Working Paper

INTERNATIONAL MONETARY FUND

IMF WORKING PAPER

WP/94/12

INTERNATIONAL MONETARY FUND

Research Department

Real Estate Price Inflation, Monetary Policy, and Expectations in the United States and Japan

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January 1994

Abstract

During the mid- to late 1980s, inflationary pressures were highly concentrated in asset markets in many industrial countries. This paper discusses why this may have occurred and then develops a forward-looking supply and demand model of the real estate market in which equilibrium prices depend on price expectations, monetary conditions, income, returns to alternative assets, and construction costs. In this model, the current equilibrium price is determined by expectations formed in different time periods by consumers and producers. The model and its more generalized dynamic specifications are estimated by maximum-likelihood methods. The empirical results do not reject the view that the relationship between real estate values and monetary policy was altered in 1980s.

JEL Classification Numbers:

R21, R31, D84, E51, E52, C12, C13

1/ The authors would like to thank David T. Coe, Robert Flood, Alexander Hoffmaister, M. Hashem Pesaran, Mark Taylor, and the participants of workshops at Cambridge University and the Research Department of the IMF for useful comments and suggestions, and Toh Kuan for excellent research assistance.

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Summary

In reviewing the asset price cycles that occurred in the 1980s in the United States and Japan, it appears that the effects of excessively expansionary monetary policies were more highly concentrated in real estate markets than is usually the case during an economic boom. The principal aim of this paper is to test the hypothesis that monetary policy affected real estate prices differently in the 1980s than it did in the 1970s. A model of price-determination is developed in which the equilibrium price of real estate relative to a more general price index is influenced by various demand and supply factors, including real income and cost variables, monetary policy variables, and expectations. Various empirical representations of the model are estimated using maximum-likelihood techniques under different assumptions about both the role of expectations and the model's dynamic structure.

The estimated equations suggest that monetary policy variables were important determinants of the relative price of real estate in the United States and Japan, and that there was a structural break in both countries in the 1980s. In particular, the results indicate that interest rates became a statistically more significant determinant of real estate values. Moreover, the within-sample predictions of the model indicate that the relative price of real estate would have increased less in the United States, and adjustments would have been less volatile in Japan, had the structural break not occurred.

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I. Introduction and Overview

During the 1980s, many industrial countries experienced a dramatic accumulation of debt that was accompanied by booms in asset markets and dramatic increases in asset prices. As the events during 1990-92 have demonstrated, the price increases in asset markets generally were not sustained and many countries experienced a period of asset price deflation. This period of intense financial activity occurred against a background of structural changes in domestic and international financial markets; expansionary macroeconomic policies, followed by economic overheating and then monetary tightening toward the end of the decade; and changes in the economic and financial behavior of households, businesses, and financial intermediaries in response to these structural and macroeconomic changes. 1/

As in earlier episodes of overheating, monetary and credit aggregates expanded rapidly in the 1980s in those countries that experienced asset price inflation. In the United States and Japan--the two largest industrial countries to experience asset price inflation--monetary and credit policies played a significant role in these developments. Moreover, the effects of excessively expansionary monetary policies appear to have been more highly concentrated in real estate markets and, in Japan, in equity markets than is usually the case during economic booms. 2/ If there was a greater concentration of inflationary pressure in real estate markets in the 1980s, then one would expect to observe a structural break in the relationship between real estate prices and monetary variables in the 1980s. Although this is not a direct test of the "concentration hypothesis," if the hypothesis of a structural break cannot be rejected, then the concentration hypothesis would appear to have some credence and further testing would be warranted.

The principal aim of this paper is to test this hypothesis by exploring the short- and long-run relationships between monetary policy variables and real estate prices and whether these relationships were altered in the 1980s. To this end a general model of real property prices is developed and applied to the real estate markets in the United States and Japan with particular emphasis on the role of expectations. Property ownership is demanded for the services it provides as well as for its investment value as an asset, and ownership decisions are therefore based on, among other factors, current prices relative to the expectations of future price movements. The supply of new property, on the other hand, is influenced by the expectations of current prices formed at the time when the construction decision is made, as well as construction costs.

1/ For a comprehensive review of these developments in the industrial countries see Schinasi and Hargraves (1993). For a flow-of-funds perspective on asset price inflation in the United States, Japan, and the United Kingdom see Hargraves, Schinasi, and Weisbrod (1993).

2/ Property prices also rose, and then dropped, sharply in the United Kingdom, the Nordic countries and other industrial countries.

The paper is organized as follows. Section II reviews the relevant recent economic developments in the United States and Japan. Section III develops a general model of the real property market, Section IV presents the empirical representations of this model, and Section V discusses the empirical results. These results provide support for the hypothesis that relative property prices responded differently to changes in monetary policy in the 1980s than in the 1970s. The final section summarizes the main arguments, draws conclusions, and discusses some important unanswered questions.

II. The Role of Monetary Conditions in the Asset Price Inflation 1/

In the 1980s both Japan and the United States experienced dramatic increases in debt (Chart 1) and asset prices, in particular in real property markets (Chart 2). Towards the end of the decade many countries experienced overheating and monetary policy was tightened to restore aggregate demand growth to more sustainable and noninflationary rates. Several countries entered recessions while others experienced sharp reductions in growth. Inflation rates generally declined, and in 1992 inflation in some countries had reached levels not seen since the 1960s. Moreover, the most recent business cycles were substantially different than previous ones in that asset price movements, and the corresponding movements in private sector balance sheets, had a much greater impact on the duration and depth of the economic downturns, and the recoveries were delayed and much weaker than is typical of cyclical recoveries.

Monetary conditions both played a role in, and were importantly affected by, asset price developments. With the benefit of hindsight, monetary and financial data suggest that by 1985-86 both money and credit growth were excessive in Japan and credit growth was unusually high in the United States. 2/

For Japan, measures of both money (M2 + CDs) and credit growth suggested that inflationary pressures were building in the mid- to late 1980s. Growth in the monetary aggregates was high and variable, yet nominal GDP growth was relatively low and inflation measured by the GDP deflator was fairly steady at its lowest level in decades (Chart 3). This divergence may

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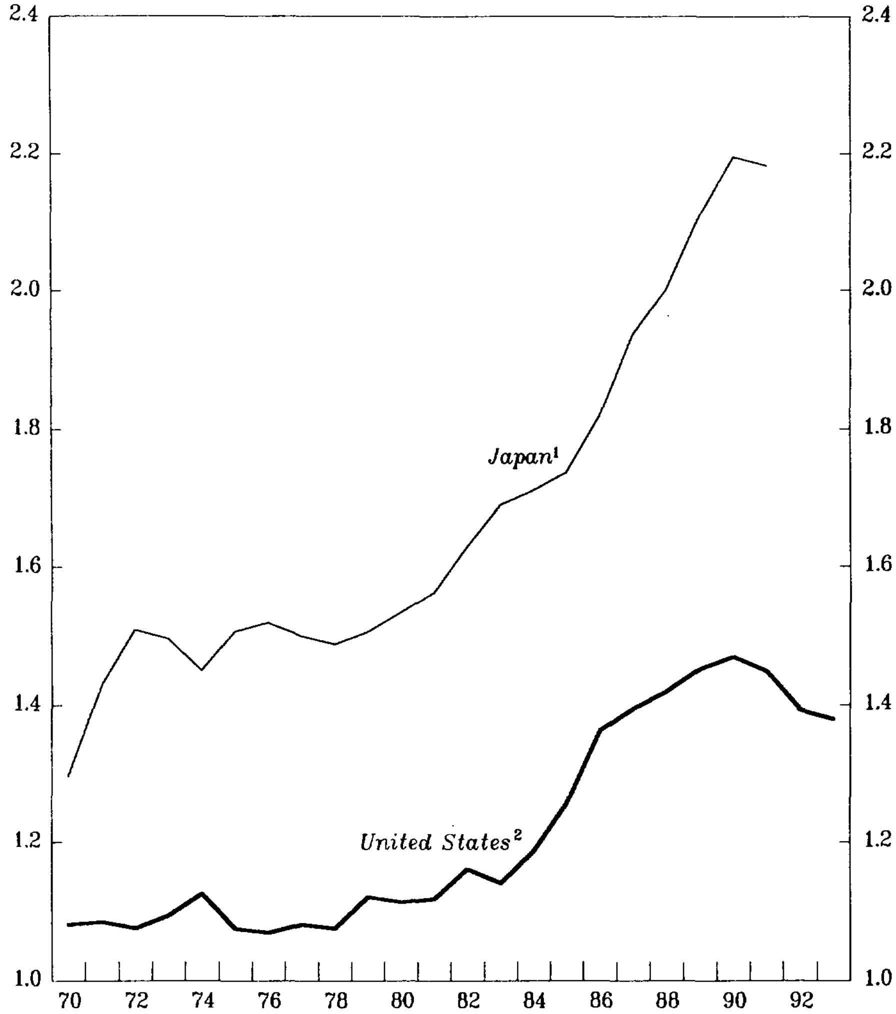
1/ Other factors also were important in channelling excess liquidity to asset markets including financial innovation and deregulation, heightened competition among financial intermediaries, tax incentives, a relative decline in traditional business investment opportunities, and generally restrained demand in goods and labor markets. See Schinasi and Hargraves for further analysis of these factors.

2/ Overly expansionary money and credit policies also were evident in many other countries that experienced asset price inflation, including the United Kingdom, Australia, New Zealand, the Nordic countries, and Switzerland.

Chart 1. Total Private Nonfinancial Sector Debt

(Ratio to GDP, end of period)



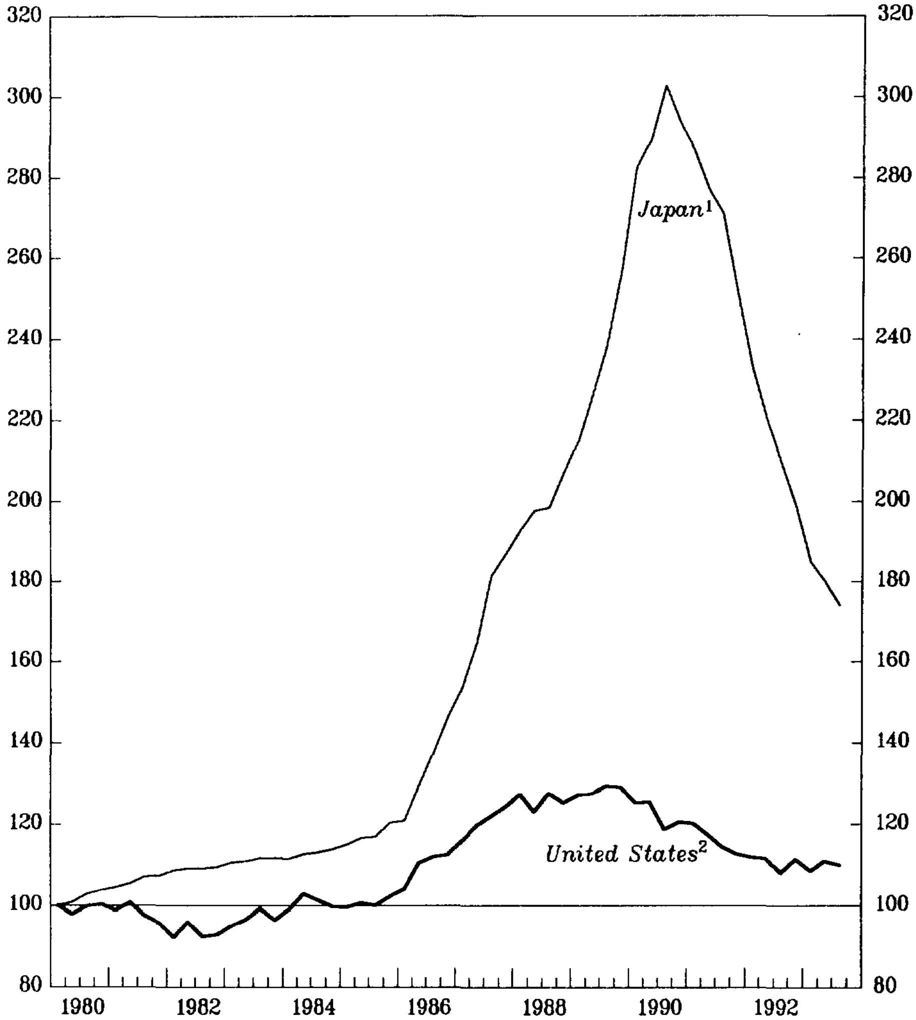
Sources: For the United States, Data Resources, Inc. data base; and for Japan, Economic Planning Agency, National Income Accounts.

[1]Total financial liabilities of the private nonfinancial sectors less trade credit.

[2]Total credit market debt outstanding of the private nonfinancial sectors.

Chart 2. Property Prices

(As a ratio to the consumer price index; 1980:Q1 = 100)

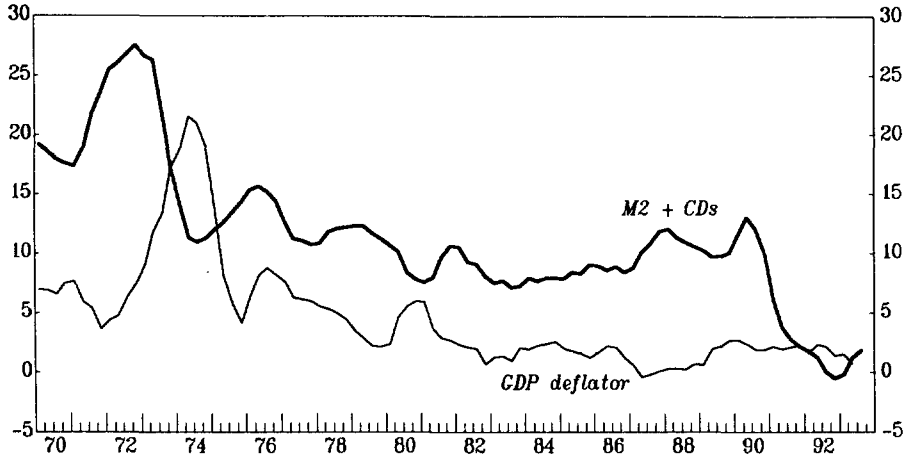


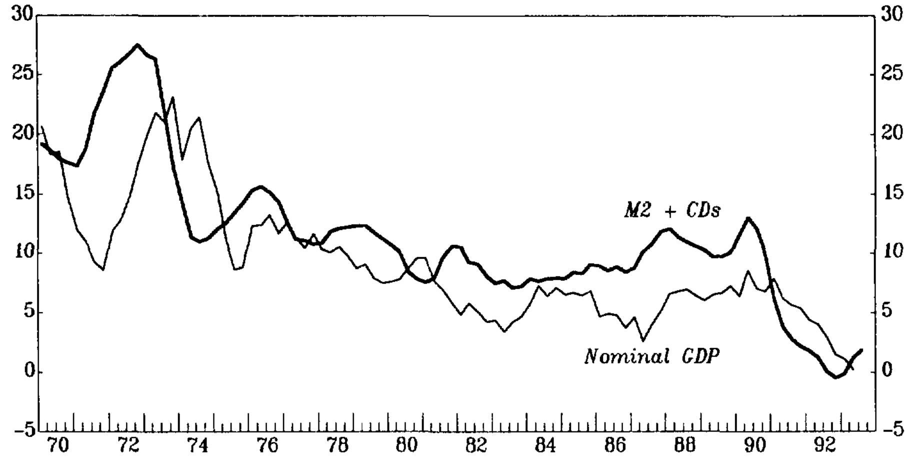
Sources: For the United States, Data Resources, Inc. data base; and for Japan, Japan Real Estate Institute, Bulletin of Japan Land Prices.

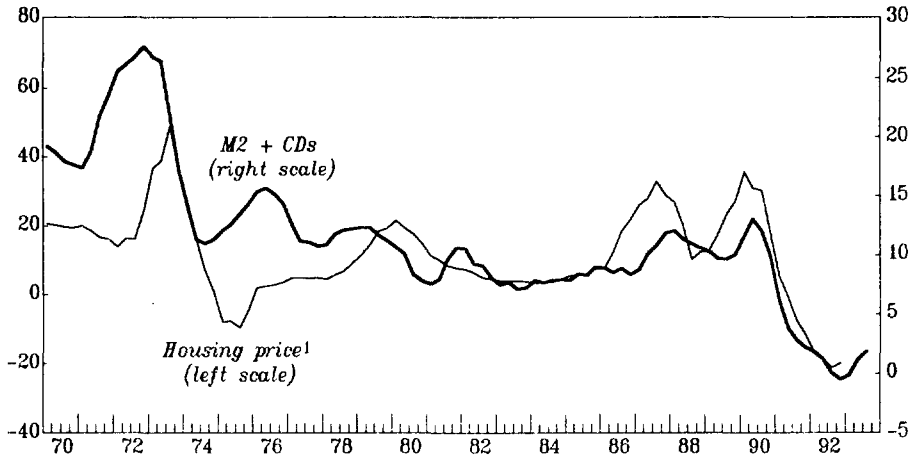
[1] Urban residential land price in six largest cities.

[2] Average price of a new house.

Chart 3. Japan: Money, Income, and Prices
(Percent change from four quarters earlier)







[1]Urban residential land price in six largest cities.

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have reflected a breakdown in the 1980s of the money-price relationships that had prevailed in the 1970s and may have been associated with changes in the transmission of money and credit growth to goods prices and asset prices. "Excess" money and credit growth--that is, money and credit growth in excess of growth in real economic activity--increased and remained high during this period (Chart 4). Moreover, the annual gaps between excess money growth and measured inflation (GDP deflator), and between excess credit growth and inflation, averaged 3 1/4 percentage points and 3 3/4 percentage points, respectively, and may have provided the impetus for the inflation in real estate, and other asset, markets that occurred in the mid- to late 1980s. 1/

In the United States, there had been a fairly close relationship in the 1970s between the growth of narrow money and inflation (as measured by the GDP deflator), and between money growth and nominal GDP growth (Chart 5). After the 1981-82 recession, however, higher growth in both the narrow and broad monetary aggregates was associated with lower or stable inflation and lower growth in nominal GDP. 2/ This apparent change in the relationship between money growth and goods-price inflation was in part the result of much higher real economic growth in the United States in 1983-88. Moreover, during this expansionary period, excess money growth in the United States was generally consistent with measured inflation; the gap between excess money growth and inflation was a negligible annual average of 1/4 of 1 percentage point (Chart 6, top panel).

The growth of the monetary aggregates in the United States, which were the primary intermediate indicators for monetary policy, did not suggest that general inflation pressures might be building in asset markets. In addition, changes in tax incentives and demographic trends pointed to higher relative prices in real estate markets. The expansion of credit, however, far exceeded the expansion in the real economy (see Chart 6, bottom panel). Even though money growth was in line with measured goods-price inflation, credit growth would have been consistent with much higher inflation (in the GDP deflator), suggesting that inflation pressures might be building in the economy. During the 1980s, the annual gap between excess credit growth and actual inflation (in the GDP deflator) averaged 2 1/2 percentage points in the United States. The cumulative effect of this excess credit growth turned out to be considerable, especially in commercial real estate markets.

1/ "Excess" is defined as the difference between growth in the monetary or credit aggregate in question and growth in real GDP. Ex ante, this gap can be viewed as potential inflationary pressure in markets for flow goods and services. Ex post, this excess is measured inflation (GDP deflator) and changes in velocity, but an alternative to the velocity explanation is that inflation occurs elsewhere in the economy such as in asset markets. For a further discussion see IMF (1993).

2/ Supporting evidence for Japan is reported in Meredith (1992) and in Corker (1990).

Thus, a cursory examination of monetary and credit aggregates in both Japan and the United States suggests that there was a change in the relationship between monetary policy and goods-price inflation, which remained low. This view is also consistent with the apparent "breakdown" in the estimated demand for money function in the United States (see for example Boughton (1991)). Real estate prices surged during this same period, however, suggesting that there was a change in the way monetary policy affected asset prices, in general, and real estate prices, in particular. More specifically, an important change in the regulatory environment in the United States and Japan was that deposit interest rate ceilings were eliminated by the early 1980s in both countries. Prior to this change, monetary policy affected aggregate demand through a credit-rationing mechanism: a reduction by the central bank in the supply of reserves would lead to an increase in interest rates on assets above those on bank deposits (which were fixed); funds held in deposits would flow out of the banking system seeking higher returns, and bank-credit would decline or become more restrictive. When the central bank eased and supplied reserves to the banking system interest rates would generally decline below rates paid on bank deposits, funds would flow back into the banking system, and bank lending would increase. In this regulatory regime, changes in interest rates were anchored, to some extent, by the fixed ceilings on bank deposit interest rates and the disintermediation that occurred as a result of these ceilings. This mechanism was no longer operative in the 1980s and one would expect to observe a change in the way monetary policy affected aggregate demand; in particular one would expect to see interest rates play a more important role in discouraging or encouraging aggregate demand in the 1980s. It would therefore be reasonable to expect that asset markets (and especially real estate markets) would be affected in some way by this change. 1/

The confluence of overexpansionary financial policies, financial innovation and deregulation, tax reforms, and demographic changes during the late 1970s and early 1980s may, therefore, have led to a structural change in the way monetary policy affected the allocation of liquidity and credit between goods markets and asset markets, and a concentration of excess liquidity (and excess credit) in asset markets during the late 1980s. To test this hypothesis, the next section develops a model of the real estate market that allows for the influence of monetary policy variables on equilibrium real estate prices.

III. A Model of Real Property Prices

This section develops a formal model of price-determination in the real property market in order to evaluate the impact of monetary policy variables on real estate prices. To illustrate the implications of the investment value of ownership, and to highlight the assumptions behind the simple net-

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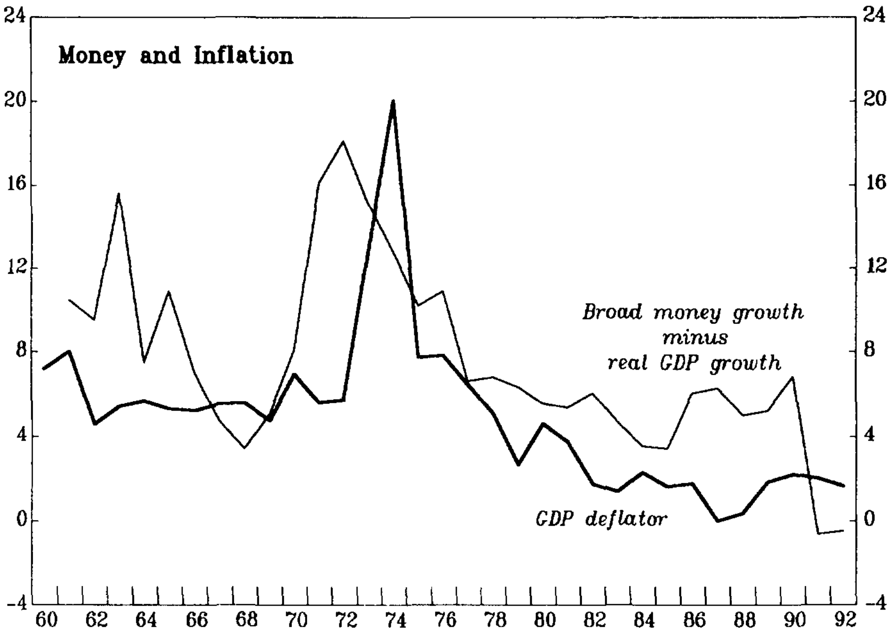
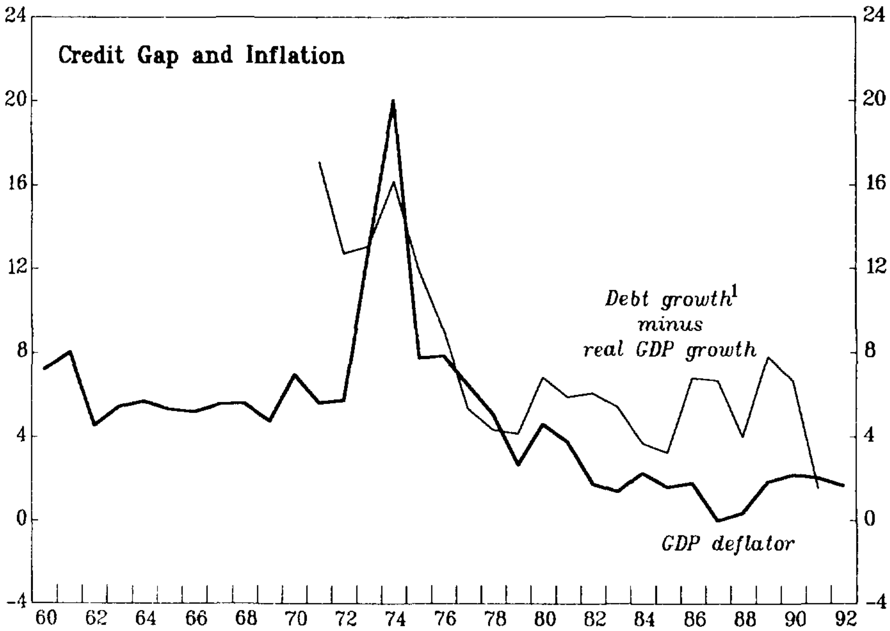
1/ The results reported below generally support this hypothesis.

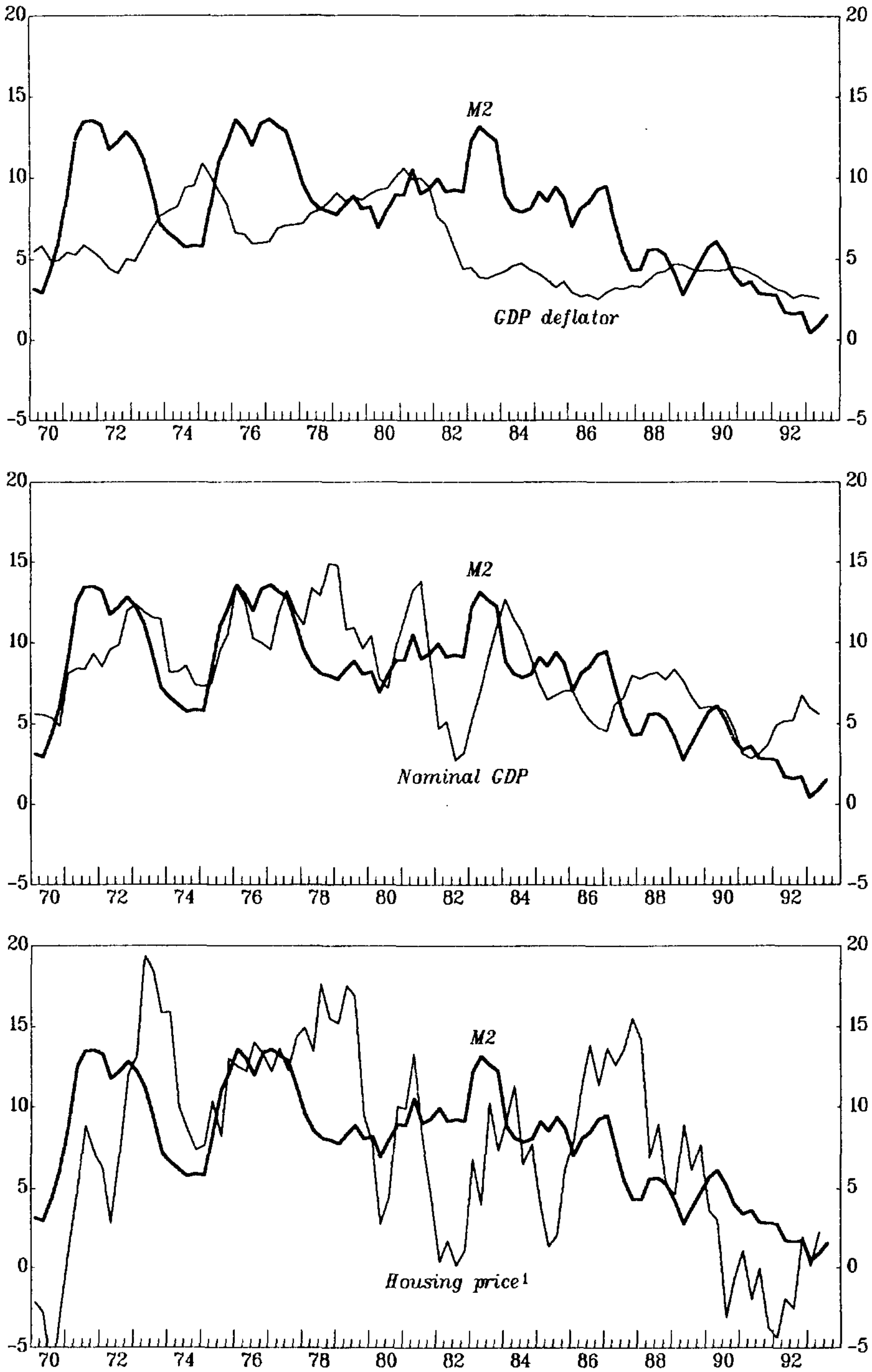
Chart 4. Japan: Money, Debt, and Inflation





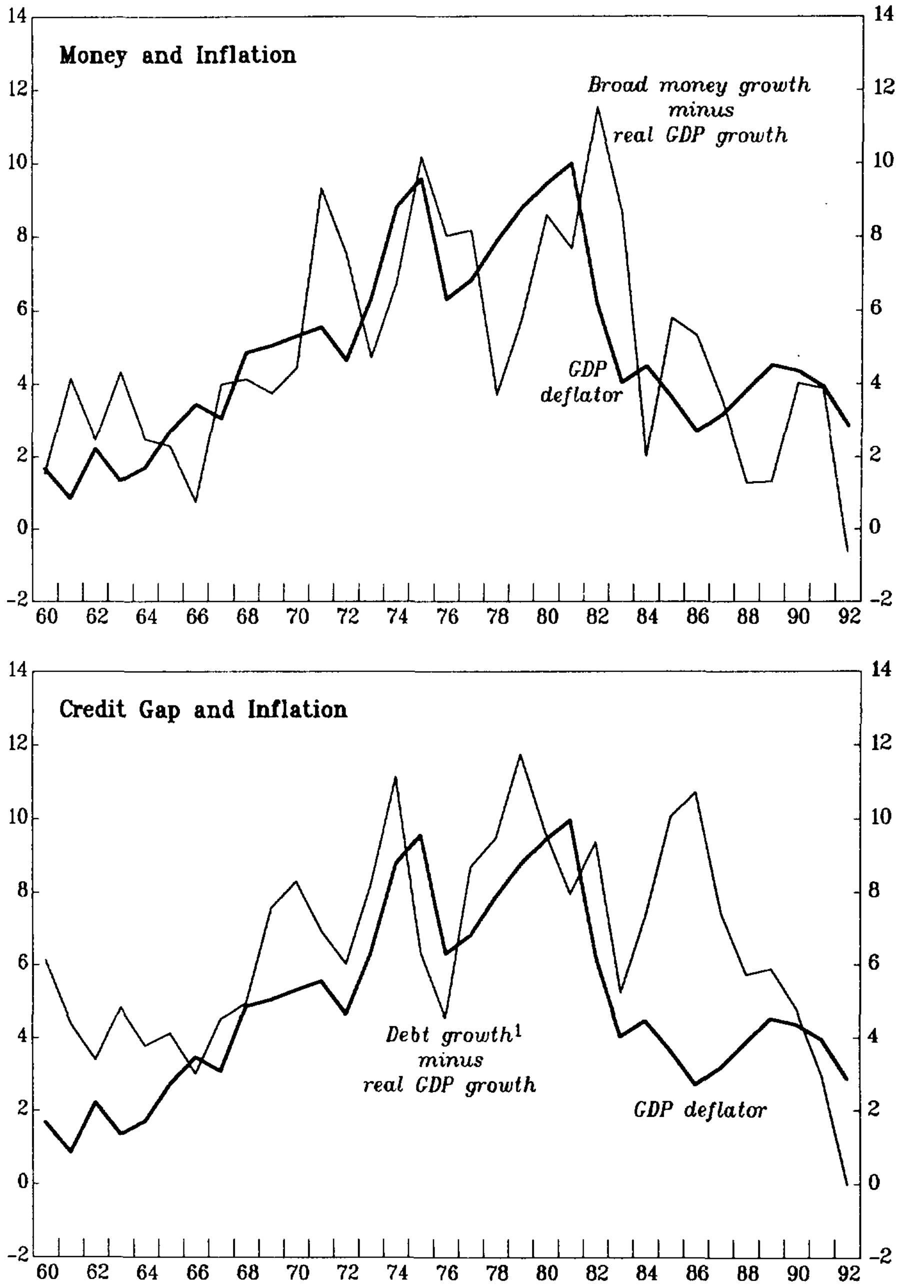
[1]Total financial liabilities of the private nonfinancial sectors less trade credits.

Chart 5. United States: Money, Income, and Prices
(Percent change from four quarters earlier)



¹Average price of a new house.

Chart 6. United States: Money, Debt, and Inflation



[1]Total credit market debt outstanding of the private nonfinancial sectors.

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present-value model of property prices typically used in models of housing prices we first examine a simple arbitrage model. Equilibrium in this case implies the equalization of returns on alternative assets and price is determined by the discounted value of the stream of all future net rents from ownership. A more elaborate model is then developed in which prices are influenced by various demand and supply-side factors and (endogenous) risk premia create a differential between market-clearing equilibrium returns. The implied model for property prices is then estimated by the maximum-likelihood method under different assumptions regarding the role of expectations and the dynamic structure for both the United States and Japan. The hypothesis is that the relationship between relative property prices and monetary policy was altered in the 1980s, for a number of reasons that cannot all be directly tested.

1. The arbitrage condition as a model of property prices

Consider an economy with forward-looking agents where real property is valued for its services as well as its future expected yield. The net return (loss) to ownership per unit of time is determined by the expected net capital gain (loss) resulting from changes in the property price and mortgage interest payments (or return forgone by not holding wealth in an interest-bearing form). The alternative to ownership is renting. As far as consumption services are concerned, these alternatives are assumed to provide the same utility so that agents are indifferent between ownership and renting. In addition, under the assumptions of perfect capital markets, risk-neutrality, and zero transactions costs, the alternatives of owning the property or owning a short-term lease on the property are perfect substitutes. Assuming that the supply of housing is not perfectly elastic, and abstracting from taxes, maintenance costs, and depreciation, equilibrium requires

$$\frac{R_t^h}{P_t^h} = i_t - \frac{E(\Delta P_{t+1}^h \mid \Omega_t)}{P_t^h} , \tag{1}$$

where R_t^h, P_t^h and i_t are, respectively, the rental value of a house per unit of time, the nominal price of a house, and the nominal interest rate. E is the expectations operator and Ω_t is the information available at time t. This equation represents the standard arbitrage condition. In equilibrium, returns to the alternatives of ownership and renting should be equal so that agents are indifferent between borrowing to purchase the property or renting. Under the assumptions that the interest rate remains constant over time ($i_t = i$) and rents are exogenously determined, equation (1) determines property prices:

$$P_t^h = \frac{1}{1+i} E(P_{t+1}^h | \Omega_t) + \frac{1}{1+i} R_t^h . \tag{2}$$

If expectations are formed rationally and optimization implies the following transversality condition

$$\lim_{N \to \infty} \left(\frac{1}{1+i}\right)^N E(p_{t+N} | \Omega_t) = 0 , \tag{3}$$

then bubbles are ruled out. 1/ Equation (2) can then be solved to give the property price in terms of the constant interest rate and all the future expected rental costs:

$$P_t^h = \sum_{j=0}^{\infty} \left(\frac{1}{1+i}\right)^{j+1} E(R_{t+j}^h | \Omega_t) . \tag{4}$$

This simple net present value model suggests that the "fundamental" price of real property is equal to the discounted value of the future stream of rents. The introduction of maintenance costs, depreciation, taxes, or exogenous risk premia in the above analysis would not cause any qualitative complications.

The arbitrage argument is the basis of the user-cost model of property price determination. In its simple form the arbitrage model assumes that owning and renting (with wealth held in the form of interest-bearing assets) are perfect substitutes (except possibly for exogenously determined risk premia). The user-cost model can be extended to incorporate an analysis of the supply of new property as a function of current prices and construction costs. As long as the rental value and other determinants of the "fundamental" price remain exogenous, however, supply conditions will not have any impact on property prices, although they will themselves be influenced by prices. This recursive structure disappears, and the system becomes simultaneous, under the assumption that the rental value of housing is unobservable and is influenced by the housing stock among other variables. This is the basis of the model developed in Kearle (1979), Poterba (1984) and (1990), and many other papers on house prices (see, for example, Lim (1992), for a review of this literature). Empirical applications of user-cost models typically consist of estimating an extended

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1/ For a discussion of bubbles see, for example, Flood and Garber (1980), Blanchard and Watson (1982), and Garber (1989).

form of equation (1) that takes account of taxes and other factors, and assumes that the rental value is determined by income, demographic factors, and the outstanding stock of houses (see, for example, Meen (1990)). Price expectations in these empirical models often are not treated as rational expectations and are modeled in a manner not necessarily consistent with the solution to the model.

2. Property prices in a model of supply and demand with expectations

Although the arbitrage model is useful for illustrative purposes and rightly emphasizes the asset value of real estate, it has had limited success in explaining housing prices movements. We now develop a model which generalizes the arbitrage model by bringing together supply and demand decisions in an explicit manner and by stressing the role of expectations formation on both sides of the market. 1/ Demand is based on portfolio-decision-making where alternative assets are not perfect substitutes, and where supply depends on expected price movements and construction costs. The assumption of imperfect asset substitution implies that endogenously-determined risk premia create a wedge between returns on different forms of assets (including property-ownership) in equilibrium. Equilibrium returns on different assets (and the risk premia) are determined by the exogenous factors that influence supply and demand for assets (which could include other exogenous rates of returns) at the market-clearing equilibrium. In what follows we examine the market for real estate property under the assumption that returns on alternative assets as well as rental costs (which we assume equal the value of rental services in equilibrium) are exogenously determined.

To develop the demand side of the model suppose that wealth may be held in the form of money, interest-bearing assets (bonds), and real estate. 2/ The supply of money is an exogenous policy variable and its (negative) rate of return is the inflation rate. The rate of return on bonds is determined exogenously but the quantity of bonds is demand-determined. Additions to wealth are identically equal to saving out of income, and changes in the values of assets (including bonds, real estate, and the money supply). However, because the equilibrium quantities of bonds and real estate are endogenously determined, the only asset that appears as a determinant of demand is the money supply; of course income and exogenous rates of returns on assets are also important determinants of demand, in part because of their effect on wealth.

1/ Ericsson and Hendry (1985) develop an econometric model of supply and demand for new houses in the UK but do not incorporate the role of expectations or monetary policy variables in the analysis.

2/ We do not include the equity markets in the following analysis, in part due to the highly unpredictable nature of equity price movements. But note that in any case equity prices would have been determined endogenously and thus would not have entered the reduced-form equation for real estate prices.

Agents maximize utility as a function of consumption subject to a wealth constraint. By analogy with standard portfolio selection under uncertainty, the net proportion of wealth held in alternative forms will depend on returns on all assets, their real current price, labor income, and total wealth. Defining all returns in real terms, demand for property-ownership can be hypothesized to depend negatively on its current price (relative to the general price level) and the real interest rate, which determine the cost of owning real estate. Demand can be expected to rise when the expected real capital gain on property rises, or when real rents (the cost of the alternative of renting), or the inflation rate (the cost of holding wealth in the form of money or other nominal assets) rise. Income and the real supply of money can have a positive or negative effect on demand depending on demographic and other factors. The supply of existing property depends on the same variables that determine total demand for property because it also involves portfolio selection. Thus the difference between total demand and the demand for the existing supply of real estate that is, the demand for new property, also will depend on these same variables. The following log-linear relationship is postulated

$$d_t = -\alpha_1 p_t + \alpha_2 E(\Delta p_{t+r} | \Omega_t) + Z_{1t} , \qquad (5)$$

where d_t is the log of the demand for new property (or demand for the stock of property minus the supply of existing properties), p_t is the log of the price of real property relative to a basket of consumption goods, and r is the length of time before the asset value of the property can be realized. The value of r can be larger than one period because real estate is an illiquid asset and its purchase and sale take time. Finally, Z_{1t} is the sum of all other factors that affect demand. These include real rental costs, the real interest rate, the general rate of inflation, the real money supply, real income and a disturbance term. Note that monetary policy in this model will affect the property markets directly through changes in the supply of money and the interest rate, but also indirectly through its impact on inflation, as well as through the future expectations of these variables. 1/

It is important to emphasize that d_t is the difference between total demand for property and supply of existing properties. Total demand for the stock of real property is satisfied by the supply of new as well as existing properties. Decisions regarding the supply of existing properties are

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1/ Note that in the above analysis mortgage rates are assumed to be flexible and determined by the current rate of interest. Mortgage rates that are fixed for periods of time would generate limited dependence in the model. A proper analysis of the resulting limited-dependent rational-expectations model would be beyond the scope of this paper. See Pesaran and Samiei (1992a) and (1992b), for an analysis of these types of models in the more complex situation when the dependent variable is bounded.

incorporated in the portfolio-selection discussed above because they concern asset-holding rather than production and therefore depend on future expected price movements. Supply of new property, on the other hand, is a production decision. A supplier who decides to build a structure but also decides not to sell it immediately, makes two related decisions: a production decision that depends on price expectations for the period when the property would be ready, and an asset decision, which in this example would be to postpone sale in the expectation of higher prices in the future. The former decision is incorporated in the equation for supply of new houses below, while the latter is captured by the demand for new property discussed above.

Decisions about the supply of new properties can be analyzed from a production point of view. Because production takes time, the current supply of new properties depends on the current period's expected price formed at the time when the decision to build is made. Supply also depends on building costs and the cost of raising capital (the interest rate). Thus:

$$s_t = \delta E(p_t | \Omega_{t-q}) + Z_{2t} , \tag{6}$$

where s_t denotes supply of new property (in logarithms) and q is the length of time it takes to build a structure. The sum of other factors, including shocks, that affect supply is denoted by Z_{2t}.

Property prices are determined by equating demand and supply for new properties:

$$p_t = \frac{\alpha_2}{\alpha_1 + \alpha_2} E(p_{t+r} | \Omega_t) - \frac{\delta}{\alpha_1 + \alpha_2} E(p_t | \Omega_{t-q}) + \frac{1}{\alpha_1 + \alpha_2} (Z_{1t} + Z_{2t}) . \tag{7}$$

Thus p_t is a function of its expected r-period ahead future value, its expected current value formed at time $t-q$, and exogenous variables. This is an equation with mixed current and future expectations of the dependent variable and with a complicated timing structure for the information sets. The solution of this equation under the assumption of rational expectations is given by (see Appendix I for derivation):

$$p_t = \sum_{i=0}^{\infty} (\gamma_1 + \gamma_2)^{r.i} E(Y_{t+r.i} | \Omega_t) + \frac{\gamma_2}{\gamma_1} \sum_{i=0}^{\infty} (\gamma_1 + \gamma_2)^{r.i} E(Y_{t+r.i} | \Omega_{t-q}) , \tag{8}$$

where

$$\gamma_1 = \frac{\alpha_2}{\alpha_1 + \alpha_2} \quad \text{and} \quad \gamma_2 = -\gamma_1 \frac{\delta}{\alpha_1 + \alpha_2 + \delta} , \tag{9}$$

and $Y_t = (Z_{1t} + Z_{2t})/(\alpha_1 + \alpha_2)$.

This solution has two main features: it involves sums of future expectations with lead times that are multiples of r, the order of future expectations in the demand function, and it includes expectations with respect to information sets both at time t and time $t-q$, resulting from the presence of expectations on the supply side.

Special cases of interest arise by noting that, in general, γ_1 is expected to be positive and γ_2 negative. When supply does not respond to expected prices γ_2 will be zero and the following solution will result:

$$p_t = \sum_{i=0}^{\infty} \gamma_1^{r.i} E(Y_{t+r.i} | \Omega_t) . \tag{10}$$

With further assumptions, in particular perfect asset substitutability and constant interest rates, the solution given by (10) would reduce to the simple net present value model given by (4). The opposite polar case arises when expected future prices do not influence demand. In this case both $\gamma 1$ and $\gamma 2$ will be zero, and the model will only contain current expectations. The solution is obtained by setting α_2 equal to zero in (7) and eliminating the expectations term by taking expectations from the two sides of the equation. This gives

$$p_t = \rho\, E(Y_t | \Omega_{t-q}) + Y_t , \tag{11}$$

where $\rho = -\delta/(\sigma_1 + \delta)$ and Y_t is defined as before with $\alpha_2 = 0$. Finally, when neither supply nor demand respond to price expectations we will simply have:

$$p_t = Y_t . \tag{12}$$

IV. Empirical Representations of the Model

Having derived and eliminated the expectations of the dependent variable, equation (8) for relative property prices may now be estimated by the maximum-likelihood method, taking account of nonlinearities and the various restrictions imposed on the parameters by rational expectations. For estimation we need to specify the exogenous variables explicitly and the stochastic process that generates them. The latter is required in order to derive the expectations terms. Note that estimating the reduced form equation for prices does not allow the identification of the parameters in the structural equations, α_1, α_2, and δ because of the smaller number of reduced-form parameters (γ_1 and γ_2). The alternative of estimating the structural equations, which would require data on the supply of new properties, is not attempted here.

The model as it stands is in terms of levels of variables which are likely to contain unit roots. Campbell and Shiller (1988) address the issues of non-stationarity and cointegration in a simple net present value model. The model discussed here has a rather complex structure by comparison. However, the argument presented in Campbell and Shiller (1988) can shed light on some of the issues involved. Consider equation (13) below.

$$y_t = \beta \sum_{i=0}^{\infty} \gamma^i E(x_{t+i} | \Omega_t) \quad . \tag{13}$$

By rearranging terms, this may be rewritten as

$$\Delta y_t = \frac{\beta}{1-\gamma} \sum_{i=0}^{\infty} \gamma^i E(\Delta x_{t+i} | \Omega_t) - e_t \ , \tag{14}$$

where

$$e_t = y_{t-1} - \frac{\beta}{1-\gamma} x_{t-1} \tag{15}$$

Equation (14) has a clear resemblance to the error-correction formulation of long-run dynamic relationships, with the coefficient of the error-correction term equal to minus one and the short- and long-run coefficients of the exogenous variable equal to $\beta\gamma^i/(1-\gamma)$ and $\beta/(1-\gamma)$, respectively. Campbell and Shiller (1987) test the restrictions implied by rational expectations by estimating an unrestricted VAR representation of Δx_t and e_t which would both be stationary if x_t and y_t were I(1) and cointegrated. Note that this requires an estimate of the long-run elasticity--which can be obtained by a first-stage estimation of the cointegrating relationship--in order to calculate e_t which is required in estimating the VAR. Cuthberston and Taylor (1990) use a similar technique in a more elaborate context to test the assumption of rational expectations in a demand for money function with adjustment costs. The above procedure aims at testing for the restrictions imposed by rational expectations on a general dynamic relationship between the dependent and the independent variables, rather than deriving parameter estimates for the restricted model.

A different approach is followed here. In order to examine the effect of exogenous variables, in particular monetary factors, in the determination of house price inflation, and also test for rational expectations, we estimate and contrast four specifications of the model developed in the paper: specification S_1 where expectations play no role at all and house prices are a function of Y_t only (equation 12); specification S_2 which generalizes S_1 by specifying an error-correction formulation of the model; specification S_3 which is the general solution to the model with the restrictions implied by rational expectations (equation 8); and finally specification S_4 which generalizes S_3 by removing the restriction that the error-correction coefficient is minus one and by including the lagged-dependent variable in the equation.

Although S_4 is not as general as a VAR specification, it has a relatively general dynamic structure. If it dominates S_3 on statistical criteria then the results would be consistent with the hypothesis of a mixed rational-adaptive expectations structure. A comparison of the estimation results for S_3 and S_4 with those for S_1 and S_2, furthermore, will test the assumption of rational expectations in the model developed in the paper. The advantage of estimating and comparing the above specifications is that various hypotheses may be tested in a transparent manner. We will examine these specifications in more detail below.

By comparison with Campbell and Shiller (1987) and Cuthbertson and Taylor (1990), the rational expectations solution in the present case has a much more complicated structure. This is because of the different time periods with respect to which expectations are formed and because the summations refer to lead-times that are multiples of r. The transformation proposed in the above studies may be applied in the present case only if the order of differencing of the variables (and thus the order of lag in the error-correction formulation) is also r. Under this assumption and including both current and r-period lagged values of the exogenous variables in Y_t

$$Y_t = \alpha_1' \mathbf{x}_t + \alpha_2' \mathbf{x}_{t-r} , \tag{16}$$

where $\mathbf{x}_t$ is the vector of exogenous variables (to be defined below) and α_i's are parameters, equation (8) may be re-arranged to give

$$\Delta_r p_t = \frac{1}{1-\gamma_1-\gamma_2}\sum_{i=0}^{\infty}(\gamma_1+\gamma_2)^i\,[\beta_1'+\beta_2'(\gamma_1+\gamma_2)]E(\Delta_r\mathbf{x}_{t+r.i}|\Omega_t)$$
$$+\frac{\gamma_2}{\gamma_1}\frac{1}{1-\gamma_1-\gamma_2}\sum_{i=0}^{\infty}(\gamma_1+\gamma_2)^i\,[\beta_1'+\beta_2'(\gamma_1+\gamma_2)]E(\Delta_r\mathbf{x}_{t+r.i}|\Omega_{t-q}) \quad (17)$$
$$-\,[p_{t-r}-\frac{(\gamma_1+\gamma_2)(\beta_1'+\beta_2')}{\gamma_1(1-\gamma_1-\gamma_2)}\mathbf{x}_t]\;.$$

This is specification S_3 discussed above. The last expression in (17) is the error-correction term. Removing the restriction that the coefficient of this term is minus one, and including the lagged dependent variable in the equation gives specification S_4:

$$\Delta_r p_t = \frac{1}{1-\gamma_1-\gamma_2}\sum_{i=0}^{\infty}(\gamma_1+\gamma_2)^i\,[\beta_1'+\beta_2'(\gamma_1+\gamma_2)]E(\Delta_r\mathbf{x}_{t+r.i}|\Omega_t)$$
$$+\frac{\gamma_2}{\gamma_1}\frac{1}{1-\gamma_1-\gamma_2}\sum_{i=0}^{\infty}(\gamma_1+\gamma_2)^i\,[\beta_1'+\beta_2'(\gamma_1+\gamma_2)]E(\Delta_r\mathbf{x}_{t+r.i}|\Omega_{t-q}) \quad (18)$$
$$+\,\delta\,[p_{t-r}-\frac{(\gamma_1+\gamma_2)(\beta_1'+\beta_2')}{\gamma_1(1-\gamma_1-\gamma_2)}\mathbf{x}_t]+\rho\Delta_r p_{t-1}\;.$$

When $\delta = -1$ and $\rho = 0$, S_3 is obtained.

Specifications S_1 and S_2 are obtained easily from above and are as follows:

$$\Delta_r p_t = \beta_1'\Delta_r\mathbf{x}_t - [\,p_{t-r}-(\beta_1'+\beta_2')\mathbf{x}_t]\;, \quad (19)$$

and

$$\Delta_r p_t = \beta_1'\Delta_r\mathbf{x}_t + \delta\,[p_{t-r}-(\beta_1'+\beta_2')\mathbf{x}_t]+\rho\Delta_r p_{t-1}\;. \quad (20)$$

It is important to note that although S_1 and S_3 are simply reparametrized versions of the corresponding equations in levels, their estimates, and those of the equations in levels, will not be equivalent since, in all of the above specifications, the VAR formulation to derive expectations is in terms of differences rather than levels, consistent with the assumption that the exogenous variables are I(1) but not cointegrated.

The variables included in $\mathbf{x}_t$ are m_t, y_t, $i_t - E(\pi_{t+1}|\Omega_t)$, π_t, c_t and R_t, which respectively denote real broad money (M2 in the United States and M2 + Cds in Japan), real GDP, the real long term interest rate (10-year rates), the rate of consumer price inflation, construction costs in real terms, and residential rent in real terms. 1/ They enter the price equations because the real money supply and real GDP affect wealth (as discussed on page 8), because the interest rate, inflation rate, and rental on property represent the returns on alternative assets, and because construction costs are a determinant of supply. We assume that the exogenous variables (with nominal rather than the real interest rate) follow a VAR process. The parameters of this process are estimated and used to derive the expectations of the exogenous variables. The real interest rate is then derived by subtracting the nominal interest rate from the expected inflation in the following period derived from the VAR specification. The future expected real interest rate is computed similarly. Equations (17) to (20) are then estimated under the assumption that the disturbance term is normally distributed and satisfies the classical properties.

Because our primary purpose is to assess the change in the impact of monetary policy on real estate prices, slope dummies are included for the variables that are directly affected by monetary policy, namely the money supply, the interest rate, and inflation. These dummy variables take values of zero in the first period and one in the second period. The structural break is assumed to be known by the agents when expectations are formed, so that the dummy variables enter the determination of expected property prices in the same way that other exogenous variables do. Clearly this procedure is somewhat rudimentary because it does not specify the exact mechanism or channels through which financial liberalization (and the other structural changes) may have affected the relationship between monetary policy and real estate prices. Loosely speaking, however, the idea is that financial liberalization and other structural changes reduced the effect of liquidity constraints and thereby altered the elasticities of demand for real estate with respect to monetary-policy-related variables.

1/ The data sources are *International Financial Statistics*, *Data Resources Inc.* database, *Nikkei Services*, and *Bulletin of Japan Land Prices*. The data are available from the authors on request. All the estimations are done using Gauss version 3.1.

V. The Empirical Results

The data used for estimation are quarterly from 1971:I to 1992:IV for the United States and 1971:II to 1992:II for Japan. The first period is assumed to end in 1983:IV. 1/ For completeness we have reported, in Appendix II, the empirical results for the United States and Japan for each of the four model specifications. The best equation for each country according to statistical criteria were then re-estimated excluding insignificant variables (Table 1). 2/

As indicated in Appendix II, the preferred specification for the United States is S_4. The estimated results for this specification suggest that the real money supply, the inflation rate, and construction costs are important determinants of property prices in the United States throughout the period (see Table 1). As indicated by the dummy monetary variables, the real interest rate is a significant determinant in the second period only, both in the short and in the long run, while the long-run effect of the real money supply becomes smaller in the second period. This observed increase in the importance of the interest rate in the 1980s is consistent with the lifting of ceilings on deposit interest rates and the resulting shift from a monetary policy that operated through a quantity-of-credit-rationing scheme (discussed in the final paragraph of Section II) to one which operated through credit market conditions more generally, including quantities and prices. Both the error-correction term and the lagged dependant variable have coefficients that are significantly different from zero, and in the case of the former also significantly different from minus one. Finally, note that the null hypothesis of no serial correlation of order four is tested and not rejected by the Lagrange Multiplier test. In summary, there are important differences in the estimated equations for the United States between the two time periods, which indicate a "structural" change in the second period: the short-run effect of the real money supply on real estate prices is different in the second period; the real interest rate is important only in the second period; and the coefficient on the inflation rate switches signs between the two periods.

The parsimonious representation of the preferred specification for Japan, model S_2, shows that in the long run the real money supply and real construction costs are important determinants of property prices in both the 1970s and 1980s, and that real interest rates are important only in the 1980s (see Table 1). Moreover, the short-run coefficients of all of the

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1/ Although 1982:IV, which was the end of the recession, is a more natural breakpoint, the evidence for a structural break was somewhat stronger for 1983:IV.

2/ Values of r equal to 1 and 4 were tried for both countries and based on the goodness of fit of the estimated equations and tests of serial correlation, r=4 in the case of USA and r=1 in the case of Japan were preferred. The alternative sets of results are available on request. q was set equal to 4 in both cases.

Table 1. Maximum-Likelihood Estimates of the Preferred Specifications 1/

	United States	Japan
$\Delta_r m_t$	1.3335 (6.4525)	0.3398 (1.1343)
$\Delta_r m_t \cdot D$	-0.6349 (-2.3211)	1.3816 (4.6953)
$\Delta_r y_t$	--	--
$\Delta_r (i_t - \pi^e_{t+1})$	--	--
$\Delta_r (i_t - \pi^e_{t+1}) \cdot D$	-0.9685 (-2.8020)	1.4870 (3.3633)
$\Delta_r \pi_t$	0.9625 (1.7037)	--
$\Delta_r \pi_t \cdot D$	-2.2997 -(2.1788)	1.4187 (2.8148)
$\Delta_r c_t$	1.0557 (4.0327)	0.2940 (3.0512)
$\Delta_r R_t$	0.4114 (1.7034)	0.9608 (2.7467)
m_{t-r}	2.1896 (13.7787)	2.9544 (11.1542)
$m_{t-r} \cdot D$	--	--
y_{t-r}	--	-2.3030 (-6.0227)
$i_{t-r} - \pi^e_{t+1-r}$	--	--
$(i_{t-r} - \pi^e_{t+1-r}) \cdot D$	-2.0098 (-2.8339)	-2.6149 (-2.0836)
π_{t-r}	3.1413 (4.5992)	--

Table 1 (concluded). Maximum-Likelihood Estimates of the Preferred Specifications 1/

	United States	Japan
$\pi_{t-r} \cdot D$	-5.6892 (-2.9724)	--
C_{t-r}	2.0584 (4.6147)	1.7650 (4.6706)
R_{t-r}	--	--
$\hat{\delta}$	-0.4812 (-6.9063)	-0.1778 (-5.5787)
$\hat{\rho}$	0.2832 (4.1041)	0.3399 (4.5310)
$\hat{\gamma}_1$	-0.6318 (-6.4920)	--
$\hat{\gamma}_2$	--	--
$\hat{\sigma}$	0.0168	0.0161
ℓ	215.9446	216.8477
R^2	0.9098	0.8346
F_{sc}	1.0201	1.2632

1/ The dependent variable is the percentage change in relative property prices ($\Delta_r P_t$). The order of lag and the order of expectations in the demand function are four (r=4) for the United States and one (r=1) for Japan. The order of expectations in the supply function is four (q=4) and the horizon for forward recursion in deriving the rational expectations solution is 50. t-statistics appear in parenthesis below the coefficient estimates. D is a dummy variable that is zero up to 1983:IV and one thereafter, σ is the estimate of the standard error of the residuals, ℓ is the maximized value of the log-likelihood function, R^2 is the multiple correlation coefficient defined as 1-σ^2/Var($\Delta_r P_t$) and F_{sc} is the Lagrange multiplier test for serial correlation of order 4 (* indicates significance at 5 percent). Other notation is as in the text. The order of the VAR specification in all cases is 8.

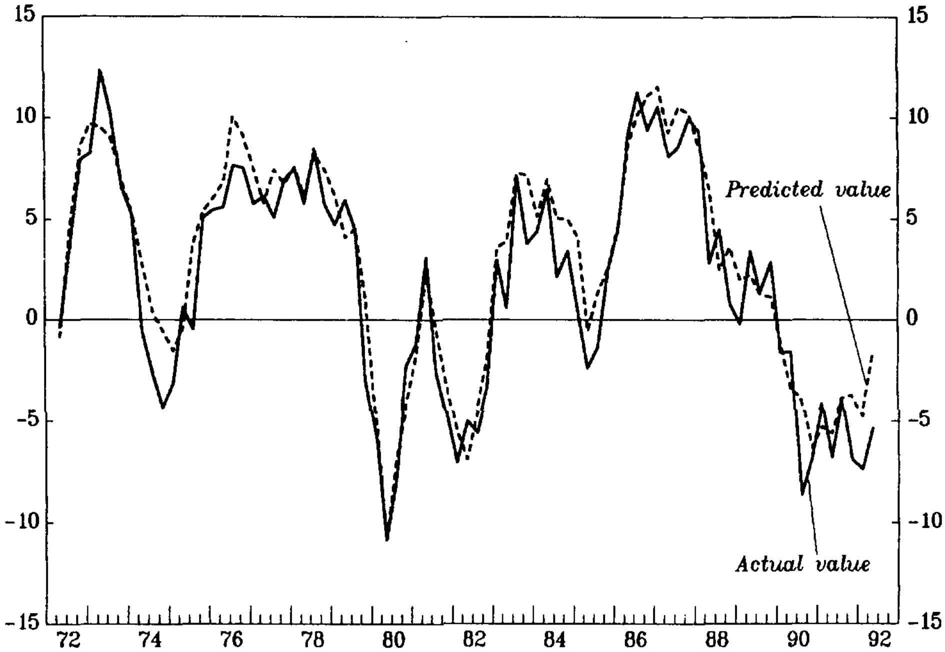
monetary variables--the money supply, the interest rate, and the inflation rate--are only significant in the 1980s. Therefore, as in the United States, there appears to have been a structural change in the 1980s in the effect of monetary variables on relative property prices in Japan. Finally note that in contrast to the experience in the United States, real GDP is a significant long-run determinant of relative property prices in Japan--a fall in prices relative to other goods as income rises--and rental costs are significant only in the short-run.

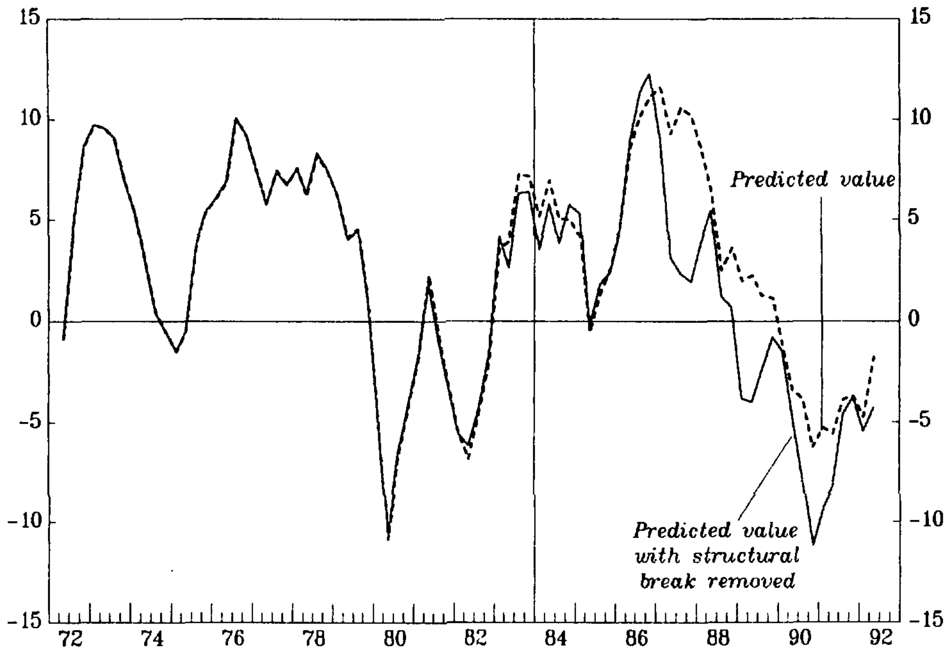
The estimated equations presented in Table 1 clearly indicate a structural change in the way that monetary variables influenced the relative price of real property in both the United States and Japan. It is not possible, however, to determine directly from the coefficients of these estimated equations whether monetary variables were more, or less influential in the 1980s than in the 1970s. To examine this issue by means of simulation, one would need to specify the order of contemporaneous causality in the VAR system in order to compute the direct effect of, say, a change in the nominal money supply on property prices as well as its indirect effects through other exogenous variables. Rather than make possibly arbitrary assumptions with regards to the order of causality we address instead a different question: how would relative property prices have responded to the actual realizations in the 1980s of monetary variables had the estimated structural relationships that prevailed in the 1970s been carried forward to the 1980s? This question can be answered by generating the predictions in the 1980s of the estimated equations under the assumption that the coefficients on the dummy monetary variables are zero; that is, under the assumption that there was no structural change in the relationship between property prices and monetary variables in the 1980s.

These predictions are presented in Chart 7 for the United States and Chart 8 for Japan. In each chart the top panel depicts the actual and predicted values of the dependant variable using the preferred models, and the bottom panel compares predictions when the coefficients on the dummy monetary variables take their estimated values and predictions when these coefficients are set equal to zero. As is shown in the lower panels, the estimated models predict that inflation in relative property prices would have been lower in the United States, and less volatile in Japan in the 1980s had the estimated structural changes not taken place (that is, when the coefficients on the dummy variables are set equal to zero). The two panels taken together clearly indicate that the dummy monetary variables importantly contribute to explaining both the rise and then the fall in relative property price inflation in both the United States and Japan in the 1980s.

Chart 7. Unites States: Actual and Predicted Relative Property Prices[1]

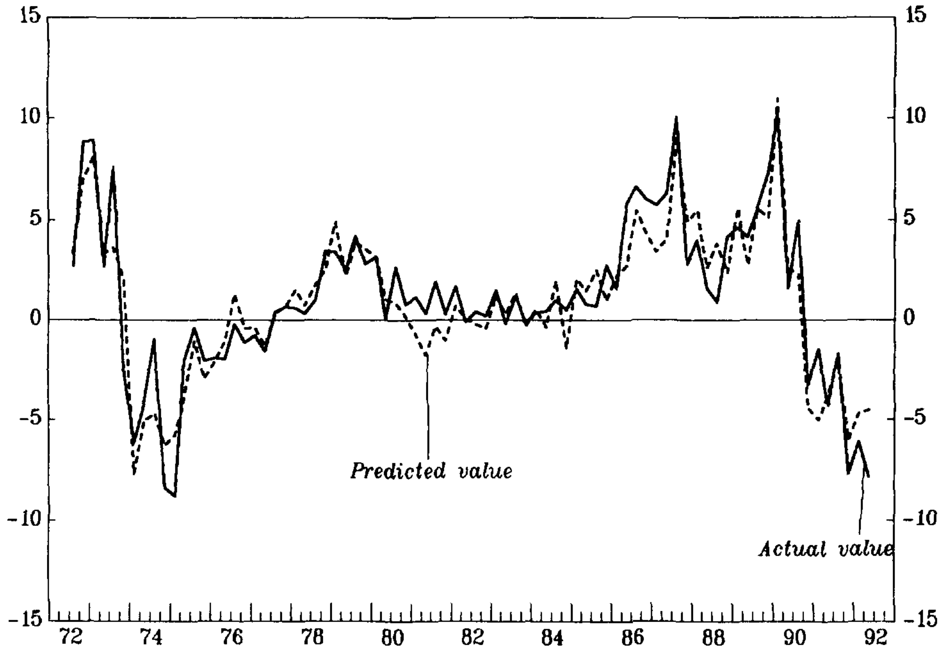
(Annual change, in percent)

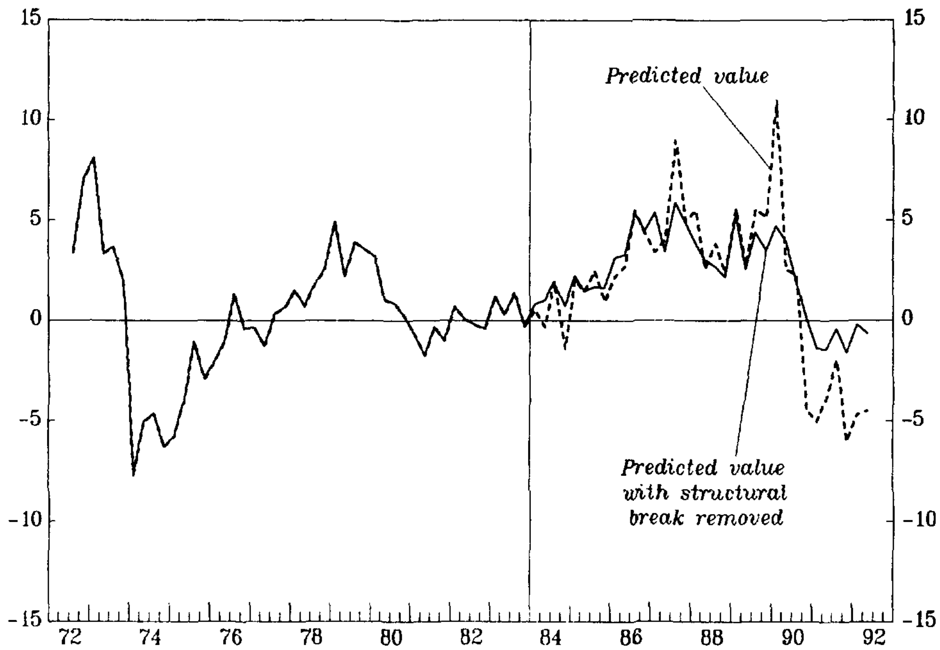




[1]Predicted values are obtained using the preferred model for the United States as shown in Table 1. The predicted values with structural break removed are obtained using the same model but with the slope dummy coefficients set equal to zero. The difference between the two sets of predicted values prior to the structural break arises from the presence of expectations in the estimated model for the United States.

Chart 8. Japan: Actual and Predicted Relative Property Prices[1]
(Quarterly change, in percent)





[1]Predicted values are obtained using the preferred model for Japan as shown in Table 1. See also footnote to Chart 1.

VI. Conclusions

Some broad conclusions may be drawn. First, the estimated equations support the hypothesis that monetary variables are generally important in influencing real estate prices. Second, the equations suggest quite strongly that the impact of monetary variables on property prices changed in the second period (that is, in the period 1983:IV to 1992:II) in both the United States and Japan, a period of rapid financial innovation and deregulation. 1/ This observed change is consistent with a shift from a quantitiy-of-credit rationing scheme, as occurred in both the United States and Japan, to one in which interest rates play a more active role. Third, on the supply side, construction costs are significant determinants of house prices in both countries. Fourth, for both countries, the restrictive dynamics implied by rational expectations is rejected by a more general error-correction structure.

Furthermore, the results generally do not appear to support the expectations hypotheses on either the demand or the supply sides of the models derived in this paper; demand expectations appear to be significant in the United States but with a sign opposite to that suggested by the model. This lack of support for the expectations hypotheses modeled in the paper may partly reflect the difficulty in choosing appropriate values for the orders of expectations in the supply and demand functions. However, it is also consistent with--but is not necessarily implied by--the presence of "rational bubbles" in property markets. 2/ Bubbles, which were assumed not to exist in the rational expectations solution examined in this paper (equation A7 in Appendix I) would, in general, introduce non-linear functions of the exogenous variables in the solution. This issue is an important one in understanding sharp and extreme movements in asset prices, but it is clearly beyond the scope of the present paper and will remain as a topic for further research.

The model developed and estimated above could be extended in a number of directions that are beyond the scope of the present paper. In particular, an important role could be played by transaction costs which, by comparison with financial assets, are relatively high in the case of the housing market. The presence of these costs may generate rigidities in the housing market by causing a wait-and-see policy on the part of the sellers when the market is weak, thus affecting the volume transacted rather than prices. To incorporate transactions costs in the analysis and allow for a more explicit treatment of the effects of financial liberalization on asset demands, it would be useful to more explicitly examine the agent's decision-

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1/ This evidence is also compatible with changes arising from factors other than financial liberalization, including demographic changes and tax reform.

2/ See, for example, Flood and Garber (1980), Blanchard and Watson (1982), and Garber (1989). See also Lim (1991) for an empirical examination in the case of the U.K. housing market.

making problem. Finally, prices, rents, and monetary policy variables have been treated as exogenous variables in this paper, but clearly they may themselves be influenced by house prices. Taking account of these general equilibrium effects could be important empirically.

In addition, there are a number of important, more general, hypotheses relating to the asset price inflation of the 1980s, that were not tested in this paper in part because testing them properly would have required more than just a model of the housing market. First, it would be useful to rigorously examine the joint hypothesis that the monetary transmission process changed for both goods prices and asset prices in the 1980s, as suggested in section II of the paper. If the process of inflation in goods (and labor) markets changed in the 1980s, then this would have immediate policy implications for macroeconomic policy in the 1990s, especially as the industrial countries emerge from their period of weak growth, and achieve more buoyant recoveries. Second, it also would be useful to explicitly and simultaneously examine the joint effects of monetary policy, financial liberalization, and other factors--such as tax policy and demographics--on real estate values, in particular, and on asset prices, in general, during the 1970s and 1980s. This would help to quantify the importance of each of these factors and further clarify the extent to which the asset price inflations could have been avoided, for example, by restraining monetary policy sooner. Third, and perhaps more fundamentally, a more explicit treatment of the relationship between asset prices (real estate prices), wealth, and aggregate demand would lead to a greater understanding of why the recent recoveries from recession in a number of industrial countries, and most notably in the United States, were significantly weaker than previous cyclical recoveries.

Rational Expectations Solution of the Model

Let $Y_t = (Z_{1t} + Z_{2t})/(\alpha_1 + \alpha_2)$ and note that from Equation (7) in the text, taking expectations with respect to Ω_{t-q}, and re-arranging terms we have:

$$E(p_t \mid \Omega_{t-q}) = \frac{\alpha_2}{\alpha_1 + \alpha_2 + \delta} E(p_{t+r} \mid \Omega_{t-q}) + \frac{1}{\alpha_1 + \alpha_2 + \delta} E(Y_t \mid \Omega_{t-q}) \ . \qquad \textbf{(A1)}$$

Substituting back into (7) we obtain:

$$p_t = \gamma_1 E(p_{t+r} \mid \Omega_t) + \gamma_2 E(p_{t+r} \mid \Omega_{t-q}) + W_t \ , \qquad \textbf{(A2)}$$

where:

$$W_t = \frac{\gamma_2}{\gamma_1} E(Y_t \mid \Omega_{t-q}) + Y_t \ , \qquad \textbf{(A3)}$$

and

$$\gamma_1 = \frac{\alpha_2}{\alpha_1 + \alpha_2} \ , \quad \gamma_2 = - \gamma_1 \frac{\delta}{\alpha_1 + \alpha_2 + \delta} \ . \qquad \textbf{(A4)}$$

Having eliminated the current expectations of the dependent variable from Equation (7) in the text, the equation now contains two future expectations terms which refer to the same period but are formed at different time periods, namely t and $t-q$. To derive the stationary forward solution of this equation we use forward recursion.

Consider period $t+r$ in (A2) and take expectations with respect to Ω_{t-q}:

$$E(p_{t+r} \mid \Omega_{t-q}) = (\gamma_1 + \gamma_2) E(p_{t+2r} \mid \Omega_{t-q}) + E(W_{t+r} \mid \Omega_{t-q}) \ . \qquad \textbf{(A5)}$$

Next consider period $t+2r$ and again take expectations with respect to Ω_{t-q}:

$$E(p_{t+2r} \mid \Omega_{t-q}) = (\gamma_1 \quad \gamma_2) E(p_{t+3r} \mid \Omega_{t-q}) + E(W_{t+2r} \mid \Omega_{t-q}) \ . \qquad \textbf{(A6)}$$

Substitute back in (A5) and repeat this process for $t+3r$, $t+4r$, ..., in order to recursively eliminate higher order expectational terms. Assuming the following transversality condition holds

$$\lim_{N\to\infty} (\gamma_1 + \gamma_2)^N E(p_{t+r.N} | \Omega_{t-q}) = 0 , \tag{A7}$$

the solution for expectations conditional on information at $t-q$ is given by

$$E(p_{t+r} | \Omega_{t-q}) = \sum_{i=1}^{\infty} (\gamma_1 + \gamma_2)^{r.i-1} E(W_{t+r.i} | \Omega_{t-q}) . \tag{A8}$$

Now consider period $t+r$ again and but take expectations with respect to Ω_t:

$$E(p_{t+r} | \Omega_t) = \gamma_1 E(p_{t+2r} | \Omega_t) + \gamma_2 E(p_{t+2r} | \Omega_{\min(t,t-q+r)}) + E(W_{t+r} | \Omega_t) . \tag{A9}$$

This has a more complicated form than (A5) because the period when the suppliers form expectations, $t-q+r$, is after $t-q$ but may precede the current period depending on the size of r relative to q. We assume that r is greater than or equal to q to simplify the solution. The general case only introduces some extra algebra relating to a few observations. Equation (A9) can now be written as:

$$E(p_{t+r} | \Omega_t) = \gamma_1 E(p_{t+2r} | \Omega_t) + \gamma_2 E(p_{t+2r} | \Omega_t) + E(W_{t+r} | \Omega_t) . \tag{A10}$$

Following the same recursive procedure as before we obtain

$$E(p_{t+r} | \Omega_t) = \sum_{i=1}^{\infty} (\gamma_1 + \gamma_2)^{r.i-1} E(W_{t+r.i} | \Omega_t) . \tag{A11}$$

Substituting in (A2) for the expectations terms from (A8) and (A11) gives the solution to the equation:

$$p_t = \gamma_1 \sum_{i=1}^{\infty} (\gamma_1 + \gamma_2)^{r.i-1} E(W_{t+r.i} | \Omega_t)$$
$$+ \gamma_2 \sum_{i=1}^{\infty} (\gamma_1 + \gamma_2)^{r.i-1} E(W_{t+r.i} | \Omega_{t-q}) + W_t \, . \tag{A12}$$

In terms of Y_t we have:

$$p_t = \sum_{i=0}^{\infty} (\gamma_1 + \gamma_2)^{r.i} E(Y_{t+r.i} | \Omega_t) + \frac{\gamma_2}{\gamma_1} \sum_{i=0}^{\infty} (\gamma_1 + \gamma_2)^{r.i} E(Y_{t+r.i} | \Omega_{t-q}) \, . \tag{A13}$$

This is Equation (8) in the text.

Estimated Equations for the Alternative Model Specifications

This Appendix presents the estimated equations for all four model specifications discussed in Section IV of the paper. The results for the United States and Japan are presented in Tables 2 and 3, respectively.

For the United States, the estimated equations indicate that in the long run, in all four specifications the real money supply, construction costs, and inflation are significant determinants of the real property price throughout the period (that is, in both the 1970s and 1980s), while the real interest rate is generally significant only in the second period (the 1980s). Real money supply, construction costs and inflation are also generally significant in the short run. It should be noted that real GDP is not an important determinant of relative property prices in the more general specifications, which include expectations terms, the unrestricted error correction term, or the lagged dependant variable. Although a long-run positive relationship between income and the relative price of real estate can be expected to exist--because ownership of real estate can be viewed as a luxury good--this relationship may not be observed over a twenty-year period in an economy where home-ownership is already widespread, as in the United States. Looking at individual specifications, it is clear that the more general dynamic structure included in S_2 and S_4 is not rejected by the data. Although the expectations variable from the demand side has a significant coefficient (γ_1), the sign is opposite to that implied by the model. Purely on the basis of statistical criteria (likelihood ratio tests), S_4 is the preferred specification.

In the specifications for Japan, the real money supply is a significant determinant of real property prices in the long-run in all four specifications, and there is no short-run dynamic term that is uniformly significant across the four specification. As in the case of the United States, the more general dynamic structure in S_2 and S_4 are supported by the data on the basis of testing for restrictions as well as for the presence of serial correlation. Neither expectations variable is significant in the specification of the models for Japan. Model S_2, which includes both the error correction term and the lagged dependant variable, but which excludes expectations terms, is clearly not rejected by S_4 (using a likelihood ratio test) and therefore is judged on statistical criteria to be the preferred specification.

The preferred specifications were re-estimated with insignificant terms excluded, using the criterion of a t-statistic of less than 1.4 as the cut-off. These are presented in Table 1 in the text.

Table 2. United States: Maximum-Likelihood Estimates of the Rational Expectations Model for Relative Property Prices 1/

(1971:I-1992:II)

	S_1	S_2	S_3	S_4
$\Delta_r m_t$	0.6645 (1.9500)	0.6719 (2.1974)	2.7244 (4.9289)	1.4413 (3.8238)
$\Delta_r m_t \cdot D$	0.0815 (0.1450)	-0.6750 (-1.2721)	0.4243 (0.7754)	-1.3514 (-2.2027)
$\Delta_r y_t$	0.7763 (4.3870)	0.4661 (2.5763)	0.0839 (0.3115)	0.1669 (0.7192)
$\Delta_r(i_t - \pi^e_{t+1})$	-0.0752 (-0.2440)	-0.0404 (-0.1465)	1.1874 (2.5942)	0.3406 (1.1797)
$\Delta_r(i_t - \pi^e_{t+1}) \cdot D$	0.3974 (0.7429)	0.1619 (0.3370)	-2.9465 (-4.1446)	-1.0815 (-2.4707)
$\Delta_r \pi_t$	1.6935 (2.3971)	1.0500 (1.6085)	2.6393 (3.1511)	1.6699 (1.9817)
$\Delta_r \pi_t \cdot D$	0.6522 (0.7518)	-0.2863 (-0.3484)	-0.0504 -(0.0392)	-3.7648 (-2.3922)
$\Delta_r C_t$	0.9326 (3.6695)	0.7283 (2.7914)	1.3638 (3.1332)	1.2503 (3.1698)
$\Delta_r R_t$	0.5501 (1.3972)	0.6488 (1.8330)	1.0164 (1.4062)	0.9530 (2.1082)
m_{t-r}	0.8324 (3.0136)	1.0575 (2.4328)	3.6809 (3.3671)	1.7090 (2.3209)
$m_{t-r} \cdot D$	0.3464 (0.8303)	-0.4100 (0.5858)	0.7288 (0.8345)	-0.8631 (-0.8248)
y_{t-r}	0.5778 (2.4306)	0.8255 (2.1944)	0.0169 (0.0297)	0.7388 (1.2359)
$i_{t-r} - \pi^e_{t+1-r}$	0.2137 (0.9174)	0.3422 (0.8641)	0.3549 (0.6204)	-0.3973 -(0.6515)
$(i_{t-r} - \pi^e_{t+1-r}) \cdot D$	-0.8827 (-2.7876)	-1.1685 (-2.2205)	-4.3140 (-3.8076)	-1.3109 (-1.4798)
π_{t-r}	2.5675 (3.4941)	3.5740 (2.8608)	3.8833 (4.0398)	3.9546 (2.3737)

Table 2 (concluded). United States: Maximum-Likelihood Estimates of the Rational Expectations Model for Relative Property Prices 1/

(1971:I-1992:II)

	S_1	S_2	S_3	S_4
$\pi_{t-r} \cdot D$	-0.1418 (-0.1355)	-2.7585 (-1.3858)	-0.7876 (-0.4126)	-8.3587 (-2.3305)
C_{t-r}	0.9761 (4.0545)	1.3706 (3.0358)	1.9968 (2.8383)	2.5878 (3.2824)
R_{t-r}	0.1461 (0.4652)	0.8254 (1.4415)	-0.3724 (-0.4749)	1.1808 (1.3147)
$\hat{\delta}$	--	-0.5879 (-5.6438)	--	-0.3895 (-3.9078)
$\hat{\rho}$	--	0.2405 (2.6447)	--	0.2337 (2.9745)
$\hat{\gamma}_1$	--	--	-1.5230 (-4.8753)	-0.4877 (-3.8790)
$\hat{\gamma}_2$	--	--	0.4835 (1.4614)	-0.1127 (-1.2209)
$\hat{\sigma}$	0.0199	0.0177	0.0182	0.0158
ℓ	202.4096	211.6439	209.6337	220.8330
R^2	0.8739	0.8996	0.8945	0.9200
F_{sc}	1.7031	4.4347*	0.3297	1.3053

1/ See footnote to Table 1.

Table 3. Japan: Maximum-Likelihood Estimates of the Rational Expectations Model for Relative Property Prices 1/

(1971:II-1992:II)

	S_1	S_2	S_3	S_4
$\Delta_r m_t$	2.4796 (2.8839)	0.6269 (1.5014)	1.1446 (1.6698)	0.0103 (0.0211)
$\Delta_r m_t \cdot D$	0.9137 (0.9576)	0.7916 (1.7283)	-0.5163 -(0.9600)	1.3487 (2.1004)
$\Delta_r y_t$	-1.0401 (-1.5860)	0.1053 (0.3386)	-0.4855 (-0.8906)	0.5433 (1.0299)
$\Delta_r(i_t - \pi^e_{t+1})$	-0.9785 (-1.6548)	-0.0397 (-0.1416)	-1.6361 (-3.1732)	-0.1780 (-0.3867)
$\Delta_r(i_t - \pi^e_{t+1}) \cdot D$	0.4220 (0.3762)	1.6658 (3.1720)	-0.9324 (-0.9732)	2.2326 (2.6850)
$\Delta_r \pi_t$	0.9571 (1.5935)	0.3652 (1.3017)	-0.3030 -(0.6125)	0.4613 (1.2606)
$\Delta_r \pi_t \cdot D$	2.2049 (1.8991)	0.9713 (1.7880)	0.8365 (1.0365)	1.4728 (2.1406)
$\Delta_r c_t$	0.0156 (0.0667)	0.3008 (2.7176)	-0.0300 (-0.1467)	0.1170 (0.4543)
$\Delta_r R_t$	0.8294 (1.0485)	1.0350 (2.7096)	0.2413 (0.4240)	1.6383 (3.3954)
m_{t-r}	3.3614 (11.2544)	4.5124 (4.4258)	1.0271 (4.2799)	5.8715 (2.5307)
$m_{t-r} \cdot D$	-0.1515 (-1.3762)	-0.6578 (-1.6976)	-0.1044 (-2.5701)	-0.9604 (-1.4990)
y_{t-r}	-2.5607 (-7.2021)	-3.8690 (-3.2113)	-0.7308 (-3.5094)	-5.1554 (-2.0456)
$i_{t-r} - \pi^e_{t+1-r}$	1.8617 (3.2957)	1.2658 (0.7438)	0.3848 (2.5323)	1.7430 (0.7118)
$(i_{t-r} - \pi^e_{t+1-r}) \cdot D$	-1.5926 (-2.1381)	-5.6398 (-2.0654)	-0.1231 (-0.6219)	-5.8504 (-1.4845)
π_{t-r}	3.3522 (4.6279)	1.1749 (0.4932)	1.2258 (3.8429)	0.6584 (0.1909)

Table 3 (concluded). Japan: Maximum-Likelihood Estimates of the Rational Expectations Model for Relative Property Prices 1/

(1971:II-1992:II)

	S_1	S_2	S_3	S_4
$\pi_{t-r} \cdot D$	0.7667 (1.0604)	-2.6742 (-1.0584)	0.5076 (2.0807)	-2.8025 (-0.7780)
C_{t-r}	0.5680 (2.2659)	2.0453 (2.1150)	0.2860 (2.8838)	3.1344 (1.6580)
R_{t-r}	0.1022 (0.2699)	-0.9414 (-0.7789)	-0.1861 (-1.5597)	-1.2279 (-0.7317)
$\hat{\delta}$	--	-0.1554 (-3.0358)	--	-0.1304 (-2.5218)
$\hat{\rho}$	--	0.3028 (3.8587)	--	0.2690 (3.1337)
$\hat{\gamma}_1$	--	--	0.5155 (5.3958)	0.0968 (0.9040)
$\hat{\gamma}_2$	--	--	0.1348 (2.4712)	-0.0242 (-0.9459)
$\hat{\sigma}$	0.0329	0.0152	0.0302	0.0149
ℓ	159.5909	221.1523	166.4728	222.9382
R^2	0.3079	0.8515	0.4173	0.8580
F_{sc}	11.9408*	1.6479	4.0953*	0.9951

1/ See footnote to Table 1.

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