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Determinants of Prefectural House Price Dynamics in Japan 1980-2002

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The purpose of this paper is to explore the dynamics of real house prices by estimating serial correlation and mean reversion coefficients from a panel data of 46 prefectures for 1980 to 2002 in Japan. The serial correlation and mean reversion parameters are shown to vary cross-sectionally with population growth and real income growth. These parameters are also shown to vary cross-sectionally with changes in real user costs and real construction costs. Serial correlation is higher in prefectures with higher population growth. Serial correlation is also higher in prefectures with more volatile changes in real user costs. Mean reversion is higher in prefectures with higher income growth. Mean reversion is lower in prefectures with more volatile changes in real construction costs.

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Key Words

House price dynamics, Panel data, Serial correlation, Mean reversion, Japan

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 it was in 1986 when the rise began accelerating rapidly. The rise in land prices spread from Tokyo to major cities such as Osaka and Nagoya and then later to other urban areas. What determines these land and housing price movements in Japan? Especially, what determines swings in regional house prices in Japan?

The purpose of this paper is to address these issues by analyzing house price movements across local metropolitan areas in Japan by focusing on both short horizon serial correlation and long horizon mean reversion. Although there are several studies about housing price movements across local metropolitan areas in the U.S. and Sweden such as Case and Shiller (1989), Abraham and Hendershott (1992, 1996), Capozza and Seguin (1996), Capozza, Hendershott, Mack and Mayer(2002), Malpezzi(1999) and Hort(1998), there are no comparable studies for Japan. This is the first detailed empirical study of regional housing price movements covering almost all Japanese prefectures that focuses on both short horizon serial correlation and long horizon mean reversion .

In this study, prefectures, analogous to states in the United States, are units of observation. The data encompasses 46 of 47 prefectures and spans 23 years from 1980 to 2002. The panel data includes all Japanese prefectures for which annual data on the prices of single-family detached owner occupied housing, annual income, population, construction costs, residential and nonresidential land area, assessment values for property tax purpose, total floor space of the average house and a local consumer price

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

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 Section5 offers some concluding remarks.

2. Model

We assume 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.

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

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(1989, 1990), DiPasquale and Wheaton(1996)).

We assume, following Abraham and Hendershott (1996) and Capozza, Hendershott, Mack and Mayer(2002), that short-run dynamics in real house prices are explained by:

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

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. η is the mean reversion coefficient. That is to say, $\eta\ (0 < \eta < 1)$ is the rate of adjustment to fundamental value and λ is the adjustment coefficient to fundamentals.

We further assume, following Capozza, Hendershott, Mack and Mayer(2002), that 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 are explained by :

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

where $\delta_{jt} = \delta + \sum_i \delta^i (Y^i_{jt} - Y^{i*}_t)$ and $\eta_{jt} = \eta + \sum_i \eta^i (Y^i_{jt} - Y^{i*}_t)$. 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*}_t is the mean value. μ_{jt} represents random error.

3. Hypothesis and Data

3.1 Hypothesis

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 markets have greater anticipated house price appreciation. Higher real user cost may also correlate with more serial correlation, because buyers in the booming market (and thus higher real user cost market) may wish to buy houses as an investment and buy houses before a rapid increase in real user cost. Strong market conditions should correlate with more serial correlation.

3-2 Data

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 23 years from 1980 to 2002. 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. I 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 Standard 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 building of each prefecture from the *Construction Statistics Yearbook* of Ministry of Land, Infrastructure and Transport, 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 *Japan Statistical Yearbook* and the *National Survey of Prices*.

Population data are taken from *Japan Statistical Yearbook* .

Real housing price data is constructed by dividing the 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)* of 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 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, it is 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 mortgage interest rate is taken from average interest rates on loans and discounts of domestic banks from the *Finance and Economic Statistics Monthly* of Bank of Japan. Mortgage interest rates are a national series. 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 rational expectation. 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, real user cost which is constructed based on equation (4) varies by prefecture and year.

Table 1 presents summary statistics for those data. The prefectures included in the study are listed in the Appendix.

Figure 1 presents the aggregate development of long run determinants of aggregate real house prices. While the demographic variable increased steadily and the ratio of nonresidential area decreased steadily, the other variables have fluctuated more.

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 Japan. The long-run equilibrium real house prices 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 cost are measured in logs.

Table 2 presents estimation results of equation (1). Model A of Table 2 is estimated using OLS based on pooled data. Model B of table 2 is estimated using a two-way fixed effects panel model by incorporating both prefecture and year fixed effects. Based on the F statistic, the evidence is strongly in favor of both the prefecture specific and the year specific effects. We reject these fixed effects are equal zero at the 0.001 confidence level.

All explanatory variables have the expected sign, and almost all are significant. As expected, real house prices are positively related to real income, population, real construction cost and are negatively related to real user cost and the ratio of nonresidential land area. Real user cost and the log of real income are highly significant.[2]

4-2 Short-run Dynamic adjustment equation

Next, we estimate equation (2) using the estimates of P* from the first stage regression. We use P* from the estimation results of Model B in Table 2. 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 2(1)-(4) show the movements of difference in log real house prices and their

[2] Seko(2003) has shown that Japanese regional housing price trends are predictable by economic fundamentals.

short run determinants in the Tokyo Metropolis, Akita, Nagasaki and Mie prefectures for 1981 to 2002. Tokyo has the most volatile difference in log real house prices, higher population and income growth, while Akita has the least volatile difference in lagged log real house prices. Again, Nagasaki has the lowest population growth, while Mie has the lowest income growth. It is clear from these figures that among different prefectures movements of difference in log real house prices and their determinants vary very much.

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 all prefectures are rejected based on F-test. Real house prices in Japan show a strong serial correlation, with a coefficient of 0.32. This figure is similar to findings in US studies. In addition, real house prices take a very long time to converge to their long-run fundamental values, with a coefficient of 0.14. The adjustment coefficient λ shows that current real house prices overadjust to predicted real house price levels in the year of the shock.

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

Models B and C of Table 3 present the estimation results of equation (3). Both of them are estimated using OLS. Faster growth in population and real user cost are associated with greater autocorrelation. Faster growth in real income is associated with greater mean reversion, which is consistent with the search model. As expected, an

increase in real construction cost lowers mean reversion. While the results on the impact of various factors explaining the degrees of serial correlation and mean reversion are consistent with the hypothesis, they are weaker than the results for the US.

5. Conclusion

This paper explored the dynamics of regional real house prices by estimating serial correlation and mean reversion coefficients from panel data for 46 prefectures between 1980 to 2002 in Japan. The results showed that variation in the cyclical behavior of real house prices across prefectures is due to more than just variation in local economies. House prices react differently to economic shocks depending on such factors as prefecture size, growth rates, construction costs and real user costs.

From a policy perspective, this study suggests ways to reduce the volatility of real house prices. The development of a futures market may help to ensure more efficient pricing in Japan as it does in the US. In addition , reducing the volatility of the effective property tax rate may also help to ensure more efficient pricing in Japan, as the real user costs we constructed are highly significant.

It is also worth to pursue further comparative analysis among different countries and identify the determinants of regional real house price dynamics.

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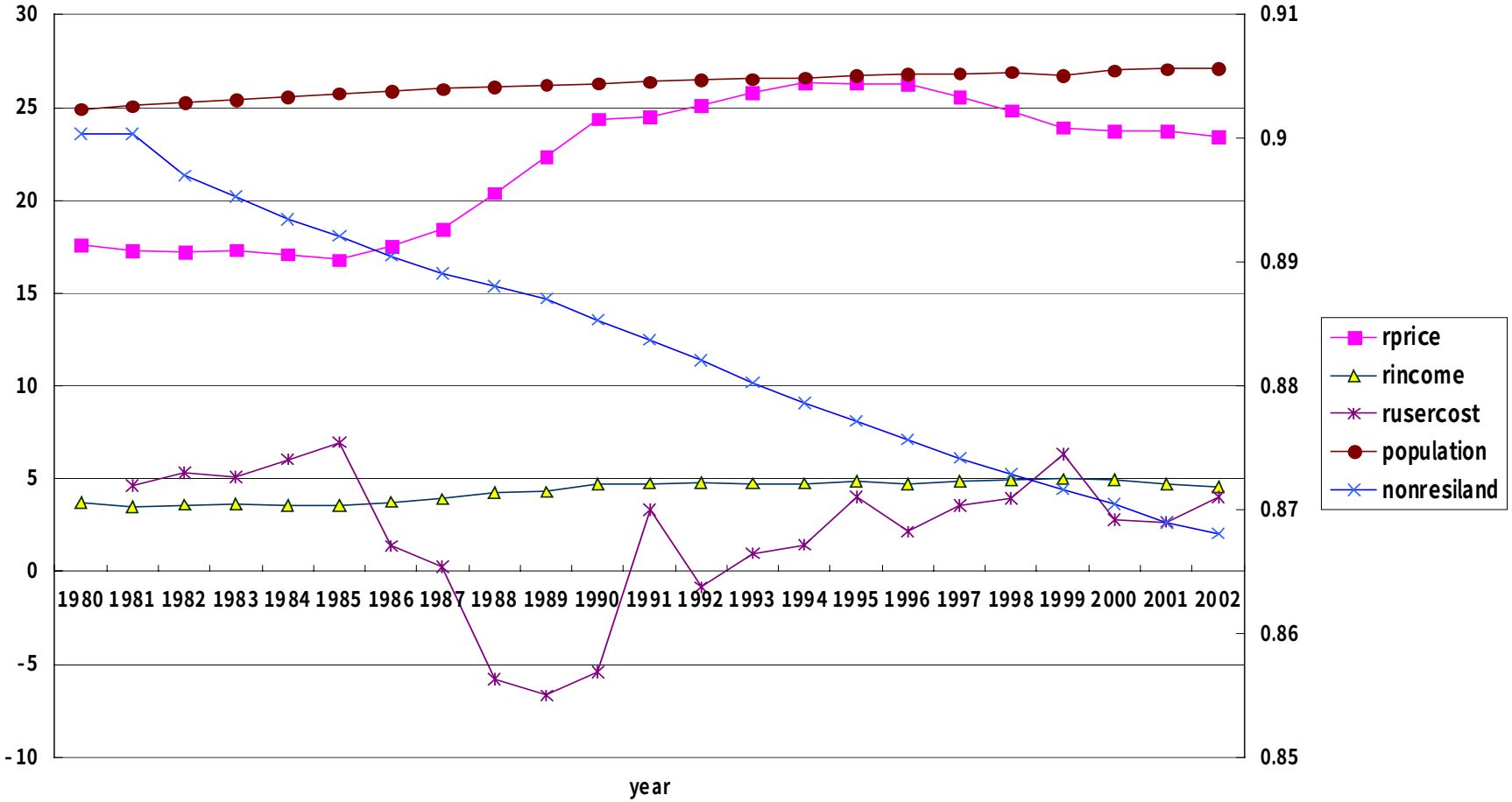
Table 1 Summary Statistics

Variable	No. of Obs	Mean	Std. Dev.	Min	Max
Real House Price	1058	21.991	5.406	8.495	46.906
Real Income	1058	4.349	0.658	2.821	6.843
Real Construction Cost	1081	0.122	0.034	0.010	1.037
Ratio of Nonresidential Area	1081	0.884	0.105	0.442	0.978
Population(10^3)	1081	2625.057	2395.591	604	12219
Real User Cost	1012	2.101	9.039	-174.497	69.107

Figure 1 Aggregate real house prices and their long run determinants



All variables except ratio of nonresidential area are measured on the leftside vertical axis.

Figure 2(1) Log real house price difference and its short run determinants in Tokyo Metropolis

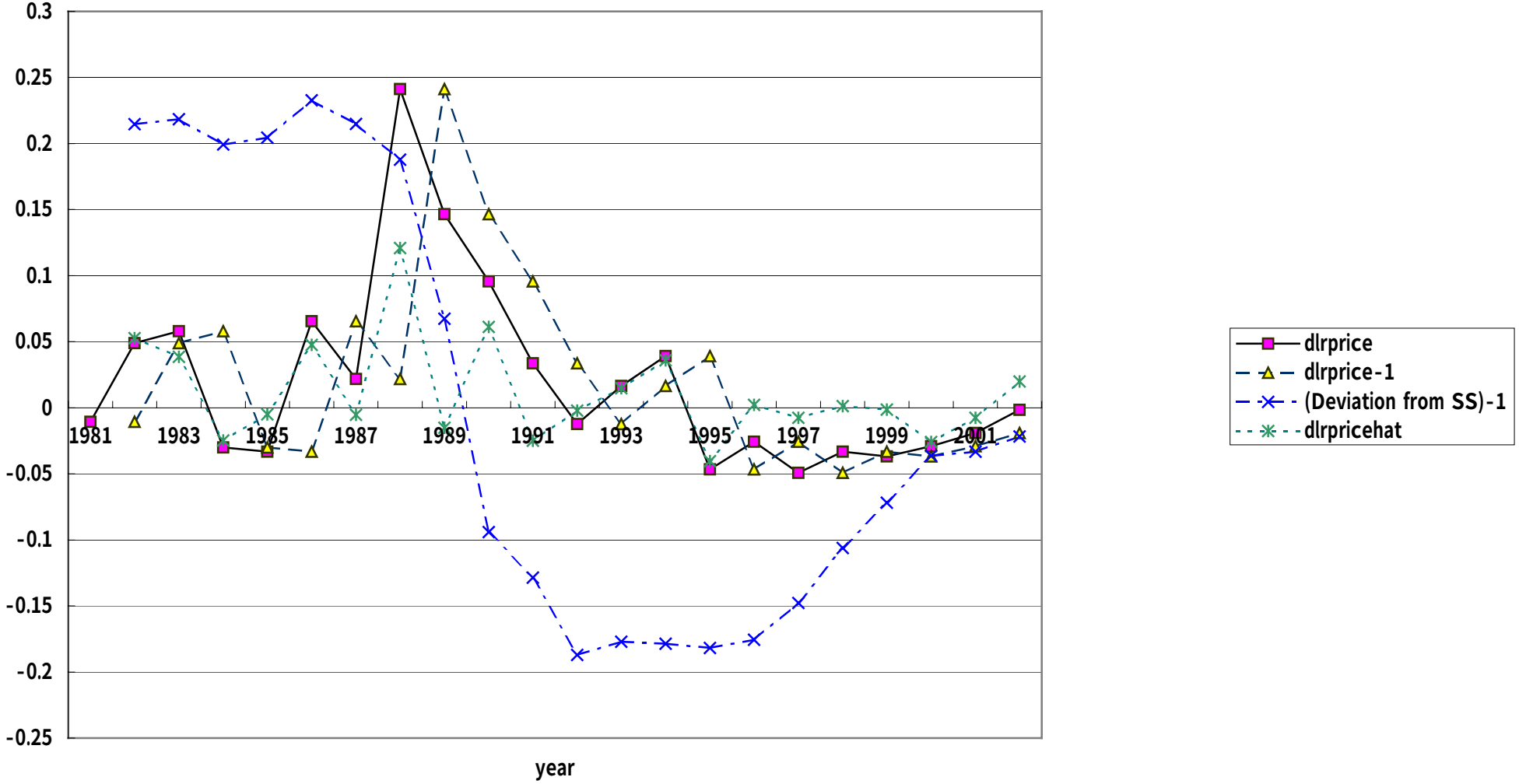


Figure 2(2) Log real house price difference and its short run determinants in Akita prefecture

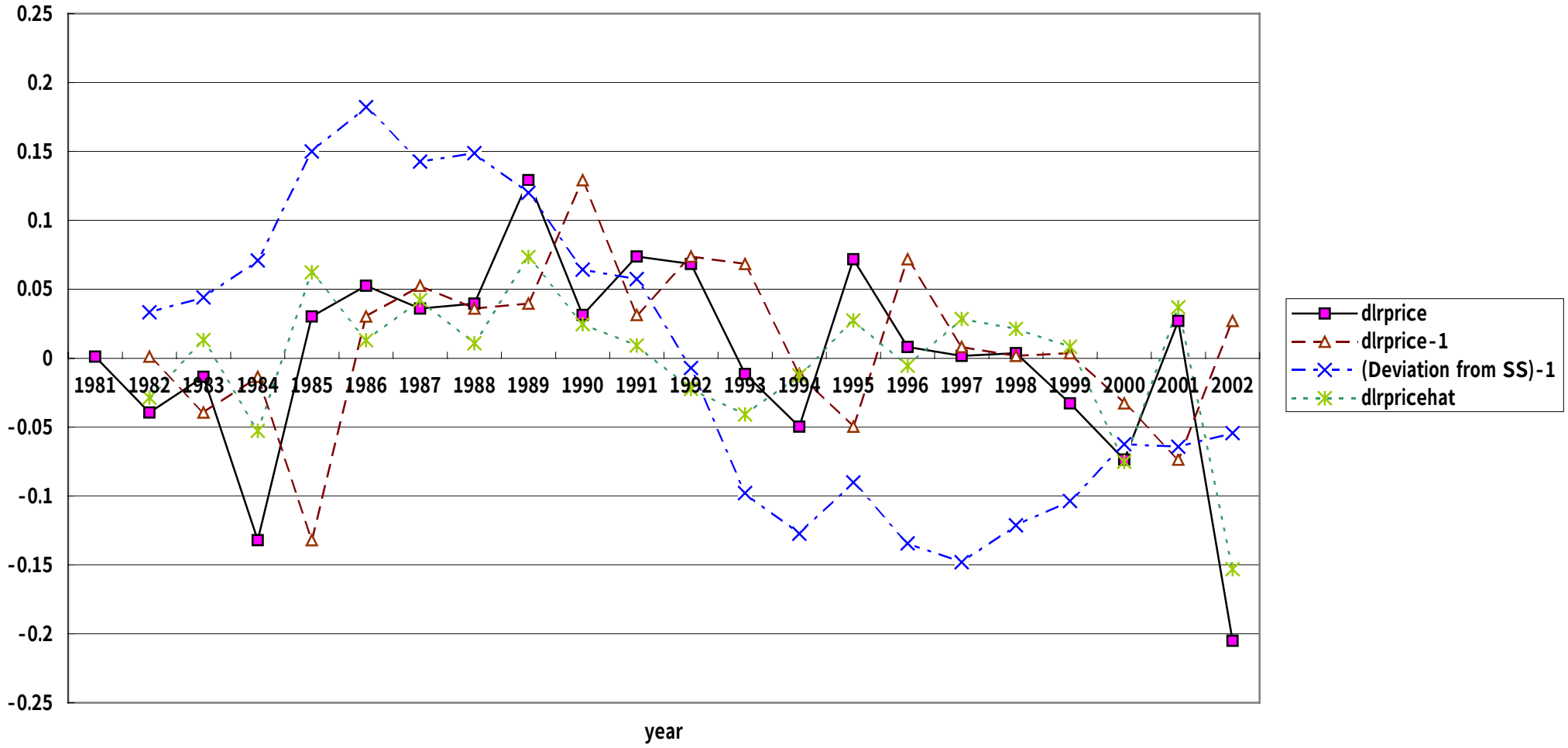


Figure 2(3) Log real house difference and its short run determinants in Nagasaki prefecture

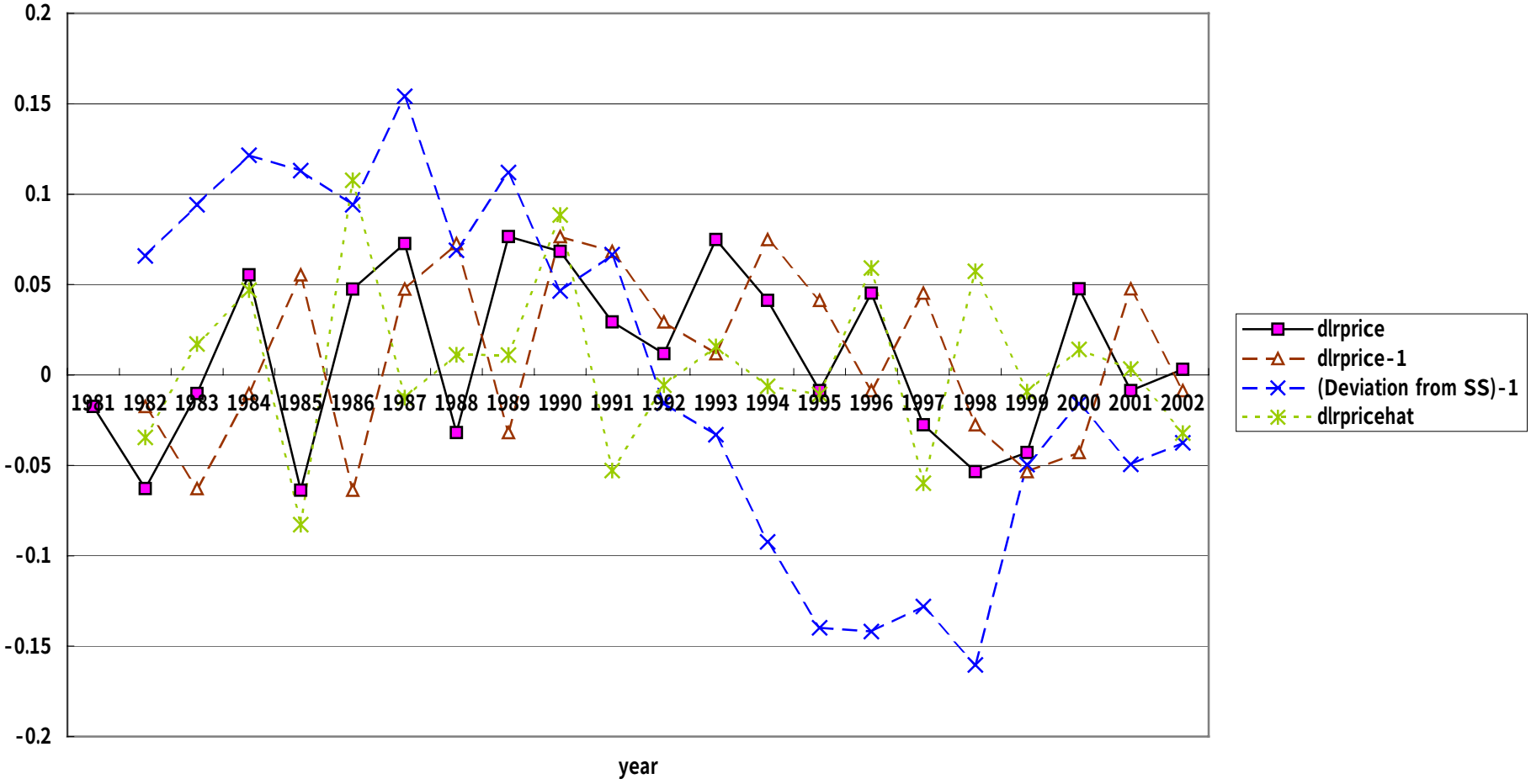


Figure 2(4) Log real house price difference and its short run determinants in Mie prefecture

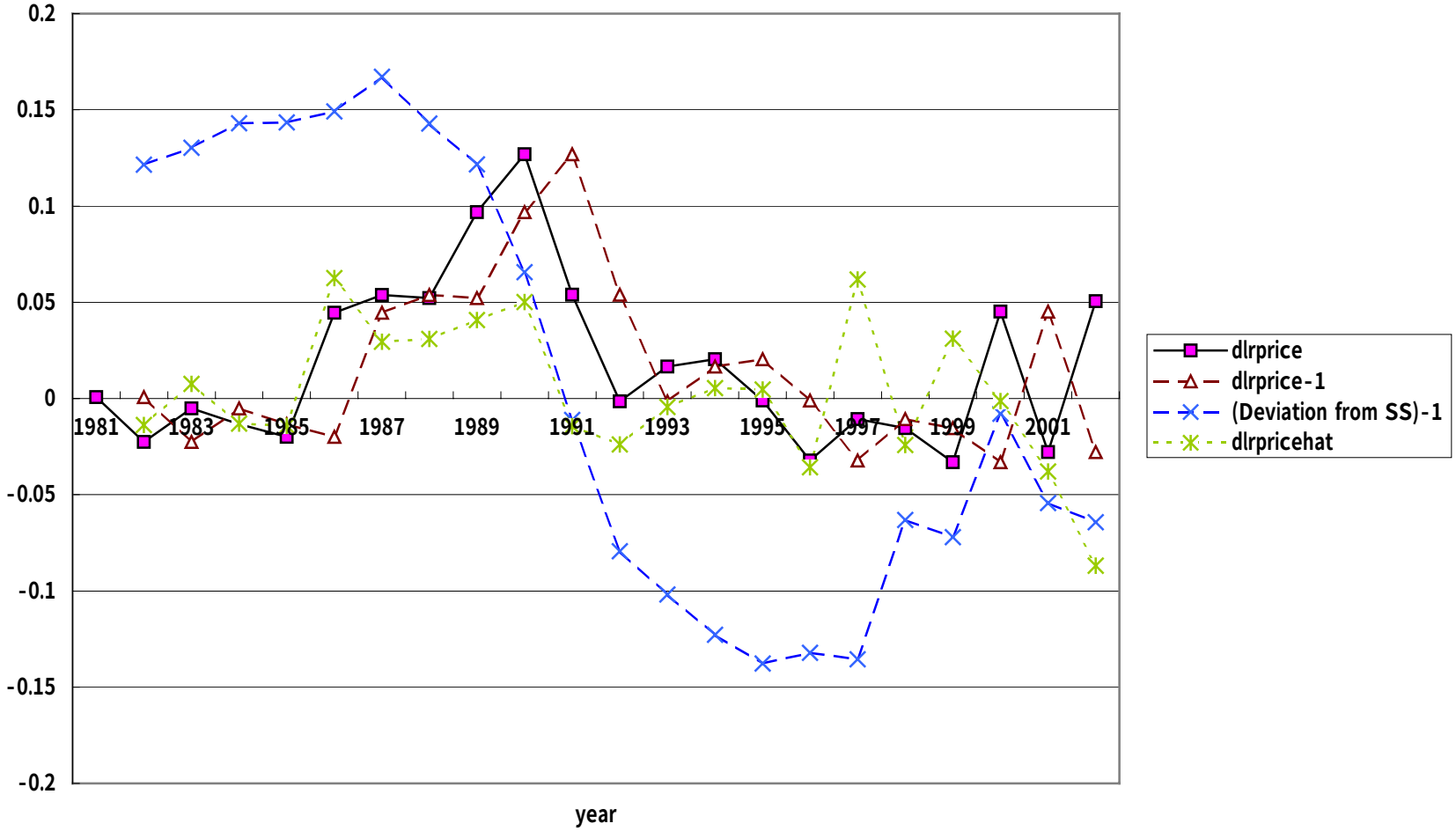


Table 2 Steady State Regression

Dependent variable is the log of Real House Prices.

	Model										
Variable	A: OLS estimates based on Pooled data				B: Parameter estimates of two way fixed effects model (prefecture, year)						
	Coef.	Std. Err.	t	P>|t|	Coef.	Std. Err.	t	P>|t|			
Log of Real Median Income	0.994	0.027	36.634	0.000	0.481	0.039	12.427	0.000			
Log of Real Construction Cost	0.243	0.020	12.337	0.000	0.034	0.013	2.566	0.010			
Log of Nonresidential Land Ratio	-0.305	0.034	-9.120	0.000	-0.240	0.192	-1.251	0.211			
Log of Population	0.008	0.007	1.149	0.251	0.318	0.085	3.761	0.000			
Real User Cost	-0.002	0.000	-5.539	0.000	-0.003	0.000	-12.248	0.000			
Intercept	2.036	0.084	24.119	0.000	-0.001	0.637	-0.002	0.998			
Adjusted R^2	0.794				0.935						
Number of observations	1012				940						

Table 3 Second Stage Price Change Regression

Dependent variable is the First Difference of the log of Real House Prices. Ordinary least squares estimates of equation (1) with steady state values estimated from Model B of table 2.

Variable	Model											
	A				B				C			
	Coef.	Std. Err.	t	P>|t|	Coef.	Std. Err	t	P>|t|	Coef.	Std. Er	t	P>|t|
Change in the First Stage Fitted	1.133	0.035	32.800	0.000	1.111	0.035	32.000	0.000	1.110	0.033	33.600	0.000
Lagged Change in Log of Real House Price	0.316	0.024	13.010	0.000	0.303	0.024	12.440	0.000	0.322	0.023	14.020	0.000
Change in Population times Lagged Log Real House Price Change					0.002	0.001	3.230	0.001				
Change in Real User Cost times Lagged Log Real House Price Change									0.002	0.000	10.670	0.000
Deviation from Steady State	0.137	0.015	8.900	0.000	0.127	0.016	8.050	0.000	0.102	0.015	6.900	0.000
Change in Real Income times Deviation from Steady State					0.132	0.052	2.550	0.011				
Change in Log Real Construction Cost times Deviation from Steady State									-0.197	0.066	-2.980	0.003
Adjusted R^2	0.587				0.593				0.633			
Number of observations	966				966				966			

Appendix Table A Japanese Prefectures

Prefecture Number	Prefecture Name
1	Hokkaido
2	Aomori
3	Iwate
4	Miyagi
5	Akita
6	Yamagata
7	Fukushima
8	Ibaraki
9	Tochigi
10	Gunma
11	Saitama
12	Chiba
13	Tokyo
14	Kanagawa
15	Niigata
16	Toyama
17	Ishikawa
18	Fukui
19	Yamanashi
20	Nagano
21	Gifu
22	Shizuoka
23	Aichi
24	Mie
25	Shiga
26	Kyoto
27	Osaka
28	Hyogo
29	Nara
30	Wakayama
31	Tottori
32	Shimane
33	Okayama
34	Hiroshima
35	Yamaguchi
36	Tokushima
37	Kagawa
38	Ehime
39	Kochi
40	Fukuoka
41	Saga
42	Nagasaki
43	Kumamoto
44	Oita
45	Miyazaki
46	Kagoshima