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UNINFORMED BUYERS, MARKET INFORMATION AND VOLATILITY OF PRICES: A Theory of Asset Markets with High Transaction Costs

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Abstract

This paper analyses asset markets with high transaction costs, of which the real-estate market is one example. It is shown that the existence of uninformed buyers trying to extract information from prices gives sellers *probabilistic market power* in that sellers can influence the probability for their asset to be sold.

The influx of such uninformed buyers contributes greatly to volatile price movement in these markets. The more disperse their expectations are, the more volatile the prices are. The result suggests that a surge of new investors caused by internationalization of the domestic economy and "liberalisation" of financial markets may be responsible for the volatility of real estate prices found in the late 1980s.

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1. INTRODUCTION

The last decade has witnessed marked volatility in real-estate markets in many industrialized countries. The most dramatic example is found in Japan. Figure 1 shows the movement of real commercial land prices in Japan after 1962. A dramatic upsurge started in Tokyo around 1984, spreading to the other large cities. In 1984, the rate of real price change reached well over 40% annually, which was unprecedented since the era of high economic growth. In some areas where demand was so intense (notably Shinjuku area which was the emerging business centre at that time), it was often reported that prices were doubled, tripled or quadrupled only in one month. The price marked its peak at 1990, and a sharp and prolonged decline followed. The movement after 1992 is not shown here, but the price was still declining even in the present time (as of 1994). This bust of the real-estate boom triggered or at least prolonged the second worst recession in the post-second World War Japanese history.[1]

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Figure 1.1: The Annual Rate of Change of Real Commercial Land Prices in Japan: Six Largest Cities, 1962-1992

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However, the Japanese example is no at all unique. In the recent past, the United Kingdom, Sweden, Australia and other countries experienced a significant real-estate boom, and downfall that followed caused serious troubles in the financial system and the economy as a whole.

The conventional interpretation of such a turbulent behaviour of real-estate prices is that it is one manifestation of "bubbles" found in asset markets in general. Among various possible interpretations of bubbles, rational bubbles have been the centre of discussion. In the laymen's term, rational-bubble interpretation argues that the price of land deviates from its fundamental value and keeps going up, since rational investors assume that other investors assume that the price is going up. Their expectations are self-fulfilling up until to some point and then collapse, which leads to a sharp decline after a surge of prices.

There are, however, various problems in this conventional rational-bubble interpretation. Firstly, the rational bubble argument provides us with no explanation of why it started in the 1980s. Secondly, it also fails to supply the account

[1]See Nishimura [8] for more detailed account of the history of Japanese land prices after the second World War. Ito [5, Chapter 14] provides us with a concise summary of the Japanese literature on this subject.

of what caused its collapse that followed. More fundamentally, the argument assumes the market is efficient, but there are now a number of studies questioning the validity of the efficient market hypothesis in real estate markets.[2] Perhaps most revealing evidence is found in Japan, which is summarized in Figure ??. The excess rate of return on commercial real estates, which must be serially uncorrelated under the hypothesis of the efficient market, is shown in this figure. This figure reveals that the market behaviour is at least consistent with the hypothesis up until 1985, but the behaviour clearly violates the hypothesis afterward.

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Figure 1.2: Biannual Excess Rate of Return on Commercial Real Estates in Japan
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In this paper, I propose an alternative theory of the recent turbulent real-estate price behaviour, which is based on high transaction costs characterizing real-estate markets. High transaction costs are considered as one of the most important determinants of market transactions in real estates.[3] However, high transaction costs are not sufficient to produce turbulent price behaviour. It is the influx of new investors relatively uninformed about the market that produces and amplifies the volatility. In this sense, "liberalization" and "internationalization" of domestic economies coupled with de-regulation of financial markets in the 1980s played an important role. It brought into real-estate markets a surge of new investors not well-informed about the market.

Consider a market of high transaction costs. High transaction costs imply that arbitrage is insufficient in this market. Then, suppose a substantial number of uninformed buyers with heterogeneous expectations enter the market.[4] These buyers are uncertain and have different opinion about the profitability of particular land. This implies that land owners can expect positive probability for their land to be sold even though they put higher price tag than the land's intrinsic value (which is often called the fundamental value). Sellers can affect the probability of sales by changing their price, since a high price may diminish the probability, while a low price increases it. Therefore, sellers of land now have

[2]See, for example, Case and Shiller [2]. Problems concerning tests of rational bubbles are extensively discussed in Flood and Hodrick [4].

[3]Because of this high cost, the real estates market is a *thin* market. According to the Institute of Construction Economics (KENSETSU KEIZAI KENKYUJO), the total market value of land in Tokyo was about 460 trillion yen in 1988, but only 2-trillion-worh of land was actually transacted in that year.

[4]In fact, around 1984, there was an influx of foreign financial institutions entering Tokyo financial markets, and many domestic firms based in other areas than Tokyo expanded their operation in Tokyo.

probabilistic market power. Sellers now raise their price over their real-estates' intrinsic value if the raise increases their expected wealth.

Moreover, uninformed buyers try to extract information from the market as rational economic agents, especially form prices that they observe. This implies that sellers can influence buyers' information through manipulating their price offer. This is another source of probabilistic market power. Sellers can affect the probability for their land to be sold by their price, through affecting buyers' expectations.

The market with uninformed investors can be characterized as the market of *probabilistically monopolistic competition.* Therefore, the market price of land is higher than its intrinsic, fundamental value.

There are several interesting implications in this probabilistically monopolistic competition. Firstly, in this asset market of high transaction costs, heterogeneity among buyers is one of the most important determinants of price behaviour. Prices are more volatile in this thin market of high transactions than in the thick market of low transaction costs, so long as buyers' expectations are sufficiently diverse among them. Moreover, the more disperse the buyers expectations are, the more volatile the prices are. Thus, disagreement among buyers causes turbulent price behaviour.

Secondly, there is positive correlation between the fundamental value of the land and the deviation of its market price from it. Namely, the higher the fundamental value is, the larger the deviation of the price from the fundamental value is. This implies that the market is more volatile when the interest rate is low than when the rate is high. This is consistent with the Japanese experience of the 1980s, since this decade was characterized by a sharp decline of the effective real rate of interest for many real-estate buyers.

Finally, rational expectations are shown to be destabilizing in this market. Prices are more volatile in the case of "rational" expectations in which buyers' expectations about change in fundamentals are correct on the average, than in the case of "sticky" expectations in which buyers expect no change.

The paper is organized as follows. In Section 2, a model of the land market is presented where there are substantial transaction costs and a substantial number of uninformed buyers. The process of expectation formation of these buyers is examined carefully there, and equilibrium is characterized as rational expectations equilibrium with limited information availability. The major characteristics of the market are derived in Section 3. Section 4 examines the case in which buyers are informed. It is shown there that, even though the market is characterized by high transaction costs, the market outcome is not much different from the market with no transaction cost, when we are concerned only with macro variables, namely, the average price. Section 6 contains remarks on the limitation of the present analysis and its possible extentions.

2. LAND MARKET WITH UNINFORMED BUYERS

2.1. The Setting: The market of heterogeneous pieces of land.

I consider a once-and-for-all market of land ownership. The market is open in this period, and the ownership is exchanged. From the next period on, there is no market of land ownership.

There are N heterogeneous pieces of land, where N is so large that we can employ the law of large numbers as approximation. Thus, there are N sellers on one side of the market. On the other side of the market, there are M buyers. M is also assumed to be large, so that the law of large numbers also applies.

Throughout this paper, the lower-case variable denotes the logarithm of the upper-case variable. Let X_i be the intrinsic value of the ith piece of land[5], and x_i be its logarithm: $x_i = \log X_i$. Then, we assume

$$X_i = YW_i, \text{ or equivalently, } x_i = y + w_i \tag{2.1}$$

where Y is the (geometric-)average intrinsic value and W_i is the idiosyncratic intrinsic component. $w_i = \log W_i$ is a draw from normal distribution $N(0, \sigma_w^2)$. Therefore, if all investors were informed, the price of the ith land would be X_i and the average land price would be Y.

High Transaction Costs.

The market is characterised by the existence of high transaction costs, both fixed and variable. The market is not well-organised, and buyers have difficulty to locate sellers, to assess future profitability of particular land for sale, and to negotiate terms of trade with sellers. This is partly due to heterogeneity of land and that of land owners.[6] Consequently, a substantial fixed cost limits the number of buyers in the market, and a substantial variable cost restricts the number of sellers buyers can visit economically.

To capture these high transaction costs for buyers, (1) the number of buyers M is smaller than the number of sellers N, and (2) one buyer can visit randomly only one seller (i.e., one piece of land).

Influx of New Investors.

In order to concentrate the effect of new investors in the land market, I assume in this and next sections that no seller wants to be a buyer, and that M buyers are all new investors who are not well-informed about the market. The land market in which a seller is also a buyer will be discussed later in Section 4.

[5] X_i is the discounted present value of future rents on this land.

[6] If land were homogeneous, then information about land is easily obtained, and negotiation is not so hard. Thus, high transaction costs pre-suppose heterogeneity.

Result of Negotiation.

To simplify analysis, I assume that sellers offer prices, and buyers determine whether they accept them or not. The assumption of take-it-or-leave-it price offer by sellers is made partly due to the fact that it is a reasonable description of the land market in Japanese large citites around 1985, and partly due to avoid complexity of bilateral negotiation under imperfect information.[7]

Uninformed Buyers with Heterogeneous Expectations.

Buyers in this market are new investors who do not know X_i, Y, and W_i. Moreover, buyers' prior information about them may differ from one another. However, buyers are endowed with rational expectations about the *structure* of the market in the sense that they know the true stochastic structure of market variables.

Since buyers visit one seller, they have information about this seller's price. Moreover, I assume that the following public information is available in the market. Buyers form their expectations about X_i, Y, and W_i using all available information including this price information.

Public Average-Price Information.

There is a government agency which surveys all prices posted in the market and announces its average as the average land price P, or in the logarithmic form $p = \log P$. This information is freely available to all participants in the market.[8]

Imperfect Information of Sellers.

Sellers are also endowed with rational expectations about the structure of the market. Firstly, they have perfect information about their own land. Thus, they can observe their own X_i. Secondly, they know the objective probability of structure of the market, including distribution of their land to be sold.

However, their information is imperfect in the sense that they do not know what expectations the particular buyer visiting them has about X_i, Y, and W_i.

[7] In the case of certainty, we have relatively robust results about the outcome of bilateral bargaining. See, for example, Rubinstein [10]. However, we have only scant results in the case of uncertainty and imperfect competition. The complication arises since a proposal from one side of the bargaining reveals not only his stance in bargaining but also his information. He must consider this informational exchange into account in considering his move.

[8] In Japan, the Land Agency plays this role and announces KOJI CHIKA (the "posted land price"). In practice, the posted land price is the estimated average of land prices posted in the market. Although the announcement of the posted land price lags six months, I assume for simplicity that such average price information is concurrently available. In fact, the land agency has recently begun announcing the TANKI CHIKA DOUKOU (the "current land-price movement"), which is an abridged version of the posted price, and its announcement lags only three months.

Sequence of Events.

I consider the following sequence of events in this market. First, sellers determine their prices simultaneously, relying on available information. (Sellers are not allowed to change their prices afterward). Then, buyer visit sellers and get public average-price information. Buyers update their expectations rationally, and determine whether to buy the land relying on the updated expectations. I analyse the rational expectations equilibrium (or a variant of Bayesian Nash equilibrium) of this market.

2.2. Uninformed Buyers Extracting Information about $x_i = \log X_i$.

Uninformed buyers rationally form their expectations based on their limited knowledge about the market, and decide whether to buy the land or not relying on their information. At the beginning, they have their own prior information about the market, which is summarised in their subjective distribution about relevant economic variables determining prices. They then have price information from the market. They form posterior distribution based on this price information in the Bayesian manner. They then update their expectations about relevant variables based on the posterior distribution, which are utilised in their decision in the market.

Information about the Structure of Prices.

I assume that buyers have rational expectations about equilibrium price structure. That is, they have perfect information about the price structure:

$$P_i = Z\,(YU)^{\omega_y}\,(W_iV_i)^{\omega_w}\,,\ \text{or equivalently, } p_i = z + \omega_y(y+u) + \omega_w(w_i+v_i); \quad (2.2)$$

$$P = Z\,(YU)^{\omega_y}\,,\ \text{or equivalently, } p = z + \omega_y(y+u) \quad (2.3)$$

where

Z is a constant term,

ω_y is the elasticity of the price P_i to *macro* variables, Y and U.

ω_w is the elasticity of the price P_i to *micro* variables, W_i and V_i.

Macro variables consist of the average intrinsic value Y and the average non-intrinsic component, U.[9] Micro variables consist of idiosyncratic intrinsic component W_i and the idiosyncratic non-intrinsic component V_i.

[9]Note that $\omega_y = 1$ and $U = 1$ if market participants have perfect information, transaction costs are negligible, and there is no financial imperfection.

Here Z, ω_y and ω_w are undetermined coefficients which will be determined in rational expectations equilibrium. The source of U and V_i will become apparent in the following analysis.

Prior Information about the Determinants of Prices.

Buyers have prior information about the determinants of prices. There may be various informational exchange among buyers and sellers, prior to the opening of the market. The crucial assumption in this paper is that buyers may have heterogeneous expectations.

There are two types of the price determinants: macro ones and micro ones. For analytic simplicity, I assume that buyers have homogeneous micro expectations and heterogeneous macro expectations. Thus, the heterogeneity considered here is macro-expectational.

(i) Micro expectations. Buyers are assumed to have the following expectations about the micro variables. They assume $w_i = \log W_i$ and $v_i = \log V_i$ are independent random variables with normal distributions $N(0, \sigma_w^{2*})$ and $N(0, \sigma_v^{2*})$, respectively. Since the objective mean of w_i is zero, their expectations about the idiosyncratic intrinsic component is rational.[10] Later in this section, it will be shown that the actual mean of v_i is zero in equilibrium, so that their expectations about the idiosyncratic non-intrinsic component is also rational.

(ii) Macro expectations. However, buyers may have heterogeneous expectations about the average intrinsic value Y and the average non-intrinsic component U. Their expectations are characterised by probability distributions. The jth buyer's prior distribution of $y = \log Y$ is $N(y_j^*, \sigma_y^{2*})$, that of $u = \log U$ is $N(u_j^*, \sigma_u^{2*})$, and he considers that y and u are independent. (This independence assumption by buyers turns out to be correct in equilibrium).

Thus, we assume that their expectations may differ from one another with respect to (the logarithm of) the mean of the average intrinsic value, y_j^*, and (the logarithm of) the mean of the average non-intrinsic component, u_j^*. However, the variances are the same among uninformed investors, indicating the degree of subjective uncertainty is the same. Macro and micro variables are assumed to be independent.

Concurrent Price Information.

Let us consider the jth buyer visiting the ith seller. The buyer gets two pieces of concurrent information. First, he has public information about the average price of the land, P, or in logarithm, $p = \log P$. Second, he comes to know the ith seller's price, P_i, or in logarithm, $p_i = \log P_i$.

[10] To be precise, I assume that their expectations about w_i is rational in the first moment.

Updating Expectations.

Rearranging terms and using the above definitions, we have two basic relations determining informational content of prices:

$$\omega_w^{-1}(p_i - p) = w_i + v_i;$$
$$\omega_y^{-1}(p - z) - y_j^* - u_j^* = (y - y_j^*) + (u - u_j^*). \tag{2.4}$$

Since w_i, v_i, $y - y_j^*$, and $u - u_j^*$ are independent, we get the following rational expectations of x_i from the above relations

$$E^j(x_i \mid p_i, p) = E^j(w_i + y \mid p_i, p) = E^j(w_i \mid p_i, p) + y_j^* + E^j(y - y_j^* \mid p_i, p)$$
$$= a\omega_w^{-1}(p_i - p) + y_j^* + b\{\omega_y^{-1}(p - z) - y_j^* - u_j^*\}, \tag{2.5}$$

where

$$1 > a = \frac{\sigma_w^{2*}}{\sigma_w^{2*} + \sigma_v^{2*}} > 0; 1 > b = \frac{\sigma_y^{2*}}{\sigma_y^{2*} + \sigma_u^{2*}} > 0. \tag{2.6}$$

Here E^j represents the expectation operator with respect to the subjective distribution of the jth buyer.

2.3. Buyer's Decision

The buyer is assumed to be risk-neutral, although this assumption is not essential. Let $W_{initial}(j)$ be the initial wealth of the jth buyer. Then, the expected total wealth when the buyer purchases the land is,

$$E^j(W_{buy}(j) \mid p_i, p) = E^j(X_i \mid p_i, p) - P_i + W_{initial}(j),$$

while the expected utility of not purchasing the land is simply

$$E^j(W_{not\ buy}(j) \mid p_i, p) = W_{initial}(j).$$

Consequently, the optimal decision rule of the ith buyer observing (p_i, p) is to buy if $E^j(W_{buy} - W_{not\ buy} \mid p_i, p) \geq 0$, and not to buy if otherwise. Since we have as the first-order approximation:[11]

$$E^j(X_i \mid p_i, p) \approx \exp\left(E^j(x_i \mid p_i, p)\right),$$

the jth buyer's optimal decision rule is

[11] To be exact, we have $E^j(X_i \mid p_i, p) = \exp\left(E^j(x_i \mid p_i, p) + \frac{1}{2}Var(x_i \mid p_i, p)\right)$,and where $Var(x_i \mid p_i, p) = \sigma_y^{2*} + \sigma_w^{2*}$. However, this complication does not change the qualitative result of this paper, I use the approximation $E^j(X_i \mid p_i, p) \approx \exp\left(E^j(x_i \mid p_i, p)\right)$.

$$\text{Buy if } E^j(x_i \mid p_i, p) - p_i \geq 0;$$

$$\text{Don't buy if otherwise.}$$

2.4. Distribution of Expectations among Buyers

In general, the distribution of (u_i^*, y_i^*) among buyers is characterized by joint-distribution $\Pr(y_j^* \geq y, u_i^* \geq u) = F(y, u)$. In order to simplify analysis, I concentrate the following form of joint-distribution in which heterogeneity of expectations is solely about the average intrinsic value y_j^*.

(1) buyers' expected average non-intrinsic component is homogeneous and equal to u^*, (i.e., $u_j^* = u^*$); and

(2) the distribution of y_i^* among buyers is the Gibbs distribution,[12] of which the distribution function is

$$\Pr(y_j^* \geq y) = 1 - \frac{1}{1 + e^{k(y-y_0)}}. \tag{2.7}$$

Here y_0 is the median, and $1/k$ represents the degree of dispersion. If $1/k \to 0$ (i.e., $k \to \infty$), then the distribution is concentrated at y_0. On the contrary, if $1/k \to \infty$ (i.e., $k \to 0$), then the distribution becomes very dispersed. I assume

$$1/k < (\sigma_y^{2*} + \sigma_u^{2*})/\sigma_u^{2*},$$

which implies that there is an upper limit in the dispersion.

At this stage, it is possible to assess the probability of the land being sold to a visiting buyer, when the average price is p and the seller's offer is p_i.

First, note that $E^j(x_i \mid p_i, p) = a\omega_w^{-1}(p_i - p) + y_j^* + b\{\omega_y^{-1}(p - z) - y_j^* - u^*\}$ since $u_j^* = u^*$. The critical value of y which making the buyer indifferent between purchase and non-purchase, which is denoted by $y(p_i, p)$ must satisfy

$$a\omega_w^{-1}(p_i - p) + y(p_i, p) + b\left(\omega_y^{-1}(p - z) - y(p_i, p) - u^*\right) - p_i = 0.$$

Therefore, we have

$$y(p_i, p) = rp_i + sp + t$$

where

[12] This Gibbs distribution can be derived as the equilibrium distribution of appropriate informational exchange process among buyers, which may precedes the opening of the land market. See Aoki [1] and references therein.

$$r = \frac{1 - a\omega_w^{-1}}{1-b}; s = \frac{a\omega_w^{-1} - b\omega_y^{-1}}{1-b}; t = \frac{b\omega_y^{-1}z + bu^*}{1-b} \tag{2.8}$$

The probability of one buyer visiting one seller is M/N and the buyer will purchase land if and only if its y_j^* exceeds or is equal to $y(p_i, p)$. Consequently, the probability of being sold, $\phi(p_i, p; z, \omega_y, \omega_w)$, is

$$\phi(p_i, p) = \frac{M}{N} \frac{1}{1 + e^{k(y(p_i,p) - y_o)}}.$$

2.5. Seller's Imperfect Information: Probabilistic Market Power

Sellers have perfect information about the probability for their land to be sold, i.e., $\phi(p_i, p; z, \omega_y, \omega_w)$. However, they do not know their visitor's y_i^* and u^*. Thus, they can influence the probability of successful sale by changing their own p_i, although they cannot make sale certain. This implies that sellers have *probabilistic market power.*

A seller is said to have market power if he faces a downward-sloping demand, that is, if he can *in a continuous manner* influence the demand for his product by changing his own price.[13] Interpreting in a more general term, the market power is the ability to change own utility continuously by altering own price. In this market, the seller can influence his expected utility continuously by altering his price. Therefore, the seller has market power, not through changing demand as in the traditional market, but through changing the probability of successful sale.

2.6. Seller's Decision

I assume that sellers are heterogeneous in their financial condition. Some sellers have great necessity to liquidate their land holding, while others do not. The former will sell their land even though the price may be below its intrinsic value. This heterogeneity is the source of idiosyncratic non-intrinsic component V_i in the price structure, as will be shown eventually in this section.

To capture the difference in financial need, I assume that (1) the seller must incur penalty when he fails to sell the land and (2) the penalty differs among sellers. For example, suppose that the seller happens to inherit the land, so that he must pay the inheritance tax. If he can sell the land, he will pay the tax from the proceed. However, if not, he must finance the inheritance tax, which may result in selling other financial assets in an unfavourable state. Thus, the seller

[13]Of course, the seller can influence the demand by changing his price in the obvious way in the perfectly competitive market. However, he cannot continuously affect the demand by altering his price, since the demand is zero if his price is above the market price and infinity if it is below the market price.

may incur penalty when he is unable to sell the land.[14] The penalty, however, will differ substantially among sellers. For some, the penalty is negligible, while for others it may be quite substantial.

When the ith seller sells his land, then his wealth is

$$W_{sold}(i) = P_i + W_{o/t\ land}(i),$$

where $W_{o/t\ land}(i)$ is his wealth other than the land. When the land is not sold, the seller incurs the idiosyncratic penalty Δ_i. Therefore, the penalty is subtracted from the sum of the intrinsic value of land and the wealth other than the land if the land is not sold. Consequently, the wealth when the seller fails to sell the land is

$$W_{not\ sold}(i) = X_i + W_{o/t\ land}(i) - \Delta_i$$

I assume $\delta_i = \log \Delta_i$ is normally distributed among sellers, whose mean is zero and variance is σ_δ^2.

Let us recall that the probability of being sold is $\phi(p_i, p)$ when the seller's price is p_i while the average price is p. Consequently, the expected wealth of the seller $EW(i)$ is then,

$$EW(i) = \phi(p_i, p) W_{sold}(i) + (1 - \phi(p_i, p)) W_{not\ sold}(i)$$

$$= \phi(p_i, p)(e^{p_i} - e^{x_i} + e^{\delta_i}) + (e^{x_i} - e^{\delta_i} + W_{o/t\ land}).$$

The first-order condition of the maximisation of the above expected wealth with respect to the own price p_i yields

$$\frac{\partial \phi(p_i, p)}{\partial p_i}(e^{p_i} - e^{x_i} + e^{\delta_i}) + \phi(p_i, p)e^{p_i} = 0,$$

or equivalently,

$$\frac{\phi(p_i, p)}{-\frac{\partial \phi(p_i, p)}{\partial p_i}} = 1 - e^{x_i - p_i} + e^{\delta_i - p_i}.$$

Since

$$\frac{\phi(p_i, p)}{-\frac{\partial \phi(p_i, p)}{\partial p_i}} = \frac{\frac{M}{N}\frac{1}{1+e^{k(y(p_i,p)-y_0)}}}{-\frac{M}{N}\frac{-ke^{k(y(p_i,p)-y_0)}}{\left(1+e^{k(y(p_i,p)-y_0)}\right)^2}\frac{\partial y(p_i,p)}{\partial p_i}} = \frac{1 + e^{k(rp_i+sp+t-y_0)}}{ke^{k(rp_i+sp+t-y_o)}r},$$

the first-order condition becomes

$$e^{-k(rp_i+sp+t-y_0)} = H(p_i, x_i, \delta_i),$$

where

$$H(p_i, x_i, \delta_i) = rk\left(1 - e^{x_i - p_i} + e^{\delta_i - p_i}\right) - 1.$$

[14]In fact, to pay the inheritance tax is one of the major reasons for land owners to sell their land in Japan.

Here r, s, and t are defined in (2.8).

The above equation implicitly defines the optimal price of the ith seller as a function $p^*(p, x_i, \delta_i, t, y_0)$ of the average price p, the individual intrinsic condition x_i, and the individual financial position (represented by the penalty of being unsold) δ_i.

2.7. Seller's Optimal Price Rule

In the following analysis, I assume that the linear approximation of $\log H(p_i, x_i, \delta_i)$ with respect to its arguments is sufficiently accurate, and derives the linear price function $p^*(p, x_i, \delta_i, t, y_0)$ using this approximation.

In order to get the linear optimal price rule, let us take the first-order Taylor expansion of $\log H(p_i, x_i, \delta_i)$ around $(p_i, x_i, \delta_i) = (0,0,0)$. Since we have

$$\frac{\partial \log H}{\partial p_i} = 0; \frac{\partial \log H}{\partial x_i} = \frac{-rk}{rk-1}; \frac{\partial \log H}{\partial \delta_i} = \frac{rk}{rk-1},$$

around $(p_i, x_i, \delta_i) = (0,0,0)$, we obtain

$$-k\,(rp_i + sp + t - y_o) = \log H(p_i, x_i, \delta_i) \approx \log(rk-1) - \frac{rk}{rk-1}\,(x_i - \delta_i)\,.$$

It should be noted here that $rk - 1$ must be positive in order that the approximation is valid. It can be shown that this condition is satisfied under our assumption.[15] Consequently, the (approximate) linear optimal price rule is

$$p_i = -\frac{s}{r}p + \frac{1}{rk-1}(x_i - \delta_i) + \frac{1}{r}y_0 + \left(\frac{1}{rk}\log(rk-1) - \frac{1}{r}t\right) \qquad (2.9)$$

2.8. Equilibrium and Determination of Undetermined Coefficients

From the above relations, we can compute rational expectations values of the undetermined coefficients, ω_y, ω_w and z, and ultimately, equilibrium prices.

Taking account of the fact that p is the average of p_i, we have

$$p = \frac{r}{(r+s)\,(rk-1)}y + \frac{1}{r+s}y_0 + \frac{1}{r+s}\left(\frac{1}{k}\log(rk-1) - t\right). \qquad (2.10)$$

Since we have (2.8) and have assumed

$$p = z + \omega_y(y + u),$$

[15] It can be shown by examining the equilibrium relations presented later in this section. Specifically, we have $\omega_w = 1/(rk-1)$ from (2.14) , and $\omega_w > 0$ from (2.15). Therefore, we get $rk - 1 > 0$.

the following equalities must be satisfied.

$$z = \frac{1}{r+s}\left(\frac{1}{k}\log(rk-1) - \frac{b\omega_y^{-1}z}{1-b}\right)$$
$$= \frac{1-b}{1-b\omega_y^{-1}}\left(\frac{1}{k}\log\left(\frac{1-a\omega_w^{-1}}{1-b}k-1\right) - \frac{b\omega_y^{-1}z}{1-b}\right); \tag{2.11}$$

$$\omega_y = \frac{r}{(r+s)(rk-1)}. \tag{2.12}$$

$$\omega_y u = \frac{1}{r+s}\left(y_0 + \frac{b}{1-b}u^*\right)$$

Substituting (2.10) into the optimal price rule (2.9), we obtain

$$p_i = -\frac{s}{r}\left(\frac{r}{(r+s)(rk-1)}y + \frac{1}{r+s}y_0 + \frac{1}{r+s}\left(\frac{1}{k}\log(rk-1) - t\right)\right)$$
$$+\frac{1}{rk-1}(x_i - \delta_i) + \frac{1}{r}y_0 + \frac{1}{r}\left(\frac{1}{rk}\log(rk-1) - t\right) \tag{2.13}$$
$$= z + \omega_y y + \frac{1}{r+s}\left(y_0 + \frac{b}{1-b}u^*\right) + \frac{1}{rk-1}w_i - \frac{1}{rk-1}\delta_i.$$

Since we have assumed (2.2), which is rewritten here for convenience,

$$p_i = z + \omega_y(y+u) + \omega_w(w_i + v_i),$$

we obtain

$$\omega_w = \frac{1}{rk-1} = \frac{1}{\frac{1-a\omega_w^{-1}}{1-b}k - 1} = \frac{1-b}{(1-a\omega_w^{-1})k - (1-b)}, \tag{2.14}$$

by matching coefficients. This relation immediately implies

$$\omega_w = \frac{ak + (1-b)}{k-(1-b)} = a + \frac{(1+a)(1-b)}{k-(1-b)} > a > 0. \tag{2.15}$$

because the assumption that $1/k < (\sigma_y^{2*} + \sigma_u^{2*})/\sigma_u^{2*}$ implies $k > 1-b$.

By substituting (2.8), (2.15) into (2.12), and by rearranging terms,[16] we have

$$\omega_y = \omega_w + (b-a) > 0. \tag{2.16}$$

since $\omega_w > a$. Finally, substituting (2.15) and the above relation into (2.11), we get

$$z = \frac{1-b}{k}\log\left(\frac{1-a\omega_w^{-1}}{1-b}k - 1\right). \tag{2.17}$$

[16]We have

$$\omega_y = \frac{r}{(r+s)}\omega_w = \frac{1-a\omega_w^{-1}}{1-b\omega_y^{-1}}\omega_w = \frac{\omega_w - a}{1-b\omega_y^{-1}},$$

This implies $\omega_y - b = \omega_w - a$, which produces (2.16).

2.9. The Source of Non-Intrinsic Components of Prices

It is worth noting where the non-intrinsic components u and v_i come from. First, equation (2.13) shows that the average non-intrinsic component u stems from y_0 and u^*:

$$\begin{aligned} u &= \tfrac{1}{\omega_y}\tfrac{1}{r+s}\left(y_0 + \tfrac{b}{1-b}u^*\right) \\ &= \tfrac{1}{\omega_y}\tfrac{1-b}{1-b\omega_y^{-1}}\left(y_0 + \tfrac{b}{1-b}u^*\right) = \tfrac{1-b}{\omega_y-b}\left(y_0 + \tfrac{b}{1-b}u^*\right), \end{aligned} \tag{2.18}$$

where (2.14) is employed. Thus, the average of the buyers' expectations y_i^* of the average intrinsic value, y, and the buyers' expectation u^* about the non-intrinsic component u, are the sources of average non-intrinsic component u.

Second, the same equation reveals that idiosyncratic non-intrinsic component v_i has its origin in δ_i:

$$v_i = -\frac{1}{\omega_w}\frac{1}{rk-1}\delta_i = -\delta_i. \tag{2.19}$$

where (2.14) is utilised. Therefore, the penalty δ_i that the seller incurs when he fails to sell the land, which represents his financial need, is the source of idiosyncratic non-intrinsic component v_i.

3. DETERMINANTS OF THE DEVIATION FROM THE FUNDAMENTAL VALUE

3.1. Equilibrium Prices: Perfect Information versus Imperfect Information

In this section, I compare the equilibrium price behaviour with the price behaviour in the market where information is perfect, transaction costs are negilible, and idiosyncratic financial need is absent. In the latter market, the land price is determined by its fundamental value, that is, the intrinsic value of the particular land. Specifically, I show in this section that the heterogeneity is the major determinant of the deviation of the market price from the corresponding fundamental value.

If information is perfect, there is no transaction cost, and idiosyncratic financial need is absent, then the perfect-information equilibrium individual price is

$$p_i^{perf} = x_i = y + w_i,$$

while the perfect-information equilibrium average price satisfies

$$p^{perf} = y.$$

However, in the land market where information is imperfect, transaction costs are large, and there is idiosyncratic financial need on the side of sellers, the previous section has shown that the imperfect-information equilibrium individual price is

$$p_i^{imp} = z + \omega_y \left[y + \frac{1-b}{\omega_y - b} \left(y_0 + \frac{b}{1-b} u^* \right) \right] + \omega_w (w_i - \delta_i)$$

while the imperfect-information equilibrium average price is

$$p^{imp} = z + \omega_y \left[y + \frac{1-b}{\omega_y - b} \left(y_0 + \frac{b}{1-b} u^* \right) \right]. \tag{3.1}$$

3.2. Heterogeneity and The Magnitude of Price Volatility

In this section, I examine the effect heterogeneity, or dispersion, of expectations among buyers on the magnitude of price volatility. I conider both of micro volatility, which is the elasticity of individual prices p_i to individual idiosyncratic shocks w_i, and macro volatility, which is the elasticity of the average price p to a change in the average intrinsic value y.

Micro volatility.

Let us first consider micro volatility, that is, the elasticity of the individual price with respect to individual idiosyncratic shock w_i. We have the following proposition.

PROPOSITION 1 (Micro Volatility). (1) Imperfect Information and micro volatility. *The price becomes more volatile with respect to the micro intrinsic variable w_i under imperfect information than under perfect information (i.e., $\omega_w > 1$), if the expectations are sufficiently disperse in such a way that the degree of dispersion $(1/k)$ satisfies*

$$\frac{1}{k} > \frac{1-a}{2(1-b)}. \tag{3.2}$$

(2) Micro volatility and heterogeneity. *An increase in the dispersion (i.e., $1/k$) of the expectations unambiguously increases the micro volatility, that is, $\partial\omega_w/\partial(1/k) > 0$.*

Proof. From (2.15), we have

$$\omega_w = a + \frac{(1+a)(1-b)}{k-(1-b)} = 1 + \frac{2(1-b)-(1-a)k}{k-(1-b)}.$$

Inspection of the second equality shows that the first half of the proposition holds, and that of the first equality reveals that the second half holds. □

The second half (2) of this propostion shows that the individual price is more volatile with respect to the idiosyncratic intrinsic value when expectations among buyers are more diverse. The diverse expectations imply that the probability of successful sale does not diminish rapidly even though the seller raises his price. Therefore, the seller has incentive to put higher price than in the case of relatively homogeneous expectations.[17]

The first half (1) of the proposition shows that imperfect-information prices are more volatile that perfect-information ones so long as the expectation dispersion is sufficiently large. It is now well-known that economic agents' decision becomes concervative if information about their own condition is imperfect, because of their fear of confusing their own conditions with macro conditions. (Here $1-a$ represents the degree of imperfect information). This reduces the sensitivity of prices with micro conditions. Thus, the dispersion must be sufficiently large to dominate this effect in order that imperfect-information prices are more volatile.[18]

[17]The logic behind this property is similar to the one found in the search literature (see, for example, Lippman and McCall [6]). The incentive to search increases as heterogeneity among sellers increases, since the probability of getting profitable offer increases.

[18]It is also known that imperfect-information about the average price *increases*, rather than

Macro volatility.

I consider two cases. In the first case, the macro expectations of buyers are "sticky", in the sense that the average y_0 of buyers' expectations about the average intrinsic value y does not change when y changes, and that buyers' expectations u^* about the non-intrinsic component u does not change when u changes. Here I assume that $y_0 = 0$ and $u^* = 0$ for simplicity, even though y and u are not zero. In the second case, the macro expectations of buyers are "rational", in the sense that y_0 coincides with the actual y and that u^* is equal to the actual u.

A. Sticky Macro Expectations.

In the case of sticky expectations, we have from (3.1)

$$p^{imp} = z + \omega_y y.$$

Thus, ω_y is the elasticity of the average price with respect to the macro condition, y. Then, we have

PROPOSITION 2 (Macro Volatility: Sticky Case). (1) Imperfect information and macro volatility. *The price becomes more volatile with respect to the macro intrinsic variable* y *under imperfect information than under perfect information (i.e.,* $\omega_y > 1$*), if the expectations are sufficiently disperse in such a way that the degree of dispersion* $(1/k)$ *satisfies*

$$\frac{1}{k} > \frac{1}{2-b+a}.$$

(2) Macro volatility and heterogeneity. *An increase in the dispersion (i.e.,* $1/k$*) unambiguously increases the macro volatility* $\partial\omega_y/\partial(1/k) > 0$.

Proof. From (2.16), we have

$$\omega_y = \omega_w + (b-a) = 1 + (1-b)\frac{(2-b+a)-k}{k-(1-b)}. \tag{3.3}$$

It is obvious from this expression that the first half of this proposition holds. The second half is trivial since $\partial\omega_y/\partial(1/k) = \partial\omega_w/\partial(1/k)$ and that we know PROPOSTION 1. □

The reason the diverse expectations raises macro volatility is the same as in the case of micro volatility. However, (3.3) shows that the relative magnitude of micro and macro volatility depends on the micro expectation sensitivity a and macro expectation sensitivity b. Note that (2.5) and (2.6) show that a is the

decreases, the volatility (see Nishimura [9]). Therefore, we find $1-b$ (the degree of imperfect information about the average price) in the denominator of (3.2), rather than in the numerator.

sensitivity of the expected individual intrinsic value with respect to the micro information $p_i - p$, while b is its sensitivity to macro information p. Consequently, if buyers are more sensitive to macro information than micro one ($b > a$), then macro volatility exceeds micro sensitivity, and *vice versa.*

The following proposition, which is the immediate corollary of the above propositions, describes the relationship between the fundamental value and the deviation from it.

PROPOSITION 3 (Deviation and Fundamental Value). *Under the same assumption of PROPOSITION 2, the larger the macro intrinsic value (i.e., the fundamental value), the larger the deviation from the fundamental value is (i.e.,* $\partial\left(p^{imp} - p^{perf}\right)/\partial y > 0$*).*

Proof. This is because $p^{imp} - p^{perf} = z + (\omega_y - 1)y$, and that $\omega_y > 1$. □

This implies that the deviation from the fundamental value itself depends on the level of the fandamental value. Specifically, the higher the fundamental value is, the larger the deviation is. For example, the lower the interest rate is (which implies a higher fundamental value Y), the larger the deviation is.[19]

B. Rational Macro Expectations.

In the case of rational macro expectations, we have from (3.1)

$$p^{imp} = z + \omega_y^{rational} y + \frac{\omega_y b}{\omega_y - b} u,$$

where

$$\omega_y^{rational} = \omega_y \left(1 + \frac{1-b}{\omega_y - b}\right). \tag{3.4}$$

Then, we have the following proposition clarifying the effect of rational expectations.

PROPOSITION 4 (Macro Volatility: Rational Case). *The price is more volatile under rational expectations than under sticky expectations.*

Proof. Since (3.3) implies $\omega_y - b = \omega_w - a$, we have $\omega_y > b$ because of (2.15). Consequently, (3.4) implies $\omega_y^{rational} > \omega_y$. □

[19]This property is particularly important in understanding the upsurge of real estate prices in Japan during the 1980s. Because of various downward pressure on loan rates, the level of loan rates applicable to ordinary investors were unprecedentedly low in that period.

This proposition implies that rational macro expectations amplify, rather than dampen, the volatility of prices. Under perfect information, rational macro expectations contribute to the stability of the market. In contrast, rational macro expectations are de-stabilizing when information is imperfect.

3.3. Uncertainty and the Magnitude of Price Volatility

Next, I consider whether an increase in buyers' subjective assessment of uncertainty about micro and macro conditions amplifies or dampens the price volatility. By definition, $1-a = \sigma_v^{2*}/\left(\sigma_w^{2*}+\sigma_v^{2*}\right)$ represents buyers' (subjective) uncertainty about micro condition w_i. If this is close to unity, then buyers do not rely very much on micro information $p_i - p$ in estimating w_i. On the contrary, if $1-a$ is close to zero, then they are confident that $p_i - p$ is a good estimate of w_i. Similarly, $1-b = \sigma_u^{2*}/\left(\sigma_y^{2*}+\sigma_u^{2*}\right)$ measures buyers' (subjective) uncertainty about macro condition y.

In this section, I show that the effect of uncertainty is just opposite between micro and macro conditions. The following propositions reveal that increased micro uncertainty (an increase in $1-a$) *reduces* price volatility, while increased macro uncertainty (an increase in $1-b$) *raises* price volatility.

PROPOSITION 5 (Micro Uncertainty and Volatility). *An increase in uncertainty about micro condition, that is, an increase in $1-a$, unambiguously reduces micro and macro volatility ($\partial\omega_w/\partial(1-a) < 0$, $\partial\omega_y/\partial(1-a) < 0$).*

Proof. This is because we have

$$\frac{\partial\omega_w}{\partial a} = \frac{k}{k-(1-b)} > 0; \frac{\partial\omega_y}{\partial a} = \frac{1-b}{k-(1-b)} > 0.$$

□

PROPOSITION 6 (Macro Uncertainty and Volatility). *An increase in uncertainty about macro condition (an increase in $1-b$) unambiguously increases micro volatility ($\partial\omega_w/\partial(1-b) > 0$). It increases macro volatility ($\partial\omega_y/\partial(1-b) > 0$) so long as*

$$\frac{1}{k} > \left(1-b+\frac{1+a}{2}+\left(\left(\frac{1+a}{2}\right)^2+(1-b)(1+a)\right)^{\frac{1}{2}}\right)^{-1} \tag{3.5}$$

Proof. Straightforward calculation shows

$$\frac{\partial\omega_w}{\partial b} = \frac{-(1+a)k}{(k-(1-b))^2} < 0,$$

and

$$\frac{\partial \omega_y}{\partial b} = 1 + \frac{-(1+a)k}{(k-(1-b))^2} = \frac{k^2 - 2\left(1 - b + \frac{1+a}{2}\right)k + (1-b)^2}{(k-(1-b))^2}.$$

Thus, we have $\partial \omega_y / \partial (1-b) > 0$ if (3.5) holds. □

This asymmetry between micro and macro uncertainty can be interpreted in the following way. As explained earlier, when some unobservable micro variable becomes more uncertain, rational economic agents become conservative with respect to their expectations and thus their action, taking account of the possibility of confusing true change with noise. Consequently, buyers are more insensitive to micro condition, which implies sellers do not change their price as much as before. Therefore, prices become more rigid.

The same conservatism is also found with respect to macro condition. But this conservative attitude results in a more volatile average price, rather than stable one. This is because it hinders contemporaneous *learning* on the side of buyers about macro condition, which might have reduced the dispersion of expectations. Since the dispersion of expectations is the source of volatile price behaviour as extensively discussed earlier in this section, this hindrance of learning increases the volatility.[20]

Table 3.1 shows numerical examples highlighting the characteristics of price behaviour. The first two columns of this table show that price elasticity to shocks, that is, volatility of prices, becomes very large when buyers' expectations are diverse. In fact, these columns reveal high sensitivity of volatility to the dispersion parameter $1/k$.

The third to fifth column of the table exemplifies the effect of uncertainty on price volatility. This table shows that an increase in macro uncertainty has a significant effect on the volatility of the average price.

[20]See Nishimura [9] for the effect of uncertainty on price behaviour in product markets.

4. LAND MARKET WITH INFORMED BUYERS

Let us now consider the land market with informed buyers. I still retain the assumption of high transaction costs and idiosyncratic financial need for sellers. I show in this section that the market outcome is essentially the same as in the market with no transaction cost, so long as buyers are well-informed.

To capture the difference between uninformed and informed buyers in the market of high transaction costs and imperfect information, I assume that informed buyers know the average intrinsic value y, though they do not know particular land's intrinsic value x_i. One possibility of such informed buyers is land owners. Since land owners have been participating in the market for long period, they are likely to accumulate macro information about the market which new, uninformed investors do not have. However, they are not likely to know particular land's individual intrinsic value other than their own's.

Following the previous sections, I still assume that there are M buyers, and that they can visit only one piece of land because of large transaction costs.

As before, the buyer knows the price structure such that

$$p_i = z + \omega_y^{informed}(y+u) + \omega_w^{informed}(w_i + v_i); \text{ and } p = z + \omega_y^{informed}(y+u).$$

The buyer gets p_i and p, and forms rational expectations about x_i. The buyer purchases the land if

$$E(x_i \mid p_i, p, y) - p_i = E(w_i \mid p_i, p) + y - p_i = a\left(\omega_w^{informed}\right)^{-1}(p_i - p) + y - p_i \geq 0.$$

It is then clear that the probability of being sold, $\phi(p_i, p)$, satisfies

$$\phi(p_i,p) = \begin{pmatrix} 0 \text{ if } p_i > \frac{y - a\left(\omega_w^{informed}\right)^{-1} p}{1 - a\left(\omega_w^{informed}\right)^{-1}} \\ \\ \frac{M}{N} \text{ if } p_i \leq \frac{y - a\left(\omega_w^{informed}\right)^{-1} p}{1 - a\left(\omega_w^{informed}\right)^{-1}} \end{pmatrix}.$$

Therefore, the optimal strategy of the ith seller is

$$\left\{ \begin{array}{c} \text{to post price } p_i = \frac{y - a\left(\omega_w^{informed}\right)^{-1} p}{1 - a\left(\omega_w^{informed}\right)^{-1}} \text{ if } e^{p_i} \geq e^{x_i} - e^{\delta_i} \\ \\ \text{to quit the market if otherwise} \end{array} \right\}. \tag{4.1}$$

It should be noted here that the average price p is in fact the average of all posted prices. Consequently in equilibrium, we have

$$\left[1 - a\left(\omega_w^{informed}\right)^{-1}\right] p_i = y - a\left(\omega_w^{informed}\right)^{-1} p,$$

which implies

$$p = y.$$

Thus, even though the market is characterized by high transaction costs, the average price is determined by the average intrinsic value, that is, the fundamental value. Thus, we have

$$\omega_y^{informed} = 1, u = 0, \text{ and } z = 0.$$

Next, note that the individual optimal price (4.1) depends solely on the average price p. Therefore we obtain

$$\omega_w^{informed} = 0,$$

which implies that

$$p_i = p.$$

Consequently, the individual posted price becomes homogeneous despite there is heterogeneous idiosyncratic intrinsic component w_i.

The above analysis has shown that, if one is concerned only with the average price, the market outcome is exactly the same in the market of high transaction costs as in the market of low transaction costs. High transaction costs and imperfect information about individual intrinsic value make individual prices of land deviate from its intrinsic (fundamental) value, but the deviation is cancelled out in aggregation.

5. CONCLUDING REMARKS

This paper has shown that a market of high transaction costs may exhibit volatile price behaviour if there are a number of uninformed buyers having heterogeneous expectations and trying to extract information from prices. It has also been revealed that the more diverse expectations are, the more volatile price behaviour is. The deviation from the fundamental value has been shown to be larger when the unknown fundamental value itself is higher. Moreover, increased (subjective) uncertainty about macro market conditions on the side of buyers increases the volatility of prices.

According to this model, the culprit causing real estate booms and following busts in many industrialized countries is the influx of relatively uninformed investors into the real estate markets characterized by high transaction costs. The surge of these new investors were brought by internationalization and liberalization of financial markets in the 1980s. The model also suggests that this type of volatile price behaviour may happen in any market with high transaction costs. Thus, volatile price behaviour is likely to be observed in stock markets of developing countries as well as in their real estate markets.

There are, however, several limitations in this model. Firstly, the model is a static equilibrium model, so that intertemporal price behaviour is not explicitly analysed. Specifically, the heterogeneity of expectations on the side of buyers is assumed, and the evolution of these expectations over time is not articulated. In order to get insight in this respect, we must consider a dynamic model in which heterogeneous prior expectations are endogenized.

Secondly, the take-it-or-leave-it offer by sellers is assumed. This means that there is no negotiation on terms of trade among buyers and sellers. This assumption is made to simplify analysis, but it is unsatisfactory since intense negotiation usually takes place in real estate markets. In a more general model of real estate markets, we must consider Bayesian Nash equilibrium of a market with pair-wise bargaining under incomplete information.

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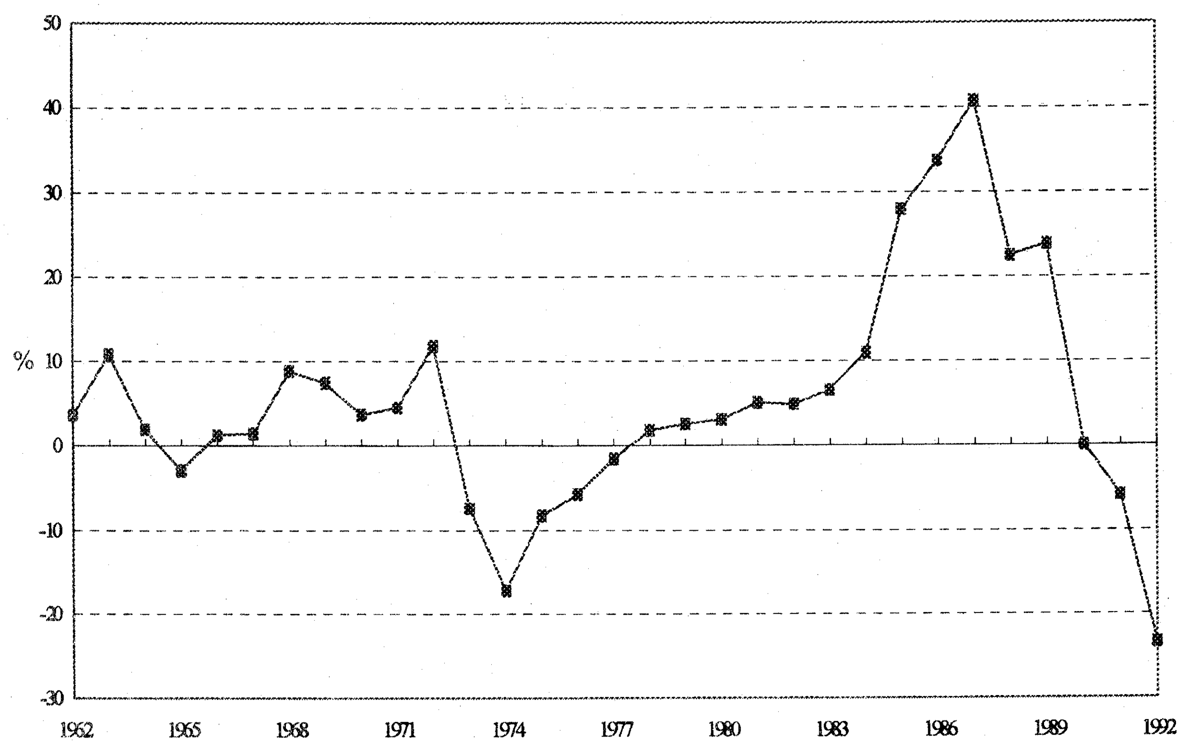
Table 3.1: Volatility: Numerical Examples

$$1-a = \frac{\sigma_v^{2*}}{\sigma_w^2 + \sigma_v^{2*}} = \text{uncertainty about micro condition}$$
$$1-b = \frac{\sigma_u^{2*}}{\sigma_y^{2*} + \sigma_u^{2*}} = \text{uncertainty about macro condition}$$
$$1/k = \text{dispersion of expectations}$$
$$\omega_w = \text{elasticity of price to micro shock}$$
$$\omega_y = \text{elasticity of price to macro shock}$$

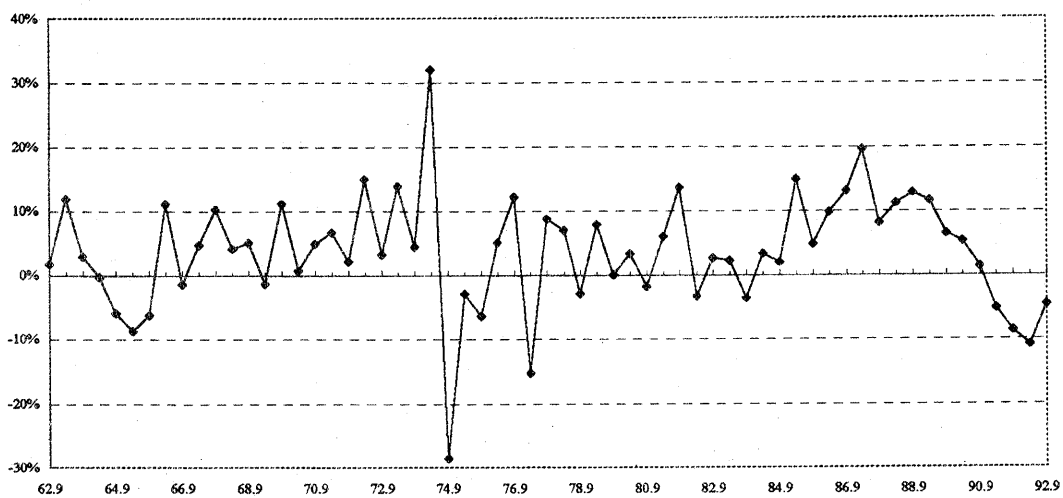
	relatively dispersed	relatively homogeneous	reference case	higher micro uncertainty	higher macro uncertainty
$1-a$	0.5	0.5	0.5	0.8	0.5
$1-b$	0.5	0.5	0.5	0.5	0.8
$1/k$	1.67	0.53	1	1	1
ω_w	8	1.04	2	1.4	6.5
ω_y	8	1.04	2	1.7	6.2

Figure 1.1
The Annual Rate of Change of Real Commercial Land Prices
in Japan: Six Largest Cities, 1962-1992



Source: Nishimura [8, Table 1].

Figure 1.2
Biannual Excess Rate of Return
on Commercial Real Estates in Japan



Source: Nishimura [8, Table 2].