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 the housing bubble in the 1980s? To address this question, we use a unique micro price dataset which we have compiled from individual listings (or transactions) in a widely circulated real estate advertisement magazine. This dataset contains more than 700 thousand listings of housing rents over the last twenty years. We start from the analysis of microeconomic rigidity and then investigate its implications for aggregate price dynamics, closely following the empirical strategy proposed by Caballero and Engel (2007). We find that 90 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 United States. 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 the intensive and extensive margins of rent adjustments are small, resulting in a slow response of the CPI for rent to aggregate shocks. We show that the CPI inflation rate would have been higher by 1 percentage point during the bubble period, and lower by more than 1 percentage point during the period following the burst of the bubble, if Japanese housing rents were as flexible as those in the United States.

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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 a rapid reversal in the early 1990s. This wild swing led to a significant deterioration of the balance sheets of firms, especially of financial firms, thereby causing a decade-long stagnation of the economy. Another recent example is the U.S. housing market bubble, which started sometime 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 for rent so stable? This is an important question because, as emphasized by Goodhart (2001), housing rent is a key variable linking asset prices and price indices of goods and services such as the CPI.

We start from the analysis of individual housing rents using micro data and then proceed to the investigation of the implications for aggregate rent indices, including the CPI for rent. To do 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 set 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 United States is about 29 percent per year, while Hoffmann and Kurz-Kim (2006) find that the corresponding figure in Germany is 78 percent. We also find that 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, at least partially, accounts for the 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 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, the intensive margin) and the fraction of units for which rents were adjusted (the extensive margin). We find that the intensive and the extensive margins account for 87 and 13 percent, respectively, of the Caballero-Engel 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 United States. 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 following the burst of the bubble, 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 on 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 the extensive margins. In Section 5, we evaluate the quantitative importance of our findings by reestimating CPI inflation in the 1980s and 1990s under the assumption that stickiness in housing rents were as low as in the United States. Section 6 concludes the paper.

2 Data

Two types of housing rent adjustment can be distinguished: rents are adjusted when a new tenant arrives and a new contract between the tenant and the landlord is made; or they are 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., the contract is rolled over). To investigate these two types of rent adjustments, we construct two datasets: 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: The Two Datasets

	Recruit Data		Daiwa Data	
Sample period	1986-2006		March 2008	
Frequency	Weekly		One month	
Area	The 23 special wards of 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 meters)	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 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	n.a.	n.a.

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 lettings information in Japan.

Our dataset has two important features. First, *Shukan Jutaku Joho* provides 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 only use the price in the final week because this 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., such companies *automatically* report it to Recruit whenever a turnover occurs in one of the housing units they manage. Thus, we were able to create a complete panel dataset for those housing units, containing information on the exact timing of the start and the 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 the nearest station, and so on.

Table 1 presents the basic properties of this dataset. The Recruit dataset covers the

[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 looking for a new tenant and thus withdraws the listing. We were allowed access information regarding which the two reasons applied for individual cases and discarded those where the owner withdrew the listing.

[2]Recruit Co., Ltd. provided us with information on contract prices for about 24 percent of the entire listings. Using this information, we were able to confirm that prices in the final week were almost always identical with the contract prices (i.e., they differed at a 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 nearest station	Time distance to the nearest station (walking time)
TT	Commuting time to central business district	Minimum of journey time by train during the daytime to seven major stations in 2005
BS	Balcony space	
RT	[Market reservation time	Period between the date when the unit first appeared in the magazine and the date when it was 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	Main windows 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	Train line dummy	kth train line (1, otherwise 0)
TD_l	Time dummy	lth quarter (1, otherwise 0)

23 special wards of Tokyo for the period 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 the units are mainly for single-person households.[4] The average time to the nearest station is 7.2 minutes and the commuting time to the central business district is about 10 minutes, indicating that the units in the dataset largely consist of units with high transportation convenience. Table 2 provides a list of attributes related to the housing units, which we will use later in the 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.[5] Figure 1 shows that the selling price indices exhibited a sharp rise from 1986 toward

[3]Shimizu et al. (2004) report that the Recruit data cover more than 95 percent of the entire transactions in the 23 special wards of Tokyo. On the other hand, its coverage for suburban areas is very limited. We use only information for the units located in the special wards of Tokyo.

[4]The floor space of units for rent is much smaller than that of 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. The units for sale are for families with two or more members.

[5]Crone et al. (2004) and Gordon and Goethem (2005) conduct a similar exercise for the United States using micro data from the American Housing Survey. Ito and Hirono (1993) use the Recruit data to obtain a hedonic estimate of Japanese rental and selling prices in 1981-1992.

the end of 1987. After a temporary decline in 1988, they then rose once again until peaking at the end of 1990, when they reached levels about three times as high as those at the beginning of the sample period.[6] In contrast to these large swings in the selling price indices, the rental price index has been fairly stable, implying substantial fluctuations in the rent-price ratio, or capitalization rate. However, if we compare our rent index with the CPI for rent, we arrive at a different picture. Figure 2 compares our index and the rent index taken from the CPI for 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 for 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 for 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 emerged.

The Daiwa Data Although the Recruit data have the advantage that they cover a large number of units over a long period, they only cover rental prices adopted in new contracts and provide no information on rents in rollover contracts. However, with information only on new contracts, it is next to impossible to estimate the frequency of rent adjustments. To cope with this problem, we construct another dataset which contains information on both new and rollover contracts. This dataset is produced from contract documents for 15,639 housing units in the Tokyo metropolitan area (four prefectures, consisting of Saitama, Chiba, Tokyo, and Kanagawa). Those units are managed by Daiwa Living Co., Ltd., one of the largest property management companies in Tokyo. This dataset contains information on rollover contracts made between landlords and existing tenants, including the date of contract renewal and the rent levels before and after, as well as similar information on new contracts. Information on the 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, meaning that we cannot examine the time-series properties of this dataset. In addition, it is necessary to point out 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 is likely to be higher than usual. Despite these shortcomings, the Daiwa data provides valuable

[6]This result is similar to the one obtained by Shimizu and Nishimura (2006, 2007), who estimated a selling price index by hedonic regression, but used a different data source.

cross-sectional information, including the frequency of rent adjustments, both in new contracts and in rollover contracts. Details on the Daiwa dataset are also provided in Table 1.

3 Frequency of Rent Adjustments

Recent empirical studies on 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 U.S. CPI, while Campbell and Eden (2006) and Abe and Tonogi (2007) use scanner data from the United States and Japan. However, these studies mainly focus on stickiness in goods prices, and with the exception of Genesove (2003) for the United States and Hoffmann and Kurz-Kim (2006) for Germany, no detailed investigations have been conducted on stickiness in housing rents.

Let us define two indicator variables. The first, I_{it}^N, takes a value of one if unit turnover occurs and a new contract is made between a landlord and a new tenant with regard to unit i in period t, and zero otherwise. Similarly, I_{it}^R takes a value of one if a renewal contract is made between a landlord and an existing tenant with regard to unit i in period t, and zero otherwise. The 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 of no rent adjustments, $\Pr(\Delta R_{it} = 0)$, can be expressed as follows

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

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 is expressed by the second and third terms on the right-hand side.

3.1 Frequency of rent adjustments in March 2008

Table 3 presents the estimation results for the various probabilities appearing in equation (1) using the Daiwa data. The event of unit turnover and a resulting new contract takes place for 526 out of the 15,639 units, indicating that the monthly probability of

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)

unit turnover is 0.034. Similarly, the event of contract renewal occurs for 594 units, indicating that the monthly probability of contract renewal is given by $\Pr(I_{it}^R = 1) = 0.038$. More interestingly, 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 $\Pr(\Delta R_{it} = 0 \mid I_{it}^R = 1) = 0.970$.[7] 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 rollover units, and that this is 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.

Using these 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), analyzing disaggregated price data from the Japanese CPI, report 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). Our result thus indicates that housing rents are 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 United States. Genesove (2003), for example, analyzing micro data of the American Housing Survey, reports 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 for which the contract was renewed) in the sense that there was no rent hike in the month that the Daiwa data are for, while there

[7]Genesove (2003) reports that 14 percent of turnover units experience no change in rent. Our estimate of no rent adjustment in a new contract is much higher than the U.S. estimate.

were 18 rent decreases. This asymmetry is surprising, given that the average rent level was fairly stable in March 2008, and that there was a non-negligible number of rent increases among the turnover units in the same month. This could be seen as evidence that landlords cannot raise rents at the time of contract renewal because of various legal restrictions, such as the Land Lease and House Lease Law. More importantly, however, the probability of no rent adjustment is much higher for the rollover units than the turnover units, and the difference between the two is too large to be attributable merely to the absence of rent hikes for rollover units. This suggests that factors other than legal restrictions, such as implicit long-term contracts between landlords and existing tenants, play a more important role in rent stickiness at the time of contract renewal.

To discover the reasons for this rent stickiness, we conducted an interview-based survey. Regarding rent stickiness at the time of contract renewals, many of the interviewed landlords/real-estate management companies pointed out that their pricing strategy is not to set the housing rent as high as possible, but to encourage existing (good) tenants to continue to stay as long as possible. This explanation seems to be consistent with the existence of some sort of transaction costs, such as the mobility costs for the tenant, search costs both for the tenant and the landlord, an so on. With regard to rent stickiness at the ime of unit turnover, some of the landlords/real-estate management companies pointed out that if the rent for a new contract is adjusted downward and other tenants in the same building realize this, the landlord (or real-estate management company) would be forced to accept requests for rent reductions from those other tenants.[8]

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

[8]Ito and Hirono (1993) use the Recruit data for 1981-1992, although they do not look at the probability of no rent change. They argue that rental prices in the Recruit data are "free from stickiness" simply because they are new contracts. However, they also state that "one caveat to our argument is that even in new listings, rents in one room may not be too different from units in the same building, if the building are soley for rental housing (like apartment housings)".

is very close to unity as we saw in Table 3, $\widehat{\Pr}(\Delta R_{it} = 0)$ will be a good approximation of $\Pr(\Delta R_{it} = 0)$.

Figure 4.1 shows the result. The blue line with the diamond symbols represents the annualized values of $\widehat{\Pr}(\Delta R_{it} = 0)$ for each year. Its value for 2007 is 0.89, which is slightly higher 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 no rent adjustment fluctuates substantially over time but never goes below 0.8. Therefore it is always well above Genesove's (2003) estimate for the United States.

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 0.96 in 1986 to 0.85 in 1991. To investigate this fall in stickiness more closely, 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 the square symbols and the latter one by the green line with the triangular symbols. We see that the latter probability declined substantially from 0.044 in 1986 to 0.003 in 1991, and this contributed 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 this period of high rent inflation.[9]

In estimating the probability of no rent adjustment shown in Figure 4.1, we assume that rent adjustments occur only in the form of a change in the monthly payment from a tenant to a landlord. However, housing rents can be adjusted in other forms: they can be adjusted through a change in the contract-signing fee (*reikin*), which is paid at the time a new contract is signed and is non-refundable; they can be adjusted through a change in the security-deposit (*shikikin*), which is returned when the unit is vacated (but the cost of any damage can be deducted). If these forms of payments were adjusted frequently during the sample period, then our estimate of no rent adjustment suffers from an upward bias. In other words, housing rents could be much less sticky than shown in Figure 4.1. To quantitatively evaluate this bias, we reestimate the probability $\widehat{\Pr}(\Delta R_{it} = 0)$ under an alternative definition of no rent adjustment in which $\Delta R_{it} = 0$ if neither the monthly payment nor the contract-signing fee changes. The result is shown in Figure 4.2. The probability of no rent adjustment is now a few percentage

[9]Empirical studies testing the 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 high inflation periods. Our result is consistent with these findings, suggesting that there exists a common mechanism governing stickiness both in goods and in housing services.

points lower than before, but the difference is small, indicating that changes in the contract-signing fee are of no quantitative importance.[10]

4 State-Dependent or Time-Dependent Pricing

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

In the previous section, we have shown that the frequency of rent adjustments is very low. This implies, ceteris paribus, that the CPI for 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 the low frequency of price adjustments. In this section, we will estimate the responsiveness of a rent index, such as the CPI for rent, to aggregate shocks using 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 to 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 coincide with R^*_{it}. We denote the 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 (1993a) refer to as the "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, this indicates state-dependent pricing, and time-dependent pricing otherwise.

[10] It is often said that an increasing number of landlords are recently offering *reikin*-free rental housing to attract new tenants, but this is not confirmed by our dataset. Also, the Recruit data contains no information regarding changes in security deposits.

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

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

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

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

The expression on the left-hand side is 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 a higher frequency of adjustments leads to greater 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 units that were with $x > 0$ before the shock occurs (and therefore the landlord sought to lower the rent) and increasing it for units that were with $x < 0$ before the shock occurs (and therefore the landlord wanted to raise the rent). Put differently, more landlords increase rents and fewer landlords decrease rents, thereby leading to a positive 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 for which the rent level is adjusted as a consequence of aggregate shocks. On the other hand, the first term, which captures additional rent increases (or reduced rent decreases) resulting from the rent adjustments for those units whose rents were going to be adjusted anyway, is referred to as the intensive margin. Note that the extensive margin effect could increase or decrease the Caballero and 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 $\Lambda(x)$ paying 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:

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

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 in Tokyo are renewed every two years, so that we calculate the monthly probability of contract renewal by 1/24. However, as for the other three conditional probabilities, we have no a priori reason to believe that they do not depend on x, so that we must estimate them explicitly.

To this end, we need to estimate the target rent level R_{it}^* and do so using hedonic regressions. 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 cannot observe the target rent level for, say, unit j, for which no turnover takes place in period t. However, it is still possible to estimate R_{jt}^* using information on the target rent levels for 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 the rent for unit j in that period. In this hedonic regression, we use only observations in which the rent level differs from the previous one.

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

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

Month in 2006	Floor space	Age of building	Time to 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

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 vertical axis represents the probability of unit turnover per month. In estimating this probability, we use only a subset of the Recruit data, discarding observations for which more than two years have passed since the last turnover.[11] This is because we do not have any information about rent levels after contract renewal, 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 events 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 for 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, 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 measure of price flexibility for a given x is equal to the product of $1 + \eta(x)$ and the corresponding adjustment

[11] To check the robustness of the results, we did the same exercise using the entire sample and found that the results are basically the same.

hazard. The result is presented in Figure 6.2, which 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 measure of price flexibility is more than two times as large as implied by the frequency of individual rent adjustments.

Figures 6.1 and 6.2 show that the probability of rent adjustments depends on the value of x, suggesting that a landlord is more likely to adjust the rent the wider the gap, especially if the gap is substantially negative. As we saw in Section 2, there was a sharp rise in the market rent level in the late 1980s and early 1990s. Not surprisingly, this created a large gap for units without any recent turnover, thereby raising the probability of rent adjustment for those units.[12]

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 between a landlord and an existing tenant in that unit is renewed. We conduct hedonic regressions using the Recruit data, impute the rents for 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 level (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 level, probably because of the existence of public regulations to protect tenants such as 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 measure of price flexibility.

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 estimate of $\Lambda(x)$ is about 0.008 when x falls into 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

[12]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.

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

distribution $h(x)$, which is shown in the last 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 that 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 the state dependence of the two probabilities is at least partially cancelled out. 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.[13]

4.3 Aggregation and the 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

[13] 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 last price adjustment. In most cases, they find that the hazard function is downward sloping, which is 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 more than 600 weeks. This result is basically consistent with time-dependent pricing.

of the form

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

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 level in period t, which is applied to units randomly chosen with a probability of Λ_0, and the previous rent levels, which are applied to the remaining units for which the landlords accidentally did not have chance to adjust the 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 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 at the quarterly frequency.[14]

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 rents for all units, like the CPI for 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 the 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 can estimate Λ_0 using simple OLS and obtain $\Lambda_0 = 0.032$ with a standard error of 0.004 (adjusted R-squared=0.998). This implies that the quarterly Calvo parameter is 0.968. Compared with the estimate from the micro data, the macro estimate is slightly smaller, but the estimates are still quite close to each other, thus providing another piece of 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, thus causing the CPI for rent to respond only slowly to aggregate shocks. In this section, we examine this property quantitatively by reestimating CPI inflation over the last twenty years. Specifically, given that aggregate price dynamics are described by equation (10), we assume an alternative value for Λ_0, and calculate R_t using the actual values of R_t^*.

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

Table 6: Alternative Assumptions Regarding 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

We then combine this alternative index for rents with the actual values for the other components of the CPI to obtain an alternative measure of CPI inflation.[15]

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. However, the adjustment probability at the time of unit turnover is assumed to be unity, while 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. In this case, the probability $\Pr(\Delta R_{it} \neq 0)$ equals 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 probability reported by Genesove (2003) for the United States.

The results are shown in Figure 8. The blue line represents the actual year-on-year CPI inflation rate for Tokyo. The estimated CPI inflation rate for the first case is represented by the purple line. The blue and purple lines almost always overlap, indicating that CPI inflation would not have been very different even if rents were as flexible as in Germany. However, the red line, which represents the estimates for

[15] Housing services make up 26.3 percent of the CPI, consisting of 5.8 percent for renter-occupied housing services, 18.6 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, according to the current practice of Japan's statistic bureau, changes in tenant rents are imputed to owner-occupied housing by changing weights and not by creating a new and different index of the unique costs of owner occupancy. We shall discuss later in this section about prices for owner-occupied housing services.

the second case, differs substantially from the blue one. First, the estimated inflation exceeds actual inflation by one percentage point in 1987:1Q to 1988:4Q, indicating that CPI inflation would have been higher during the bubble period. Second, turning to the period following the burst of the bubble, the estimated inflation is lower than actual inflation by more than one percentage point in 1993:1Q to 1996:4Q. More importantly, the estimated inflation rates fall below zero in the fourth quarter of 1993, indicating that deflation would have started one year earlier than it actually did. 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 United States. In sum, Figure 8 shows that high stickiness in rents had substantial impacts on the movement of the total CPI in the 1980s and 1990s.

As a second experiment, we assume that the (imputed) prices for owner-occupied housing services are very flexible and thus never deviate from the corresponding market prices, while the prices for renter-occupied housing services are as sticky as reported in the previous sections. Based on this assumption, we replace the imputed rent for owner-occupied housing in the CPI by our estimate of the market rent R^*. This treatment is perfectly consistent with the rental equivalent approach which "values the services yielded by the use of a dwelling by the corresponding *market value* for the same sort of dwelling for the same period of time" (Diewert and Nakamura 2008). The result, which is shown in Figure 9, indicates that the CPI inflation rate would have been higher by one percentage point during the bubble period and lower by two percentage points during the post-bubble period.

6 Conclusion

Why was the Japanese consumer price index for rents so stable even during the period of the housing bubble in the 1980s? To address this question, we started by analyzing microeconomic rigidity and then investigated its implications for aggregate price dynamics. We found that in each year, 90 percent of the units in our dataset saw no change in rent, indicating that rent stickiness is three times as high as in the United States. We 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 the intensive and extensive margins of rent adjustments are very small, and this is why the CPI for rent responds only slowly to aggregate shocks. We showed 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 following the burst of the bubble, if housing rents in Japan were as flexible as those in the United States.

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

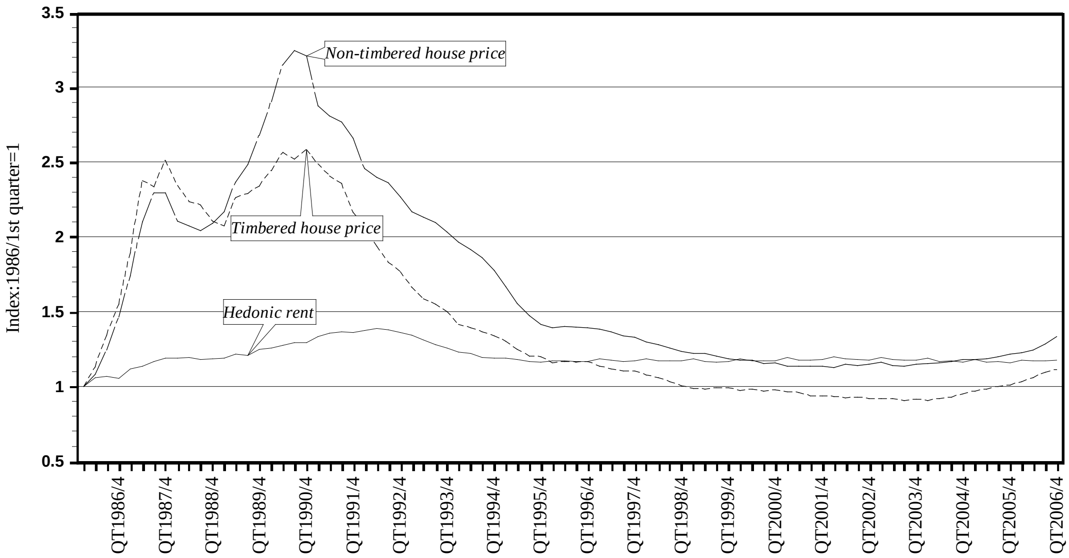

Figure 2: Hedonic Estimate versus CPI for Rent

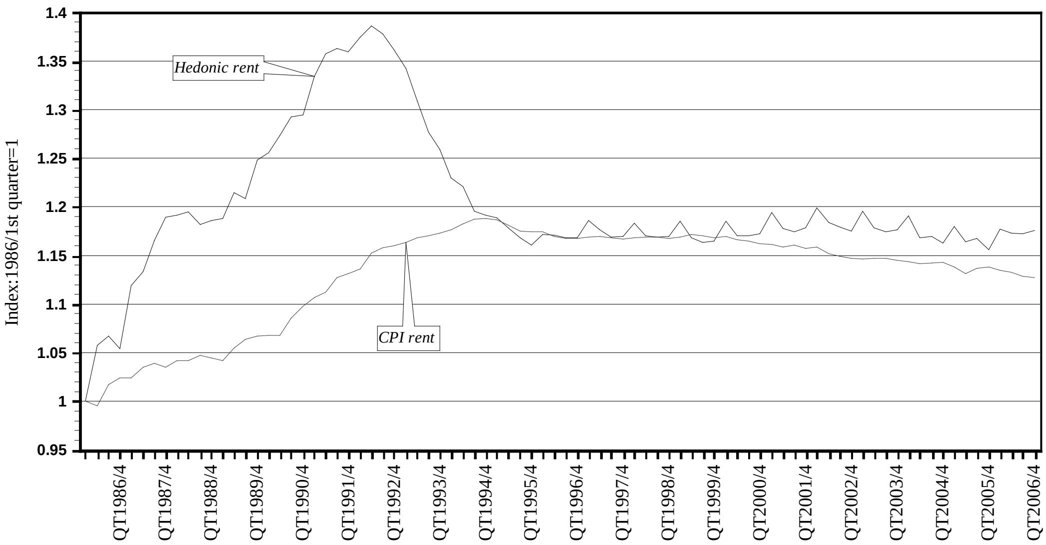

Figure 3: Cumulative Distribution Functions of Rent Growth

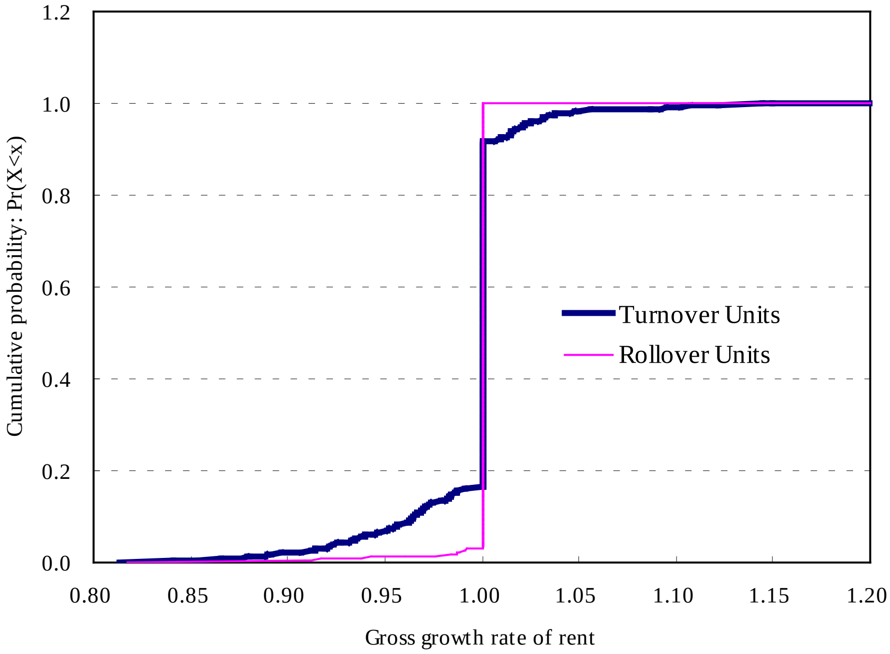

Figure 4.1: Probability of No Rent Adjustment

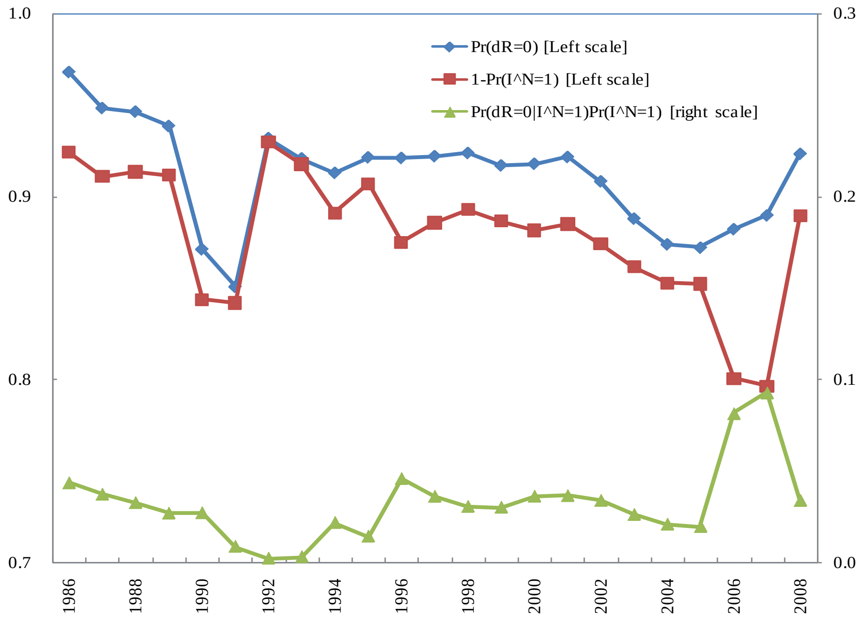

Figure 4.2: Probability of No Change in Monthly Payment and Contract-Signing Fee

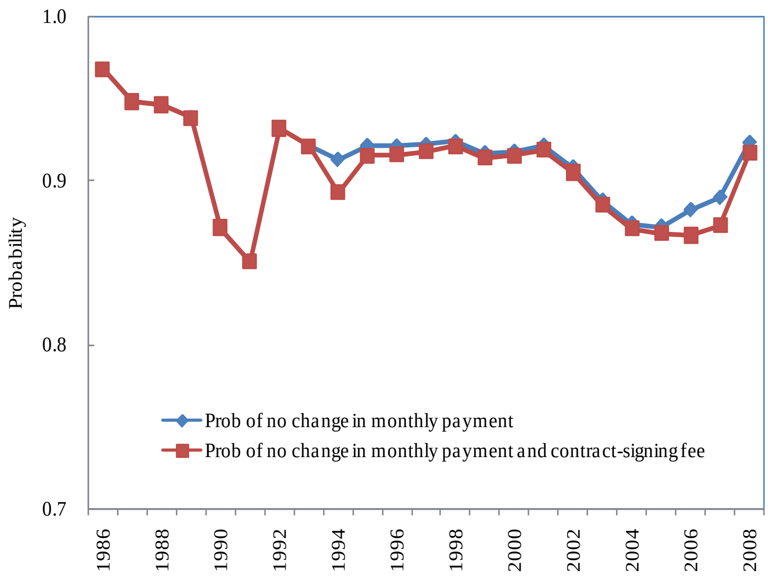

Figure 5: Probability of Unit Turnover

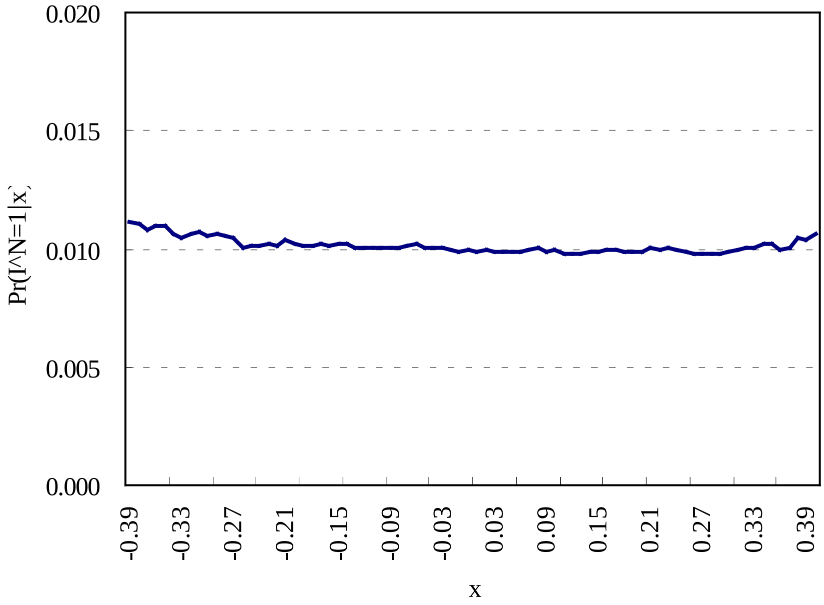

Figure 6.1: Adjustment Hazard Function for Turnover Units

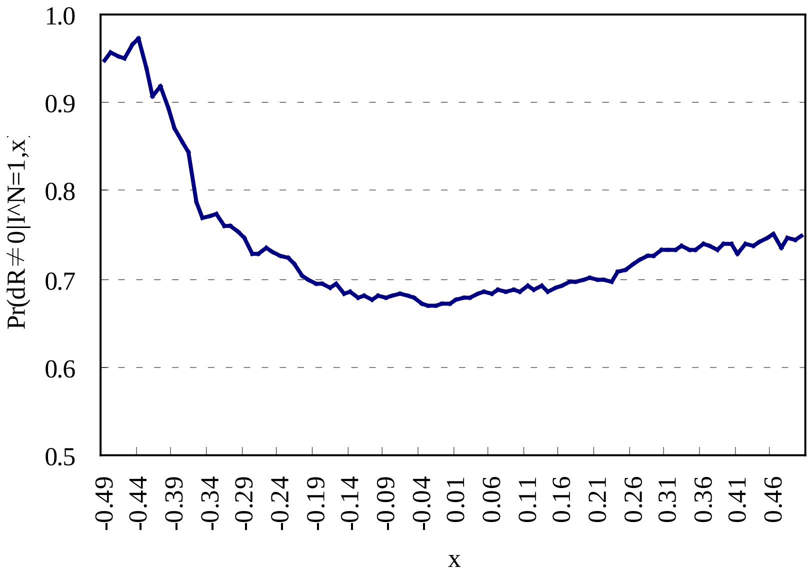

Figure 6.2: Elasticity of the Adjustment Hazard for Turnover Units with Respect to *x*

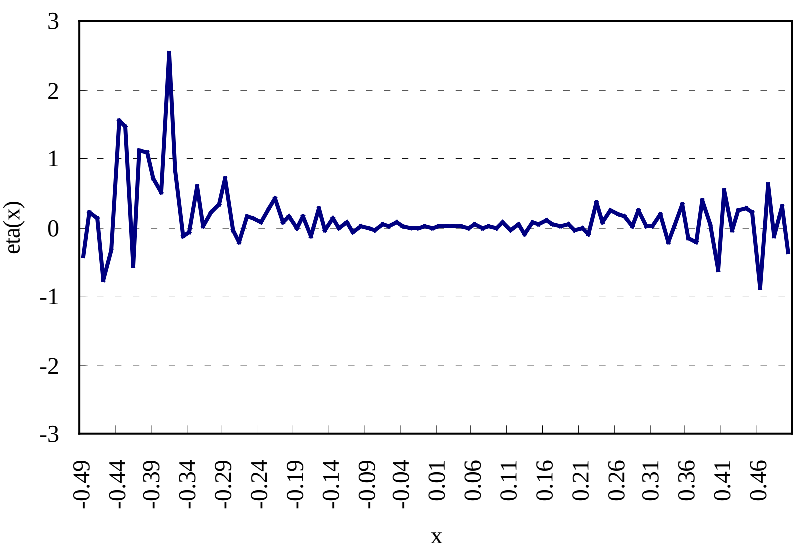

Figure 7: Adjustment Hazard Function for Rollover Units

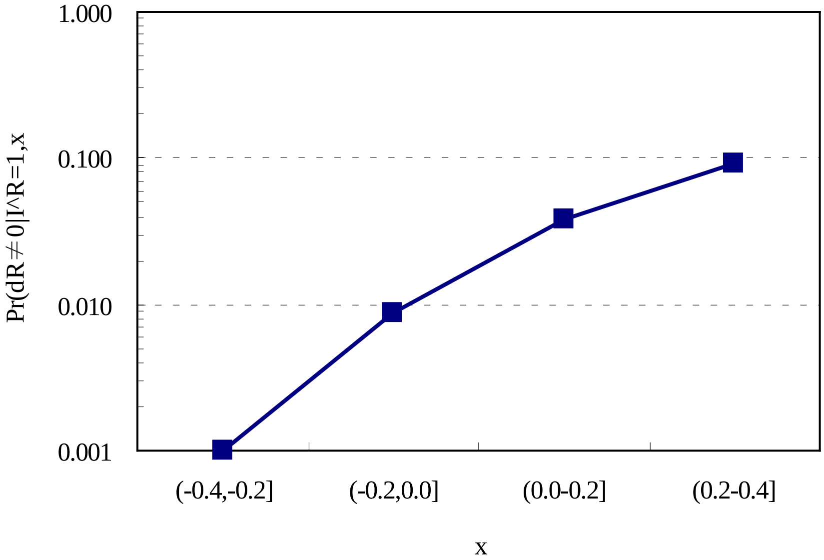

Figure 8: Reestimates of CPI Inflation Under Alternative Assumptions

Figure 9: Alternative Treatment of Owner Occupied Housing