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Downward-Sloping Term Structure of Lease Rates: A Puzzle†

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A model of the term structure of lease rates in a frictionless economy is developed and its predictions are compared with data on residential leases in Japan. The model shows that the initial lease rate for a cancellable lease must be set higher than that for a non-cancellable lease because the former rate will be repeatedly adjusted downward when the market rent decreases. More importantly, the term structure of lease rates is always upward-sloping for cancellable leases. Empirical findings show a sharp contrast with the theory. Fixed-term lease rates are often higher than open-ended long-term lease rates. Moreover, in the fixed-term lease sample, the term structure of lease rates is downward-sloping. The term structure is also heterogeneous by tenant's income. (*JEL*: D86, R31)

Key words: lease contracts, term structure, cancellation option, hedonic regression, residential real estate, option premium, Japan

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Real estate lease contracts are heterogeneous. They typically differ in their terms, in rent adjustment, and in embedded options. Coupled with physical heterogeneity of the underlying property, the contractual variations give rise to wide variations in equilibrium lease rates. Previous studies have proposed general theoretical models of lease rates that can accommodate different contractual characteristics (for example, see McConnell and Schallheim, 1983 and Grenadier, 1995). More recent studies enrich the model by introducing additional factors such as interest rate risk, tenant's credit risk, and imperfect competition (Clapham and Gunnelin, 2003, Ambrose and Yildirim, 2008, Agarwal et al., 2011, and Grenadier, 2005). However, detailed characteristics of lease rates for different types of contracts have not been fully understood. For example, Stanton and Wallace (2009) find that commercial lease rates cannot be explained by a model that incorporates interest rates, lease maturity, and contractual options.

In this study, we focus on the term structure of lease rates for "cancellable leases," with which the tenant has an early cancellation option without penalty. The term structure is important because it potentially contains a rich set of information about the expected level and the risk of rental income and discount rates. The term structure is usually considered to reflect future expected rents; e.g., an upward-sloping term structure is typically associated with higher future rents. Grenadier's (1995) "cold" and "hot" markets are in line with this view. However, we show that an upward-sloping term structure is not necessarily associated with higher expected rent when all lease contracts are cancellable by the tenant.

Specifically, we show that the lease rate for a long-term lease with the tenant cancellation option is at least as high as the lease rate for a non-cancellable long-term lease. We also show that the lease rates of repeatedly cancelled long-term leases track historical minima of market rents for newly arranged cancellable leases. More importantly, the term structure of lease rates is always upward-sloping for cancellable leases. The upward-sloping term structure holds even if short-term rents are expected to decrease in the future.
The intuition behind the upward-sloping term structure is the following. With a cancellable lease, the landlord writes an American cancellation option to the tenant and receives the option premium through regular rent payments. The value of an American option becomes larger as the term to expiration becomes longer because a longer-term option can be kept alive even after a shorter-term option expires. Thus, the landlord requires a higher premium for a longer term lease. In addition, the cancellation option offsets the negative effect of lower expected future rents on the long-term lease rate because lower expected rents increase the value of the written option, making the rent premium larger.

Next, using a data set from the Japan Household Panel Survey (JHPS) and the Keio Household Panel Survey (KHPS), we empirically analyze lease rates in the Japanese residential market. Japanese residential rental markets are ideal for studying lease cancellation options because the option is legally given to the tenant in all standard contracts. A tenant can terminate the contract on a standard unit anytime on three months' notice.

Under the current Japanese Tenant Protection Law (hereafter JTPL), there are two types of real estate lease contracts: the fixed-term lease and the general lease. The fixed-term lease, common in many other countries, was recently introduced with the March 2000 revision of JTPL. A fixed-term lease is renewed only if both the landlord and the tenant mutually agree to the terms of renewal. That is, the landlord also has the option to stop renewing the lease.

In contrast, the general lease, which has been more commonly used in Japan, severely restricts the landlord's discretion at renewal while keeping the tenant's option of early termination. Landlords are obligated to renew lease contracts and cannot evict incumbent tenants unless they provide a just cause to the satisfaction of the court.[‡] Furthermore, landlords are rarely able to increase rent enough to match appreciating market rent because of the strict requirement of a just cause for landlords. As a result, a tenant can use the same rental unit at almost the same rent on an open-ended basis. (See Iwata, 2002, and Seko and Sumita, 2007, for the discussion of the asymmetric restriction and its effects as a form of rent-control.)

We characterize both the fixed-term lease and the general lease in a single framework as cancellable leases. The general lease is an open-ended fixed-rent lease with the tenant cancellation option. Our model provides two main predictions. First, for fixed-term leases, lease rates are increasing in lease term. Second, the general lease rate is higher than any fixed-term lease rate. However, we find a sharp contrast between theory and data; contrary to the theoretical prediction, the data show a downward-sloping term structure of lease rates. We also find that the term structure is heterogeneous by tenant income. Several possibilities exist for the gap between the theory and the data. First, the current model assumes a perfect market with no transaction costs and no arbitrage. The introduction of contracting costs could make cancellation options less effective and also make short-term rents higher. Limits of arbitrage could create market segments that break the term structure. Second,

[‡] It is by Article 28 of the Tenure Law, or "Shakuchi-Shakka-Hou" of Japan.

we primarily focus on lease termination driven by a fall in market rent and omit other motives for lease termination such as job change and marriage. Incorporating these factors may help explain why fixed-term lease is less popular than general lease.[§] It is left for future research.

In all, the major contribution of our paper is two folds. First, we prove that the term structure for cancellable leases is always upward-sloping in a frictionless economy. Second, we find a sharp contrast between the theoretical prediction and the empirical results.

The paper is organized as follows. The next section presents the model. After describing data in the third section, we show empirical findings in the fourth section. The last section concludes.

Model

In this section, we show that 1) the lease rate for a cancellable long-term lease is at least as high as the lease rate for a comparable non-cancellable lease, and 2) the term structure with the cancellation option is upward-sloping. In other

[§] Adoption rate of fixed-term contracts in Japan as of March 2007 is 5.0%, of which 12.4% is detached single-family houses and 4.5% is collective housing (see *A Quick Look at Housing in Japan, 2009*, The Building Center of Japan).

words, even in the case where the expectation hypothesis holds for non-cancellable leases, it does not hold for cancellable leases. The model predicts that the term structure is always upward-sloping in Japan because all lease contracts are cancellable by tenant. In what follows, we first provide intuition and then explain a more detailed model.

For non-cancellable leases, the most basic component of the term structure is the expected market rents in the future. Under the expectation hypothesis, the long-term rental rate equals to a weighted average of expected short-term rates. The term structure of non-cancellable leases may be upward- or downward-sloping depending on the expected short-term rents in the future. Grenadier's (1995) "hot" and "cold" markets are determined by the expected rent appreciation in the future. The expectation hypothesis holds exactly if there are no risk premia or discounts for long-term rents; e.g., if landlords and tenants are risk neutral or rent risk is purely idiosyncratic.

If long-term leases are characterized as risky in relation to the wealth of a representative landlord, the long-term rent is higher than the average of short-term rents. To be more specific, if the short-term rent has a positive covariance with the asset pricing kernel (i.e., the stochastic discount factor), a long-term lease is riskier than a short-term lease. The landlord requires a higher rent for the riskier long-term lease. In this case, the term structure of lease rates for the non-cancellable leases is more likely to be upward-sloping.

However, if lease contracts are cancellable by tenant at any time, the term structure is quite different.** The term structure of cancellable leases cannot be downward-sloping even when rents are expected to decrease in the future. Suppose for now that future rents are deterministic. If future rents appreciate, the term-structure is upward-sloping by reflecting a weighted average of future rents. The cancellable lease is equivalent to the non-cancellable lease because the cancellation option is never exercised. In contrast, with certain depreciation, a long-term lease is replaced by new leases with lower rents either by cancellation or renegotiation. The cancellation option makes the long-term lease equivalent to the short-term lease. Hence, the term-structure of initial rent becomes flat.

The case of stochastic short-term rent falls between sure appreciation and sure depreciation. Due to the uncertainty in rents, the cancellation option has a positive value even if short-term rent is expected to rise. The value of the cancellation option increases with lease term. Since rent must cover the

** We primarily focus on a purely economic motive of cancellation; tenant cancels the lease when a lower rent is available in the market. Cancellation for other motives such as moving is left for future studies.

premium for the written option, the longer-term rent must be set higher, resulting in an upward-sloping term-structure.

Next, we formally prove the intuition. We adopt the "relative pricing" approach on the basis of the absence of arbitrage in the leasing market, just as for the pricing of financial assets. The no arbitrage relation holds for a wide range of equilibrium in the leasing market as long as landlords view lease contracts as income-generating assets. For a landlord, the value of a lease is the present value of planned rental payments adjusted for embedded options.

Consider a frictionless economy with discrete time, $t = 0, \ldots, \mathrm{T}$. The underlying uncertainty is represented by a filtered probability space $(\Omega, P, \mathcal{F}, (\mathcal{F}_t)_{t=0,\ldots,T})$. Given information at t (represented by the filtration $\mathcal{F}_t$), we denote conditional expectation by $\mathrm{E_t}(\cdot)$. Let an adapted stochastic process, $R_{S,t}$, denote the short-term rent for the period between t and $t+1$, with payment made at the beginning of the period. Let R_T and $\hat{R}_T$ denote the initial long-term (T-period) rents for non-cancellable leases and cancellable leases, respectively. Also let O_C denote the present value of the cancellation option. By introducing the asset pricing kernel for time t, denoted by m_t, the present values are:

$$V_S = \sum_{t=0}^{T-1} \mathrm{E}_0\left[R_{S,t}\, m_t\right], \tag{1}$$

$$V_T = \sum_{t=0}^{T-1} R_T \mathrm{E}_0[m_t], \tag{2}$$

$$\hat{V}_T = \sum_{t=0}^{T-1} \hat{R}_T \, \mathrm{E}_0[m_t] - O_C, \tag{3}$$

where $V_S, V_T,$ and $\hat{V}_T$ denote the present value of rolled-over short-term leases, the non-cancellable long-term lease, and the cancellable long-term lease, respectively. The pricing kernel can be understood as the landlord's stochastic marginal utility of wealth at time t relative to the marginal utility at time zero. We do not assume the uniqueness of the pricing kernel.

With no arbitrage in the asset market, the three values must be equal: $V_S = V_T = \hat{V}_T$. From the equality, we obtain the proposition on the relation of rents for different lease types.

Proposition 1: *Under the no arbitrage condition in a frictionless economy, the lease rate for a cancellable long-term lease is at least as high as the rate for an otherwise identical non-cancellable lease* ($\hat{R}_T \geq R_T$)*. In addition, if short-term rent is positively correlated with the asset pricing kernel, then the lease rate for a non-cancellable long-term lease is higher than the weighted average of expected short-term rents* $\left(\hat{R}_T \geq R_T > \bar{R}_S\right)$.

Proof: *By equating equations (1) and (2), and dividing both sides by T-period annuity factor,* $\sum_{u=0}^{T-1} \mathrm{E}_0[m_u]$, *we derive:*

$$R_T = \underbrace{\sum_{t=0}^{T-1} \mathrm{E}_0\left[R_{S,t}\right] \frac{\mathrm{E}_0[m_t]}{\sum_{u=0}^{T-1} \mathrm{E}_0[m_u]}}_{Expected\ rents \equiv \bar{R}_S} + \underbrace{\frac{\sum_{t=0}^{T-1} \mathrm{Cov}\left[R_{S,t}, m_t\right]}{\sum_{u=0}^{T-1} \mathrm{E}_0[m_u]}}_{Term\ premium}.$$

The first term, $\sum_{t=0}^{T-1} \mathrm{E}_0\left[R_{S,t}\right] \frac{\mathrm{E}_0[m_t]}{\sum_{u=0}^{T-1} \mathrm{E}_0[m_u]} \equiv \bar{R}_S$, *is a weighted average of expected short-term rents. The second term represents the term premium. The expectation hypothesis holds exactly when the second term is zero; e.g., rent risk is idiosyncratic or landlords and tenants are risk-neutral. The term premium or discount arises if the covariance in the second term is nonzero. If the covariance is positive, the short-term lease is less risky to the landlord because the rental income is positively correlated with her marginal utility. In this case, the landlord charges a higher rent for the long-term lease to assume the associated risk:* $R_T > \bar{R}_S$.

By equating equations (2) and (3), we derive:

$$\hat{R}_T = R_T + \underbrace{\frac{O_C}{\sum_{t=0}^{T-1} \mathrm{E}_0[m_t]}}_{Option\ premium}.$$

Because the option value, O_C, *is non-negative, we obtain* $\hat{R}_T \geq R_T$. *The equation holds with equality if the option value is zero; e.g., if the lease is not cancellable or if short-term rents will rise with probability one.* ■

Now we take a closer look at the landlord's rental income with the T-period cancellable lease. During the planned lease term, the landlord needs to accept lower lease rates when the tenant wants to exercise the cancellation option to take advantage of a low market rent. The landlord needs either to accept the rent reduction for the incumbent tenant or to find a new tenant at the current market rent. The rent is repeatedly reduced, but never raised. As a result, the actual rental rate is always kept at the historical minimum of market rents since the beginning of the first lease. This is analogous to the coupon rate in the valuation of a callable bond (see, Blume and Keim, 1988).

Let $\hat{R}_{T,t}$ denote the rent between time t and $t+1$ with the T-period leasing strategy. In other words, $\hat{R}_{T,t}$ is an adapted stochastic process with $\hat{R}_{T,0} = \hat{R}_T$, which represents the currently contracted cancellable lease rate after past cancellations. Also let $\hat{R}_{R,t}$ denote the market rent of a newly available cancellable lease at time t for the remaining term until time T: $\hat{R}_{R,t} \equiv \hat{R}_{T-t}$ at time t. The time-t rent with the T-period leasing strategy is: for $t = 1, \ldots, T-1$, $\hat{R}_{T,t} = \min\{\hat{R}_{T,t-1}, \hat{R}_{R,t}\}$. For example, the rent starts with $\hat{R}_T$ at time 0. At $t = 1$, if $\hat{R}_{R,1}$ is lower than $\hat{R}_T$, the rent is revised to $\hat{R}_{R,1}$, which is available in the market for the remaining $T-1$ periods until time T. At $t = 2$, the rent is revised again to $\hat{R}_{R,2}$ if $\hat{R}_{R,2}$ is lower than $\hat{R}_{R,1}$. By this recursive rent revision rule, the T-period strategy rent always traces the historical minimum of the market rent:

$\hat{R}_{T,t} = \min\{\hat{R}_{R,u}, u = 0, \dots, t\}$.

Figure 1 clarifies this characterization by illustrating a sample path of the market rent, $\hat{R}_{R,t}$, and the corresponding rent with the T-period strategy, $\hat{R}_{T,t}$. Although the market rent may go up and down, the rent with the T-period strategy never goes up.

=== Figure 1 around here ===

By using $\hat{R}_{T,t}$, we can write the present value of the T-period cancellable lease simply as:

$$\hat{V}_T = \sum_{t=0}^{T-1} \mathrm{E}_0\left[\hat{R}_{T,t}\, m_t\right]. \tag{4}$$

By equating equations (3) and (4), the value of the cancellation option is:

$$O_C = \sum_{t=0}^{T-1} \mathrm{E}_0\left[\left(\hat{R}_T - \hat{R}_{T,t}\right) m_t\right]. \tag{5}$$

The value of the cancellation option is the present value of the gap between the initial rent (10 in Figure 1) and the continually revised rent under the T-period strategy (the solid line in Figure 1) for all possible states. The option value is larger if the expected future rents are lower.

Now we analyze the term structure of rents for the cancellable lease. Intuitively, the option value makes the term structure more upward sloping because the value of American option is increasing in the term to maturity: $\partial O_C / \partial T > 0$. Furthermore, the option value offsets the effect of decreasing expected rents because the option value is greater when the expected rent is lower.

For a more concrete analysis, we compare the following two leasing strategies for T period:

1) T period strategy: Starting with a T-period lease with the cancellation option at the rate, $\hat{R}_T$.
2) $T-1$ period strategy: Starting with a $T-1$ period lease with cancellable option at the rate, $\hat{R}_{T-1}$, and arranging a short-term lease for the final period at $\hat{R}_{R,T-1}$.

In each strategy, the initial lease may be replaced by a new cancellable lease if the market rent becomes lower. The two strategies must give the same present value to the landlord to eliminate arbitrage opportunities. Let $\hat{R}_{T,t}$ and $\hat{R}_{T-1,t}$ denote the rental rate as of time t, possibly after several cancellations, for T period and $T-1$ period strategies, respectively.[††] Define Conditions (a) and (b):

Condition (a): At least one lease has not been cancelled until period $T-1$ $(\text{i.e., } \hat{R}_{R,t} > \min\{\hat{R}_T, \hat{R}_{T-1}\} \, for \; \forall t \leq T-2)$.

Condition (b): The market rent in the final period is higher than the T period strategy rent $(\text{i.e., } \hat{R}_{R,T-1} > \hat{R}_{T,T-2})$.

By focusing on the final period, we can show the following lemma on the lease rate.

Lemma: *In the final period, the* $T-1$ *period strategy rent* $(\hat{R}_{T-1,T-1})$ *has first-order stochastic dominance over the T period strategy rent* $(\hat{R}_{T,T-1})$ *. In particular, the T period strategy gives a strictly lower rent than the* $T-1$ *period strategy if both conditions* (a) *and* (b) *hold. Otherwise, both strategies give the same rent:* i.e.,

$$\hat{R}_{T,T-1} < \hat{R}_{T-1,T-1} \quad if \; (a) \; \hat{R}_{R,t} > \min\{\hat{R}_T, \hat{R}_{T-1}\} \, for \; \forall t \leq T-2 \; and \; (b) \; \hat{R}_{R,T-1} > \hat{R}_{T,T-2},$$

$$\hat{R}_{T,T-1} = \hat{R}_{T-1,T-1} \quad otherwise.$$

[††] $\hat{R}_{T-1,t}$ denotes the rent with the T-1 period *strategy* rather than with the T-1 period *lease*. Thus, $\hat{R}_{T-1,T-1}$ is the rent between time $T-1$ and T with the $T-1$ period strategy.

Proof:

There are three cases on the final period rent.

First Case: The T *period strategy gives a strictly lower rent than the* $T-1$ *period strategy in the final period if both conditions* (a) *and* (b) *hold.*

If the initial T *period rent is higher than the* $T-1$ *period rent* $\left(\text{i.e.}, \min\{\hat{R}_T, \hat{R}_{T-1}\} = \hat{R}_{T-1}\right)$*, Condition* (a) *implies that the* T *period strategy rent between* $T-2$ *and* $T-1$ *is* $\hat{R}_{T,T-2} = \min\{\hat{R}_{R,t}; t \leq T-2\}$ *and the* $T-1$ *period strategy rent is* $\hat{R}_{T-1,T-2} = \hat{R}_{T-1}$*. By Condition* (b)*, the* T *period strategy rent is unchanged in the final period* $\left(\hat{R}_{T,T-1} = \hat{R}_{T,T-2}\right)$ *but the* $T-1$ *period strategy's lease expires and the rent is adjusted upward to* $\hat{R}_{T-1,T-1} = \hat{R}_{R,T-1}$*. The same condition* (b) *also implies that the* T *period strategy rent is strictly lower than the T-1 period strategy rent:* $\hat{R}_{T,T-1} < \hat{R}_{T-1,T-1}$*.*

If the initial T period rent is lower than the T-1 period rent $\left(\text{i.e.}, \min\{\hat{R}_T, \hat{R}_{T-1}\} = \hat{R}_T\right)$*, Condition (a) implies that the T period strategy rent between T-2 and T-1 is* $\hat{R}_{T,T-2} = \hat{R}_T$ *and the T-1 period strategy rent is* $\hat{R}_{T-1,T-2} = \min\{\hat{R}_{R,t}; t \leq T-2\}$*. By Condition (b), the T period strategy rent is unchanged in the final period* $\left(\hat{R}_{T,T-1} = \hat{R}_{T,T-2} = \hat{R}_T\right)$*. The T-1 period strategy rent is* $\hat{R}_{T-1,T-1} = \min\{\hat{R}_{R,t}; t \leq T-1\}$*. The same condition (b) also implies that* *the T period strategy rent is strictly lower than the T-1 period strategy:* $\hat{R}_{T,T-1} < \hat{R}_{T-1,T-1}$.

Second Case: The final rent is $\hat{R}_{T,T-1} = \hat{R}_{T-1,T-1} = \hat{R}_{R,T-1}$ *for both strategies if Condition (a) holds but Condition (b) does not hold* $(\hat{R}_{R,T-1} \leq \hat{R}_{T,T-2})$.

Whether or not the initial T period rent is higher than the T-1 period rent, the rent is adjusted to the low market rent in the final period: $\hat{R}_{T,T-1} = \hat{R}_{T-1,T-1} = \hat{R}_{R,T-1}$.

Third Case: The final rent is $\hat{R}_{T,T-1} = \hat{R}_{T-1,T-1}$ *for both strategies if Condition (a) does not hold.*

Since both leases have been cancelled at the same time, both strategies use the same rent between T-2 and T-1: $\hat{R}_{T,T-2} = \hat{R}_{T-1,T-2} = \min\{\hat{R}_{R,t}; t \leq T-2\}$. *If the market rent is higher in the final period, both strategies keep the current lease:* $\hat{R}_{T,T-1} = \hat{R}_{T-1,T-1} = \hat{R}_{T,T-2}$. *Conversely, if the market rent is lower, both leases are cancelled and rents are adjusted to the market rent:* $\hat{R}_{T,T-1} = \hat{R}_{T-1,T-1} = \hat{R}_{R,T-1}$.

The $T-1$ *period rent is strictly higher than the* T *period rent in the first case, and it is equal to the* T *period rent in the second and third cases. As a result,* *the cumulative distribution function of* $\hat{R}_{T,T-1}$ *is at least as high as that of* $\hat{R}_{T-1,T-1}$*, and strictly higher in some states.* ■

Corollary: *The expected rent for the final period is strictly lower with the T period strategy*: $\mathrm{E}_0\left[\hat{R}_{T,T-1}\right] < \mathrm{E}_0\left[\hat{R}_{T-1,T-1}\right]$.

Because the $T-1$ period strategy gives a higher expected rent in the final period, it must give lower expected rents before the final period to satisfy the no arbitrage condition: $\sum_{t=0}^{T-1} \mathrm{E}_0\left[\left(\hat{R}_{T,t} - \hat{R}_{T-1,t}\right) m_t\right] = 0$. For this reason, the initial rent of the T period lease must be set higher than that of the $T-1$ period lease. Formally, by using the corollary, we obtain the key proposition of this study.

Proposition 2: *Under the no arbitrage condition in a frictionless economy, the term structure of lease rates is upward sloping if the tenant can terminate the lease at any time before maturity:* $\hat{R}_u > \hat{R}_{u-1}$ *for any lease term* $u = 2, \ldots, T$.

Proof: *Suppose the initial* T*-period rent is not higher than* $T-1$ *period rent:* $\hat{R}_T \leq \hat{R}_{T-1}$. *The* $T-1$ *period strategy gives a weakly positive rent premium until both leases are canceled. On top of that, the* $T-1$ *period strategy gives a strictly higher expected rent in the final period as shown by the Corollary.*

Then the $T-1$ period strategy gives a strictly higher value to the landlord, which violates the no arbitrage condition. Therefore, the initial T-period rent must be higher than the $T-1$ period rent: $\hat{R}_T > \hat{R}_{T-1}$. In other words, the term structure is upward-sloping between $T-1$ and T. Since we can apply the same argument to any lease term $u \geq 2$, the term structure is upward sloping for cancellable lease. ■

We can rewrite the no-arbitrage condition as follows by introducing the first cancellation time. Let τ_1 and τ_2, $\tau_1 \leq \tau_2$, denote the first cancellation time for the T and $T-1$ period strategies, respectively:

$$\tau_1 = \begin{cases} min\{t \in \{0, \ldots, T-2\}\colon\ \hat{R}_{R,t} < \hat{R}_T\} \ or \\ T-1 \ if \ the \ T \ strategy \ has \ no \ cancellation \ until \ T-2, \end{cases}$$

and

$$\tau_2 = \begin{cases} min\{t \in \{0, \ldots, T-2\}\colon\ \hat{R}_{R,t} < \hat{R}_{T-1}\} \ or \\ T-1 \ if \ the \ T-1 \ strategy \ has \ no \ cancellation. \end{cases}$$

The no-arbitrage condition is:

$$\sum_{t=0}^{\tau_1 - 1} \mathrm{E}_0\left[\left(\hat{R}_T - \hat{R}_{T-1}\right) m_t\right] + \mathbb{I}_{\{\tau_1 < \tau_2\}} \sum_{t=\tau_1}^{\tau_2 - 1} \mathrm{E}_0\left[\left(\hat{R}_{T,t} - \hat{R}_{T-1}\right) m_t\right]$$

$$+ \mathrm{E}_0\left[\left(\hat{R}_{T,T-1} - \hat{R}_{T-1,T-1}\right) m_{T-1}\right] = 0,$$

where $\mathbb{I}_{\{\tau_1 < \tau_2\}}$ is the indicator function that takes one if $\tau_1 < \tau_2$ and zero if $\tau_1 = \tau_2$. The first term is the present value of the initial rent gap before T period lease is cancelled at τ_1. The second term is the present value of the rent gap before both leases are cancelled at τ_2. After both leases are cancelled, there is no value difference between two strategies until period $T-1$. The third term, representing the present value of the rent gap in the final period (i.e., period between $T-1$ and T), is negative almost surely because of the first-order stochastic dominance of $\hat{R}_{T-1,T-1}$ over $\hat{R}_{T,T-1}$ (see Lemma). For the no-arbitrage equation to hold, the T-period rent must be set higher than the $T-1$ period rent: $\hat{R}_T > \hat{R}_{T-1}$.

In a numerical example under some reasonable assumptions, McConnell and Schallheim (1983) show an upward-sloping term structure of cancellable lease rates in their Table 1. Figure 2 below plots their simulation results.

=== Figure 2 around here ===

Up to now, we have only considered the tenant cancellation option. Sometimes, the landlord also has options, for instance the redevelopment option. With short-term leases, the landlord can exercise the option whenever it is optimal; the option is the American type. In contrast, with a long-term lease, the landlord can exercise the option only after the current lease is terminated, analogous to a European option.‡‡ Because the option value increases with the number of exercise points, rollover of short-term leases gives the greatest option value to the landlord. With a more valuable option, the landlord is willing to accept a lower rent with short-term leases. Thus, landlord's options are an additional factor for upward-sloping term-structure.

In Japan, both fixed-term leases and general leases are cancellable at any time. Furthermore, the tenant of a general lease can renew the contract as many times as she likes at almost the same lease rate. Therefore, the general lease is characterized as an open-ended fixed-rent lease with the tenant cancellation option. Proposition 2 gives the following predictions on residential lease rates in Japan.

Prediction:

1. The rent for a general lease is higher than any fixed-term lease, and

2. The term structure of fixed-term leases is upward sloping.

Schematically, the prediction is summarized in Figure 3. In Empirical Results Section, we report contradictory results to each of the above predictions. We

‡‡ When a lease is cancellable, the lessor's redevelopment option is not European as the time to expiration is stochastic.

call the failure of the first and second predictions Puzzle I and Puzzle II, respectively.

=== Figure 3 around here ===

Data

KHPS and JHPS

The data are drawn from the Keio Household Panel Survey (KHPS) and the Japan Household Panel Survey (JHPS). Both surveys are sponsored by the Ministry of Education, Culture, Sports, Science and Technology and conducted by Keio University's Faculty of Economics, Business and Commerce in Japan. The first wave of the KHPS was conducted in January 2004 for 4,005 households that were selected with stratified two-stage sampling. Although respondents are restricted to those aged between 20 and 69 in the first wave, the demographic characteristics of the survey are representative of Japanese households. In the fourth wave, a new sample of 1,419 households was added. The most recent wave (2011) has data for 3,030 households. In the following analysis, we utilize eight waves of the KHPS between 2004 and 2011.

Beginning in 2009, the JHPS expanded the sample of KHPS. The first wave of the JHPS was conducted in January 2009 for 4,000 households. The second and third waves were conducted in subsequent years for 3,470 and 3,160 households, respectively. Because both surveys share many common items, we can augment the KHPS with JHPS.

Drawing on eight waves of the KHPS and three waves of the JHPS, we construct a sample of renters who moved into rental units after March, 2000. Since 2000, the amended JTPL has allowed the use of the fixed-term lease. For each renter, we gather the following variables: the type of lease contract, lease term, move-in year, monthly rent, deposit, building age, number of rooms, time to the nearest public transport, building type, and location. Each wave contains the information of those who moved in the previous year. The second wave of the KHPS contains additional information for previous housing tenure between 2000 and 2002. Although the original sample is panel data for both homeowners and renters, our sample is a cross-section for renters. The number of observations after deleting incomplete observations is 450 for general lease and 218 for fixed-term lease.

Descriptive Statistics of General Lease and Fixed-Term Lease

Table 1a summarizes the descriptive statistics of general leases and fixed-term leases. The average contract term of fixed-term leases is 3.1 years. The average real monthly rent of general leases is significantly lower than that of fixed-term leases. On the other hand, the average deposit for general leases is higher than that for fixed-term leases. The average age of housing unit is 16 years and 15.5 years for general leases and fixed-term leases, respectively. The major type of dwelling is a reinforced concrete building with two or more units for both types of leases. The share of wooden buildings is significantly higher for fixed-term leases. Nearly 60% of fixed-term leases are located in Kanto, which includes Tokyo.

=== Table 1a around here ===

Regarding characteristics of household head (hereafter denoted by h.h.), the share of h.h. with a fulltime job is similar between two samples. Although the mean real income of the fixed-term lease households is higher, the difference is not statistically significant. Both the average age of h.h. and the share of married h.h. are significantly higher in the general lease sample. We need to control for these differences in characteristics between two samples when we compare general lease rates with fixed-term rents. We explain our strategy in the next section.

A Comparison of Samples with Positive and Negative Predictive Errors

To compare rents for fixed-term leases and general leases, we construct the predictive error of the fixed-term lease rate by using a general lease model. First, we estimate a hedonic model of the monthly rent per square meter for general leases. The result is presented in Table 5 in the Appendix. The explanatory variables are building age, number of rooms, type of dwelling, time to the nearest station, location characteristics, region, year of contracting, deposit, and household head characteristics. We do not include lease term because it is irrelevant for general leases. Second, using the estimated model, we make the out-of-sample prediction of rent for the sample of fixed-term leases. The predicted value represents the hypothetical rent if the rental unit were leased with the general lease contract. Third, the predictive error is calculated by subtracting the predicted value from the actual fixed-term lease rate.

We divide the fixed-term lease sample into two groups by the sign of the predictive error. The sample with positive errors is inconsistent with Prediction 1, and vice versa (see Model Section). The number of observations with positive and negative errors is 112 and 106, respectively. Table 1b summarizes the descriptive statistics of the two subsamples of fixed-term leases. Without controlling for other attributes, there is no significant difference in the average length of the contract term: 3.14 years for the positive error group and 3.08 years for the negative error group. Relative to the negative error sample, the positive error sample shows a higher average real monthly rent, a smaller unit size, a higher building age, a lower share of townhouse, a lower share of non-major cities, and lower shares in Chugoku and Shikoku regions. As for the household head characteristics, the positive error sample shows lower income, smaller income dispersion, a lower share of full-time employment, a higher average age, and a higher share of male h.h.. However, these attributes are obviously correlated to each other, which makes interpretation difficult. To control for the effect of correlated attributes, we conduct a more detailed regression analysis in the next section.

=== Table 1b around here ===

Empirical Results

Empirical Model

We estimate several variations of the following equation for fixed-term lease rates:

$$perror_{it} = \alpha + \beta L'_{it} + \gamma X'_{it} + \varepsilon_{it}. \tag{6}$$

The dependent variable is the predictive error of fixed-term lease rates, $perror_{it}$, for tenant i and contracted in time t. The predictive error is as defined in Data Section. As for the independent variables, L_{it}, is the vector of lease term dummies. To capture the nonlinear relation between predictive error and lease term, we categorize lease term into four periods: (1) one year and shorter, (2) from two to three years, (3) from four to five years, and (4) six years and longer. We use the "one year and shorter" category as the reference, therefore three dummy variables are included in L_{it}. X_{it} is a vector of housing and tenant characteristics. Housing characteristics consist of the number of rooms, building age, type of dwelling, and the time distance to the nearest station/bus stop. Tenant characteristics consist of annual income, state of employment, age, sex, highest education degree, and marital status of household head. We also control for contracting year. Parameters, α, β, and γ, are estimated and ε_{it} is the stochastic error term. The estimation result, labeled as Model (a), is summarized in Table 2.

We additionally estimate a model that allows heterogeneous term structures:

$$perror_{it} = \alpha + \beta L'_{it} + \delta L'_{it} \times y_{it} + \gamma X'_{it} + \varepsilon_{it}, \tag{7}$$

where y_{it} represents the variable interacted with the lease term vector L_{it}. We select five variables for y_{it} mainly based on the significance of their estimated coefficients in equation (6). Model (b) uses the high rent growth dummy, which takes one if the average rent growth rate in the prefecture is above the national median. Theory predicts that the expected rent growth has a significant effect on the term structure of lease rates. The slope of term structure should be steeper in locations with higher rent growth expectations. Model (c) uses the high income dummy, which takes one if the real annual income of household head is equal to or greater than five million Japanese Yen (JPY). Model (d) uses the detached housing dummy. Model (e) uses the middle-to-high age dummy, which takes one if the age of household head is equal to or older than 40 years old. Estimation results of these models are summarized in Table 3.

We also estimate the model with two interaction terms to examine the omitted variables problem:

$$perror_{it} = \alpha + \beta L'_{it} + \delta L'_{it} \times y_{it} + \theta L'_{it} \times z_{it} + \gamma X'_{it} + \varepsilon_{it}, \qquad (8)$$

where z_{it} denotes the additional variable interacted with lease term. Model (f) uses both the high income dummy and the middle-high age dummy and Model (g) uses both the high income dummy and the detached housing dummy. Estimation results are summarized in Table 4.

Baseline Results

Table 2 shows the estimation results of our baseline model: Model (a) specified by Equation (6). The estimated coefficients for lease term dummies are significantly negative, with greater magnitude for longer-terms. The increasingly negative coefficients indicate that the term structure is downward sloping after controlling for differences in various characteristics. The effect is also economically significant; rent differences are up to 703 JPY for the mean monthly rent of 1,676 JPY per square meter.

Figure 4 shows the empirical model's prediction of the predictive error, evaluated at mean values for numeric variables and modes for dummy variables.[§§] As lease term increases, predictive errors monotonically decrease from positive values to negative values. This is in stark contrast to the theoretical prediction (see Proposition 2). The theoretical model in Model Section shows that the predictive error is negative for any term (Puzzle I) and the term structure is upward sloping (Puzzle II). Even if the market rent is expected to decrease in the future, it should not affect the current rent of cancellable leases as long as leases can be cancelled without transaction costs.

[§§] The mean of continuous variables are: 15.5 years for building age, 9.3 minutes for time to the nearest station, 5.32 million JPY for real annual income, and 37.1 years old for the age of household head.

=== Table 2 around here ===

=== Figure 4 around here ===

In Table 2, we also find heterogeneity with respect to the characteristics of household head and the type of dwelling. For the characteristics of the household head, real income, age, sex, and highest education attained significantly influence the predictive error. For the type of dwelling, detached housing shows a significantly negative coefficient, implying that the fixed-term lease is cheaper for detached housing than for apartment with reinforced concrete structure. The rent gap is 424 JPY per square meter, and is economically significant. We generally find insignificant effects for number of rooms, location characteristics, region, year of contracting, and deposit. In the next section, we further explore the effect of income, dwelling type, and the age of household head, not only on the intercept but also on the slope of the term structure.

Heterogeneous Term Structure

We estimate Equation (7), which includes interaction terms of lease terms with dummies for high rent growth (b), income (c),dwelling type (d) and age of household head (e). Table 3 tabulates the results. The table only reports the variables that are relevant for the term structure. Other results are generally consistent with those in Table 2.

=== Table 3 around here ===

Model (b) examines whether the term structure is different in locations with high rent growth. Proposition 1 indicates that rapidly increasing future rents are a factor that makes the slope steeper, ceteris paribus. However, this prediction is difficult to test rigorously because of the difficulty in constructing the expected growth in market rent for each house conditional on the information set of the landlord and tenant. Instead, we use the average rent growth at the prefecture level over ten years between 2000 and 2010. We test whether high growth is associated with different slopes of the term structure. The high growth dummy takes a value of one if rent growth is higher than the national median value (-2.2%). The overall term structure remains downward sloping. Since all interaction terms are insignificant, we find no evidence of more upward-sloping term structure in locations with high rental growth. The result does not change if we alternatively use the dummy that takes a value of one if rent growth is positive.

With Model (c), we find a distinct term structure for high income households. The threshold for high income is five million JPY, which is roughly the mean of the sample. The term structure for non-high income households is downward sloping. However, for high income households, the intercept is significantly negative, and the interaction terms are all significantly positive. Figure 5 shows the predicted value of Model (c), evaluated at mean values for numeric variables and modes for dummy variables. The predicted rent for high income households is lower than that for non-high income households, and particularly low with the 1-year lease. The slope is downward for both income groups beyond 2 years. Though both Puzzles I and II are present for both income groups, they are more profound for non-high income households.

=== Figure 5 around here ===

Model (d) examines whether the term structure is different for detached housing. For detached housing, the intercept is significantly negative, and the interaction terms are all significantly positive. Figure 6 shows the predicted value of Model (d), evaluated at mean values for numeric variables and modes for dummy variables. At the first glance, the term structure for the detached housing seems to be distinct, as for high income households. However, high income households tend to rent detached housing. We address the omitted variable bias by including both the high income dummy and the detached housing dummy in Model (g). The effect of interaction terms with detached housing disappears when we include the high income dummy; the effect of detached housing turns out to be spurious.

=== Figure 6 around here ===

Model (e) examines whether the lease for older h.h. exhibits a distinct term structure. Again at the first glance, there seems to be a distinct structure with a significantly negative intercept and significantly positive interaction terms. However, as we show in Model (f), the effect of interaction terms with age disappears when we include the high income dummy. The seemingly heterogeneous slope by age is the result of a positive correlation between high age and high income.

=== Table 4 around here ===

In an attempt to solve the aforementioned problem of omitted variables, we estimate Equation (8) and present the results in Table 4. Model (f) includes both high income and middle-high age dummies, and Model (g) includes both high income and detached house dummies. Coefficients of the interaction terms with the high income dummy are not very different from those in Table 3 and statistically significant in both models. In contrast, coefficients for the age and detached housing dummies become different from those in Table 3 and largely insignificant. By Wald test, we do not reject the null hypothesis that the coefficients of the interaction terms with the middle-high age dummy in model (f) are collectively zero ($Prob(\chi^2(3) > 2.306) = 0.511$). Similarly, we do not reject the null hypothesis of zero coefficients for the interaction terms with detached housing dummy in model (g) ($Prob(\chi^2(3) > 4.44) = 0.218$). Therefore, we conclude that the heterogeneity of slope is generated by income, not by age or dwelling type. The heterogeneous intercepts by age and dwelling type are still significantly negative. Age and dwelling type affects the overall rent level but not the term structure.

=== Figure 7 around here ===

Figure 7 plots the predicted value for non-detached housing in Model (g). The structure is almost identical to the one in Figure 6. The rent for high-income tenants shows a flatter term structure, which is relatively more consistent with the theory. On the rent level, the long-term contract for detached housing with young, female, and high income tenants is relatively more consistent with the theory. In contrast, the most puzzling lease is the one-year contract for reinforced concrete structured apartments with old, male, low income tenants. Such tenants seem to have relatively weak bargaining power against the landlord, but more detailed analysis is reserved for future research.

Conclusion

The term structure of lease rates is generally considered as a reflection of expected future rents. An upward-sloping structure is often associated with increasing rents in the future. In this study, we prove that the term structure for cancellable lease is upward-sloping even if future rents are expected to decrease. However, the Japanese rental market for housing, which gives an excellent sample of cancellable leases, exhibits a downward-sloping term structure. We believe that the heterogeneous slopes by tenant income are a clue to solving the puzzle. Transaction costs, limits to arbitrage, and sample selection are among potential factors that enrich the model. By solving the puzzle, we expect to gain insight into why fixed-term contracts are not so widely used in Japan.

Appendix

=== Table 5 around here ===

Reference

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Table 1a: Variable definitions and summary statistics

Variables	General lease		Fixed-term lease		Group mean
	Mean	Std.Dev.	Mean	Std.Dev.	P-values
Real rent per month (in 1,000 yen, 2010 price)	68.965	38.722	72.012	32.864	0.096
Space (in square meter)	56.180	49.203	53.436	51.350	0.238
Real rent per month (in 1,000 yen/per space , 2010 price)	1.504	0.852	1.676	0.812	0.001
Predictive error (in 1,000 yen, 2005 price)			0.040	0.707	
Deposit: multiple of monthly rent (in months)	2.476	1.962	1.939	0.954	0.000
Lease term (in years)			3.110	1.706	
Building age (in years)	16.360	10.901	15.528	10.176	0.107
Number of rooms	3.289	1.231	3.092	1.184	0.001
Type of dwelling					
Detached house	0.133	0.340	0.101	0.302	0.044
Townhouse	0.040	0.196	0.046	0.210	0.526
Apartment, reinforced concrete structure	0.622	0.485	0.550	0.499	0.002
Apartment, Wooden structure	0.200	0.400	0.294	0.456	0.000
Other type	0.004	0.067	0.009	0.096	0.133
Time to the nearest station	8.491	8.196	9.344	8.208	0.028
Location characteristics					
14 major cities	0.384	0.487	0.353	0.479	0.174
Other cities	0.551	0.498	0.587	0.493	0.125
Region					
Hokkaido	0.033	0.180	0.032	0.177	0.885
Tohoku	0.047	0.211	0.046	0.210	0.936
Kanto	0.389	0.488	0.564	0.497	0.000
Chubu	0.129	0.335	0.115	0.319	0.369
Kinki	0.180	0.385	0.096	0.296	0.000
Chugoku	0.058	0.234	0.069	0.254	0.317
Shikoku	0.024	0.155	0.028	0.164	0.673
Kyushu	0.140	0.347	0.050	0.219	0.000
Year of contracting					
2000	0.078	0.268	0.073	0.261	0.729
2001	0.084	0.278	0.101	0.302	0.210
2002	0.080	0.272	0.073	0.261	0.606
2003	0.087	0.282	0.101	0.302	0.284
2004	0.124	0.330	0.119	0.325	0.740
2005	0.096	0.294	0.092	0.289	0.784
2006	0.133	0.340	0.101	0.302	0.044
2007	0.096	0.294	0.110	0.314	0.295
2008	0.118	0.323	0.133	0.340	0.317
2009	0.067	0.250	0.069	0.254	0.856
2010	0.038	0.191	0.028	0.164	0.255
Household head characteristics					
Real annual income (in 10,000 yen, 2010 price)	510.919	321.534	531.799	419.975	0.169
Full-time employment worker (=1 if yes)	0.567	0.496	0.587	0.493	0.381
Age (in years)	38.956	12.402	37.073	11.961	0.001
Sex (=1 if female)	0.209	0.407	0.188	0.392	0.279
Highest formal education level (=1 if college)	0.229	0.421	0.243	0.430	0.473
Marital status (=1 if married)	0.284	0.452	0.225	0.418	0.005
N	450		218		

Note: The table reports descriptive statistics of the sample categorized by lease types “General lease” and “Fixed-term lease”. "Group mean comparison" represents p-value of paired t-test of equal means between two samples. The test is conducted using Welch's approximation.

Table 1b: Variable definitions and summary statistics by predictive error

Variables	Fixed-term lease				Group mean
	Predictive error >=0		Predictive error <0		
	Mean	Std.Dev.	Mean	Std. Dev.	P-values
Real rent per month (in 1,000 yen, 2010 price)	77.278	31.009	66.448	33.981	0.000
Space (in square meter)	41.839	19.188	65.689	69.031	0.000
Real rent per month (in 1,000 yen/per space , 2010 price)	2.059	0.830	1.270	0.559	0.000
Predictive error (in 1,000 yen, 2010 price)	0.569	0.498	-0.518	0.396	0.000
Deposit: multiple of monthly rent (in months)	1.936	0.893	1.942	1.018	0.945
Lease term (in years)	3.143	1.770	3.075	1.643	0.976
Building age (in years)	17.857	10.806	13.066	8.868	0.000
Number of rooms	3.232	1.237	2.943	1.111	0.133
Type of dwelling					
Detached house	0.089	0.286	0.113	0.318	0.378
Townhouse	0.027	0.162	0.066	0.250	0.011
Apartment, reinforced concrete structure	0.589	0.494	0.509	0.502	0.089
Apartment, Wooden structure	0.286	0.454	0.302	0.461	0.706
Other type	0.009	0.094	0.009	0.097	0.955
Time to the nearest station	9.250	9.369	9.443	6.813	0.827
Location characteristics					
14 major cities	0.366	0.484	0.340	0.476	0.564
Other cities	0.536	0.501	0.642	0.482	0.026
Region					
Hokkaido	0.045	0.207	0.019	0.137	0.190
Tohoku	0.054	0.226	0.038	0.191	0.460
Kanto	0.563	0.498	0.566	0.498	0.940
Chubu	0.134	0.342	0.094	0.294	0.222
Kinki	0.107	0.311	0.085	0.280	0.450
Chugoku	0.027	0.162	0.113	0.318	0.000
Shikoku	0.009	0.094	0.047	0.213	0.000
Kyushu	0.063	0.243	0.038	0.191	0.282
Year of contracting					
2000	0.089	0.286	0.057	0.232	0.229
2001	0.125	0.332	0.075	0.265	0.116
2002	0.027	0.162	0.123	0.330	0.000
2003	0.098	0.299	0.104	0.306	0.844
2004	0.134	0.342	0.104	0.306	0.352
2005	0.063	0.243	0.123	0.330	0.010
2006	0.143	0.351	0.057	0.232	0.010
2007	0.098	0.299	0.123	0.330	0.388
2008	0.098	0.299	0.170	0.377	0.012
2009	0.071	0.259	0.066	0.250	0.826
2010	0.054	0.226			
Household head characteristics					
Real annual income (in 10,000 yen, 2010 price)	469.350	232.725	597.783	546.540	0.000
Full-time employment worker (=1 if yes)	0.527	0.502	0.651	0.479	0.009
Age (in years)	38.580	12.583	35.481	11.104	0.010
Sex (=1 if female)	0.134	0.342	0.245	0.432	0.001
Highest formal education level (=1 if college)	0.268	0.445	0.217	0.414	0.227
Marital status (=1 if married)	0.214	0.412	0.236	0.427	0.580
N	112		106		

Note: The table reports descriptive statistics of the fixed-lease sample that are partitioned into two subsamples: positive predictive error group and negative predictive error group. "Group mean comparison" represents p-value of paired t-test of equal means between two samples. The test is conducted using Welch's approximation.

Table 2: Estimation results of predictive error model: Baseline model

Model	(a)		
	Coef.		t
Lease term (in years)			
1 year	reference		
2-3 years	-0.329	*	-1.687
4-5 years	-0.474	**	-2.198
over 6 years	-0.703	***	-2.731
Building age (in years)	0.014	***	3.119
Number of rooms			
1 room	-0.252		-1.072
2 rooms	0.046		0.311
3 rooms	reference		
4 rooms	-0.026		-0.232
5 rooms	0.423	**	2.277
over 6 rooms	0.250		1.069
Type of dwelling			
Detached house	-0.424	**	-2.230
Townhouse	-0.276		-1.398
Apartment, reinforced concrete structure	reference		
Apartment, Wooden structure	0.009		0.079
Other type	-0.685	***	-2.896
Time to the nearest station	-0.009	*	-1.851
Location characteristics			
Non urban areas	reference		
14 major cities	-0.202		-1.108
Other cities	-0.247		-1.499
Region			
Hokkaido	0.003		0.010
Tohoku	-0.021		-0.113
Kanto	reference		
Chubu	0.236		1.532
Kinki	0.063		0.370
Chugoku	-0.241		-1.472
Shikoku	-0.236		-1.294
Kyushu	0.312		1.498
Year of contracting			
2000	reference		
2001	0.167		0.830
2002	-0.538	**	-2.272
2003	-0.072		-0.312
2004	0.150		0.706
2005	-0.295		-1.188
2006	-0.013		-0.068
2007	-0.315		-1.524
2008	-0.181		-0.915
2009	-0.388	*	-1.764
2010	0.619	**	2.278
Deposit: multiple of monthly rent (in months)	-0.015		-0.278
Household head characteristics			
Real annual income (in 10,000 yen, 2010 price)	-0.0003	***	-2.8506
Full-time employment (=1 if yes)	-0.069		-0.665
Age (in years)	0.018	***	3.608
Sex (=1 if female)	-0.258	**	-2.012
Highest education (=1 if college)	0.215	*	1.711
Marital status (=1 if married)	-0.144		-1.179
Constant	0.174		0.543
R-suared	0.401		
Adjusted R-squared	0.266		
s	0.606		
N	218		

Note: This table shows the estimation results of our baseline model: Model (a) specified by Equation (6). The dependent variable is predictive error. Heteroskedasticity consistent standard errors are calculated. Significance level: ***:1%, **: 5%, *:10%.

Table 3: Estimation results of predictive error model

Model	(b)		(c)		(d)		(e)	
Variable interacted with lease term	High growth dummy		High income dummy		Detached house dummy		Middle-high age dummy	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Lease term (in years)								
1 year	reference		reference		reference		reference	
2-3 years	-0.255	-0.87	-0.850 ***	-3.25	-0.427 **	-2.11	-0.493 **	-2.29
4-5 years	-0.699 **	-2.12	-1.024 ***	-3.25	-0.547 **	-2.42	-0.617 **	-2.49
over 6 years	-0.725 *	-1.94	-1.101 ***	-2.97	-0.785 *	-2.61	-0.855 **	-2.06
2-3 years × interacted variable	-0.137	-0.38	1.009 ***	2.80	1.219 ***	3.04	1.008 ***	2.83
4-5 years × interacted variable	0.397	1.00	1.052 **	2.59	0.923 **	2.11	0.819 **	2.00
over 6 years × interacted variable	0.025	0.05	0.769 *	1.72	0.969 **	2.29	0.925 *	1.78
Interacted variable	-0.076	-0.22	-1.021 ***	-2.98	-1.474 ***	-4.65	-1.171 ***	-2.95
R-suared	0.421		0.428		0.412		0.419	
Adjusted R-squared	0.274		0.283		0.267		0.272	
s	0.603		0.599		0.606		0.604	
N	218		218		218		218	

Note: Table tabulates the estimation results of Equation (7), which includes interaction terms of lease terms with dummies for high rent growth (b), income (c), dwelling type (d) and age of household head (e). The dependent variable is predictive error. Only the main variables are reported since other results are generally consistent with those in Table 2. Heteroskedasticity consistent standard errors are calculated. Significance level: ***:1%, **: 5%, *:10%. High growth dummy takes 1 if rent growth rate is greater than the median rate, -2.2%. The rent growth rates of the capital city of each prefecture are taken from Consumer Price Index. High income dummy takes 1 if real annual income is greater than 5 million yen. Middle-high age dummy takes 1 if age of household head is greater than 40 years old.

Table 4: Estimation results of predictive error model with interaction terms.

Model	(f)		(g)	
Variable interacted with lease term	High income dummy & Middle-high age dummy		High income dummy & Detached house dummy	
	Coef.	t	Coef.	t
Lease term (in years)				
1 year	reference		reference	
2-3 years	-0.889 ***	-3.36	-0.860 ***	-3.20
4-5 years	-1.075 ***	-3.31	-1.033 ***	-3.20
over 6 years	-1.139 **	-2.54	-1.104 ***	-2.82
2-3 years × High income dummy	0.924 **	2.32	0.902 **	2.44
4-5 years × High income dummy	1.062 **	2.41	1.019 **	2.41
over 6 years × High income dummy	0.749	1.47	0.679	1.44
High income dummy	-0.918 **	-2.49	-1.066 ***	-3.48
2-3 years × Middle-high age dummy	0.521	1.38		
4-5 years × Middle-high age dummy	0.267	0.63		
over 6 years ×Middle-high age dummy	0.432	0.79		
Middle-high age dummy	-0.719 *	-1.83		
2-3 years × Detached house dummy			0.782 *	1.94
4-5 years ×Detached house dummy			0.420	0.93
over 6 years × Detached house dummy			0.604	1.49
Detached house dummy			-0.923 **	-2.60
R-suared	0.439		0.434	
Adj. R-squared	0.280		0.277	
s	0.600		0.601	
N	218		218	

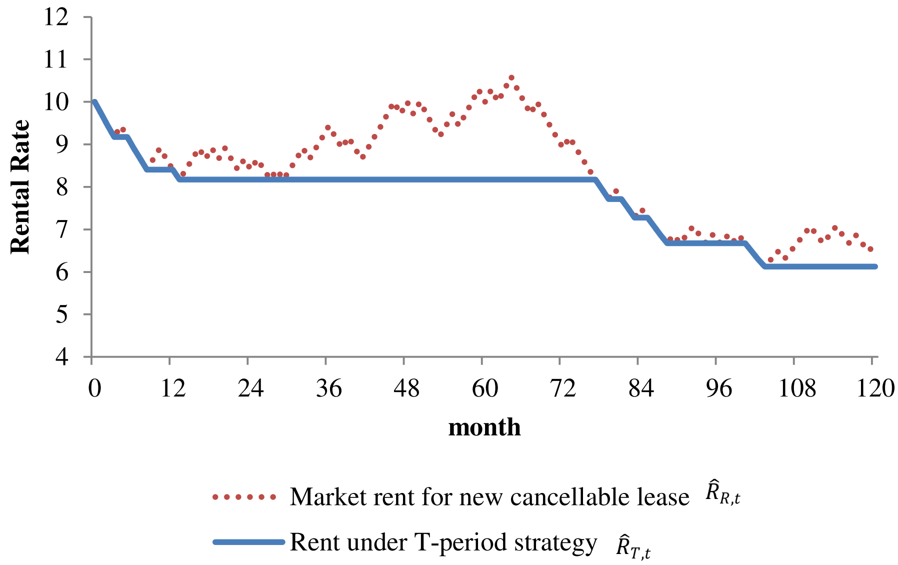
Note: The table shows the estimation results of Equation (8). The dependent variable is predictive error. Only the main variables are reported. Model (f) includes both high income and middle-high age dummies, and Model (g) includes both high income and detached house dummies. Heteroskedasticity consistent standard errors are calculated. Significance level: ***:1%, **: 5%, *:10%. High income dummy takes 1 if real annual income is greater than 5 million yen. Middle-high age dummy takes 1 if age of household head is greater than 40 years old.

Table 5: Estimation results of a hedonic model for general leases

	Coef.		t
Building age (in years)	-0.014	***	-4.63
Number of rooms			
1 room	1.097	***	6.33
2 rooms	0.321	***	2.87
3 rooms	reference		
4 rooms	-0.233	***	-3.39
5 rooms	-0.474	***	-4.07
over 6 rooms	-0.484	***	-3.07
Type of dwelling			
Detached house	0.089		0.82
Townhouse	-0.045		-0.42
Apartment, reinforced concrete structure	reference		
Apartment, Wooden structure	0.028		0.29
Other type	0.095		0.85
Time to the nearest station	-0.006		-1.37
Location characteristics			
Non urban areas	reference		
14 major cities	0.393	***	3.67
Other cities	-0.011		-0.11
Region			
Hokkaido	-0.635	***	-4.10
Tohoku	-0.551	***	-3.88
Kanto	reference		
Chubu	-0.501	***	-5.07
Kinki	-0.314	***	-3.37
Chugoku	-0.309		-1.61
Shikoku	-0.145		-0.63
Kyushu	-0.583	***	-5.98
Year of contracting			
2000	reference		
2001	-0.144		-0.86
2002	0.207		1.16
2003	-0.174		-1.02
2004	-0.198		-1.21
2005	-0.124		-0.64
2006	-0.191		-1.16
2007	-0.111		-0.61
2008	-0.011		-0.07
2009	0.023		0.11
2010	-0.469	**	-2.49
Deposit: multiple of monthly rent (in months)	0.005		0.49
Household head characteristics			
Real annual income (in 10,000 yen, 2010 price)	0.0003	***	2.80
Full-time employment (=1 if yes)	0.101		1.32
Age (in years)	0.002		0.68
Sex (=1 if female)	0.011		0.12
Highest education (=1 if college)	-0.132	*	-1.77
Marital status (=1 if married)	0.037		0.47
Constant	1.702	***	6.80
R-suared	0.467		
Adj. R-squared	0.419		
s	0.650		
N	450		

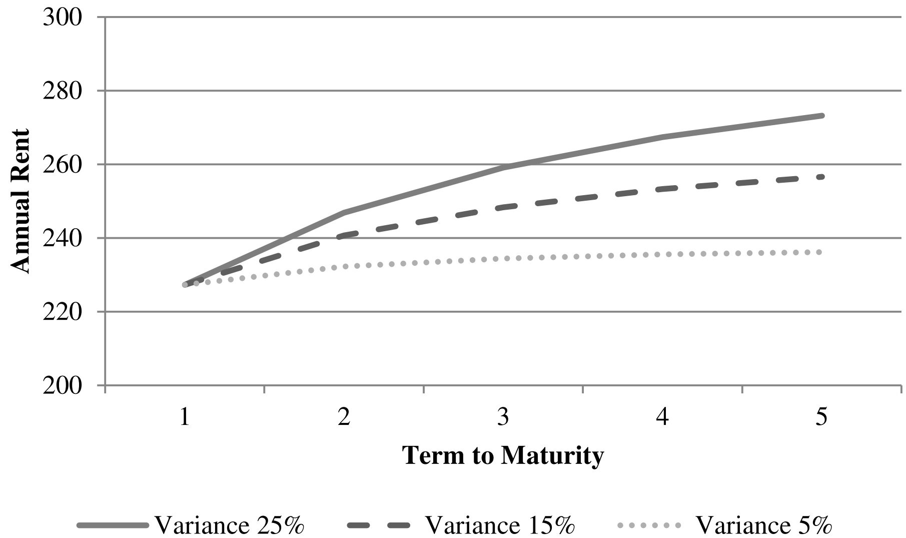
Note: The Table reports the estimation result of a hedonic model of the monthly rent per square meter for general leases. Heteroskedasticity consistent standard errors are calculated. Significance level: ***:1%, **: 5%, *:10%.

Figure 1: Sample path of the market rent and the T-period strategy rent



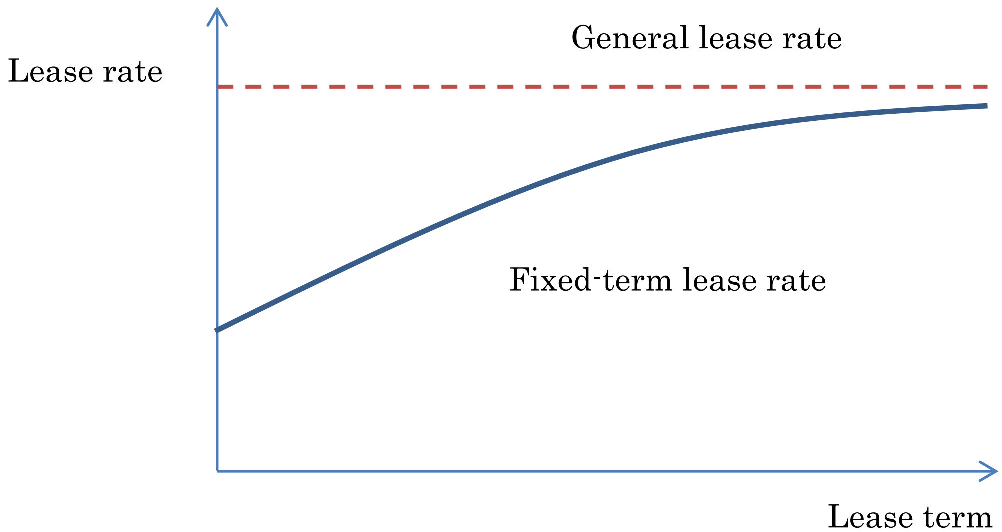
Note: This figure provides a sample path of $\hat{R}_{R,t}$, which is generated by a ten-year monthly binomial tree with a constant volatility. Initial rent, $\hat{R}_T$, is set at 10 and the volatility of rent is 10% per year.

Figure 2: Example of upward-sloping term structure of cancellable lease rates



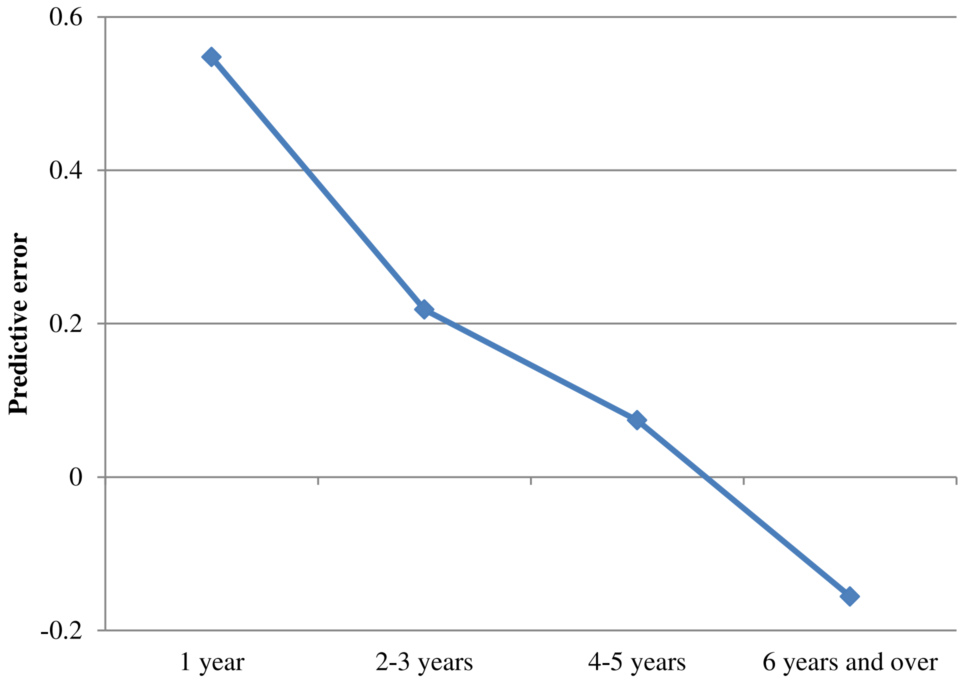
Note: This figure plots the simulation results for cancellable lease rates in Table 1 of McConnell and Schallheim (1983).

Figure 3: Model's prediction of Japanese lease term structure



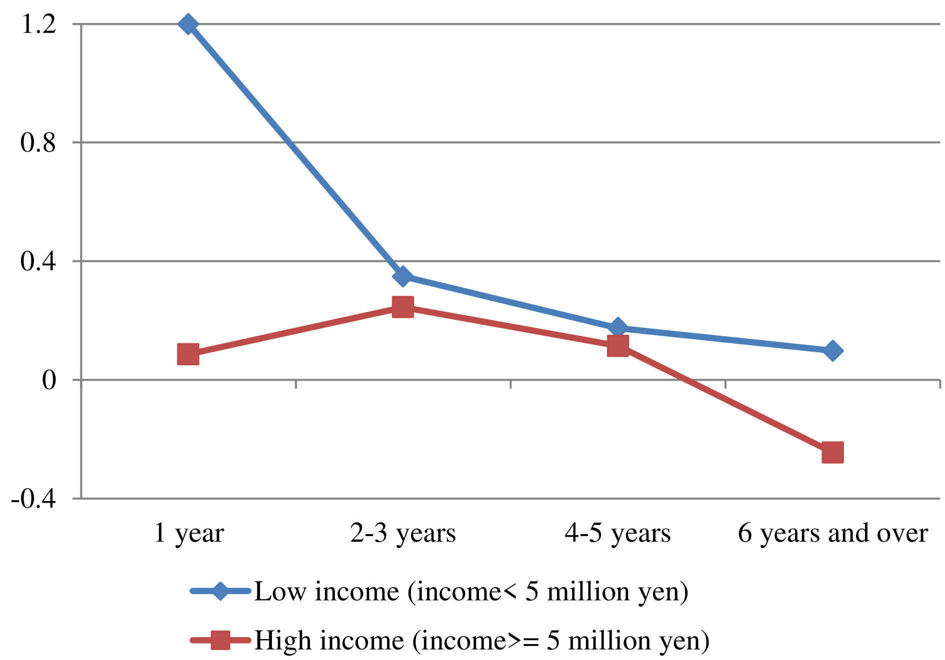
Note: This figure shows the term structures of general lease rates and fixed-term lease rates based on the prediction of the model.

Figure 4: Predicted value based on Model (a) of Table 2



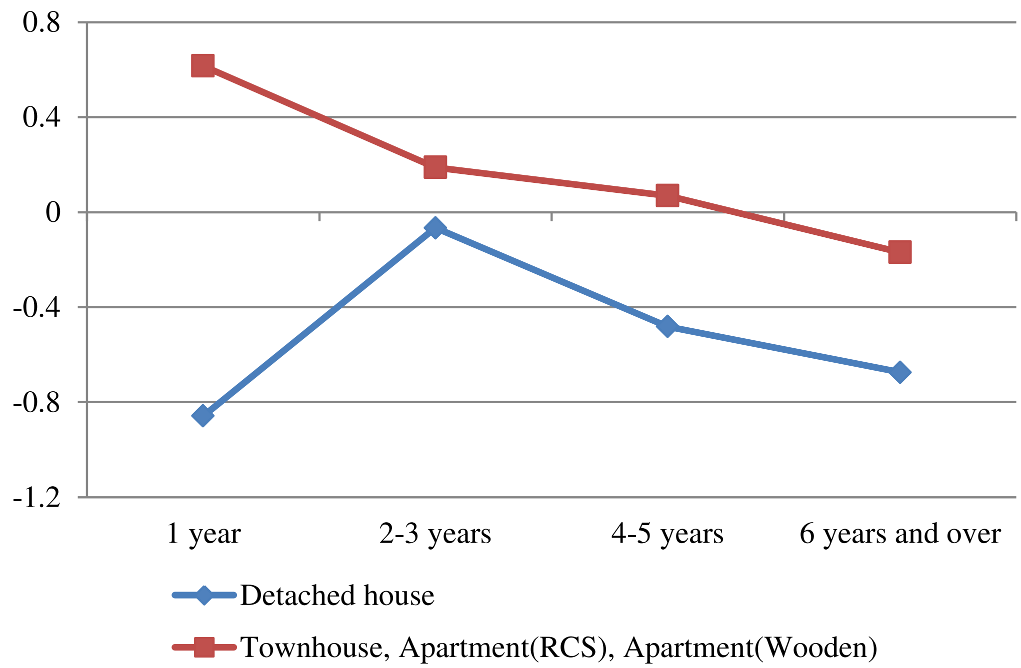
Note: The vertical axis is for the predictive error, i.e., the gap between fixed-term lease rates and general lease rates with identical characteristics of housing and tenant. The horizontal axis is for lease terms. For variables other than lease terms, mean values are used for numeric variables and modes are used for dummy variables.

Figure 5: Predicted value based on Model (c) of Table 3



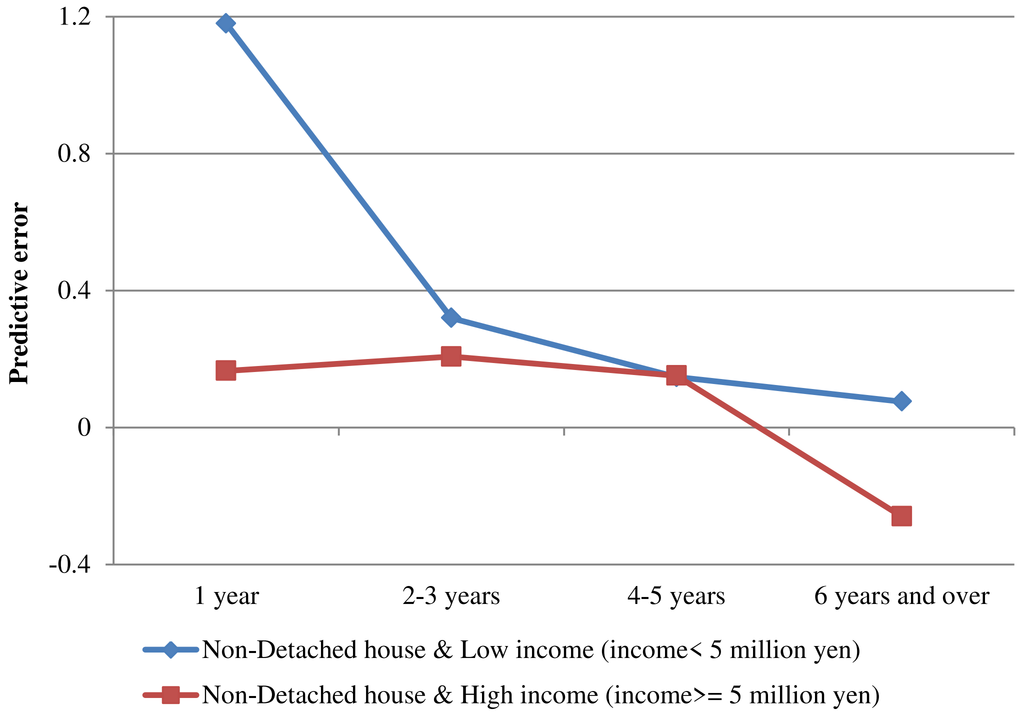
Note: The vertical axis is for the predictive error. The horizontal axis is for lease terms. For variables other than lease terms, mean values are used for numeric variables and modes are used for dummy variables. For the real annual income, we use mean value for each group; 8.075 million JPY and 3.228 million JPY for the high income group and the low income group, respectively.

Figure 6: Predicted value based on Model (d) of Table 3



Note: The vertical axis is for the predictive error. The horizontal axis is for lease terms. For variables other than lease terms, mean values are used for numeric variables and modes are used for dummy variables.

Figure 7: Predicted value based on Model (g) of Table 4



Note: The vertical axis is for the predictive error. The horizontal axis is for lease terms. For variables other than lease terms, mean values are used for numeric variables and modes are used for dummy variables.