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Asset Price Declines and Real Estate Market Illiquidity: Evidence from Japanese Land Values

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ABSTRACT

We examine the pattern of price depreciation in Japanese land values subsequent to the 1992 stock market crash. While all land values fell heavily, the data indicate that Japanese commercial land values fell much more quickly than residential land values. We confirm this fact using error-correction models that indicate faster convergence to steady state values for commercial land than residential land. We then develop an overlapping generations model with two-sided matching and search to explain this disparity. In the model, old agents own real estate and are matched each period with a young agent endowed with an unverifiable idiosyncratic service value for the old agent's real estate. When fundamentals decline, the old agents optimally "fish" for high service flow young agents by pricing above average valuation levels. This leads to higher illiquidity and default in times of price decline, as well as price persistence which is increasing in the variance of average service flows. As we would posit that the variance of service flows would be higher for residential real estate than for the commercial real estate market, this model matches the Japanese experience.

Keywords: Debt overhang, illiquidity, price persistence, Japan, real estate

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1. Introduction

Illiquid markets are markets where assets cannot be sold quickly without a discount from the equilibrium price. Land and real estate markets fit this characterization. The markets are decentralized in the extreme; participants must undergo a costly search process before buyers and sellers can be matched. Buyers of land and real estate have heterogeneous preferences for the asset service flow which they typically are unwilling or unable to credibly reveal to sellers. Sellers also differ in their desire to sell. Sellers for whom the asset has stopped providing a service flow (because, for example, the seller has moved) will be motivated to drop their price in order to sell. In contrast, sellers who have lost their equity, and carry a large debt relative to the asset value, may keep prices high in the hopes of finding a high-value buyer.

In this paper, we examine the pattern of price depreciation in Japanese land values subsequent to the 1992 stock market crash. The Japanese case is interesting because of the size of the shock to real estate markets. As we show below, all Japanese land values fell substantially subsequent to the crash. However, commercial land values fell much more quickly (and farther) than residential land values. Below, we confirm this empirical fact using an error-correction model.[1] We then develop an overlapping generations model with search to explain the empirical findings. Finally, we study how different aspects of the model economy have different implications for market illiquidity and give rise to different empirical predictions.

Our model demonstrates how the specificity of an asset, or the degree to which its use and value depends on the owner's preferences, is sufficient to generate illiquidity. All else held constant, increasing the degree of heterogeneity in the model decreases the

[1] For an application of an error-correction model to United States' housing prices, see Malpezzi (1999).

probability of sale in a single period. Thus, any market with heterogeneous agents can exhibit illiquidity and shocks to the factors that determine heterogeneity will result in changes in the severity of market illiquidity.

The main empirical features that we are trying to capture, however, are price persistence and speed of adjustment to the steady state. Market illiquidity is necessary in our framework to generate slowly adjusting prices, but it is not sufficient. To generate illiquidity, we appeal to the fact that land purchases are usually financed. Shocks to the fundamental value of land destroy equity and create a debt overhang which needs to be worked off before the economy can converge to the new steady state. The novel feature of our model is that market liquidity is the margin along which the debt overhang can be worked off. Sellers attempt to avoid default by keeping their prices above their steady state value, effectively "fishing" for high-valuation buyers.

The theoretical literature on real estate liquidity has developed along two different paths. The first path of research reflects the original concern that illiquid markets were those where expected times to sale were long. As such, this line of research borrowed heavily from the search literature to model the real estate transaction. These models were used to explore, among other things, the determinants of the optimal vacancy rate, the optimal intensity of search (Wheaton (1992)), the properties of returns on illiquid assets (Krainer and LeRoy (2002) and Williams (1995)), and why liquidity varies over the business cycle (Krainer (2001)).

While this search-based literature has been successful in modeling liquidity, it has been less successful in matching the time-series properties of real estate prices. This problem was illustrated by Krainer and LeRoy (2002) who showed that returns on illiquid assets were still martingales after properly adjusting for illiquidity. Since this liquidity adjustment was not expected to have persistence over time, this class of models could not account for the strong persistence in real estate prices.

A more profitable literature for accounting for real estate price dynamics developed around the observation that debt plays an important role in these markets. One of the more important early papers in this literature was Stein (1995).[2] In Stein's model, homeowner's make down payments in order to finance their purchases. Small declines in prices can damage collateral values, which can lead to large effects on transaction volumes, as homeowners can not raise enough of a down payment to enter the trade-up market.[3] Genesove and Mayer (1997) verify empirically many of the features of Stein's model, including the way sellers with low (or negative) equity set relatively higher prices and take longer to sell their real estate assets.

Our model differs from Stein's in that price persistence stems from the seller's outstanding debt burden, rather than down-payment constraints. The debt burden distorts the selling decision because the seller's payoffs are invariant with respect to sales price in default states, which are more probable the larger is the debt burden relative to the mean house service flow. Moreover, we extend Stein's work to a dynamic setting, which allows us to use the illiquidity attributable to debt overhangs to generate persistence in price declines subsequent to permanent decreases in asset service flows.

The dynamics in our model match empirical features that have been associated with deviations from rational behavior in the literature. For example, there is a large

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[2] Stein's paper is closely related to the fire sale literature in finance. See Shleifer and Vishny (1992). See also Kelly and LeRoy (2004) for a treatment of fire sells and liquidation that incorporates search.

[3] Kiyotaki and Moore (1996) use a similar mechanism to generate a financial role in exacerbating the volatility of business cycles.

empirical literature that finds significant serial correlation and mean reversion in the housing market, including Case and Shiller (1989), Malpezzi (1999), Meen (2002), and Capozza, et al. (2004). In the literature, serial correlation in housing markets has been explained through backward-looking expectations by market participants, sometimes referred to as "euphoria" [e.g. Case and Shiller (1989) and Capozza, et al (2004)]. In our paper serial correlation in prices emerges under rational expectations.

Our model also matches stylized facts that have been associated with "loss aversion" in the literature, such as Genesove and Mayer (2001). Genesove and Mayer find that Boston condominium owners subject to nominal losses charge prices further exceeding the property's expected selling price and experience greater illiquidity. In a sense, our model can also "rationalize" the phenomenon of loss aversion in housing on the basis of the debt overhang faced by property owners.

The paper is organized as follows. In section 2 we present the empirical evidence concerning Japanese land values. In section 3 we develop a single period model of liquidity and land prices that delivers the basic comparative statics results in the paper. In section 4 we extend the model to an overlapping generations framework and discuss transitions between alternative steady states. Section 5 concludes the paper.

2. Background Information on the Japanese Real Estate Market

2.1 General features of the Japanese real estate market

Overall, housing ownership rates in Japan are not exceptional compared to those in other developed countries. The latest survey data for the incidence of ownership in Japanese residential real estate is available from the Statistics Bureau of the Ministry of

Public Management, Home Affairs, Posts and Telecommunications for 1998.[4] Nationally, the incidence of real estate ownership in 1998 stood at 60.3 percent, somewhat lower than the ownership rate of about 65% in the United States. The rate is lower in the urban Keihinyo metropolitan area, which includes Tokyo, Yokohama, Chiba and Saitama, at 52.3 percent, and in the Keihanshin metropolitan area, which includes Osaka, Kyoto, and Kobe, at 56.1 percent. However, the Chukyo metropolitan area, which includes Nagoya, is slightly higher than the national average at 56.1 percent.

One unique feature of the Japanese real estate market is the relatively high share of down payments made on housing purchases. On average, Japanese households make down payments equal to about 30 percent of purchase prices. The need to self-finance this relatively large down-payment is often cited as a major contributor to high rates of savings among young Japanese households. For example, housing related expenditures have been found to provide the primary non-precautionary motivation for saving [Horioka (1988)]. Combined with proceeds from sales of currently-owned real estate and inheritances from relatives, the share of self-financing in housing is about 43 percent [Seko (1994)].[5] In an overlapping generations framework, Hayashi, Ito and Slemrod (1988) show that high down payments such as those found in Japan can increase the rate of savings when young in an effort to meet their self-financing needs. Indeed, the high down payment required for housing is often identified as a key reason behind Japan's high savings rate [e.g. Hayashi (1986)].

[4] The survey, known as the "Housing and Land Statistical Research" (*Jyutaku-Tochi Toukei Chosa* in Japanese) has been conducted every five years since 1948. The latest survey was done in 2003, but the results have not yet been released.

[5] Reported figure represents annual average for custom-made housing from 1984 through 1989.

As of 2001, Japanese individuals held 85.5 percent of land holdings and corporations held 14.5 percent. Holdings by corporations were higher in large cities, as individuals held only 71.3 percent of land and corporations held 28.7 percent. Land ownership by individuals has fallen steadily since 1980, according to the Ministry of Land, Infrastructure and Transport (see Figure 1).[6] This data is only available at irregular intervals, but clearly shows a notable decline in ownership by individuals between 1987 and 1993. This pattern suggests that defaults on real estate loans played a role in moving land assets from individuals to corporations after the end of the asset bubble period.

Finally, another unique aspect of Japanese housing is the relatively small market for used homes. The number of used house transactions per household in Japan in 1992 was one-tenth that in the United States in the same year [Kanemoto (1997)]. Kanemoto stresses the high costs of housing transactions in Japan as a primary reason for the low turnover rate. Housing transactions are subject to a series of taxes that total about 2 percent of housing value, as well as a capital gains tax. In addition, subsidized loans from the Government Housing Loan Corporation discriminate against used housing by placing a lower limit on the absolute value of loans to used housing and by prohibiting lending to used housing exceeding ten years in age.

2.2 Real estate price movements after the bubble collapse

We next turn to the stylized data concerning the severity of the Japanese real estate downturn. The Japanese government has almost solely published land value data for some period of time. We use this land data in the main portion of our study. As

[6] Source: Ministry of Land, Infrastructure and Transport White Paper on Land (*Tochi Hakusho* in Japanese).

discussed by Noguchi (1994), land price movements account for the bulk of movements in urban housing costs, comprising over 90 percent of housing costs in Tokyo and Osaka, and over 60 percent in all urban areas.

Price data on structures is available, but at a lower frequency. The Urban Development Association *(Toshi-Kaihatsu Kyokai* in Japanese) collects average prices of new single-family homes (excluding condominiums) for the Tokyo, Osaka and Nagoya metropolitan areas. See Figure 2. Housing prices peak between 1990 and 1991, with the Osaka region peaking in 1990 and the Tokyo and Nagoya regions peaking in 1991, and falling dramatically thereafter. Note that there is a slow decline subsequent to the asset price collapse suggestive of price rigidity that mirrors the land price series.

One sees a similar impact on condominium prices. Data on condominium prices are available beginning in 1992 for the nation as a whole, as well as the Tokyo and Osaka Ward districts from the Real Estate Economic Institute (Fudosan-Keizai-Kenkyusho). See Figure 3. There is again evidence of price persistence for the Japanese condominium market, as prices continued to fall until 1995, after which the market was relatively flat.

Weakness in the housing market appears to have been a primary factor behind the well-documented difficulties suffered by the Japanese banking sector during the 1990s. Exposure to real estate companies was increased dramatically during the bubble period, from approximately 7 percent before the period to about 11.5 percent by December 1989.[7] Some authors, such as Hoshi (2001), attribute the high growth in the share of real estate lending within the banking sector to a decline in alternative lending opportunities due to deregulation in the financial sector which allowed traditional borrowers, such as corporate clients, to issue their own commercial paper and reduce their bank borrowing.

[7] Bank of Japan.

2.4 Summary

Our review of the characteristics of the Japanese housing market identifies some important stylized facts surrounding the collapse of the Japanese real estate bubble. First, we find evidence of rigidity in Japanese real estate prices. While Japanese real estate prices fell dramatically throughout the 1990s, the price declines continue long after the 1991-1992 shock. Second, there was clearly an interaction between developments in the Japanese housing market and those in the Japanese banking sector: Declines in Japanese real estate values eroded bank collateral positions. These effects were particularly severe because of the buildup in the banking system of exposure to the real estate sector. Throughout the downturn, Japanese banks suffered, and those with higher exposure to real estate suffered more.

However, the causality also ran the other way. Real estate owners holding mortgages obtained prior to the burst of the asset price bubble faced reduced, and perhaps even negative, equity in their assets. The influence of this debt overhang is shown below to play a central role in obtaining the price rigidity observed in the data.

3. Empirical Evidence Concerning Japanese Land Values

3.1 Data

Quarterly data on changes in residential and commercial land prices are available from 1993:2 through 2003:1 from the Land Research Institute (LRI) for the Tokyo, Osaka, and Nagoya metropolitan areas. The data on land prices is plotted in Figure 4. It can be seen that land prices fell dramatically over this period in all three areas. However, two stylized facts appear to emerge in the patterns of relative price declines of residential and commercial real estate in each area: First, commercial land prices fell much more dramatically than residential prices. In Tokyo, Osaka and Nagoya, residential land prices fell by 41.4 percent, 42.7 percent, and 29.1 percent respectively over the sample period, while commercial land prices fell 72.3 percent, 73.8 percent, and 64.0 percent respectively.

Summary statistics for both the quarterly metropolitan and annual prefecture data sets are shown in Table 2. Looking first at the quarterly data, it can be seen that both residential and commercial land prices peaked in the second quarter of 1993. Both forms of land prices also fell throughout the sample, reaching their minimums on the last quarter of our sample, the first quarter of 2003. Commercial land prices are much more volatile than residential land prices for all three metropolitan areas, as measured by the ratio of the standard deviations of the series to their mean values. Finally, it appears that both commercial and residential land prices fell the least in the Nagoya metropolitan area and the furthest in the Osaka metropolitan area. The data also demonstrate that the standard deviations of commercial land prices in all three metropolitan areas are substantially larger than those of the residential land price series.

Moreover, it appears to be the case that the fall in commercial prices was more rapid than that for real estate prices. For example, by the midpoint of our sample period Tokyo residential prices had fallen by 21.9 percent, slightly more than half of their ultimate 41.5 percent decline over the course of the sample period. In contrast, by the same date, Tokyo commercial real estate prices had fallen by 57.1 percent, which represented more than three-fourths of their 72.3 percent decline over the entire sample period. Similarly, by the midpoint of our sample period, residential land prices in Osaka and Nagoya had fallen by only 17.4 percent and 16.1 percent respectively, less than half of their decline over the entire sample period, while their commercial land prices had fallen by 52.2 percent and 42.4 percent respectively, both over two-thirds of their ultimate declines over the entire sample period.

As our quarterly data only goes back to 1993, we also obtain annual prefecture data from the Research on Land Prices by the Prefecture Government to examine the run-up in land values prior to the bursting of the bubble. This data is available annually for each of the 47 prefectures on July 1, from 1976 to 2001. We therefore have 26 price observations for each prefecture, for a total of 1222 observations for each series.

The summary statistics for thiese series are also listed in Table 2. The long time series in the data implies that minimum values for residential and commercial land values were realized in the early portion of the sample, in 1976 and 1979 respectively for residential and commercial land. Land values in our prefecture data also peaked earlier than our metropolitan time series, as residential and commercial real estate values peaked in 1990 and 1991 respectively. Commercial land values again exhibit greater volatility, with the ratio of the standard deviation to the mean of the pooled commercial land value sample being almost twice the size of that for the pooled residential land value sample. As above, the prefecture data demonstrate that the standard deviation of commercial land prices is much larger than that of the residential land prices.

Averages of the prefecture data are plotted in Figure 5. The commercial land prices can again be seen to be significantly more volatile than the residential or industrial land prices. For example, we can compare the speed of decline in these averages following their peaks in the early 1990s. The residential price averages peaked in 1990, while the commercial price averages peaked in 1991. By 1996, residential prices fell by 27.9 percent, 71.5 percent of its 39.0 percent overall price decline. By the same date (which represented one less year of elapsed time), commercial prices fell by 58.0 percent, 78.1 percent of its 74.3 percent price decline by the end of our sample.[8]

3.2 Error-correction Model

To examine these empirical patterns more formally, we turn to an error-correction model. In his study of housing prices, Malpezzi (1999) estimates an error-corection model using income as the co-integrating variable with housing prices. While income would appear to be a desirable co-integrating variable , it does not appear to work well for Japan, particularly in our quarterly data. The reason is that while Japanese asset values clearly peaked in 1990 or 1991, as evidenced by the rapid subsequent declines in housing and equity market prices in Figure 5, average household income across prefectures in Japan actually continued to modestly rise until 1997. This is in part attributable to lifetime employment traditions and other characteristics that are unique to the Japanese economy, as well as the slow adjustment that took place in Japanese firms subsequent to the bursting of the Japanese asset price bubble.

For our purposes, however, it suggests that much longer time series than those available would be needed to identify the co-integrating relationship between house prices and income in Japan. In particular, it is unlikely that we could identify any discernable pattern for the ten-year period in our sample subsequent to the boom. In response, we instead turn to a forward-looking indicator of real estate service flows,

[8] If we use 1991 as our starting year for residential prices as well, the results are similar.

namely equity values proxied by the TOPIX index. Figure 5 demonstrates that there has been a close correlation between both commercial and residential real estate since the 1970s, which allows us to examine the speed of adjustment both upwards and downwards.

Our error-correction equation then describes movements in land prices, P_t towards its equilibrium long-run ratio with the value of Japanese equities as measured by the TOPIX. We entertain variants of the general specification

$$\begin{aligned}\Delta P_t &= \beta_0 + \beta_1 \Delta P_{t-1} + \ldots + \beta_n \Delta P_{t-n} \\ &+ \theta_1 \Delta TOPIX_{t-1} + \ldots + \theta_n \Delta TOPIX_{t-n} \\ &+ \gamma_1 \left(P_{t-1} - TOPIX_{t-1}\right) + \ldots + \gamma_n \left(P_{t-1} - TOPIX_{t-1}\right) + \varepsilon_t\end{aligned} \tag{1}$$

where ε_t is assumed to be an i.i.d. error term.

In particular, we expect to obtain negative coefficients on the error correction terms, the $\gamma_i 's$. This would imply that if house prices lie above their equilibrium level they will fall, while they rise if they are above their equilibrium levels. The coefficients on these terms therefore describe the speed with which land prices revert back to their long-run equilibrium relationship with the TOPIX after being shocked away from that relationship.

Quarterly results for residential and commercial land prices from the three metropolitan areas are reported in Tables 3a and 3b. We estimate a number of different specifications to assess the robustness of our results, with one and two lags of the ΔP_t,

$\Delta TOPIX_t$, and $\left(P_{t-1} - TOPIX_{t-1}\right)$ variables. The latter variable is of course the one of interest representing the error-correction term.[9]

Comparing the commercial and residential results reveals some interesting stylized facts. First, in both samples the coefficient on the first lag error-correction term is universally negative and significant, as expected, for all specifications except Model 4, which introduces a second-lag error-correction term. In this case, again for both samples, this second lag term is negative and significant while the first lag becomes insignificant. However, this relative result can be reversed with the introduction of the contemporaneous change in the TOPIX, $\Delta TOPIX_t$. Nevertheless, the net impact is negative and significant in either case, as we expect.

Comparing the magnitudes of these coefficients, our most important result is that regardless of the specification chosen, the negative error-correction term is larger in absolute value for the commercial sample than for the residential sample. This difference is significant at a five percent confidence level for Models 1 and 5. The results therefore support the hypothesis that commercial land prices revert back to their long run levels more quickly than residential land prices.

Examining the other variables in our specification, we obtain some other results. For both samples, the coefficient on ΔP_t is positive and significant at a five percent confidence level. Moreover, the coefficient for the commercial sample is uniformly smaller than that for the residential sample. Again, these results suggest that residential land prices are more persistent than commercial land prices in Japan.

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[9] We also ran the specification with the addition of a third lag for all of the specifications. The coefficient sign on the third lag was of inconsistent sign and did not always enter positively in both samples. Consequently, we restricted our analysis to those with up to two lags presented here.

The coefficient estimates on the contemporaneous and lagged $\Delta TOPIX_t$ variables are almost universally insignificant. However, we do robustly obtain a significant positive point estimate on the *NAGOYA* dummy variable, confirming our observation above that land prices fell less in Nagoya than in the other two metropolitan areas.

Our annual results using prefecture data for commercial and residential land prices are reported in Tables 4a and 4b. Our results with this data set are qualitatively similar to those for the quarterly data set. The coefficient estimate on the error-correction term is robustly negative in both samples, again with the exception of Models 4 and 6 where the second-lag error-correction term is added. In Model 4, the first lag turns positive and significant in both samples, while the second lag is negative and significant, but the sum of coefficient estimates remains negative, as expected. In the case of Model 6, the coefficient changes sign only in the case of the residential sample, while both terms remain significantly negative in the commercial sample.

Most importantly, we again obtain point estimates on the error-correction terms that are universally larger in absolute value in the commercial sample than those we obtain in the residential sample. Moreover, because our sample is much larger, the disparity in coefficient estimates is robustly different at standard significance levels. For all of the specifications that do not include a second lag of the error-correction term, Models 1, 2, 3, 5, and 7, the coefficient on the first lag error-correction term is significantly larger in absolute value for the commercial land sample than the residential land sample. For the two models that introduce the second lag, the more negative coefficient is again larger in both specifications for the commercial sample. This turns out to be the first lag in Model 4, but the second lag in model 6.

As before, we robustly obtain positive and significant coefficient estimates on the first lag of ΔP_t. However, the point estimates for this coefficient are smaller in the case of the residential sample, so this variable does not provide additional evidence of greater relative price persistence in the residential sample, as we found in our quarterly data sample.

Nevertheless, the robust results for the error-correction terms in the two samples consistently indicate that the commercial land prices converge to their long-run equilibrium relationship with the TOPIX more quickly than residential land prices.

4. A Theory of Liquidity and Debt Overhang

4.1 Setup

In this section, we introduce a theoretical model that yields predictions consistent with the stylized facts discussed above. The model is a two-period overlapping generations model. There are *N* agents born each period who live for two periods. Agents have risk neutral preferences for both consumption of housing services and consumption of consumption goods. Agents buy and consume housing services when young, and sell their houses to the next generation when old.[10]

There are two frictions in the model. First, buyers are required to finance a portion of their house purchase. Accordingly, we assume the existence of a representative intermediary. For simplicity, we assume that the value of the real estate asset is sufficient to fully collateralize the house, so that the equilibrium interest rate is fixed. As discussed above, this is not a strong assumption for Japan, where the share of

[10] Our overlapping generations setup forces old agents to sell their house. In a more general framework, we might imagine that houses come on the market because their owners need to relocate for employment purposes, or need to adjust housing consumption because of changing family size.

self-financing in housing purchases is large. The intermediary repossesses the house in case default, and proceeds to liquidate the house in the open market at the market price. For simplicity we do not model this liquidation process. The intermediary's role is simply to create debt. This debt will turn out to have important implications for asset prices following unexpected shocks to fundamentals.

The second friction in the model is that houses are bought and sold following a search process. Each period, a buyer is paired randomly with a house. The buyer's valuation of the house will depend on two things: the value to the buyer of the service flow, and the expected payoff to reselling the house in the next period. A buyer's valuation of the service flow is a draw from a distribution.

We interpret the mean of this distribution as the state variable determined by the aggregate economy. For example, the level of interest rates, the pace of economic growth, or some special amenity to a geographic area, would be expected to represent "fundamentals" that are captured in all house prices. As these variables change, all prices and all valuations are expected to follow. We interpret variation about the mean of the service flow distribution as being related to individual tastes. Specifically, we will characterize residential housing as an asset with substantial variation about the mean valuation of the service flow. The best matched buyer will value a particular house much higher than the average buyer. We will characterize commercial real estate as an asset with relatively little variation in valuation across potential buyers.

The realization of the service flow is the buyer's private information, while the seller knows only the distribution.[11] Sellers set take-it-or-leave-it prices. If a buyer

[11] Note that private information held by young agents allows them to retain some consumer surplus in this framework.

chooses not to purchase the house, he rents the house instead, paying out an amount equal in expected value to his service flow from renting.[12] That is, renting is a breakeven proposition.

Proceeding more formally, let ε be the service flow draw, and let ε be distributed according to c.d.f. *F*. Buyers must make a down payment equal to γ-percent of the asking price.[13] Faced with a house price *p*, a realization of the housing service flow ε, and a discounted expected capital gain from sale of the house next period equal to βq_{t+1}, the potential buyer will buy if and only if,

$$\gamma p_t \leq \beta q_{t+1} + \varepsilon, \tag{2}$$

where β is one minus the representative agent's discount rate, $0 < \beta \leq 1$. It is convenient to define ε^* as the reservation service flow, or the realization of ε that would leave the buyer indifferent between accepting or rejecting the seller's offer.

Given the distribution of the service flow for potential buyers and given the amount of debt the seller is carrying, the seller sets a price in order to maximize the expected value of having a house on the market. Since agents only consume housing services in the first period of life, sellers in the second period are completely homogeneous.

While we allow the seller to incorporate the impact of the current price on the probability of sale in her pricing decision, we make the simplifying assumption of not allowing her to consider the secondary impact of the current price on the buyer's future

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[12] The buyer is actually renting from the bank. If a buyer refuses to buy, the seller defaults.

[13] We abstract away from endowments of a consumption good, assuming that preferences are both linear and separable in consumption and housing consumption.

expected capital gain. Formally, we assume that sellers take q_{t+1} as given. In the absence of this simplification, the seller would need to incorporate the entire transition path in her selling decision, as raising the price today would raise future prices and future levels of debt. Note that the need for this simplification stems directly from the fact that the introduction of a search model implies some monopoly power on the part of sellers in each period.

The seller's decision problem is then to choose a price p_t that maximizes the expected proceeds of selling the house given his outstanding debt level, d_t, or

$$\begin{aligned} & q_t = \max_{\tilde{p}} \mu_t(\tilde{p})(\tilde{p} - d_t) - (1 - \mu_t(\tilde{p}))c \\ & s.t.\ \mu_t \geq 0, \\ & d_1 \geq 0, \\ & c \geq 0, \end{aligned} \tag{3}$$

where $\mu(p)$ is the probability of sale at price *p*, and *c* is a default penalty. This yields his first order condition

$$\frac{\partial \mu_t}{\partial p_t}(p_t - d_t + c) + \mu_t = 0. \tag{4}$$

The probability of sale is the probability the buyer draws a service flow at least as great as the reservation service flow, ε^*. From equation (2), this yields

$$\mu_t = 1 - F(\gamma p_t - \beta q_{t+1}). \tag{5}$$

For the special case where ε is distributed uniform on the interval $\left[\bar{\varepsilon}_t - \sigma, \bar{\varepsilon}_t + \sigma\right]$, we get

$$\mu_t = \frac{\bar{\varepsilon}_t + \sigma - \gamma p_t + \beta q_{t+1}}{2\sigma}, \tag{6}$$

and

$$\frac{\partial \mu}{\partial p} = -\frac{\gamma}{2\sigma}.$$

To close the model, we must determine the value of d_t. The representative bank that charges a fixed interest rate times the amount borrowed, or

$$d_t = R(1-\gamma)\, p_{t-1}. \tag{7}$$

We assume that $0 < R(1-\gamma) < 1$. This assumption implies that, in the steady state, revenues from the sale of the asset are non-negative, as we show below.

Given an initial debt level, *d₁*, equilibrium is a set of sequences $\{p_t, q_t, \mu_t, d_t\}_{t=1}^{\infty}$ that satisfy equations (3), (4), (6), and (7) for all *t*. The equilibrium is a Nash equilibrium, and in general will not be first best. This is due to the search friction and the heterogeneity in the model. At any point in time, a social planner could reallocate members of the young generation into houses they prefer more, thereby granting all of the young generation a consumer surplus and increasing aggregate welfare.

4.2 Analysis of the steady state

From this simple model we can derive some comparative statics results for pricing and liquidity. First, consider a seller at some date *t*, who has a given amount of outstanding debt d_t which is predetermined. By equations (4) and (6) , it is easy to show that the optimal (interior solution) value of p_t is increasing in d_t. In other words, the magnitude of the seller's debt overhang distorts the selling price upwards. However, if the interior solution violates the constraint, the optimum will be $p_t = d_t$. It is also easy to show that the number of unsold houses $N(1-\mu_t)$, is also increasing in d_t.

Second, we would expect the variance in the distribution of housing service flows to translate into higher prices and less liquidity. This would certainly be the case for an individual seller at some time *t* taking d_t as given, as can be seen by inspection from equations (4) and (6). The intuition behind these results is that the outstanding debt reduces the net profits from selling the house. Sellers facing heterogeneous buyers have the incentive to price their houses higher, essentially "fishing" for high-valuation buyers. This is particularly true when they are saddled with a debt overhang.

However, since d_t is an endogenous variable, we establish this relationship in terms of the deep parameters of the model by deriving the steady state solutions for p and μ in the appendix. In particular, we demonstrate the existence of a parameter space where $\partial p / \partial \sigma \geq 0$, and where $\partial \mu / \partial \sigma < 0$. Under these conditions, the steady-state selling price is also increasing in the seller's debt overhang, while housing liquidity is decreasing in the magnitude of the debt overhang.

To obtain some intuition for these relationships, we simulate steady state solutions for a range of parameters. As we can see in Figure 6, prices are increasing in the heterogeneity parameter σ. As the distribution of the service flow widens, sellers find it optimal to sell to an increasingly higher-valuation buyer. The magnitude of this result will, of course, depend on the mean service flow, $\bar{\varepsilon}$. If the variance is very small about the mean, the effect of small increases in variance on prices will be negligible. The figure also shows that probability of sale is decreasing in the heterogeneity parameter. This is intuitive, given our earlier result that $\frac{\partial p}{\partial \sigma} > 0$. Higher prices imply lower probability of sale or less liquidity.

Figure 7 depicts simulations of the steady state solutions as a function of after varying the mean service flow parameter. As we can see, higher mean service flows are accompanied by both higher prices and higher probabilities of sale, all else held equal. Intuitively, an increase in the mean service flow raises all potential buyer valuations ex ante. This increase is priced. But prices do not rise as high as they might, as evidenced by the fact that the probability of sale does not remain constant. This is because the variance parameter of the service flow distribution is being held fixed in these simulations. As the mean value increases, the difference between the best matched individual's valuation and the average valuation diminishes. This implies a reduction in the seller's incentive to fish for high-value buyers.

Finally, note that in general steady-state prices in this model are much more sensitive to changes in the mean service flow than to changes in the distribution (variance) of the housing service flow value to potential buyers.

Two main points emerge from our analysis of the steady state. First, holding the mean service flow fixed, assets with a large amount of dispersion in potential buyer valuations will be higher priced and less liquid. Given our belief that residential housing is an asset for which buyers display a wide distribution of willingness-to-pay, residential housing should be less liquid than commercial property. Second, prices are sensitive to changes in the mean service flow. Over time, then, we would expect that variation in prices is determined by variation in the mean service flow. Moreover, the more liquid the asset, the more volatile prices should be with respect to shocks to mean service flows or fundamentals. We make this point more precisely when we study the dynamics of the model in the next section.

3.3 Transition in a multi-period model

Our analysis of the steady state is useful for establishing the basic implications of debt and heterogeneity for prices and liquidity. However, important questions cannot be answered without dynamics. For example, given a debt overhang, how sticky will prices be? That is, how long will it take for prices to adjust following a shock to the steady state? In this section we develop a dynamic extension to the simple model that analyzes the transition of the economy following a shock to debt levels. The motivation for this exercise is found in the behavior of the Japanese real estate land prices following the bursting of the stock market bubble. The high prices and debt levels associated with the bubble period, and the bursting of this bubble is interpreted as an exogenous shock. Conversely, we could imagine that the economy was in equilibrium for some relatively high value of the mean housing service flow, and was suddenly thrown out of that steady state by a change to a lower mean housing service flow. The object, in either case, is to study the transition to the new steady state.

We simulate transition between steady states associated with mean service flow values $\bar{\varepsilon} = 1.15$ and $\bar{\varepsilon} = 1.0$. We assume agents make down payments equal to $\gamma = 20\%$ of the purchase price. The discount rate is $\beta = 0.97$. The default penalty is $c = 1.5$. For simplicity, we assume that both residential and commercial real estate have the same mean service flow. We represent residential real estate by a large variance about the mean service flow, $\sigma = 1.0$, and commercial real estate by a small variance about the mean, $\sigma = 0.5$.

Figure 8 plots the dynamic response of prices to a once-and-for-all change in the fundamental (the mean service flow). Both asset classes do not adjust immediately to the new steady state value. Rather, prices decline gradually to their new steady state levels. This is because of the debt overhang. Agents who bought houses when $\bar{\varepsilon} = 1.15$, find themselves carrying more debt than the new steady state associated with $\bar{\varepsilon} = 1.0$ implies. The economy does not instantly adjust to the new steady state price because such an adjustment would be inconsistent with the optimization rules of the sellers who have too much debt. The economy can adjust gradually by virtue of the search friction. The agents with the highest debt overhang relative to the new steady state keep prices high in the hopes of making a match with a high valuation buyer. This is akin to raising the price, so the probability of sale must fall.

Asset liquidity plummets in the early stages of the transition (see Figure 9), but then slowly improves as the price converges to the new steady state. As such, our model exhibits overshooting in the decline in liquidity subsequent to the decline in the fundamental. Overall, the new steady state is at a lower liquidity level, as the ratio of the variance to the service flow has increased. However, the initial response is greater than the steady state drop, so that after the initial response, housing liquidity increases monotonically to its new reduced steady state level.

Figure 9 also shows differences in the adjustment process between the residential and the commercial asset. The low service flow variance asset price falls farther between the two steady states. This implies that prices of the low variance asset are more volatile given the same service flow shocks. As we would identify the low variance service flow asset with Japanese commercial real estate, this property matches the data for Japan shown above, as well as the data for other countries.[14]

Even though commercial property prices have farther to fall in this transition, they still fall faster than residential prices. This is seen most clearly in Figure 10, where commercial prices have completed 99 percent of the transition within the first three periods (out of ten total periods). For residential real estate, prices complete 99 percent of their transition after five periods. Again, this matches the Japanese data and the time-series analysis in section 2.

5. Conclusion

Subsequent to the collapse of the asset price bubble in Japan, both commercial and residential real estate values fell dramatically. However, as our data and parametric results above demonstrated, commercial prices fell farther and more rapidly than residential prices. In this paper, we develop an overlapping-generations model with two-sided matching and search to explain this systematic disparity in price rigidity. In our model, old agents are matched in each period with a young agent endowed with an idiosyncratic service value from the old agent's real estate asset. When fundamentals decline, the old agent optimally "fishes" for a young agent who would obtain a high service flow from the asset by pricing above-average agent valuations. This leads to higher illiquidity and default in times of price decline, as well as persistence in price declines which is increasing in the variance of average service flows. As we would posit that the variance of service flows would be higher for residential real estate than for the commercial real estate market, this model matches the Japanese experience.

[14] Kan, Kwong, and Leung (2002) document this same stylized fact in the U.S.

APPENDIX

Comparative statics of steady-state solution

By (7), in the steady state, d satisfies

$$d = R(1-\gamma)\,p$$

By (3), q then satisfies

$$q = \mu\left[1-R(1-\gamma)\right]p$$

Substituting into the solution in (4) and taking steady state values

$$p = \frac{2\sigma\mu}{\gamma\left[1-R(1-\gamma)\right]}$$

Substituting the solution for d and q in (6) and taking steady state values

$$\mu = \frac{\bar{\varepsilon}+\sigma-\gamma p}{2\sigma-\beta\left[1-R(1-\gamma)\right]p}$$

The above two equations give us a system of two equations in two unknowns, p and μ. Solving for μ in terms of the deep parameters yields

$$2\beta\sigma\left[1-R(1-\gamma)\right]\mu^2 - 2\sigma\gamma\left[2-R(1-\gamma)\right]\mu + \gamma(\bar{\varepsilon}+\sigma)\left[1-R(1-\gamma)\right] = 0$$

The high root solution for μ satisfies

$$\mu = \frac{\sigma\gamma\left[2-R(1-\gamma)\right] + \left\{\sigma^2\gamma^2\left[2-R(1-\gamma)\right]^2 - 2\beta\sigma\gamma(\bar{\varepsilon}+\sigma)\left[1-R(1-\gamma)\right]^2\right\}^{\frac{1}{2}}}{\beta\sigma\left[1-R(1-\gamma)\right]}$$

Solution of the above equation requires the restriction that the term under the radical is positive, i.e. that

$$\sigma\gamma\left[2-R(1-\gamma)\right]^2 > 2\beta(\bar{\varepsilon}+\sigma)\left[1-R(1-\gamma)\right]^2$$

which we adopt. This condition could be interpreted as a minimum rate of discount for the representative agent.

Differentiating with respect to σ yields

$$\frac{\partial \mu}{\partial \sigma} = \frac{\bar{\varepsilon}\gamma\left[1-R(1-\gamma)\right]}{\sigma\left\{\sigma^2\gamma^2\left[2-R(1-\gamma)\right]^2 - 2\beta\sigma\gamma(\bar{\varepsilon}+\sigma)\left[1-R(1-\gamma)\right]^2\right\}^{\frac{1}{2}}}$$

We therefore obtain $\partial\mu/\partial\sigma < 0$ given the negative root of the radical term.

We next turn to the comparative static results for p. Again, by the above equations we can solve for p in terms of the deep parameters, and obtain

$$\beta\gamma\left[1-R(1-\gamma)\right]^2 p^2 - 2\sigma\gamma\left[2-R(1-\gamma)\right]p + 2\sigma(\bar{\varepsilon}+\sigma) = 0$$

The high root solution for p satisfies

$$p = \frac{\sigma\gamma\left[2-R(1-\gamma)\right] + \left\{\sigma^2\gamma^2\left[2-R(1-\gamma)\right]^2 - 2\beta\sigma\gamma\left[1-R(1-\gamma)\right]^2(\bar{\varepsilon}+\sigma)\right\}^{\frac{1}{2}}}{\beta\gamma\left[1-R(1-\gamma)\right]^2}$$

Solution of the above equation requires the same restriction as that adopted in equation (18), which we adopt. Differentiating p with respect to σ yields

$$\begin{aligned}\frac{\partial p}{\partial \sigma} &= \frac{\sigma\gamma\left[2-R(1-\gamma)\right] + \left\{\sigma^2\gamma^2\left[2-R(1-\gamma)\right]^2 - 2\beta\sigma\gamma\left[1-R(1-\gamma)\right]^2(\bar{\varepsilon}+\sigma)\right\}^{\frac{1}{2}}}{\beta\sigma\gamma\left[1-R(1-\gamma)\right]^2} \\ &+ \frac{\bar{\varepsilon}}{\left\{\sigma^2\gamma^2\left[2-R(1-\gamma)\right]^2 - 2\beta\sigma\gamma\left[1-R(1-\gamma)\right]^2(\bar{\varepsilon}+\sigma)\right\}^{\frac{1}{2}}}\end{aligned}.$$

The first term can be signed as positive because the second term in the numerator will be smaller than the first term in the numerator. However, when taking the negative root of the term under the radical the second term will be negative. To sign the entire expression as poitive, then, we require that $\bar{\varepsilon}$ is not too large. The necessary condition is

$$\beta < \frac{2\sigma^2\gamma\left[2-R(1-\gamma)\right]^2}{(\bar{\varepsilon}+2\sigma)^2\left[1-R(1-\gamma)\right]^2}.$$

References

Case, K.E. and R. E. Shiller, 1989. “The Efficiency of the Market for Single Family Homes,” *American Economic Review*. 79: 125-137.

Capozza, D. R., P. H. Hendershott, and C. Mack, 2004. “An Anatomy of Price Dynamics in Illiquid Markets: Analysis and Evidence from Local Housing Markets.” *Real Estate Economics.* 32(1): 1-32.

Genesove, D., and Mayer, C., 1997. “Equity and Time-to-Sale in the Real Estate Market.” *American Economic Review*. 87: 255-269.

Genesove, D., and Mayer, C., 2001. “Loss Aversion and Seller Behavior: Evidence from the Housing Market,” N.B.E.R. Working Paper No. 8143, March.

Hayashi, F., 1986, “Why is Japan’s Savings Rate so Apparently High?,” NBER Macroeconomics Annual, MIT Press, Cambridge, 147-210.

Hayashi, F., T. Ito, and J. Slemrod, 1988, “Housing Finance Imperfections, Taxation, and Private Saving: A Comparative Simulation Analysis of the United States and Japan, *Journal of the Japanese and International Economies,* 2(3), 215-238.

Horioka, C. Y., 1988, “Saving for Housing Purchase in Japan,” *Journal of the Japanese and International Economies*, 2(3), 351-384.

Hoshi, T., 2001. “What Happened to Japanese Banks?” *Monetary and Economic Studies,* February, 1-29.

Kan, K., Kwong S., and Leung, C., 2002. “The Dynamics and Volatility of Commercial and Residential Property Prices: Theory and Evidence.” Chinese University of Hong Kong working paper.

Kanemoto, Y., 1997. “The Housing Question in Japan.” *Regional Science and Urban Economics.* 27: 613-641.

Kelly, D., and LeRoy, S., 2003. “Liquidity and Liquidation.” Working paper, University of California at Santa Barbara.

Krainer, J., 2001. “A Theory of Liquidity in Residential Real Estate Markets.” *Journal of Urban Economics.* 49: 32-53.

Krainer, J., and LeRoy, S., 2002. “Equilibrium Valuation of Illiquid Assets.” *Economic Theory*. 19: 223-242.

Lamont, O., and Stein, J., 1999. "Leverage and House Price Dynamics in U.S. Cities." RAND Journal of Economics, 30(3), Autumn, 498-514.

Malpezzi, S., 1999. "A Simple Error Correction Model of House Prices." *Journal of Housing Economics*. 8: 27-62.

Noguchi, Y.,1994, "Land Prices and House Prices in Japan," in Y. Noguchi and J. Poterba eds., Housing Markets in the United States and Japan, National Bureau of Economic Research, University of Chicago Press, Chicago, 11-28.

Seko, M., 1994, "Housing Finance in Japan," in Y. Noguchi and J. Poterba eds., Housing Markets in the United States and Japan, National Bureau of Economic Research, University of Chicago Press, Chicago, 49-64.

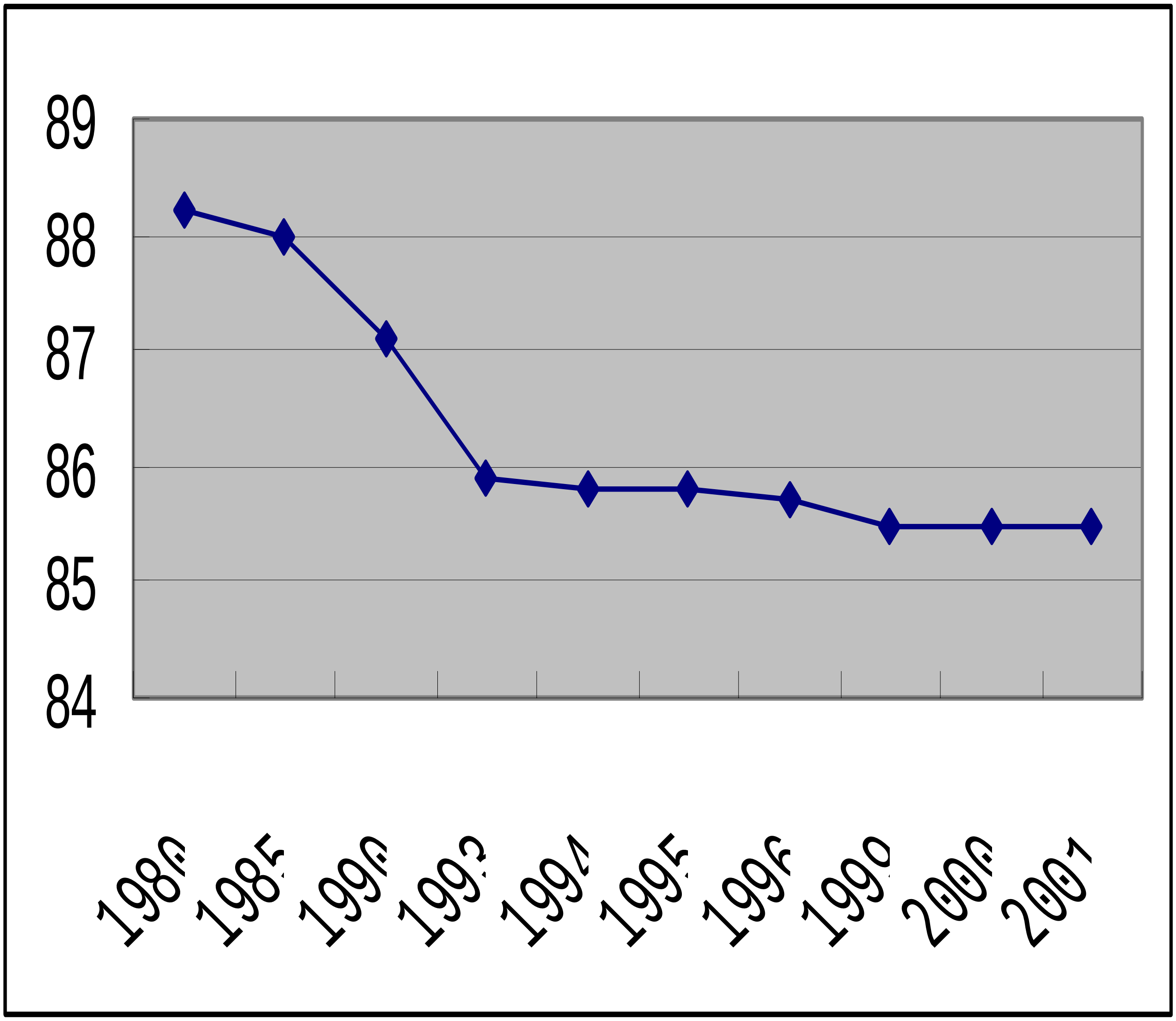
Shleifer, A., and Vishny, R., 1992. "Liquidation Values and Debt Capacity." *Journal of Finance.* 47: 1343-1366.

Stein, J., 1995. "Prices and Trading Volume in the Housing Market: A Model with Downpayment Effects." *Quarterly Journal of Economics*. 110: 379-406.

Wheaton, W., 1990. "Vacancy, Search, and Prices in a Housing Market Matching Model." *Journal of Political Economy*. 98: 1270-1292.

Williams, J., 1995. "Pricing Real Assets with Costly Search." *Review of Financial Studies*. 8: 55-90.

Figure 1
Share of Japanese Land Ownership by Individuals

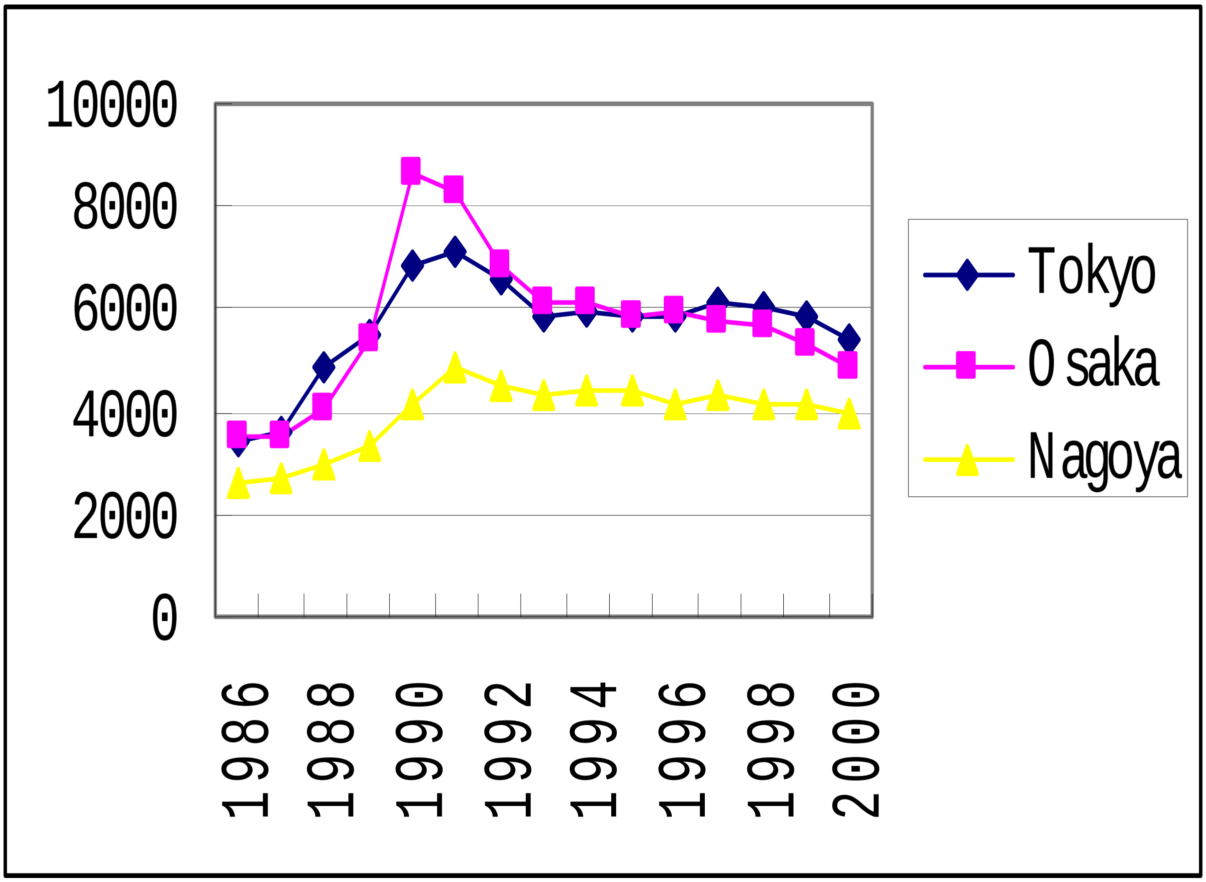


Notes: Percentage of land owned by individuals, rather than corporations. Source: Ministry of Land, Infrastructure and Transport White Paper on Land (*Tochi Hakusho* in Japanese).

Figure 2

House Prices for Tokyo, Osaka and Nagoya

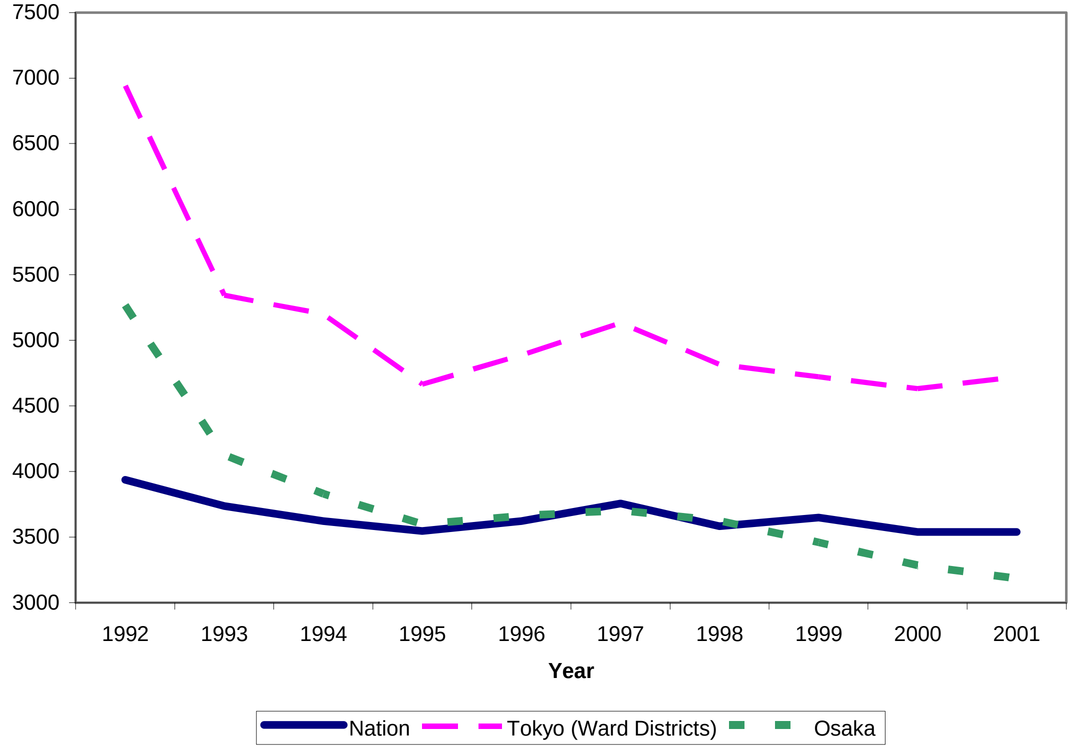
(1986-2000)



Notes: Figures are in ten-thousand yen. Average prices of new single-family houses (excluding condominiums) for the Tokyo, Osaka and Nagoya metropolitan areas.
Source: Urban Development Association *(Toshi-Kaihatsu Kyokai* in Japanese).

Figure3

Condominium Prices For Nation, Tokyo, and Osaka
(1992-2001)

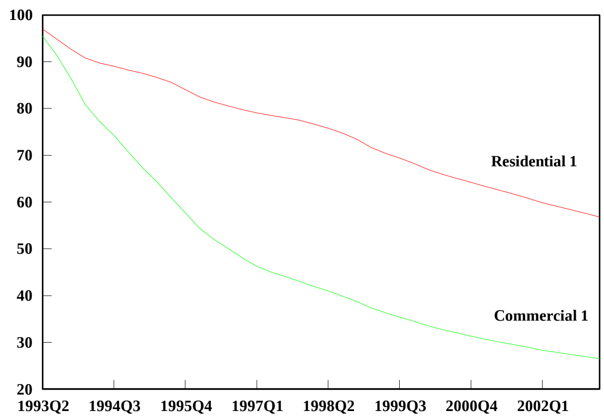


Notes: Figures are in ten-thousand yen. Average prices for condominiums for the nation as a whole, and the Tokyo and Osaka Ward districts. Source: Real Estate Economic Institute (*Fudosan-Keizai-Kenkyusho* in Japanese).

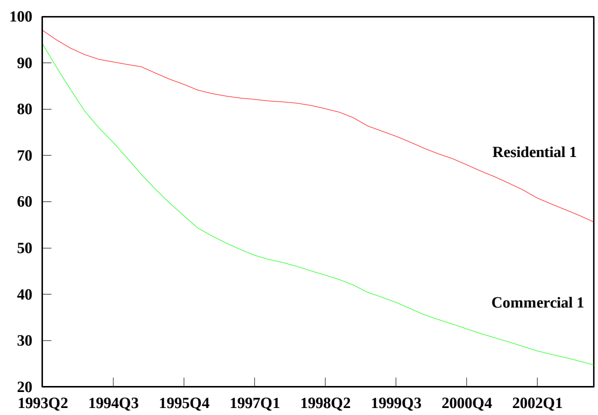
Figure 4
Land Price Data

(1993Q2 – 2003Q1)

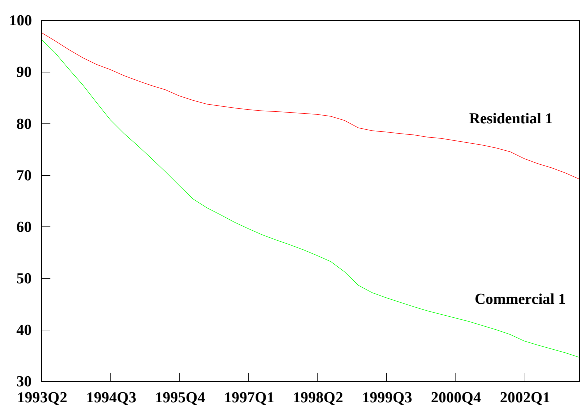
Tokyo



Osaka

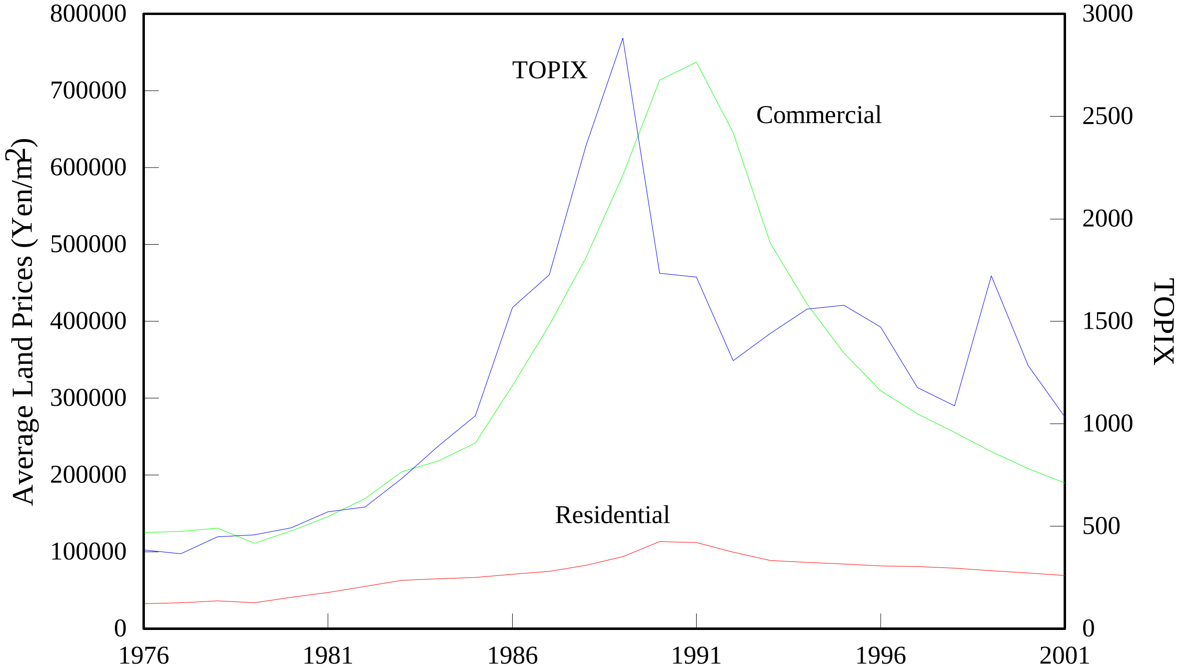


Nagoya



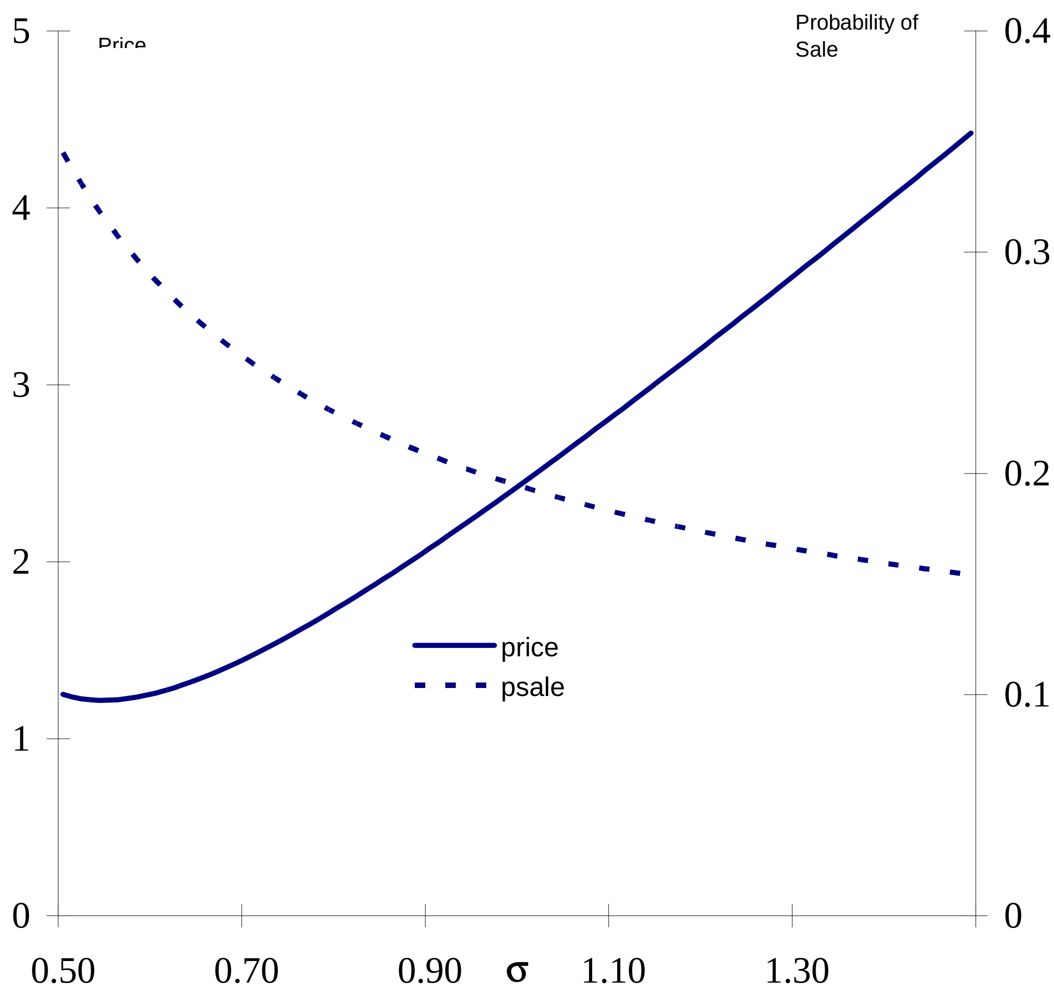
Notes: Land price data is quarterly from 1993:2 through 2003:1 for Tokyo, Osaka, and Nagoya. 1993:2=100. Source: Land Research Institute.

Figure 5
Average Prefecture Prices for Japan
(1976-2001)



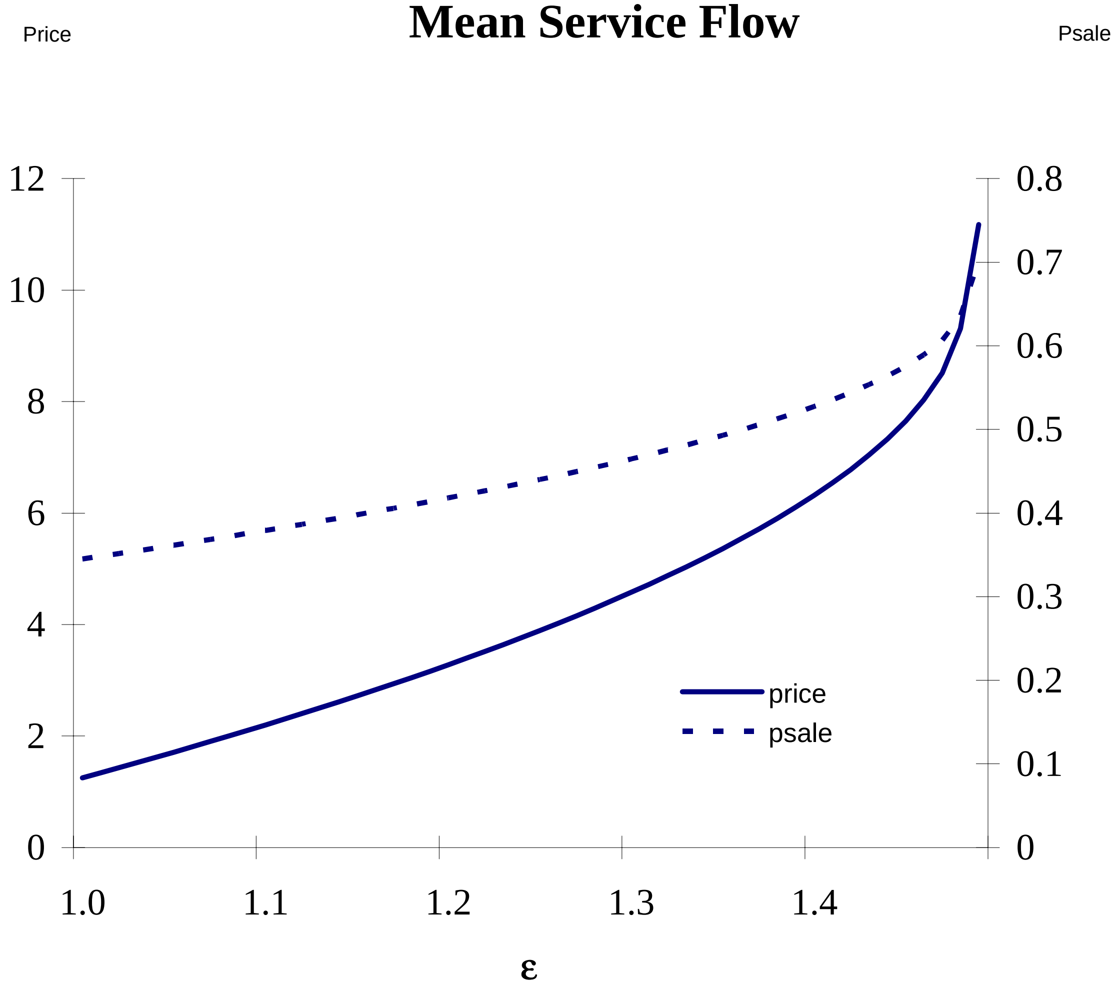
Note: Prices are average of Japanese prefecture data for each year. Average industrial prices from 1976 to 1978 do not include the Tokushimo prefecture. Average industrial prices from 1999 to 2001 do not include the Fukui prefecture. Source: Research on Land Prices by the Prefecture Government.

Figure 6
Price and Probability of Sale as Function of Service Flow Variance



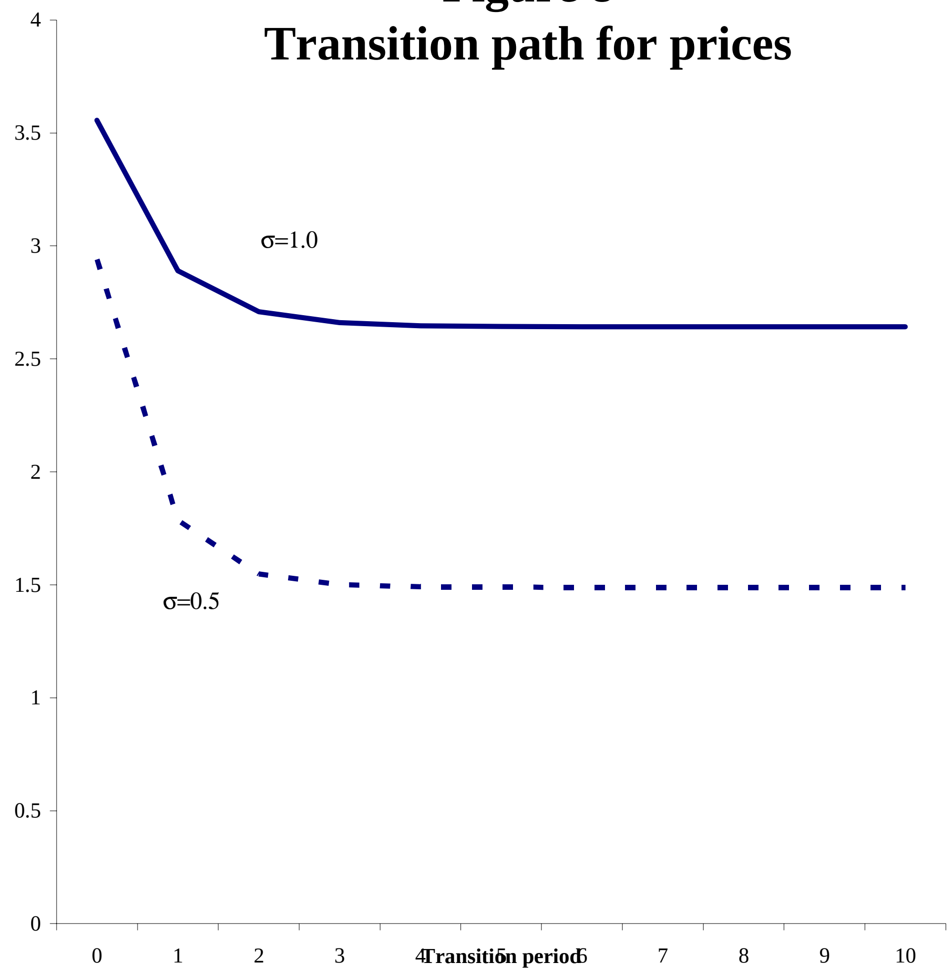
Notes: Steady-state solution for price, p, and probability of sale μ as a function of service flow variance, σ.

Figure 7
Prices and Probability of Sale as Function of Mean Service Flow



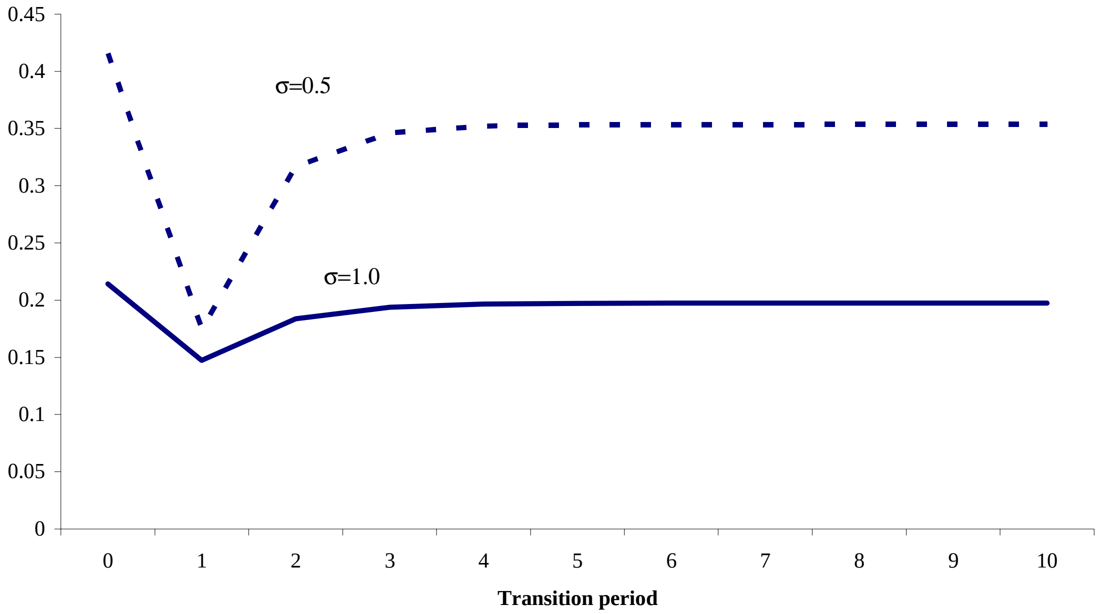
Notes: Steady-state solution for price, *p*, and probability of sale μ as a function of mean service flow, $\bar{\varepsilon}$.

Figure 8
Transition path for prices



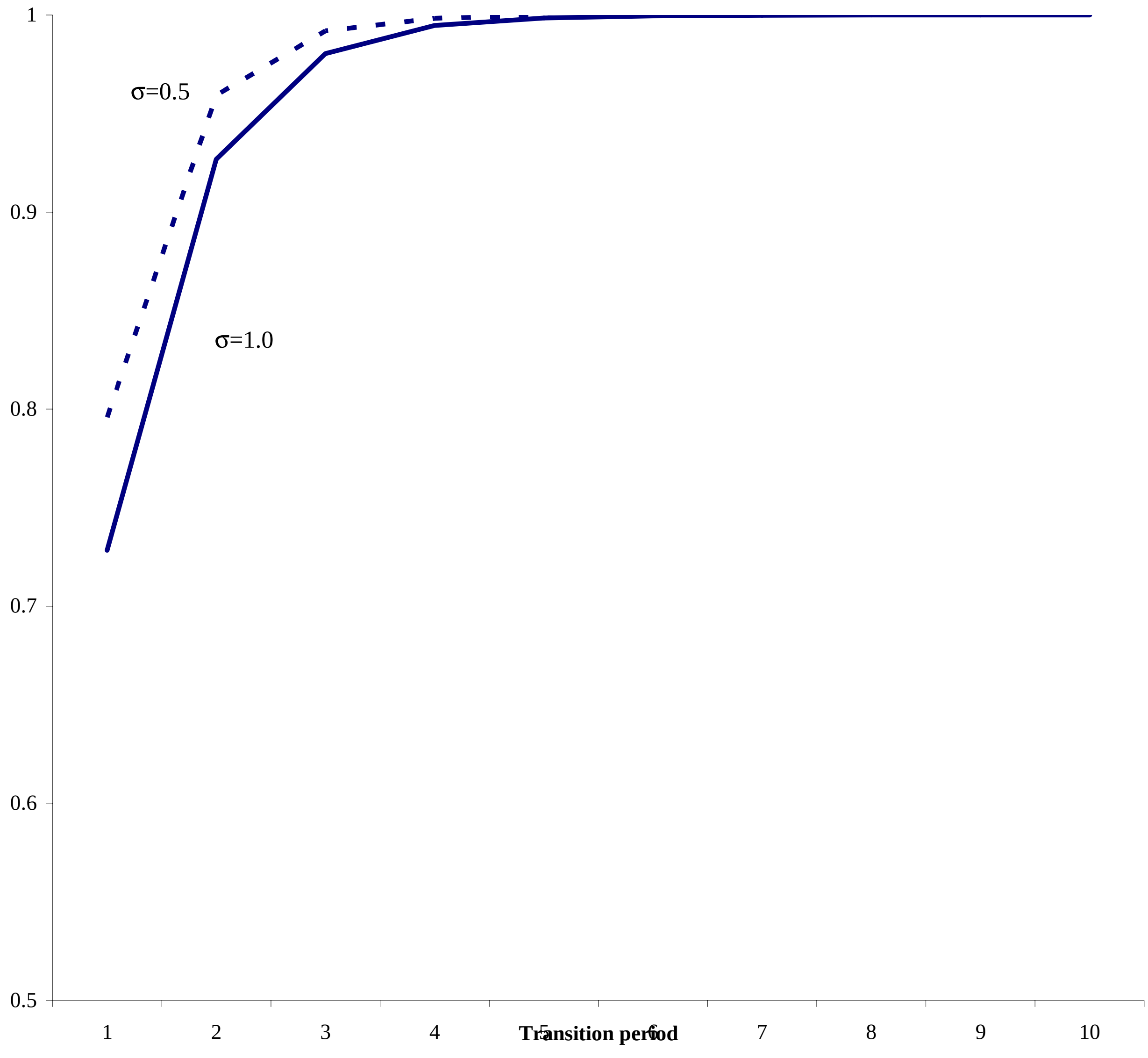
Notes: Figure depicts price dynamics following a once-and-for-all decline in the mean service flow, $\bar{\varepsilon}$, from 1.15 to 1.0. We plot time series for high value of σ, 1.0 and low value of σ, 0.5. Under low σ value prices fall farther and converge to their steady states more quickly.

Figure 9
Transition Path for Probability of Sale



Notes: Figure depicts dynamics of probability of sale, μ, following a once-and-for-all decline in the mean service flow, $\bar{\varepsilon}$, from 1.15 to 1.0. We plot time series for high value of σ, 1.0 and low value of σ, 0.5. Under both values, there is an initial steep drop in sale probability, resulting in some amount of overshooting, followed by a persistent increase in sale probablilties until they reach their steady-state values.

Figure 10
Relative Speed of Price Adjustment



Notes: Figure depicts share of total price decline achieved by time t following a once-and-for-all decline in the mean service flow, $\bar{\varepsilon}$, from 1.15 to 1.0. We plot time series for high value of σ, 1.0 and low value of σ, 0.5. Under low σ value prices converge to their steady state values more quickly.

Table 1
Real Estate Lending Among Failed Japanese banks

Failed Bank	Failure date	Real Estate Company Loans (million yen)	Percentage share of real estate loans
Hyogo Bank	August 1995	355894	16.01
Taiheiyo Bank	April 1996	120306	20.62
Tokuyo City Bank	November 1997	119937	23
Fukutoku Bank	August 1999	277011	21.48
Tokyo Sowa Bank	June 1999	353879	17.63
Niigata Chuo Bank	October 1999	77000	10.67

Notes: Figures are for March 1990. Table lists Japanese banks that failed during 1990s. August 1999 failure date represents failure of Namihaya Bank. Fukutoku Bank and Naniwa Bank were merged into Namihaya Bank in October 1998, which failed in 1999. The figures in the table are those of Fukutoku Bank in March 1990.

Table 2
Summary Statistics for Land Prices

I. Quarterly Data

	Mean	Std. Dev.	Max	Max Date	Min	Min Date
Residential Land Price1						
Tokyo	75.15	11.61	97.0	1993 Q2	56.75	2003 Q1
Osaka	77.52	11.39	97.0	1993 Q2	55.58	2003 Q1
Nagoya	81.80	7.04	97.7	1993 Q2	69.26	2003 Q1
Commercial Land Price1						
Tokyo	47.52	19.62	95.5	1993 Q2	26.52	2003 Q1
Osaka	48.08	18.74	94.1	1993 Q2	24.69	2003 Q1
Nagoya	57.53	17.74	96.4	1993 Q2	34.70	2003 Q1

II. Prefecture Data

	Mean	Std. Dev.	Max	Max Date	Min	Min Date
Residential Land Price	70491.33	23065.82	113168.10	1990	32204.26	1976
Commercial Land Price	316588.80	190137.10	737195.70	1991	111148.90	1979

Notes: Data for metropolitan areas is quarterly from 1993:2 through 2003:1, while data for prefectures is annual from 1976 through 2001. Max Date and Min Dates are dates corresponding to attainment of max and min values for price data. Source: Land Research Institute.

Table 3a
Error-correction Model results: Quarterly Data Commercial Land Values

Dependent Variable: ΔP_t

	1	2	3	4	5	6	7
Constant	-0.131** (0.009)	0.050** (0.010)	-0.042** (0.011)	-0.135** (0.009)	-0.127** (0.010)	-0.050** (0.010)	-0.050** (0.010)
ΔP_{t-1}	-	0.690** (0.061)	0.778** (0.095)	-	-	0.692** (0.065)	0.690** (0.062)
ΔP_{t-2}	-	-	-0.080 (0.090)	-	-	-	-
$\Delta TOPIX_t$	-	-	-	-	-0.013* (0.008)	-0.000 (0.005)	-0.000 (0.005)
$\Delta TOPIX_{t-1}$	-	0.002 (0.006)	0.003 (0.006)	-	-	-	0.002 (0.006)
$\Delta TOPIX_{t-2}$	-	-	0.002 (0.006)	-	-	-	-
$P_{t-1} - TOPIX_{t-1}$	-0.029** (0.003)	-0.012** (0.003)	-0.010** (0.003)	-0.001 (0.007)	-0.028** (0.003)	-0.014** (0.005)	-0.012** (0.003)
$P_{t-2} - TOPIX_{t-2}$	-	-	-	-0.029** (0.007)	-	0.002 (0.006)	-
OSAKA	-0.001 (0.002)	-0.000 (0.001)	-0.000 (0.001)	-0.001 (0.002)	-0.001 (0.002)	-0.000 (0.001)	-0.000 (0.001)
NAGOYA	0.013** (0.002)	0.004** (0.002)	0.004** (0.002)	0.013** (0.002)	0.013** (0.002)	0.004** (0.002)	0.004** (0.002)
# obs	117	114	111	114	117	114	114
R^2	0.535	0.803	0.798	0.589	0.546	0.803	0.803

Notes: Estimation by ordinary least squares. See text for model specification. * indicates statistical significance at 10% confidence level. ** indicates statistical significance at 5% confidence level.

Table 3b
Error-correction Model results: Quarterly Data
Residential Land Values

Dependent Variable: ΔP_t

	1	2	3	4	5	6	7
Constant	-0.037** (0.010)	-0.021** (0.006)	-0.014** (0.007)	-0.043** (0.011)	-0.033** (0.010)	-0.022** (0.007)	-0.022** (0.007)
ΔP_{t-1}	-	0.817** (0.055)	0.828** (0.096)	-	-	0.822** (0.056)	0.819** (0.055)
ΔP_{t-2}	-	-	-0.019 (0.096)	-	-	-	-
$\Delta TOPIX_t$	-	-	-	-	-0.008 (0.005)	0.001 (0.003)	0.001 (0.003)
$\Delta TOPIX_{t-1}$	-	0.004 (0.003)	0.005 (0.003)	-	-	-	0.004 (0.003)
$\Delta TOPIX_{t-2}$	-	-	0.007** (0.003)	-	-	-	-
$P_{t-1} - TOPIX_{t-1}$	-0.008** (0.003)	-0.007** (0.002)	-0.004* (0.002)	-0.001 (0.005)	-0.007* (0.004)	-0.011** (0.003)	-0.007** (0.002)
$P_{t-2} - TOPIX_{t-2}$	-	-	-	-0.010* (0.005)	-	0.004 (0.003)	-
OSAKA	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)
NAGOYA	0.006** (0.001)	0.001 (0.001)	0.001 (0.001)	0.006** (0.001)	0.006** (0.001)	0.001 (0.001)	0.001 (0.001)
# obs	117	114	111	114	117	114	114
R^2	0.200	0.744	0.745	0.223	0.216	0.744	0.744

Notes: Estimation by ordinary least squares. Sample pools data from Tokyo, Nagoya and Osaka metropolitan areas. See text for model specification. * indicates statistical significance at 10% confidence level. ** indicates statistical significance at 5% confidence level.

Table 4a
Error-correction Model results: Prefecture Data
Commercial Land Values

Dependent Variable: ΔP_t

ΔPC_t	1	2	3	4	5	6	7
C	0.605** (0.059)	0.696** (0.057)	0.644** (0.065)	0.848** (0.062)	0.679** (0.059)	0.826** (0.056)	0.826** (0.056)
ΔPC_{t-1}	-	0.488** (0.025)	0.422** (0.028)	-	-	0.456** (0.030)	0.502** (0.024)
ΔPC_{t-2}	-	-	0.098** (0.029)	-	-	-	-
$\Delta TOPIX_t$	-	-	-	-	0.150** (0.022)	0.184** (0.019)	0.184** (0.019)
$\Delta TOPIX_{t-1}$	-	-0.021 (0.021)	0.009 (0.021)	-	-	-	-0.045** (0.020)
$\Delta TOPIX_{t-2}$	-	-	0.167** (0.022)	-	-	-	-
$PC_{t-1} - TOPIX_{t-1}$	-0.113** (0.011)	-0.132** (0.011)	-0.126** (0.012)	0.044** (0.019)	-0.128** (0.011)	-0.113** (0.019)	-0.159** (0.011)
$PC_{t-2} - TOPIX_{t-2}$	-	-	-	-0.203** (0.019)	-	-0.045** (0.020)	-
# obs	1175	1128	1081	1128	1175	1128	1128
R^2	0.090	0.330	0.394	0.188	0.127	0.383	0.383

Notes: Estimation by ordinary least squares. Sample pools data from 47 Japanese prefectures from 1976 through 2001. See text for model specification. * indicates statistical significance at 10% confidence level. ** indicates statistical significance at 5% confidence level.

Table 4b
Error-correction Model results: Prefecture Data
Residential Land Values

Dependent Variable: ΔP_t

ΔPR_t	1	2	3	4	5	6	7
C	0.115** (0.033)	0.209** (0.035)	0.197** (0.038)	0.190** (0.036)	0.144** (0.035)	0.277** (0.037)	0.277** (0.037)
ΔPR_{t-1}	-	0.307** (0.030)	0.308** (0.030)	-	-	0.288** (0.033)	0.328** (0.030)
ΔPR_{t-2}	-	-	0.009 (0.031)	-	-	-	-
$\Delta TOPIX_t$	-	-	-	-	0.043** (0.017)	0.083** (0.017)	0.083** (0.017)
$\Delta TOPIX_{t-1}$	-	-0.030* (0.016)	-0.018 (0.016)	-	-	-	-0.040** (0.016)
$\Delta TOPIX_{t-2}$	-	-	0.123** (0.017)	-	-	-	-
$PR_{t-1} - TOPIX_{t-1}$	-0.023** (0.009)	-0.049** (0.009)	-0.049** (0.010)	0.050** (0.016)	-0.030** (0.009)	-0.028 (0.017)	-0.068** (0.010)
$PR_{t-2} - TOPIX_{t-2}$	-	-	-	-0.092** (0.015)	-	-0.040** (0.016)	-
# obs	1175	1128	1081	1128	1175	1128	1128
R^2	0.017	0.111	0.162	0.054	0.022	0.130	0.130

Notes: Estimation by ordinary least squares. Sample pools data from 47 Japanese prefectures from 1976 through 2001. See text for model specification. * indicates statistical significance at 10% confidence level. ** indicates statistical significance at 5% confidence level.