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Residential Rents and Price Rigidity: Micro Structure and Macro Consequences

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Abstract

Why was the Japanese consumer price index for rents so stable even during the period of housing bubble in the 1980s? In addressing this question, we start from the analysis of microeconomic rigidity and then investigate its implications about aggregate price dynamics. We find that ninety percent of the units in our dataset had no change in rents per year, indicating that rent stickiness is three times as high as in the US. We also find that the probability of rent adjustment depends little on the deviation of the actual rent from its target level, suggesting that rent adjustments are not state dependent but time dependent. These two results indicate that both intensive and extensive margins of rent adjustments are very small, thus yielding a slow reponse of the CPI to aggregate shocks. We show that the CPI inflation rate would have been higher by one percentage point during the bubble period, and lower by more than one percentage point during the period of bubble bursting, if the Japanese housing rents were as flexible as in the US.

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1 Introduction

Fluctuations in real estate prices have substantial impacts on economic activities. For example, land and house prices in Japan exhibited a sharp rise in the latter half of the 1980s, and its rapid reversal in the early 1990s. This wild swing led to a significant deterioration of the balance sheets of firms, especially those of financial firms, thereby causing a decade-long stagnation of the economy. Another recent example is the U.S. housing market bubble, which started somewhere around 2000 and is now in the middle of collapsing. These recent episodes have rekindled researchers' interest on housing bubbles.

In this paper we focus on the movement of housing rents during the Japanese bubble period. Specifically, we are interested in the fact that the Japanese consumer price index for rents did not exhibit a large swing even during the bubble period. Why was the CPI rent so stable? This is an important question because, as emphasized by Goodhart (2001), the housing rent is a key variable linking asset prices and the indices of goods and services prices, like the CPI.

We start from the analysis of individual housing rents using the micro data, and then proceed to the investigation of its implications about aggregate rent indices, including the CPI rent. In doing this, we construct two datasets. The first one contains 720 thousand listings of housing rents posted in a weekly magazine over the last twenty years. This is a complete panel data for more than 300 thousand units, although this covers rent adjustments only at the time of unit turnover. The second dataset is a bundle of contract documents for 15 thousand units managed by a major property management company, and covers both new and rollover contracts that were made in March 2008.

Our main findings are as follows. First, the probability of no rent adjustment is about 89 percent per year, implying that the average price duration is longer than 9 years. This is much lower than the corresponding figures in other countries: Genesove (2003) reports that the probability of no rent adjustment in the U.S. is about 29 percent per year; Hoffmann and Kurz-Kim (2006) reports that the corresponding figure in Germany is 78 percent. We also find that the rent levels were unchanged for about 97 percent of the entire contract renewals that took place in March 2008, suggesting that there exists some sort of implicit long-term contract between a landlord and an existing tenant. We argue that this accounts for, at least partially, higher stickiness in the Japanese housing rents.

Second, the probability of rent adjustment depends little on the deviation of the actual rent from its target level (or its market value), which is estimated by hedonic regressions. This suggests that rent adjustment is close to time dependent rather than state dependent. Furthermore, we estimate the Caballero and Engel's (2007) measure of price flexibility (i.e. price flexibility in terms of the impulse response function) and decompose it into the magnitude of individual rent changes (namely, intensive margin) and the fraction of adjusting units (extensive margin). We find that the intensive and extensive margins accounts for 87 and 13 percents, respectively, of the Caballero-Engel's measure of price flexibility.

Third, we evaluate the quantitative importance of the above two findings by reestimating CPI inflation under the assumption that stickiness in rents were as low as in the U.S. We find that the CPI inflation rate would have been higher by 1 percentage point during the bubble period (i.e. the latter half of the 1980s), and lower by more than 1 percentage point during the period of bubble bursting, thus deflation would have started one year earlier than it actually occurred.

The rest of this paper is organized as follows. Section 2 provides details about the two datasets we will use in this paper. Section 3 provides the estimates for the frequency of rent adjustments. In Section 4 we investigate whether rent adjustments are state-dependent or time-dependent. We estimate the measure of price flexibility proposed by Caballero and Engel (2007) and decompose it into the intensive and extensive margins. In Section 5 we evaluate the quantitative importance of our findings by reestimating CPI inflation in the 1980s and the 90s under the assumption that stickiness in housing rents were as low as in the U.S. Section 6 concludes the paper.

2 Data

Housing rents are adjusted for two different reasons: they are adjusted when a new tenant arrives and a new contract between the tenant and a landlord is made; they are also adjusted when a contract is renewed by a tenant who has decided to continue living in the same property after completing the period of the previous lease contract (i.e. rollover contract). To investigate these two types of rent adjustments, we construct two dataset: the first one is a collection of asking prices posted in a weekly magazine, covering rental prices in new contracts; the second one is a collection of contract documents for housing units managed by a property management company, covering rental prices in both new and rollover contracts.

Table 1: Two Datasets

	Recruit Data		Daiwa Data	
Sample period	1986-2006		March 2008	
Frequency	Weekly		One month	
Area	Special Wards in Tokyo		Tokyo Metropolitan Area	
Type of data	Asking prices in a magazine		Transaction prices	
Coverage	New contracts		New and rollover contracts	
Compiled by	Recruit Co., Ltd.		Daiwa Living Co., Ltd.	
Number of units	338,459		15,639	
Number of observations	718,811		15,639	
	mean	s.d	mean	s.d
Monthly rent (yen)	122,222	82,794	87,942	43,217
Floor space (square meter)	37.21	20.89	42.44	17.80
Rent per square meter (yen)	3,396	880	2,234	667
Age of unit (years)	8.75	7.74	7.45	5.17
Time to a nearest station (minutes)	7.18	4.01	10.84	5.85
Time to central business district (minutes)	10.19	6.45	25.18	14.03
Market reservation time (weeks)	9.22	8.65	na	na

The Recruit Data We collect rental prices for new contracts from a weekly magazine, *Shukan Jutaku Joho* (Residential Information Weekly) published by Recruit Co., Ltd., one of the largest vendors of residential information in Japan.

Our dataset has two important features. First, *Shukan Jutaku Joho* provides the time-series of a rental price from the week when it is first posted until the week it is removed because of successful transaction.[1] We use the price only at the final week because it can be safely regarded as sufficiently close to the contract price.[2] Second, we use information only for housing units managed by major property management companies. Based on a special contract with Recruit Co., Ltd., they *automatically* report it to Recruit whenever a turnover occurs in one of the housing units they manage. Thus we are allowed to create a complete panel dataset for those housing units, containing information about the exact timing of start and end of a contract, as well as information on the rent and the quality of each housing unit, including its age, its floor and balcony space (in square meters), commuting time to a nearest station, and so on.

Table 1 presents its basic properties. The Recruit dataset covers the twenty three

[1]There are two reasons for the listing of a unit being removed from the magazine: a new tenant is successfully found, or the owner gives up finding a new tenant and thus withdraws. We are allowed to make access to information about which of the two reasons is applied for individual cases. We discard the latter cases.

[2]Recruit Co., Ltd. provides us with information about contract prices for about 24 percent of the entire listings. Using this information, we confirm that prices at the final week are almost always identical to contract prices (i.e., they differ at the probability of less than 0.1 percent).

Table 2: Attributes of Housing Units

Variable		Definition
FS	Floor space	
AGE	Age of Building: Number of years since construction	Period between the date when the data is deleted from the magazine and the date of construction of the building
TS	Time to a nearest station	Time distance to the nearest station (walking time)
TT	Commuting time to central business district	Minimum of railway riding time during the daytime to terminal 7 stations in 2005
BS	Balcony space	
RT	Market reservation time	Period between the date when the data appear in the magazine for the first time and the date of being deleted
FF	First floor dummy	The property is on the ground floor 1, otherwise 0
HF	Highest floor dummy	The property is on the top floor 1, otherwise 0
SD	South-facing dummy	Fenestrate facing south 1, otherwise 0
THD	Timbered house dummy	Timbered house 1, otherwise 0
LD_j	Location (ward) dummy	jth administrative district 1, otherwise 0
RD_k	Railway line dummy	kth railway line 1, otherwise 0
TD_l	Time dummy (monthly)	lth quarter 1, otherwise 0

special wards of Tokyo for the period of 1986 to 2006, including the "bubble" period in the late 1980s and the early 90s. It contains 718,811 listings for 338,459 units.[3] The average monthly rent is 122,000 yen with a standard deviation of 82,000 yen. The average floor space is 37.21 square meters, indicating that they are mainly for single-person households.[4] The average time to a nearest station is 7.2 minutes and commuting time to central business district is about 10 minutes, indicating that the units in the dataset are those with high transportation convenience. Table 2 provides a list of attributes related to housing units, which we will use later in hedonic regressions.

Figure 1 depicts the movement of a housing rent index that is estimated by hedonic regression using the Recruit data, together with similar indices for selling prices that are also estimated by hedonic regressions using the selling-price data provided by Recruit. Figure 1 shows that the selling price indices exhibited a sharp rise from 1986 toward the end of 1987. After a temporary decline in 1988, they started to rise once again until peaking at the end of 1990, when they reached about three times as high as their levels

[3]Shimizu et al. (2004) reports that the Recruit data covers more than 95 percent of the entire transactions in the twenty three special wards of Tokyo. On the other hand, its coverage in suburban area is very limited. We use only information for the units located in the special wards of Tokyo.

[4]The floor space is much smaller for the units for rent than those for sale: the average floor space of non-timbered houses for sale is 56 square meters and that of timbered houses is 73 square meters. They are for families with two or more members.

at the beginning of the sample period.[5] In contrast to such a large swing in the selling price indices, the rental price index is fairly stable, implying substantial fluctuations in the rent-price ratio, or the capitalization rate. However, if we compare our rent index with the CPI rent, we get a different picture. Figure 2 compares ours and the rent index taken from the CPI in Tokyo. Our index rose until the second quarter of 1992, and started to decline immediately after that, which is to some extent (although not fully) consistent with fluctuations in the selling price indices. In contrast, the CPI rent continued to increase very slowly until the fourth quarter of 1994 and did not show any significant decline even after that. It seems that there was almost no link between the CPI rent and the rent index (and ultimately the selling price). The main purpose of this paper is to look for reasons why such a decoupling emerges.

The Daiwa Data The Recruit data has an advantage that it covers a large number of units for a long period. However, it covers only rental prices adopted in new contracts, and provides no information about rents in rollover contracts. Only with information about new contracts, it is next to impossible to estimate the frequency of rent adjustment. To cope with this problem, we construct another dataset which contains information both new and rollover contracts. This is produced from a bundle of contract documents for 15,639 housing units in the Tokyo metropolitan area (four prefectures including Saitama, Chiba, Tokyo, and Kanagawa). Those units are managed by Daiwa Living Co., Ltd., one of the largest property management companies located in Tokyo. This dataset contains information about rollover contracts made between a landlord and an existing tenant, including the date of a contract renewal and the rent levels before and after it, as well as similar information about new contracts. Information about attributes of each housing unit is also provided. A drawback of this dataset is its very short sample period: it covers only contracts made in March 2008. Therefore we are not allowed to learn about its time-series property. Also, it should be kept in mind that the Japanese fiscal and academic year ends in March, so this is a special month when a lot of workers and students move and the turnover rate could be higher than usual. Despite these shortcomings, the Daiwa data provides us valuable cross-sectional information, including the frequency of rent adjustments, both in new contracts and in rollover contracts. Details about the Daiwa data are provided in the right half of Table 1.

[5] Shimizu and Nishimura (2006, 2007) estimate a selling price index by hedonic regression using a different data source but report similar results.

3 Frequency of Rent Adjustments

Recent empirical studies about price stickiness employ micro price data to estimate the frequency of price adjustments. For example, Bils and Klenow (2004) and Nakamura and Steinsson (2007) use the source data of the US CPI. Campbell and Eden (2006) and Abe and Tonogi (2007) use the scanner data in the US and Japan. However, these studies mainly focus on stickiness in goods prices. No detailed investigation has been conducted about stickiness in housing rents, except Genesove (2003) for the US and Hoffmann and Kurz-Kim (2006) for Germany.

Let us define two indicator variables. The first variable I_{it}^N takes one if unit turnover occurs and a new contract is made between a landlord and a new tenant at unit i in period t, and zero otherwise. Similarly, I_{it}^R takes one if a renewal contract is made between a landlord and an existing tenant at unit i in period t, and zero otherwise. Housing rent for unit i in period t is denoted by R_{it}, and ΔR_{it} is defined by $\Delta R_{it} \equiv R_{it} - R_{it-1}$. Given these notations, the probability $\Pr(\Delta R_{it} = 0)$ can be expressed as follows

$$\begin{aligned}\Pr(\Delta R_{it} = 0) \quad = \quad & \left[1 - \Pr(I_{it}^N = 1) - \Pr(I_{it}^R = 1)\right] + \Pr(\Delta R_{it} = 0 \mid I_{it}^N = 1) \Pr(I_{it}^N = 1) \\ & + \Pr(\Delta R_{it} = 0 \mid I_{it}^R = 1) \Pr(I_{it}^R = 1) \qquad (1)\end{aligned}$$

The first term on the right hand side simply states that housing rents will never be changed unless a unit turnover occurs or a contract is renewed between a landlord and an existing tenant. However, the occurrence of these events is not sufficient. It is possible that the same rent level is chosen even in a new contract or in a renewed contract, which are expressed by the second and third terms on the right hand side.

3.1 Frequency of rent adjustments in March 2008

Table 3 presents various probabilities appearing in equation (1), which are estimated using the Daiwa data. The event of unit turnover and a resulting new contract takes place in 526 out of the 15639 units, indicating that the monthly probability of unit turnover is 0.034. Similarly, the event of contract renewal occurs in 594 units, indicating that the monthly probability of contract renewal is given by $\Pr(I_{it}^R = 1) = 0.038$. On the other hand, the probability that the rent level is not adjusted even in a new contract is given by $\Pr(\Delta R_{it} = 0 \mid I_{it}^N = 1) = 0.755$, while the corresponding probability in the case of contract renewal is $\Pr(\Delta R_{it} = 0 \mid I_{it}^R = 1) = 0.970$.[6] Using these

[6]Figure 3 presents the empirical cumulative hazard functions of rental growth rates for the turnover units and the rollover units. It shows that there is a large mass at unity both for the turnover and

Table 3: Rent Growth in March 2008

	Negative	Zero	Positive	Number of observations
Turnover Units	85	397	44	526
	(0.162)	(0.755)	(0.084)	(1.000)
Rollover Units	18	576	0	594
	(0.030)	(0.970)	(0.000)	(1.000)
All Units	103	15492	44	15639
	(0.007)	(0.990)	(0.003)	(1.000)

four probabilities, $\Pr(\Delta R_{it} = 0)$ turns out to be 0.991 at the monthly frequency, and 0.893 at the annual frequency. Higo and Saita (2007) reports from the analysis of disaggregated price data in the Japanese CPI that the average frequency of price change is 22 percent per month for goods and services except housing services (renter- and owner-occupied housing services), indicating that housing rents are by far stickier than prices of other goods and services. More importantly, our estimate indicates that housing rents in Japan are much stickier than those in the US; for example, Genesove (2003) reports from the analysis of micro data in the American Housing Survey (AHS) that the annual probability of no rent adjustment is 0.29, which is about one third of the corresponding Japanese figure.

Table 3 tells us more about housing rent dynamics in Japan. Rent adjustments are asymmetric for rollover units (i.e. units with contract renewal) in the sense that there was no rent hike in this month while there were 18 rent decreases. This asymmetry is surprising, given that the average rent level was fairly stable in March 2008, and that there was non-negligible number of rent increases for the turnover units in the same month. Thus this could be seen as evidence that a landlord is not allowed to raise the rent at the time of contract renewal because of various institutional restrictions, such as the Land Lease and House Lease Law. However, the probability of no rent adjustment is much higher in the rollover units than in the turnover units, and the difference between the two is too large to be accounted for merely by the absence of rent hike in the rollover units. This suggests that some factors other than institutional restrictions, like an implicit long-term contract between a landlord and an existing tenant, play a more important role in rent stickiness at the time of rent renewal.[7]

rollover units, larger for the rollover units but still substantial for the turnover units. It also shows that the lower tails are thicker both for the turnover and rollover units.

[7] We have conducted an interview-based survey about the reasons behind rent stickiness. As for rent

3.2 Frequency of rent adjustments in 1986-2008

To investigate how rent stickiness changes over time, we calculate the following probability using the Recruit data.

$$\widehat{\Pr}(\Delta R_{it} = 0) \equiv \left[1 - \Pr(I_{it}^N = 1)\right] + \Pr(\Delta R_{it} = 0 \mid I_{it}^N = 1)\Pr(I_{it}^N = 1) \tag{2}$$

Note that this probability is close to $\Pr(\Delta R_{it} = 0)$ appearing in equation (1) if the probability of no rent adjustment conditional on the event of contract renewal, $\Pr(\Delta R_{it} = 0 \mid I_{it}^R = 1)$, is close to unity. Given that the latter conditional probability is very close to unity as we saw in Table 3, $\widehat{\Pr}(\Delta R_{it} = 0)$ will be a good approximation to $\Pr(\Delta R_{it} = 0)$.

Figure 4 shows the result. The blue line with diamond symbols represents the annualized values of $\widehat{\Pr}(\Delta R_{it} = 0)$ for each year: its value in 2008 is 0.84, which is slightly lower but very close to the value reported in Table 3, indicating that there is no substantial difference between the two datasets at least in terms of this probability. We also see that the probability of rent adjustment fluctuates much over time but it never goes below 0.4, therefore it is always well above the corresponding US estimate.

Focusing on the bubble period, 1986-1991, during which the market rent level rose rapidly, we see that $\widehat{\Pr}(\Delta R_{it} = 0)$ declined substantially from 0.88 in 1986 to 0.47 in 1991. To investigate more about this fall in stickiness, we decompose this probability into $1 - \Pr(I_{it}^N = 1)$ and $\Pr(\Delta R_{it} = 0 \mid I_{it}^N = 1)\Pr(I_{it}^N = 1)$ following equation (1). The former probability is represented by the red line with rectangular symbols and the latter one by the green line with triangular symbols. We see that the latter probability declined substantially from 0.31 in 1986 to 0.02 in 1991, and this contributed a lot to the decline in $\Pr(\Delta R_{it} = 0)$, suggesting that more landlords decided to raise the rent level at the time of unit turnover so as to avoid losses resulting from keeping the rent level unchanged during the high inflation period.[8]

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stickiness at the time of contract renewals, many of the interviewees pointed out that their pricing strategy is not to set a housing rent as high as the market level, but to encourage an existing (good) tenant to continue to stay as long as possible. As for rent stickiness at the time of unit turnover, some of the interviewees pointed out that if the rent for a new contract is adjusted downward and other tenants in the same building recognize this, a landlord (or a real-estate management company) would be forced to accept the same price down requests from those tenants.

[8]Empirical studies testing implications of menu cost models, such as Lach and Tsiddon (1992) among others, find from micro data of goods prices that firms tend to adjust prices more often during the high inflation period. Our result is consistent with these findings, suggesting that there exists a common mechanism governing stickiness both in goods and in housing services.

4 State-Dependent or Time-Dependent Pricing

4.1 Caballero-Engel's definition of price flexibility: intensive versus extensive margins

We have shown in the previous section that the frequency of rent adjustments is very low. This implies, ceteris paribus, that the CPI rent responds only slowly to aggregate shocks, including fluctuations in asset prices. However, as shown by Caballero and Engel (2007), there is no one-to-one relationship between the frequency of price adjustments and the responsiveness of the price index to aggregate shocks; for example, it is possible that the price index might exhibit a quick response to aggregate shocks in spite of its low frequency of adjustments. In this section, we will estimate the responsiveness of a rent index, like the CPI rent, to aggregate shocks using the Caballero and Engel's (2007) definition of price flexibility.

Let us denote the rent level in an economy with no rent stickiness by R^*_{it}, and refer it as the target rent level. For simplicity we assume the target rent follows a process of the form:

$$\Delta \log R^*_{it} = \Delta\xi_t + \nu_{it} \tag{3}$$

where $\Delta\xi_t$ represents aggregate shocks, while ν_{it} is iid idiosyncratic shocks with zero mean. Because of rent stickiness, R_{it} does not necessarily coincides with R^*_{it}. We denote a price gap, or price imbalance, between the two by $X_{it} \equiv \log R_{it-1} - \log R^*_{it}$. We assume that the probability of rent adjustments depends on this gap, and define $\Lambda(x)$ as

$$\Lambda(x) \equiv \Pr(\Delta R_{it} \neq 0 \mid X_{it} = x). \tag{4}$$

The function $\Lambda(x)$ is what Caballero and Engel (1993) refers to as "adjustment hazard function". This is a useful tool to discriminate between state-dependent and time-dependent pricing. If the probability $\Pr(\Delta R_{it} \neq 0)$ depends, positively or negatively, upon a state variable x, it is state-dependent pricing, and time-dependent pricing otherwise.

Given the above setting, we are able to see how the average rent level responds to aggregate shocks. Denoting the response of the rent of unit i in period t to an aggregate shock in period t by $\Delta \log R_{it}(\Delta\xi_t, X_{it})$ and its aggregated counterpart by $\Delta \log R_t(\Delta\xi_t)$, we have

$$\Delta \log R_t(\Delta\xi_t) \equiv \int \Delta \log R_{it}(\Delta\xi_t, x)h(x)dx = -\int (x - \Delta\xi_t)\Lambda(x - \Delta\xi_t)h(x)dx \tag{5}$$

where $h(x)$ is the cross-section distribution (ergodic distribution) of the state variable x. Differentiating this equation with respect to $\Delta\xi_t$ and evaluating at $\Delta\xi_t = 0$ yields

$$\lim_{\Delta\xi_t \to 0} \frac{\Delta \log R_t}{\Delta\xi_t} = \int \Lambda(x)h(x)dx + \int x\Lambda'(x)h(x)dx. \tag{6}$$

The expression on the left hand side is the Caballero and Engel's (2007) measure of price flexibility, which is basically the impulse response function. The first term on the right hand side of this equation represents the frequency of rent adjustments, implying that higher frequency of adjustments leads to more price flexibility in terms of the impulse response function. However, there exists no one-to-one relationship between these two because of the presence of the second term, which could take a positive or negative value depending on the sign of $\Lambda'(x)$.

To illustrate this, suppose the probability of rent adjustments becomes higher as the actual rent deviates more, positively or negatively, from the target level, so that $\Lambda'(x) > 0$ for $x > 0$ and $\Lambda'(x) < 0$ for $x < 0$. This is called the increasing hazard property by Caballero and Engel (1993b). In cases in which this property is satisfied, a positive aggregate shock ($\Delta\xi_t > 0$) leads to a decrease in x for each unit through an increase in R^*_{it}, thereby decreasing the adjustment hazard for the units that were with $x > 0$ before the shock occurs (and therefore sought to lower the rent), and increasing it for the units that were with $x < 0$ before the shock occurs (and therefore wanted to raise the rent). Put differently, more landlords increase the rents and less landlords decrease the rents, thereby contributing to enhancing the response of the aggregate rent level. This is the effect represented by the second term of (6). Caballero and Engel (2007) refer to the second term as the "extensive margin effect" in the sense that this term captures a change in the fraction of housing units in which the rent levels are adjusted, as a consequence of aggregate shocks. On the other hand, the first term, which captures an additional rent increase (or reduced rent decreases) resulting from the larger rent adjustment in the units whose rents were going to be adjusted anyway, is referred to as intensive margin. Note that the extensive margin effect could increase or decrease the Caballero-Engel's measure of price flexibility depending on the sign of $\Lambda'(x)$. In the rest of this section, we will estimate the adjustment hazard function $\Lambda(x)$ with a special attention to its curvature.

4.2 Estimates of intensive and extensive margins: adjustment hazard functions

Let us start by defining the adjustment hazard function as follows.

$$\begin{aligned}\Lambda(x) &= \Pr(\Delta R_{it} \neq 0 \mid I_{it}^N = 1, X_{it} = x) \Pr(I_{it}^N = 1 \mid X_{it} = x) \\ &\quad + \Pr(\Delta R_{it} \neq 0 \mid I_{it}^R = 1, X_{it} = x) \Pr(I_{it}^R = 1 \mid X_{it} = x)\end{aligned} \tag{7}$$

Among the four conditional probabilities appearing in this equation, the probability of contract renewal, $\Pr(I_{it}^R = 1 \mid X_{it} = x)$, does not depend on x. Usually housing lease contracts are renewed every two year in Tokyo, so that we calculate its monthly probability by 1/24. However, as for the other three conditional probabilities, we have no a priori reason to believe that they would not depend on x, so that we must estimate them explicitly.

In doing this, we need to estimate the target rent level R_{it}^*. We use hedonic regressions to estimate it. Suppose that a unit turnover occurs and a new contract with a rent level different from the previous one is made in period t for each of the units $i, i+1, i+2, \cdots$. Each of the new rent levels should be identical to the corresponding target level, since it is the level which a landlord has freely chosen among alternatives. These new rent levels are observable in the Recruit data, but we are not allowed to observe a target rent level for, say, unit j, in which no turnover takes place in period t. However, it is still possible to estimate R_{jt}^* using information about the target rent levels for the units $i, i+1, i+2, \cdots$. We first run a hedonic regression in period t using the new rent levels, as well as various attributes, for all of the turnover units, and then use the regression results to impute for the rent of the unit j in that period.

Specifically, we adopt a method called "overlapping period hedonic model" proposed by Shimizu et al. (2007), in which the coefficient on each of the attributes of housing units is allowed to change over time. We also allow the coefficients to differ across subway/railway lines so as to improve the fitness. Table 4 presents a part of the regression results for the Yamanote Line for the period of January 2006 to December 2006. We repeat this for the 96 subway/railway lines, impute for the rents of those units without turnover, and finally obtain R_{it}^* for all units contained in the two datasets.

Figure 5 shows the monthly estimate of $\Pr(I_{it}^N = 1 \mid X_{it} = x)$. The horizontal axis measures the value of x, while the horizontal axis represents the probability of unit turnover per month. In estimating this probability, we use only a subset of the Recruit data by discarding the sample in which more than two years have passed since the

Table 4: Estimated Coefficients in Hedonic Regressions for Housing Units along the Yamonote Line

Month in 2006	Floor space	Age of building	Time to a nearest station	Commuting time to CBD	Adjusted R2	Number of observations
Jan 2006	-0.298	-0.032	-0.084	-0.189	0.720	45,093
Feb	-0.297	-0.032	-0.084	-0.189	0.719	45,203
Mar	-0.297	-0.032	-0.084	-0.189	0.719	44,884
Apr	-0.296	-0.032	-0.084	-0.188	0.718	44,305
May	-0.295	-0.032	-0.085	-0.188	0.719	43,231
Jun	-0.294	-0.032	-0.085	-0.188	0.718	43,064
Jul	-0.295	-0.032	-0.085	-0.188	0.718	42,090
Aug	-0.294	-0.032	-0.086	-0.188	0.718	41,520
Sep	-0.293	-0.032	-0.086	-0.188	0.718	41,345
Oct	-0.293	-0.032	-0.086	-0.188	0.718	40,297
Nov	-0.294	-0.033	-0.087	-0.189	0.718	39,741
Dec	-0.297	-0.033	-0.087	-0.190	0.719	38,911

last turnover.[9] This is because we do not have any information about the rent levels after contract renewals, which usually takes place two years after the start of a new contract. Figure 5 clearly shows that the probability of unit turnover does not depend on x, suggesting that unit turnover is caused by purely random and exogenous event such as marriage, childbirth, and job transfer.

Figure 6.1 shows the estimate of $\Pr(\Delta R_{it} \neq 0 \mid I_{it}^N = 1, X_{it} = x)$, namely the probability that a new rent level, which is different from the previous one, is chosen for unit i in period t, given that a unit turnover occurs and thus a new contract is made in that unit. We see from this figure that the adjustment hazard is about 0.65 when x is around zero, but it monotonically increases with x, reaching 0.75 when $x = 0.5$. Similarly, the probability monotonically increases as x goes below zero until it finally reaches very close to unity for x below -0.4. To evaluate the curvature of the adjustment hazard function, we calculate its elasticity with respect to x in Figure 6.2, which is defined by

$$\eta(x) \equiv \frac{d \log \Pr(\Delta R_{it} \neq 0 \mid I_{it}^N = 1, X_{it} = x)}{d \log x}.$$

Note that, as seen from equation (6), the Caballero-Engel's measure of price flexibility for a given x is equal to the product of $1 + \eta(x)$ and the corresponding adjustment hazard. Figure 6.2 shows that $\eta(x)$ exceeds unity when x is -0.35 or smaller, implying that the extensive margin effect is positive and substantial, so that the Caballero-Engel's measure of price flexibility is more than two times as large as implied by the

[9] To check the robustness of results, we have done the same exercise using the entire sample. We confirm that the results are basically the same.

Table 5: Adjustment Hazard Functions in Equation (7)

	$x \in (-0.4, -0.2]$	$x \in (-0.2, 0.0]$	$x \in (0.0, 0.2]$	$x \in (0.2, 0.4]$
$\Pr(I_{it}^N = 1 \mid X_{it} = x)$	0.010	0.010	0.010	0.010
$\Pr(I_{it}^R = 1 \mid X_{it} = x)$	0.042	0.042	0.042	0.042
$\Pr(\Delta R_{it} \neq 0 \mid I_{it}^N = 1, X_{it} = x)$	0.736	0.680	0.688	0.719
$\Pr(\Delta R_{it} \neq 0 \mid I_{it}^R = 1, X_{it} = x)$	0.000	0.009	0.038	0.091
$\Lambda(x)$	0.008	0.007	0.008	0.011
$h(x)$	0.082	0.312	0.348	0.161

frequency of individual rent adjustments.

Figures 6.1 and 6.2 show that the probability of rent adjustment depends on the value of x, suggesting that a landlord is more likely to correct it if the gap is wider, especially if the gap is far below zero. As we saw in Section 2, there was a sharp rise of the market rent level in the late 1980s and the early 90s. Not surprisingly, this created a large gap for the units without any recent turnover, thereby raising the probability of rent adjustment in those units.[10]

Figure 7 presents the estimate of $\Pr(\Delta R_{it} \neq 0 \mid I_{it}^R = 1, X_{it} = x)$, namely the probability of rent adjustment for unit i in period t, given that a lease contract is renewed between a landlord and an existing tenant in that unit. We do hedonic regressions using the Recruit data, impute for the rents of the units without turnover in the Daiwa data, and finally calculate the adjustment hazard. Figure 7 shows that the probability tends to change with x. Specifically, the probability is high when the actual rent level exceeds the target one (i.e. $x > 0$), although it is still far below unity even when x is in the range of 0.2 and 0.4. On the other hand, the probability is very close to zero when x is below zero. This suggests that it is relatively easy for a landlord and an existing tenant to reach an agreement of lowering the rent when it is substantially high relative to the target level, but it is extremely difficult for a landlord to propose a rent hike to an existing tenant even when the current rent level is far below the target one, probably because of the existence of public regulations to protect tenants, like the Land Lease and House Lease Law. Note that the increasing hazard property extensively discussed by Caballero and Engel (1993b) is not satisfied when x is below zero, contributing to lowering the Caballero-Engel's measure of price flexibility.

[10]Campbell and Eden (2006) estimate an adjustment hazard function for goods sold at supermarkets, and find that the adjustment hazard increases monotonically as the price in a store deviates from the sales-weighted average of prices for the same good at all other stores.

Finally, we sum up the above three conditional probabilities, together with the probability of contract renewal, $\Pr(I_{it}^R = 1 \mid X_{it} = x) = 1/24$, to obtain a monthly estimate of $\Lambda(x)$ in equation (7). The result is presented in Table 5. The estimates of $\Lambda(x)$ is about 0.008 when x belongs to the range of $(-0.4, -0.2]$, $(-0.2, 0.0]$, and $(0.0, 0.2]$, and 0.011 when $x \in (0.2, 0.4]$, indicating that the adjustment hazard does not depend on the gap between the actual and target rent levels. To quantify this finding further, we calculate the first and second terms in equation (6) using the estimated ergodic distribution $h(x)$, which is shown at the final row of Table 5. We have

$$\int \Lambda(x)h(x)dx = 0.0084, \int x\Lambda'(x)h(x)dx = 0.0013, \text{ and } \lim_{\Delta\xi_t \to 0} \frac{\Delta \log R_t}{\Delta \xi_t} = 0.0097 \quad (8)$$

This indicates that rent flexibility in terms of the impulse response function is not substantially different from the one in terms of the frequency of individual rent adjustments. In sum, each of the two probabilities of rent adjustment, namely $\Pr(\Delta R_{it} \neq 0 \mid I_{it}^N = 1, X_{it} = x)$ and $\Pr(\Delta R_{it} \neq 0 \mid I_{it}^R = 1, X_{it} = x)$, is indeed state dependent, but the degree of dependence on x is still limited in each of the two probabilities, and state dependence in the two probabilities are cancelled out at least partially. On the other hand, neither the probability of unit turnover nor the probability of contract renewal depends on x. Consequently, the estimate of $\Lambda^{'}(x)$ turns out to be very close to zero.[11]

4.3 Aggregation and microfoundation of the Calvo parameter: micro-macro consistency

If the adjustment hazard does not depend on x, i.e. $\Lambda(x) = \Lambda_0$, then we have

$$\int \Delta \log R_{it}\ di = -\int x\Lambda(x)h(x)dx = -\Lambda_0 \int x_{it}\ di \quad (9)$$

That is, the average of individual rent growth is inversely proportional to the average of individual gaps. Rearranging this yields an equation for aggregate price dynamics of the form

$$R_t = \Lambda_0 R_t^* + (1 - \Lambda_0)R_{t-1} \quad (10)$$

[11]Recent studies address the issue of time versus state dependent pricing using the method of duration analysis. Specifically, many researches examine whether the probability of price adjustment increases with the elapsed time since the final price adjustment. In most cases they find that the hazard function is downward sloping, which is not consistent neither with time dependent nor state dependent pricing. We have applied this duration analysis to the Recruit data and found that the probability of unit turnover does not depend much on the elapsed time, except that it is very low if the elapsed time is less than 100 weeks and very high if the elapsed time is longer than 600 weeks. This result is basically consistent with time dependent pricing.

where R_t is an aggregate rent index defined by $R_t \equiv \int \log R_{it} di$, and R_t^* is a corresponding target rent index defined by $R_t^* \equiv \int \log R_{it}^* di$. This equation can be interpreted as stating that the aggregate rent level in period t is a weighted average of the new rent levels in period t, which are applied for the units randomly chosen with the probability of Λ_0, and the previous rent levels, which are applied for the remaining units that accidentally did not have chance to adjust their rents. In this way, $1 - \Lambda_0$ in this equation can be regarded as the Calvo parameter, i.e. the probability of not receiving a random signal of price adjustment in the Calvo's (1983) model. As we saw in the previous section, the value of Λ_0 estimated from the micro data is 0.025, and the implied Calvo parameter is 0.975.[12]

A convenient feature of equation (10) is that it contains only macro variables which do not depend on i. The variable R_t is an aggregate index of housing rents of all units, like the CPI rent. On the other hand, R_t^* is an aggregate index of target rent levels, which can be proxied by the estimated coefficients on the time dummies in hedonic regressions we conducted in the previous subsection using the Recruit data. Given the quarterly time-series data for these two aggregate variables at hand, we are allowed to estimate Λ_0 by a simple OLS to get $\Lambda_0 = 0.032$ with its standard error of 0.004 (adjusted R squared=0.998). This implies that the quarterly Calvo parameter is 0.968. Comparing with the estimate from the micro data, the macro estimate is slightly smaller, but still quite close to each other, thus providing another evidence that adjustments of housing rents are not state-dependent but time-dependent.

5 Reestimates of CPI Inflation

We have seen in the previous sections that the probability of individual rent adjustments is very low, and that it depends little on price imbalances. These two facts imply that price flexibility in terms of the impulse response function is low, and thus causing the CPI rent to respond only slowly to aggregate shocks. In this section, we evaluate this property in a quantitative way by reestimating CPI inflation over the last twenty years. Specifically, given that aggregate price dynamics is described by equation (10), we assume an alternative value for Λ_0, and calculate R_t using the actual values of R_t^*. Then we combine this alternative index for rents with the actual values for the other

[12]The estimate of Λ_0 at the monthly frequency, 0.0084 in equation (8), is converted to the quarterly frequency by $1 - (1 - 0.0084)^3 = 0.025$.

Table 6: Alternative Assumptions about Rent Stickiness

	Actual	Assumption 1	Assumption 2	Assumption 3
$\Pr(I_{it}^N = 1)$	0.010	0.010	0.010	0.010
$\Pr(I_{it}^R = 1)$	0.042	0.042	0.042	0.083
$\Pr(\Delta R_{it} \neq 0 \mid I_{it}^N = 1)$	0.695	1.000	1.000	1.000
$\Pr(\Delta R_{it} \neq 0 \mid I_{it}^R = 1)$	0.034	0.200	1.000	1.000
$\Pr(\Delta R_{it} \neq 0)$				
Monthly frequency	0.008	0.018	0.052	0.093
Quarterly frequency	0.025	0.054	0.147	0.255
Annual frequency	0.096	0.199	0.471	0.691

components of the CPI to obtain an alternative CPI inflation.[13]

We consider three alternative values for Λ_0 as presented in table 6. In the first case, we assume that both $\Pr(I_{it}^N = 1)$ and $\Pr(I_{it}^R = 1)$ are identical to the actual values. But the adjustment probability at the time of unit turnover is assumed to be unity, and the adjustment probability at the time of contract renewals is assumed to be 0.3, which is about six times as large as the actual value. Given these assumptions, $\Pr(\Delta R_{it} \neq 0)$ turns out to be 0.018 at the monthly frequency and 0.199 at the annual frequency. This value is almost equal to the one reported by Hoffmann and Kurz-Kim (2006) for Germany. The second case differs from the first one in that the adjustment probability at the time of contract renewals is assumed to be unity. Then the probability $\Pr(\Delta R_{it} \neq 0)$ equals to 0.471 at the annual frequency. The third case differs from the second one in that contract renewals are assumed to occur every year (rather than every two year). The probability $\Pr(\Delta R_{it} \neq 0)$ is 0.691 at the annual frequency, which is close to the one reported by Genesove (2003) for the U.S.

The results are shown in Figure 8. The blue line represents the actual year-to-year CPI inflation rates in Tokyo. The estimated CPI inflation rates in the first case are represented by the purple line. The blue and purple lines almost always overlap, indicating that CPI inflation would not have been changed much even if rents were as flexible as in Germany. However, the red line, which represents the estimates in the second case, differs substantially from the blue one. First, the estimated inflation exceeds the actual one by one percentage point in 1987:1Q to 1988:4Q, indicating that

[13] The share of the total CPI allocated to housing services is 26.3 percent, consisting of a 5.8 percent for renter occupied housing services, 28.6 percent for owner occupied housing services, and 1.9 percent for housing maintenance and others. We treat prices for both renter- and owner-occupied housing services as housing rents R_t, because changes in tenant rents are imputed to owner-occupied housing by changing weights but not by creating a new and different index of the unique costs of owner occupancy.

CPI inflation would have been higher during the bubble period. Second, turning to the period of bubble bursting, the estimated inflation is lower than the actual one by more than one percentage point in 1993:1Q to 1996:4Q. More importantly, the estimated inflation rates fell below zero in the fourth quarter of 1993, indicating that deflation would have started one year earlier than it actually occurred. These differences are more noticeable in the third case (represented by the green line), in which rents are assumed to be as flexible as in the U.S. In sum, Figure 8 shows that high stickiness in rents had substantial impacts on the movement of the total CPI in the 1980s and the 90s.

6 Conclusion

Why was the Japanese consumer price index for rents so stable even during the period of housing bubble in the 1980s? In addressing this question, we have started from the analysis of microeconomic rigidity and then investigated its implications about aggregate price dynamics. We have found that ninety percent of the units in our dataset had no change in rents per year, indicating that rent stickiness is three times as high as in the US. We have also found that the probability of rent adjustment depends little on the deviation of the actual rent from its target level, suggesting that rent adjustments are not state dependent but time dependent. These two results indicate that both intensive and extensive margins of rent adjustments are very small, and this is why the CPI rent responds only slowly to aggregate shocks. We show that the CPI inflation rate would have been higher by one percentage point during the bubble period, and lower by more than one percentage point during the period of bubble bursting, if the Japanese housing rents were as flexible as in the US.

References

[1] Bils, M., and P. J. Klenow (2004), "Some Evidence on the Importance of Sticky Prices," *Journal of Political Economy* 112(5), 947-985.

[2] Caballero, Ricardo J., and Eduardo M.R.A. Engel (2007), "Price stickiness in Ss models: New interpretations of old results," *Journal of Monetary Economics* 54, 100-121.

[3] Caballero, Ricardo J., and Eduardo M.R.A. Engel (1993a), "Microeconomic Rigidities and Aggregate Price Dynamics," *European Economic Review* 37, 697-717.

[4] Caballero, Ricardo J., and Eduardo M.R.A. Engel (1993b), "Microeconomic Adjustment Hazards and Aggregate Dynamics," *Quarterly Journal of Economics* 108, 359-383.

[5] Calvo, Guillermo (1983), "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics* 12, 383-398.

[6] Campbell, J. R., and B. Eden (2006). "Rigid Prices: Evidence from U.S. Scanner Data," Vanderbilt University.

[7] Crone, Theodore M., Leonard I. Nakamura, and Richard P. Voith (2004), "Hedonic Estimates of the Cost of Housing Services," Federal Reserve Bank of Philadelphia, Working Paper No. 04-22.

[8] Crone, Theodore M., Leonard I. Nakamura, and Richard P. Voith (2006), "The CPI for Rents: A Case of Underestimated Inflation," Federal Reserve Bank of Philadelphia, Working Paper No. 06-7.

[9] Genesove, David (2003), "The Nominal Rigidity of Apartment Rents," *Review of Economics and Statistics* 85(4), 844-853.

[10] Golosov, M., and R. E. Lucas (2007). "Menu Costs and Phillips Curves," *Journal of Political Economy* 115, 171-199.

[11] Goodhart, Charles (2001), "What weight should be given to asset prices in the measurement of inflation?" *Economic Journal* 111, 335-356.

[12] Gordon, Robert J., and Todd vanGoethem (2005), "A Century of Housing Shelter Prices: Is there a Downward Bias in the CPI," NBER Working Paper 11776.

[13] Hoffmann, Johannes, and Jeong-Ryeol Kurz-Kim (2006), "Consumer price adjustment under the microscope: Germany in a period of low inflation," Deutsche Bundesbank Discussion Paper No.16.

[14] Ito, Takatoshi, and Keiko Nosse Hirono (1993), "Efficiency of Tokyo Housing Market," Bank of Japan, *Monetary and Economic Studies*, Vol. 11, No. 1.

[15] Klenow, P. J., and O. Kryvtsov (2005). "State-Dependent or Time-Dependent Pricing: Does It Matter for Recent U.S. Inflation," Stanford University.

[16] Nakamura, E., and J. Steinsson (2007). "Five Facts about Prices: A Reevaluation of Menu Cost Models," Harvard University.

[17] Shimizu, C. and K. G. Nishimura, (2006), "Biases in Appraisal Land Price Information: The Case of Japan," *Journal of Property Investment and Finance*, Vol.26, No.2, 150-175.

[18] Shimizu, C. and K. G. Nishimura, (2007), "Pricing structure in Tokyo metropolitan land markets and its structural changes: pre-bubble, bubble, and post-bubble periods," *Journal of Real Estate Finance and Economics*, Vol.35 (4), 475-496.

[19] Shimizu, C., K. G. Nishimura, and Y. Asami (2004), "Search and Vacancy Costs in the Tokyo Housing Market: An Attempt to Measure Social Costs of Imperfect Information," *Review of Urban and Regional Development Studies*, Vol.16, No.3, 210-230.

Figure 1: House Prices and Housing Rent in 1986-2006

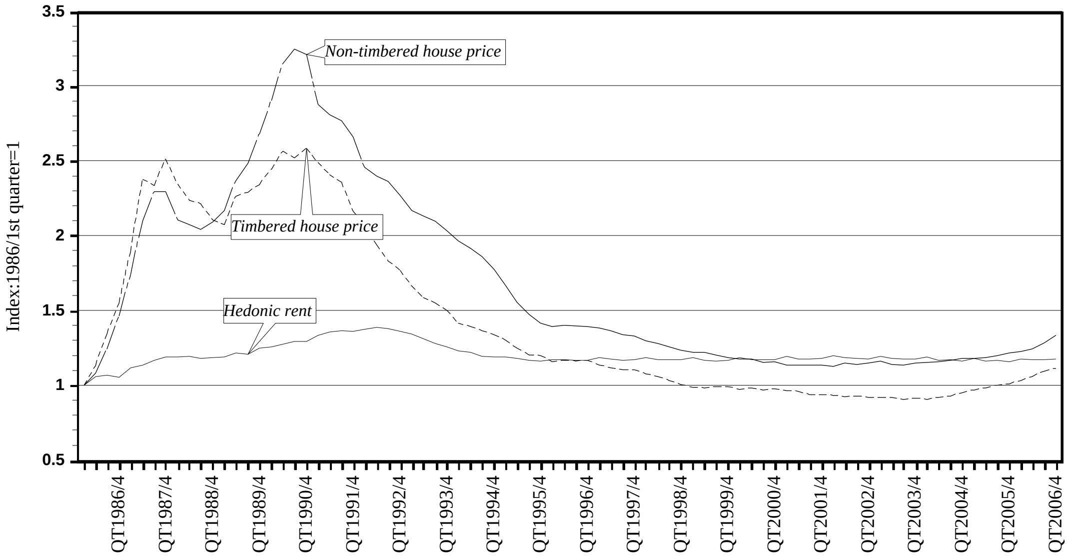

Figure 2: Hedonic Estimate versus CPI Rent

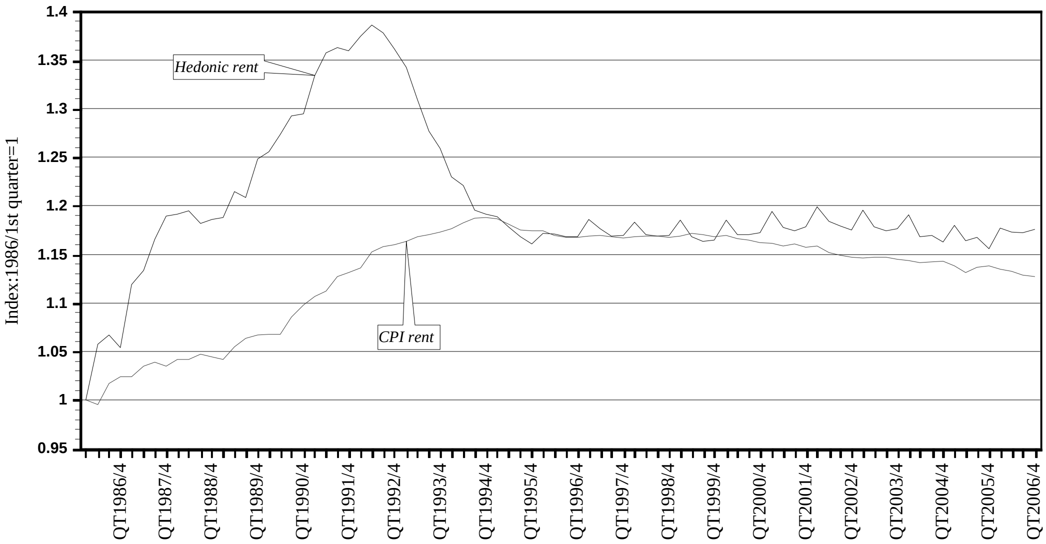

Figure 3: Cumulative Distribution Functions of Rent Growth

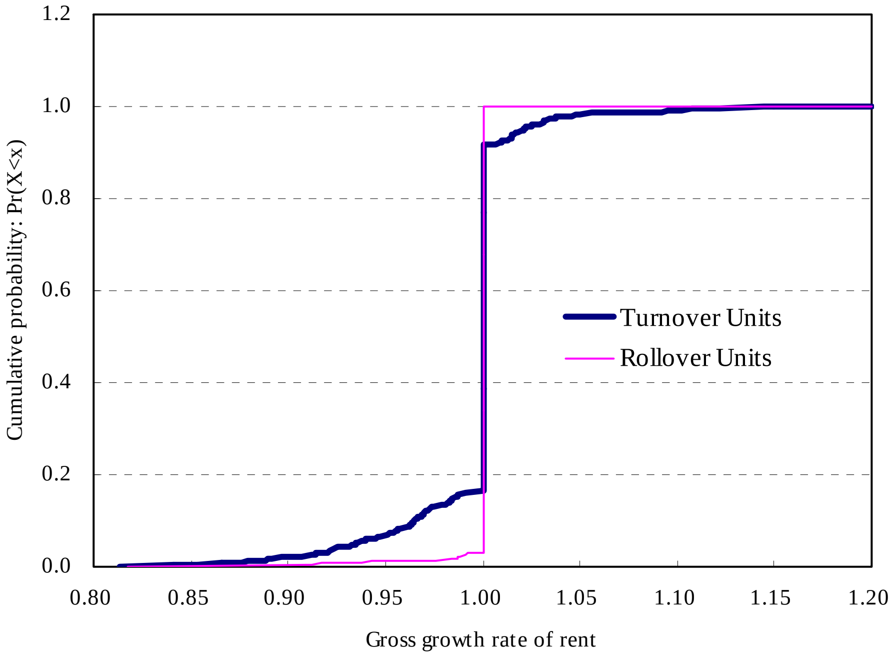

Figure 4: Probability of No Rent Adjustments

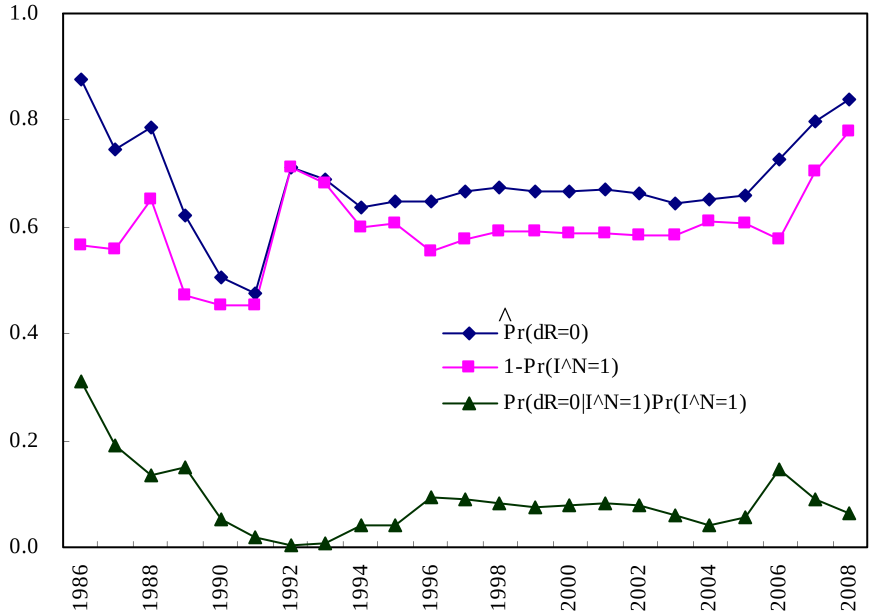

Figure 5: Probability of Unit Turnover

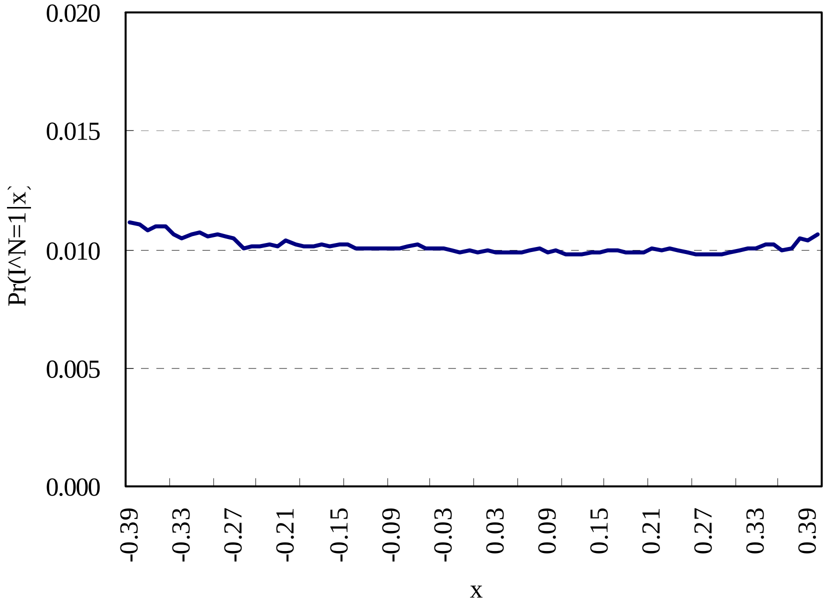

Figure 6.1: Adjustment Hazard Function for Turnover Units

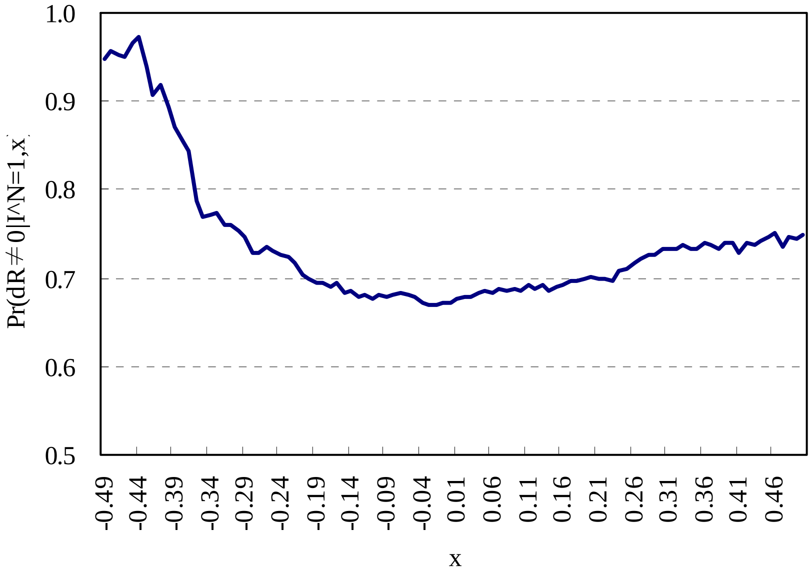

Figure 6.2: Elasticity of the adjustment hazard for turnover units with respect to *x*

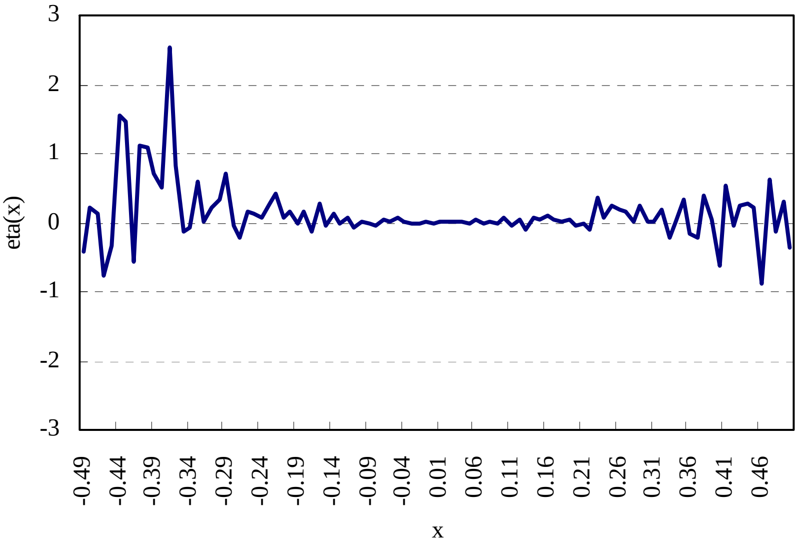

Figure 7: Adjustment Hazard Function for Rollover Units

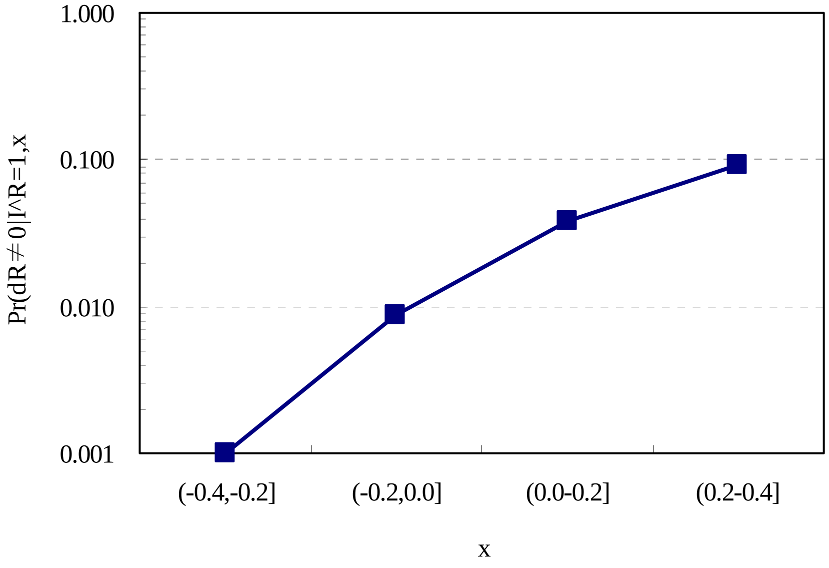

Figure 8: Reestimates of CPI Inflation under Alternative Assumptions