46 prefectures into 2 areas, - i.e. prefectures where a greater fraction of homeowners are highly leveraged from GHLC (have high GHLC loan-to-value ratios = low non-GHLC loan-to-value ratios) and prefectures with low GHLC loan-to-value ratios(= high non-GHLC loan-to-value ratios). The names of the prefectures are listed in Appendix 1.

The owner-occupied housing purchase price, annual income per household data and average floor space data are taken from the *Annual Report on the Borrowers Survey of House for Installment Sale* issued by the Government Housing Loan Corporation(GHLC). The housing price data reflects the prefectural average purchase price for ready-built houses purchased by those who borrow funds from the GHLC. The household annual income is based on those borrowers' reported average income. The survey comprises 46 prefectures and spans 25 years from 1980 to 2004. It does not cover Okinawa prefecture due to a lack of relevant data. Although using price series such as this is subject to criticism on the grounds that it does not control for quality improvements in the housing stock (see for example, Case and Shiller(1990) and Gyourko and Voith (1992), footnote 2), quality-adjusted price data for the vast majority of prefectures in Japan are not available. We use this GHLC data because it is available and provides broad cross-section time-series data. Although this price series is not

quality-adjusted price data in the strict sense, the owner-occupied housing in this data must meet some housing construction standards. Housing financed by the GHLC must conform to not only the Building Standards Law and related ordinances, but also to the housing construction standards established by the GHLC. The GHLC enforces these requirements through design and on-site inspections conducted by local government inspectors, thus ensuring that borrowers purchase quality housing.

To estimate construction costs, we use total floor space and total approximate estimation of construction costs for residential buildings in each prefecture from the *Construction Statistics Yearbook* issued by the Ministry of Land, Infrastructure and Transport. We divide total approximate estimation of construction costs by total floor space, and finally obtain a measure of construction costs by dividing it by a construction deflator.

The CPI index on interregional (prefectural) differences and time-series differences are taken from the *Japan Statistical Yearbook* and the *National Survey of Prices*.

Population data are taken from the *Japan Statistical Yearbook* .

Real housing price data is constructed by dividing the unit GHLC housing price data by the combined CPI index. The combined CPI index is constructed from the regional difference index of consumer prices in every year and the general time-series consumer price index as follows: the regional difference index of consumer prices are available in every year for every prefecture by setting the national average CPI at 100. By adjusting the national average CPI in every year to the general time-series CPI, it is possible to calculate a time-series adjusted regional difference index of consumer prices by combining the regional difference index of consumer prices to the time-series adjusted national average CPI.

Real income data are constructed by dividing the GHLC income data by the combined CPI index.

The ratio of nonresidential land area, a measure of the percentage of the land around the prefecture that is available for development, is constructed from total privately owned land area and total residential area of each prefecture from the *Summary Report on Prices, etc. of Fixed Assets (Land)* issued by the Ministry of Public Management, Home Affairs, Posts and Telecommunications. We first divide total residential area by total privately owned land area, obtain its ratio and finally obtain the ratio of nonresidential area by subtracting this ratio from unity.

Real user costs in Japan, which capture the cost of homeownership, consist of weighted average of real mortgage rate m, property tax rate t_h and expected rate of real house price inflation $\frac{\Delta P}{P}$ as follows. As depreciation, maintenance and repair expenditures are assumed to amount to a constant fraction of the house value, they are excluded. The income tax rate is also not included in Japan, because mortgage interest payments are not tax deductible.

$$\text{User cost } UC = m + t_h - \frac{\Delta P}{P} \qquad (4)$$

The weighted average of real mortgage rates consists of the multiplication of the GHLC borrowing interest rate by the share of GHLC loans and the multiplication of the non-GHLC interest rate by the share of the non-GHLC loans. The non-GHLC mortgage interest rate is taken from average interest rates on loans and discounts of domestic banks from the *Finance and Economic Statistics Monthly* of the Bank of Japan. Mortgage interest rates are a national series. We assume the non-GHLC loan interest rate is equal to the individual's opportunity cost of capital. The effective property tax

rate is calculated as follows. Although the standard property tax rate is 0.014, the effective property tax rate is much lower than 0.014, as the property tax assessment value is lower than the market value. As the *Summary Report on Prices, etc. of Fixed Assets (Land)* of the Ministry of Public Management, Home Affairs, Posts and Telecommunications reports the unit property tax assessment price per square meter of both land and structure for each prefecture in every year, we obtain the unit property tax assessment price per square meter of house by summing them up. We obtain the unit market price of the house per square meter of floor space from the GHLC data. Finally, we obtain the effective housing property tax rate by multiplying the ratio of the unit property tax assessment price to the unit market price of the house by the standard tax rate 0.014. The effective housing property tax rate thus varies by prefecture and year. As for the expected rate of real house price inflation $\frac{\Delta P}{P}$, we assume it is equal to the expected rate of real CPI increase. As for the expectation formation mechanism, we assume rational expectations. That is to say, the expected inflation rate at time t is equal to the actual inflation rate that happens from time t to t+1 (see DiPasquale and Wheaton(1996)). The expected inflation rate thus also varies by prefecture and year. In sum, in each region real user cost which is constructed based on equation (4) varies by prefecture and year. It is quite different from Capozza, Hendershott, and Mack (2004) in which user cost is mainly a time-series variable.

Table 1 presents summary statistics for those data. Figure 3 presents real house prices and their long run determinants in the low GHLC loan-to-value ratio prefectures. Figure 4 presents real house prices and their long run determinants in the high GHLC loan-to-value ratio prefectures. While the demographic variable increased steadily and

the ratio of nonresidential area decreased steadily in relatively more densely populated urban regions, the other variables have fluctuated more. Figures 5(1)-(3) graphically present average real house prices, real family income, real construction cost, real user cost, population and ratio of nonresidential area in the high and low GHLC loan-to-value ratio prefectures.

4. Empirical Estimation

4-1 Long-run Steady State Regression

First, we estimate the long run steady state price equation (1) based on panel data in each area. The long-run equilibrium real house prices in each area are a function of the real user cost, the real construction cost of converting land from non-residential(and/or agricultural use) to new residential use, and the size of the prefecture which is measured by population and real average income. All variables except real user costs are measured in logs.

Table 2 presents estimation results of equation (1). It is estimated using a one-way fixed effects panel model by incorporating prefecture fixed effects in each region.

It is expected that real house prices are positively related to real income, population and real construction costs while being negatively related to real user costs and nonresidential land ratio.

The coefficients on real income have the expected sign and are significant in every area. The coefficients on real user cost have the expected sign and are also significant in each area. The coefficients on construction costs have the expected sign and are significant in each area.

4-2 Short-run Dynamic Adjustment Equation

Next, we estimate equation (2) using the estimates of P* from the first stage regression. In equation (2), δ is the serial correlation coefficient, η is the mean reversion coefficient and λ is the contemporaneous adjustment of real prices to current shocks. Figure 6 presents real house prices and long-run equilibrium house prices from 1980 to 2004 in some prefectures.

Model A in Table 3 presents the estimation results of equation (2). The estimation was done by OLS, because the significance of the fixed effects for prefectures are rejected based on the F-test. Real house prices show a positive serial correlation in prefectures with low GHLC loan-to-value ratios, but prefectures with high GHLC loan-to-value ratios show a negative serial correlation. In prefectures with high GHLC loan-to-value ratios, real house prices converge to their long-run fundamental values faster than in prefectures with low GHLC loan-to-value ratios. Mean reversion is lower and serial correlation is positive in relatively low GHLC loan-to-value ratios areas (Chiba, Saitama, Tokyo, Kanagawa, Aichi, Siga, Kyoto, Nara and Osaka). Mean reversion is higher and serial correlation is negative in relatively high GHLC loan-to-value ratio areas.

Finally, we estimate equation (3) using the estimates of P* from the first stage regression. As explained in 3-1, population growth and real user cost changes (due to expectations about the housing market) , real construction cost (supply side factors) and real income (search costs) are hypothesized to correlate with serial correlation and mean reversion coefficients. That is to say, in this equation, serial correlation and mean reversion in each region are allowed to vary both by prefecture and by year.

Models K and K2 of Table 3 present the estimation results of equation (3). All of

them are estimated using OLS. It is expected that faster growth in population and real user cost are associated with greater autocorrelation. An increase in real construction cost is expected to lower mean reversion. Faster growth in real income is associated with higher mean reversion. All explanatory variables have the expected sign and almost all are significant only in the relatively high GHLC loan- to-value ratio areas.

Figure 7 plots the fitted values for the autocorrelation and mean reversion parameters for the 2 areas based on Table 3. The realizations are spread over two of the four ranges and encompass both oscillatory and non oscillatory behavior. Four ranges in Figure 7 are described based on the difference equation rewritten from equation (3). (See Capozza, Hendershott and Mack (2004) for details.) In Figure 7, only prefectures with high GHLC loan-to-value ratios lie in the non-oscillatory range. The realizations in all regions lie in the convergent range.

5. Conclusion

This paper has explored the relationship between homeowner borrowing patterns from the government public housing loan corporation (GHLC) and house-price dynamics by estimating serial correlation and mean reversion coefficients from a panel data of 46 prefectures for 1980 to 2004 in Japan. Our principal finding is that in prefectures where a greater fraction of homeowners are highly leveraged from GHLC –i.e. have high GHLC loan-to-value ratios (= low non-GHLC loan-to-value ratio) – housing prices react less sensitively to prefecture–specific shocks. That is to say, the fitted values for mean reversion and serial correlation in all prefectures with high GHLC loan–to-value ratio lie in the convergent non-oscillatory ranges. In contrast, the fitted values for mean reversion and serial correlation in all prefectures with high non-GHLC

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Figure1:Real house prices from 1980 to 2004 in high GHLC loan-to-value ratio prefectures and other prefectures

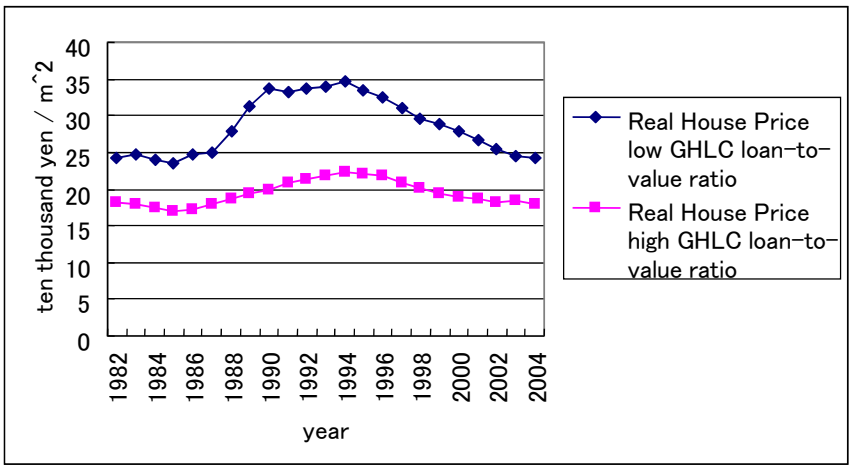


Figure2. Prefecture average GHLC loan-to-value ratios

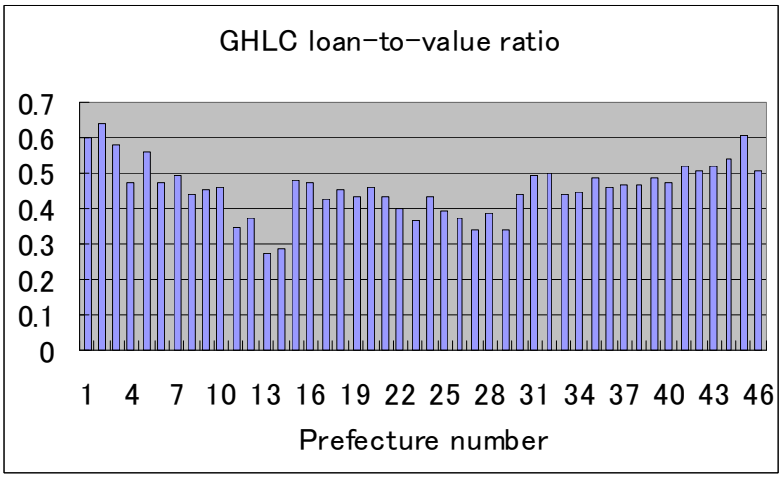


Table 1 Summary Statistics for Japanese Data (1980-2003)

Hokkaido-Tohoku(except Miyagi)					
Variable	Number of	mean	stdev	min	max
Real House Price (ten thousand yen/m^2)	144	17.25175	2.135172	11.30193	22.6087
Real family income (million yen)	144	4.260024	0.598642	2.821066	5.83653
Real Construction Cost (ten thousand yen/m^2)	144	0.104702	0.016761	0.010776	0.129528
Real User Cost	138	0.026966	0.024397	-0.04507	0.072492
Population (thousand)	144	2193.285	1585.612	1176	5699
Ratio of nonresidential area	144	0.965759	0.010846	0.929	0.985122
Minami-Kanto(Tokyo, Kanagawa, Chiba, Saitama)					
Variable	Number of	mean	stdev	min	max
Real House Price (ten thousand yen/m^2)	96	33.21194	7.535684	23.23438	53.06146
Real family income (million yen)	96	5.078024	0.810928	3.767801	6.750888
Real Construction Cost (ten thousand yen/m^2)	96	0.148634	0.02055	0.110402	0.207393
Real User Cost	92	0.027853	0.023576	-0.02651	0.071841
Population (thousand)	96	7924.229	2483.917	4735	12219
Ratio of nonresidential area	96	0.764499	0.103827	0.461	0.909572
Chubu(except Aichi)					
Variable	Number of	mean	stdev	min	max
Real House Price (ten thousand yen/m^2)	216	20.12783	2.429069	14.38978	26.43356
Real family income (million yen)	216	4.21937	0.580645	2.988879	5.428591
Real Construction Cost (ten thousand yen/m^2)	216	0.121715	0.016252	0.01088	0.156555
Real User Cost	207	0.027048	0.024086	-0.04273	0.081785
Population (thousand)	216	1786.514	867.5169	794	3786
Ratio of nonresidential area	216	0.939186	0.019295	0.836	0.967783
Kinki					
Variable	Number of	mean	stdev	min	max
Real House Price (ten thousand yen/m^2)	144	25.31168	3.998463	18.46371	35.22017
Real family income (million yen)	144	4.424389	0.561692	3.178599	5.315885
Real Construction Cost (ten thousand yen/m^2)	144	0.134117	0.013841	0.100826	0.170637
Real User Cost	138	0.028711	0.022912	-0.0323	0.081342
Population (thousand)	144	3399.868	2811.098	1061	8818
Ratio of nonresidential area	144	0.891709	0.104637	0.439	0.97485
Chugoku-Shikoku(except Hiroshima)					
Variable	Number of	mean	stdev	min	max
Real House Price (ten thousand yen/m^2)	216	19.76879	2.422345	8.271254	25.38079
Real family income (million yen)	216	4.259113	0.655222	2.996547	6.842912
Real Construction Cost (ten thousand yen/m^2)	216	0.118146	0.013905	0.010167	0.138342
Real User Cost	207	0.04159	0.079334	-0.03889	0.532323
Population (thousand)	216	1142.352	456.7208	604	2739
Ratio of nonresidential area	216	0.955403	0.020946	0.856	0.984403
Kyushu(except Fukuoka)					
Variable	Number of	mean	stdev	min	max
Real House Price (ten thousand yen/m^2)	144	17.80753	1.548665	14.69112	22.15036
Real family income (million yen)	144	4.196235	0.562162	3.078916	5.190226
Real Construction Cost (ten thousand yen/m^2)	144	0.108112	0.01058	0.08693	0.128392
Real User Cost	138	0.026806	0.022754	-0.04048	0.067533
Population (thousand)	144	1413.361	350.401	866	1866
Ratio of nonresidential area	144	0.943382	0.009057	0.906	0.956669
Nation					
Variable	Number of	mean	stdev	min	max
Real House Price (ten thousand yen/m^2)	1104	21.41103	5.477666	8.271254	53.06146
Real family income (million yen)	1104	4.35257	0.65229	2.821066	6.842912
Real Construction Cost (ten thousand yen/m^2)	1104	0.121798	0.033556	0.010167	0.207393
Real User Cost	1058	0.027	0.023	-0.045	0.089
Population (thousand)	1104	2660.637	2419.036	604	12219
Ratio of nonresidential area	1104	0.919501	0.075283	0.439	0.985122

Figure 3 Real House Prices and their Long Run determinants in the low GHLC loan-to-value ratio prefectures

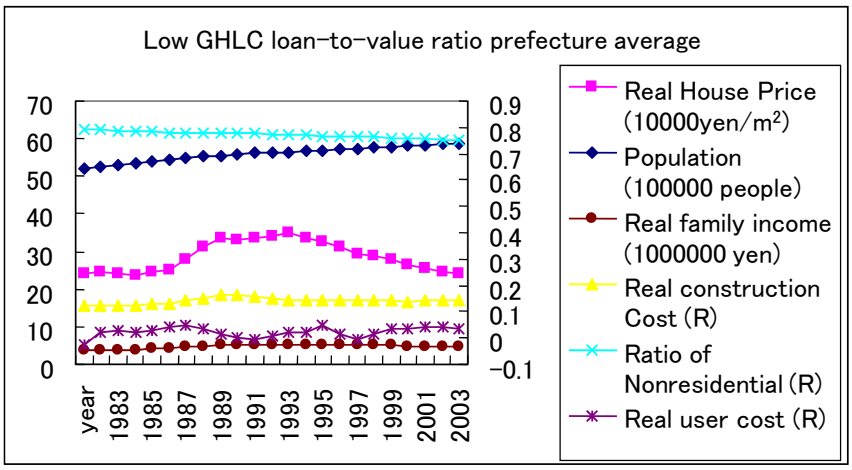


Figure 4 Real House Prices and their Long Run determinants in the high GHLC loan-to-value ratio prefectures

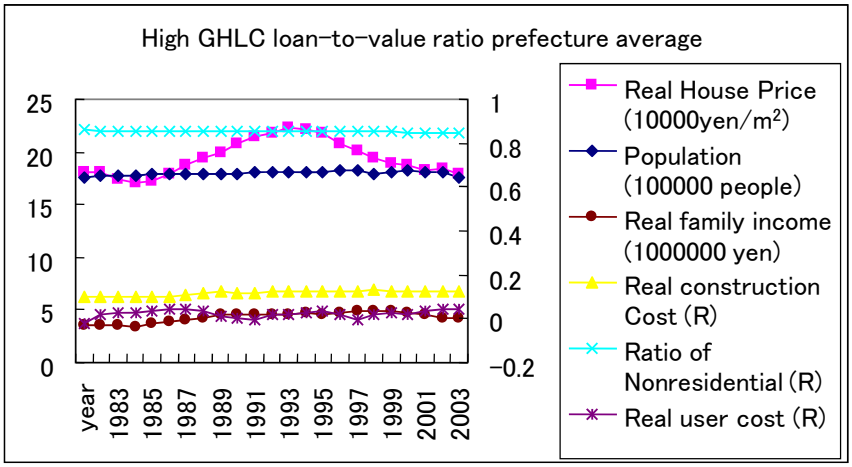
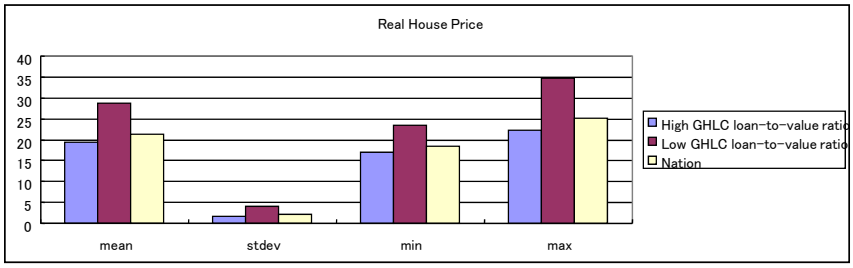


Fig 5(1):Statistics for Japanese Data



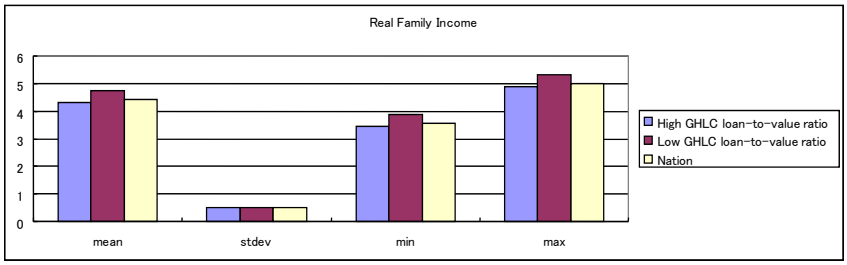
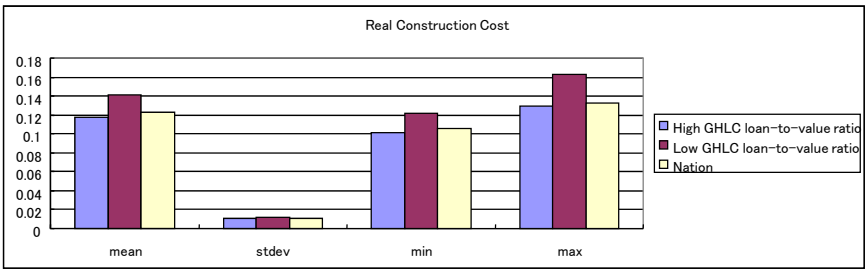


Fig 5(2):Statistics for Japanese Data



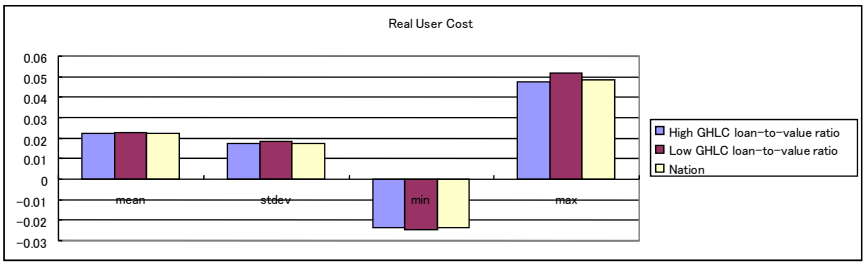
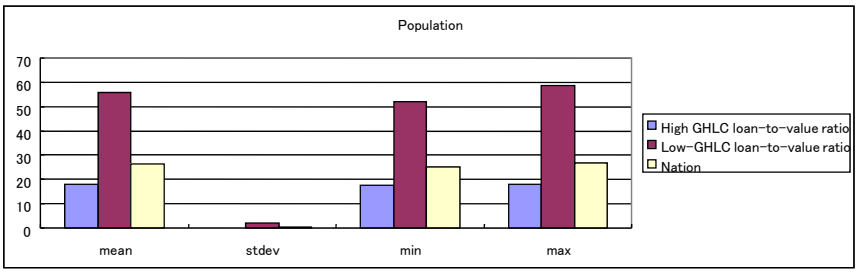
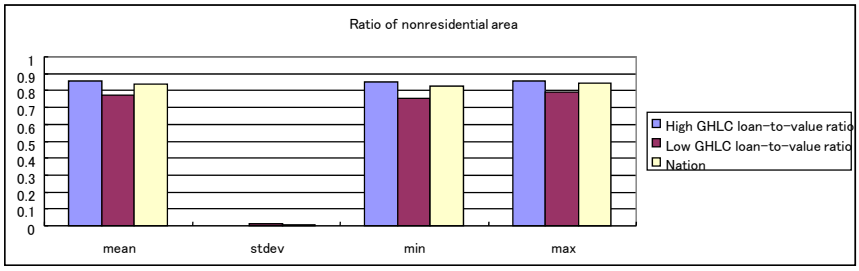
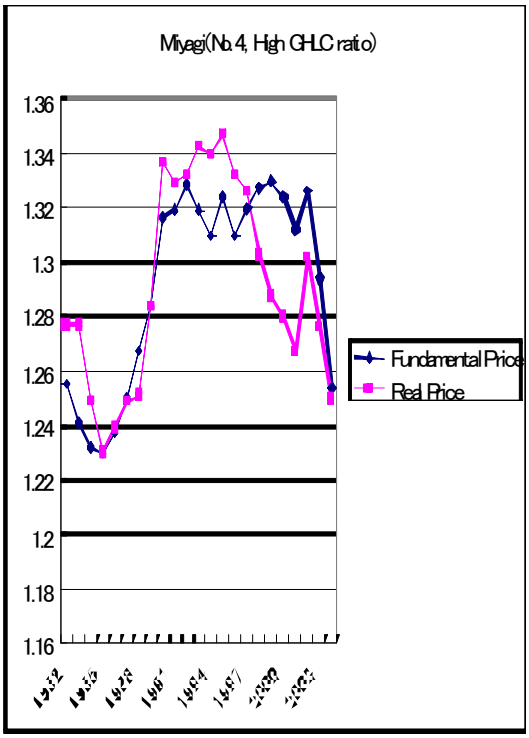


Fig 5(3):Statistics for Japanese Data





- Figure 6: Real House Prices and Long-run Equilibrium House Prices from 1980 to 2004 in some prefectures.



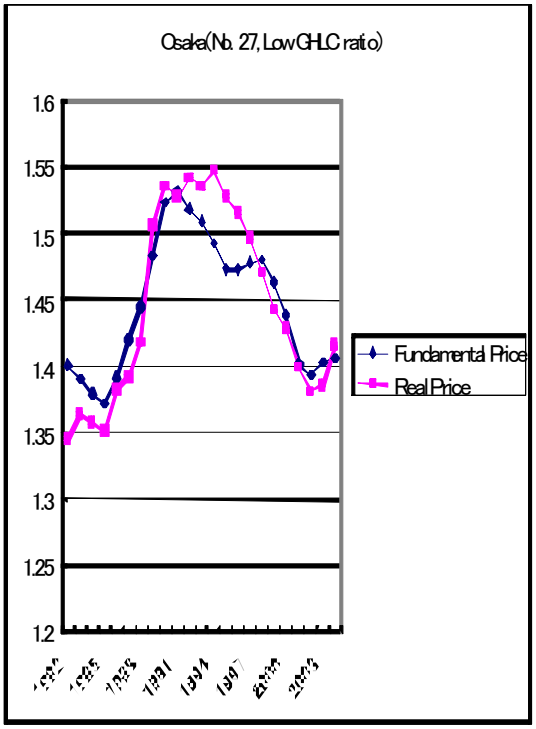


Table 2: Steady State Regression: Dependent Variable is the log of Real House Prices

(1)Prefectures with low GHLC loan-to-value ratios(Chiba, Saitama, Tokyo, Kanagawa, Aichi,Shiga, Kyoto, Nara, Osaka, Hyogo)		
Variable	one-way fixed(region)	
	coef	p-value
Log of Real Family Income	0.826725	0
Log of Real Constrution Cost	6.98E-01	0
Log of Nonresidential land Ratio	1.54892	0
log of Population	-0.79018	0
Real User Cost(Backward, weighted interest)	-0.05595	0.599
F-test(time dummy=0 region dummy=0)		
F-test(region dummy=0)		
F-test(time dummy=0)		
Adjusted R2	0.894357	
Number of Obs	230	

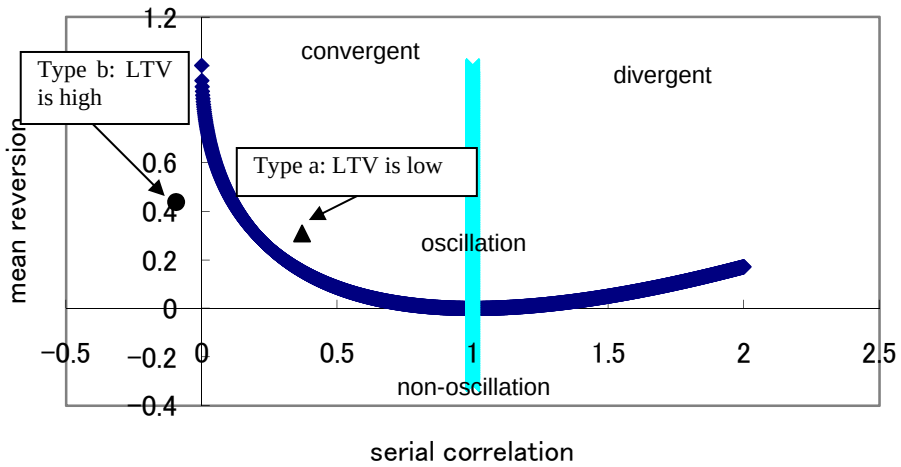
(2)Prefectures with high GHLC loan-to-value ratios		
Variable	one-way fixed(region)	
	coef	p-value
Log of Real Family Income	0.535104	0
Log of Real Constrution Cost	6.42E-02	0.002
Log of Nonresidential land Ratio	7.08607	0
log of Population	0.942165	0
Real User Cost(Backward, weighted interest)	-0.17749	0.005
F-test(time dummy=0 region dummy=0)		
F-test(region dummy=0)		
F-test(time dummy=0)		
Adjusted R2	0.662085	
Number of Obs	828	

Table 3: Second Stage Price Change Regression

(1)Prefectures with low GHLC loan-to-value ratios(Chiba, Saitama, Tokyo, Kanagawa, Aichi,Shiga, Kyoto, Nara, Osaka, Hyogo)						
Variable	A		K		K2	
	coef	p-value	coef	p-value	coef	p-value
Lagged Change in Log of Real House Price(P2)	3.72E-01	0	3.95E-01	0	3.87E-01	0
Deviation from Steady State(P3)	0.304388	0	0.286075	0	0.29262	0
Change in the First Stage Fitted(P4)	0.452917	0	0.426606	0	0.425936	0
Change in population * P2			-7.31E-04	0.349		
Change in Real Income *P2						
Change in Real Construction Cost *P2						
Change in Real User Cost *P2			-2.41211	0.388		
Change in Population *P3						
Change in Real Income *P3			-0.050794	0.598		
Change in Real Construction Cost *P3			28.4744	0.01	25.6063	0
Change in Real User Cost *P3						
F-test(time dummy=0 region dummy=0)						
F-test(region dummy=0)						
Adjusted R2	0.50613		0.533473		0.53638	
Number of Obs	210		210		210	

(2)Prefectures with high GHLC loan-to-value ratios						
	A		K		K2	
	coef	p-value	coef	p-value	coef	p-value
Lagged Change in Log of Real House Price(P2)	-9.29E-02	0.01	-1.02E-01	0.005	-1.09E-01	0.003
Deviation from Steady State(P3)	0.463782	0	0.439518	0	0.434722	0
Change in the First Stage Fitted(P4)	0.428992	0	0.423318	0	0.406702	0
Change in population * P2			2.58E-03	0.053		
Change in Real Income *P2						
Change in Real Construction Cost *P2						
Change in Real User Cost *P2			3.21E+00	0.006	3.21534	0.006
Change in Population *P3						
Change in Real Income *P3			0.159951	0.023	0.150794	0.031
Change in Real Construction Cost *P3			-7.16555	0.6		
Change in Real User Cost *P3						
F-test(time dummy=0 region dummy=0)						
F-test(region dummy=0)						
Adjusted R2	0.26802		0.285647		0.280298	
Number of Obs	756		756		756	

Figure 7: The fitted values for the mean reversion and serial correlation parameters for high GHLC loan-to-value ratio prefectures and low GHLC loan-to-value ratio prefectures in Japan



▲Type a: Low GHLC loan-to-value ratio prefectures (Chiba, Saitama, Tokyo, Kanagawa, Aichi, Shiga, Kyoto, Nara, Osaka, Hyogo)

●Type b: High GHLC loan-to-value ratio prefectures (36 remaining prefectures)

Table 4:Japanese prefectures and regions(1)

Prefecture name	Prefecture number	GHLC LTV ratio is low
Hokkaido	1	
Aomori	2	
Iwate	3	
Miyagi	4	
Akita	5	
Yamagata	6	
Fukushima	7	
Ibaraki	8	
Tochigi	9	
Gunma	10	
Saitama	11	○
Chiba	12	○
Tokyo	13	○
Kanagawa	14	○
Niigata	15	
Toyama	16	
Ishikawa	17	
Fukui	18	
Yamanashi	19	
Nagano	20	
Gifu	21	
Shizuoka	22	

Table 4:Japanese prefectures and regions(2)

Aichi	23	○
Mie	24	
Shiga	25	○
Kyoto	26	○
Osaka	27	○
Hyogo	28	○
Nara	29	○
Wakayama	30	
Tottori	31	
Shimane	32	
Okayama	33	
Hiroshima	34	
Yamaguchi	35	
Tokushima	36	
Kagawa	37	
Ehime	38	
Kochi	39	
Fukuoka	40	
Saga	41	
Nagasaki	42	
Kumamoto	43	
Oita	44	
Miyazaki	45	
Kagoshima	46	