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Asset Price Fluctuations in Japan: What Role for Monetary Policy?

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This paper examines the nature of fundamental disturbances that have accounted for fluctuations in Japanese nominal and real land prices during the post-war period. A distinction is made between macroeconomic supply and demand shocks, as well as land-market specific shocks, in the context of a dynamic structural VAR model. The results indicate that shocks to aggregate demand—a category encompassing most monetary policy shifts—explain only a small part of the movement in land prices around the longer-term rising trend. Aggregate supply shocks are an important explanatory factor. Much of the variance in land prices also is attributable to factors originating in the land market itself, potentially including speculative bubbles.

I. Introduction

Wide swings in asset prices are a source of concern to central bankers primarily because of their effects on the amplitude of the business cycle, the general price level and the stability of the financial system. Operating instruments largely under the direct control of the central bank—non-borrowed reserves, discount rates, and so on—unambiguously affect the prices of short-term debt instruments such as interbank loans and short-term government paper. However, the effects of monetary policy on longer-term asset prices, including long-term debt instruments, equities and land prices, are less clear from both a theoretical and empirical perspective.

The "liquidity effect" of a monetary stimulus, for example, puts upward pressure on long-term bond prices but may be offset by term premia associated with higher expected inflation and greater uncertainty (risk) over the future course of policy. The net effect on long-term bond prices is theoretically ambiguous. Similarly, although equities represent claims on real assets, empirical evidence indicates that real stock prices perform poorly during periods of inflation.[1]

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[1] *See* Ely and Robinson (1989) for a review of the theory and U.S. evidence on the failure of equities to maintain their value during inflationary periods.

Central bankers are often of two minds over how to interpret the direction of causality running between monetary policy and longer-term asset prices. In some instances, movements in monetary variables such as the money supply are interpreted as an endogenous response to fluctuations in longer-term asset prices and other economic factors.[2] But at other times, fluctuations in these asset prices are attributed to changes in the stance of monetary policy and, more generally, monetary conditions.[3]

This paper investigates the role of monetary policy on a particularly important asset price in Japan—the nominal and real price of land. Policy discussion and academic research have focused on the high level of land prices in Japan by international comparison.[4] Estimates in late 1991, for example, put the total value of Japanese land at about five times that of the United States compared with a land mass only 4 % as large. This amounts to about 20 % of the world's total wealth (Stone and Ziemba, 1993).

Few existing empirical studies have focused on monetary factors, nor have they attempted to explicitly identify the independent role of monetary policy, in the determination and volatility of land prices. This is surprising given the importance of land and other asset prices, particularly in real terms, in policy discussions and commentary surrounding Japanese monetary policy. The studies which have attempted to shed light on the importance of monetary factors have relied primarily on indirect evidence; namely, correlations between land prices and either interest rates or money / credit growth.[5]

These studies provide valuable information, but in some instances interest rates, money aggregates and credit aggregates are misleading indicators of the stance of monetary policy. Monetary as well as real factors (*e.g.* technology developments, oil price fluctuations, trade liberalization, and so on) influence interest rates, for example, and each have potentially different effects on the price of land. This may be one reason that regressions of land prices on interest rates are so sensitive to the particular sample period chosen. That is, during some periods supply-side factors such as oil supply shocks may dominate interest rate movements, while in other periods explicit actions by the mone-

[2]The Bank of Japan, for example, attributes the slowdown in money growth in Japan in 1992 to "...sluggishness of the economy and asset-price deflation" (Bank of Japan, 1993, p. 2).

[3]The Bank for International Settlements, for example, draws the connection between monetary policy and asset price movements working through the credit channel in the latter part of the 1980s: "...easy monetary policy appears to have been partly responsible for the rapid growth in credit during the asset price upswing, particularly in some of the countries experiencing the largest price cycles. To different degrees, the policy stance in Sweden, Norway, Finland and Japan was arguably not consistent with restraint in borrowing" (Bank for International Settlements, 1993, p. 167). Similarly, a study investigating the rise in land prices in the 1980s by the Research Department of the Bank of Japan states that: "...higher growth in money supply under relaxed monetary conditions has usually been a source of land price increases" (Bank of Japan, 1990, p. 10).

[4]*See*, for example, Boone (1989), Boone and Sachs (1989), Takagi (1989), Ando, *et. al.* (1991), Bank of Japan (1990), Cutts (1990), Ito (1989, 1991, 1993), Ito and Hirono (1993), Stone and Ziemba (1993).

[5]*See*, for example, Takagi (1989), Bank of Japan (1990), Rose (1990), Ando, *et. al.* (1991), Frankel (1991) and Ito (1993). These studies are discussed in section II.

tary authorities may play the more important role. Similarly, money and credit growth movements are partly endogenous, typically influenced by changes in real economic activity and money/credit demand shifts.[6]

Given the focus of previous research, and the difficulties in identifying a clear causal link running from monetary policy actions to land prices, it remains unclear (i) whether the disturbances generating land price fluctuations in Japan are primarily macroeconomic in nature, as opposed to originating mainly from changing conditions in the land market, and (ii) whether the macroeconomic disturbances originate primarily from shifts in monetary conditions.

To address these questions we examine the nature of the disturbances that have accounted for post-war fluctuations in Japanese nominal and real land prices. We distinguish between macroeconomic and land-specific shocks in the context of a dynamic simultaneous equations model of Japan and investigate fluctuations in both nominal and real (relative) land prices. The primary concern over land prices in Japan is their rapid rise relative to the general price level and we focus on this distinction in our empirical work.

In identifying "fundamental disturbances", and their effects on land prices, we must make some assumptions about the underlying structure of the economy. For this purpose we accept the standard neoclassical (and classical) model's assumption of long-run money neutrality. That is, output in the steady state (long-run equilibrium) is assumed to be determined solely by "supply-side factors" such as the availability of factor supplies, technology, trade openness, and so on. Monetary factors, and more generally aggregate demand disturbances, are assumed by the neoclassical model to have only temporary effects on the level of output, but may have permanent effects on the price level.[7]

Following this approach, and employing the statistical methodology of Blanchard and Quah (1989) which imposes constraints on the long-run dynamics of the model, we define those disturbances estimated as having only transitory effects on output as aggregate demand shocks, and those having both short- and long-run effects as aggregate supply disturbances. As long as long-run money neutrality holds, aggregate demand

[6]The link between credit expansion for real estate purchases and the stance of monetary policy may be especially weak, as it reflects other factors such as the relative demand for real estate and developments in other loan markets.

[7]This is the standard textbook model with a vertical long-run output supply curve, and sticky prices and wages. Aggregate supply shocks shift the long-run (and short-run) aggregate supply curve, having short-term as well as permanent effects on output, *i.e.* the equilibrium level of output is changed. Aggregate demand shocks shift the aggregate demand curve and have only transitory effects on output, *i.e.* the level of equilibrium output is not changed. Clearly, monetary policy could have permanent effects on output when credit markets are imperfect, investment uncertainties are large and elements of hysteresis exist in labor, trade and investment markets. However, most economists view these as "second order" effects. The real business cycle (RBC) paradigm, by contrast, imposes much stronger assumptions, often ruling out the possibility that monetary shocks have even transitory output effects.

shocks will fully encompass monetary disturbances. In this case, measuring the total effect of aggregate demand shocks will provide us with an upper bound on the extent to which monetary shocks have influenced land price fluctuations.[8]

The rest of the paper is organized as follows. Section II provides a selective review of previous work on land price determination in Japan. We argue that the role of aggregate demand or monetary factors in land price movements has not been clearly identified in previous studies. Section III discusses what may be inferred about the link between monetary policy and land price fluctuations from summary statistics. Section IV presents the model and methodology. Section V presents the empirical results and Section VI concludes the paper.

II. Land Prices and Money: Interpreting the Existing Evidence

Some indirect evidence on the role of monetary policy may be gleaned from studies measuring the effect of interest rates on land prices. Predictions from both present value/ portfolio balance models and regression equations have been employed to draw a link between interest rates and land prices. For example, the Bank of Japan (1990) and Frankel (1991) both use the present value approach.

The present value formula equates the price of land to the present discounted value of future rents (assuming no speculative bubbles), and the interest rate enters as the discount factor. The present value, and implied "fundamental" land price, is higher when rents are expected to grow quickly and lower when interest rates rise. Using this formula for prediction purposes, the Bank of Japan study suggests that relaxed monetary policy was a factor in the land price increases in Japan following the Plaza Agreement of September 1985 when interest rates were lowered. Frankel surveys the literature and also evaluates the recent data. He concludes that low real interest rates and high expected growth rates help explain the high *level* of land prices in Japan, but *not* the large increase in the 1980s.[9]

In a somewhat different tack based on the predications of a two-asset portfolio balance model (where land is the risky asset and deposits the risk-free asset), Takagi (1989) argues that the reduction in interest rates and quantitative expansion of credit stimulated demand for land, and allowing land price speculation: "It is difficult to deny that these factors account for skyrocketing land prices in metropolitan Tokyo" (pp. 126-27). The role of monetary factors was not the focus of his study, however, and no

[8]However, when monetary policy actions have permanent effects on the real economy they will be identified as supply shocks rather than demand shocks.

[9]Other factors have also contributed to the high price of land in Japan. Boone (1989), Boone and Sachs (1989) and Ito (1993) argue that higher expected growth of the Japanese economy, combined with very inelastic land supply due in part to institutional constraints, is expected to lead to rapid growth in rents and hence the high land value in Japan. *See* Frankel (1991) and Stone and Ziemba (1993) for surveys of the literature.

empirical evidence on this point is presented. Moreover, he notes that other analysts have argued for causation running the other way: the upsurge in land prices, and associated increase in the mortgage value of land, may have served to increase the volume of mortgage loans made on land.

Regression estimates linking land prices to interest rates also have given mixed results. Ando, *et. al.* (1991), in a study published by the Economic Planning Agency, investigate the correlation of land prices (and expected land prices) with real GNP growth, inflation, interest rates, the Marshallian 'k' (nominal income/nominal money) and other factors. They use a panel data set with annual data over the 1971-87 period for different groupings of Japanese cities and prefectures. Although their results vary with sample selection (set of cities or prefectures), they generally find a significant positive correlation between regional land prices and both interest rates and the Marshallian 'k' measure.[10]

By contrast, using nation-wide aggregate time-series data over 1956-88, Ito (1993) finds that nominal land price increases are not significantly correlated with nominal (or real) interest rates. He finds a significant positive correlation with inflation and real GNP growth, however. The estimated coefficients (t-statistic) on inflation, GNP growth and nominal interest rates are 1.096 (2.463), 1.566 (3.718) and -0.495 (-0.327), respectively. He concludes that "...monetary policy in the sense of interest rate policy does not seem to have caused fluctuations in the land price increase" (p. 25).

Yoshino (1993) considers a simple VAR model with the interest rate, real output, money supply, price level, exchange rate, share price and the land price as jointly endogenous variables. The model is estimated with quarterly data over the 1971-79 and 1980-92 sample periods. He argues that while both interest rates and money growth influenced land prices in the 1970s, money growth has since played the dominant role, perhaps reflecting the expansion of banking lending to real estate. Causality is difficult to determine, however, as land prices enter significantly in the interest rate (early sample period) and money supply equations (early and late sample periods). Only the interest rate appears to be a significant determinant of land prices, however, and only in the early sample period.[11]

Finally, Sato (1991) regresses land price growth on money (M2 + CDs) growth lagged two periods (the other regressors are one and two period lags of land price

[10]Similarly, Rose (1990) finds an inverse correlation between land value and interest rates, but the significance levels also vary greatly with model specification. The equation estimated is the land value index regressed (over the 1954-87 and 1969-87 sample periods) on per capita income, population and interest rates for the 6 largest cities, 134 smaller cities and the full sample of 140 cities.

[11]Specifically, the significance value of the F-statistic for the call rate (M2+CD growth) in the land price change equation is 0.001 (0.16) in the 1971 Q2-1979 Q4 sample and 0.89 (0.36) in the 1980 Q1-1992 Q1 sample. The signficance value for the land price in the call rate equation (money growth equation) is 0.04 (0.017) in the early sample and 0.91 (0.004) in the late sample period.

growth). With semi-annual data observations from 1962 Q1-1989 Q3, he finds that lagged money growth is positive (coefficient equal to 0.29) and significant (standard error equal to 0.11) in the land price inflation equation. Sato argues that land prices have followed predictable, counter-cyclical cycles with nominal GNP growth.[12]

These studies provide some evidence on the link between monetary policy and land prices, but on this point also fall short on several counts. As noted above, changes in interest rates or money growth rates are not always an appropriate proxy for the stance of monetary policy, reflecting the influence of both aggregate demand and supply disturbances. In addition, monetary impulses influence land prices not only through interest rates, but also through other channels such as real income and credit. A reduced form approach, which allows for more channels of monetary transmission would be preferable. A clear distinction should also be made between the effects of monetary disturbances on real land prices as opposed to nominal land prices. In sum, a direct connection between monetary disturbances and land prices, either real or nominal, has not been firmly established.

III. Statistical Contours

Identifying the link between monetary policy and asset price fluctuation is complicated by uncertainty over the appropriate indicator of monetary stance. The Bank of Japan uses several instruments for monetary control, and its emphasis on each has evolved over time in response to changes in the financial system and economic environment. The Bank also relies on a variety of indicators to judge the intermediate stance of policy, and the relative importance of these indicators similarly has changed over time.[13] Also, the measures themselves (money or interest rates) represent not only control variables but also are subject to other economic disturbances.

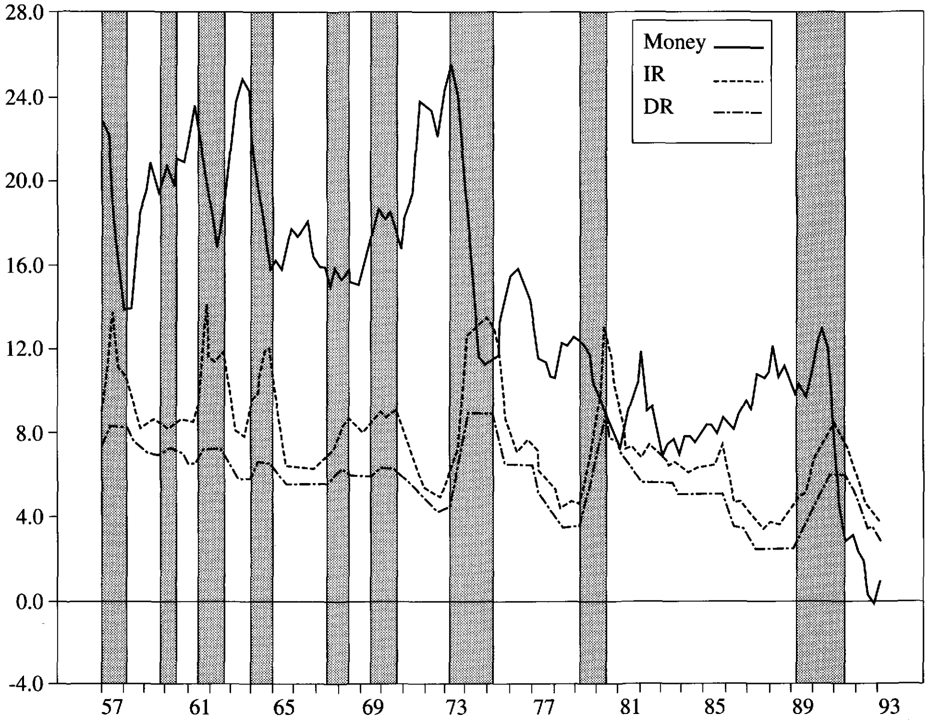
Nonetheless, the most common monetary indicators have followed similar patterns over the past four decades. Figure 1 shows the growth rate (over previous 4 quarters) of the money supply (M2+CDs), the interbank interest rate and the discount rate. The discount rate and the interbank interest rate are two of the primary operating instruments of the Bank of Japan, and the growth rate of the broad money supply is an important intermediate indicator of policy stance. The shaded areas reflect periods of rising discount rates.

Periods of rising discount and interbank interest rates have almost always preceded falling rates of money growth. Similarly, episodes of rapidly increasing money growth

[12]Sato's model is based on a dynamic form of the IS/LM framework where land enters as a fixed factor of production. His theoretical model suggests that agents will underpredict (overpredict) land price inflation when it is rising (falling).

[13]*See* Hutchison (1986, 1988) and Ito (1992) for descriptions of the changing nature of Bank of Japan operating procedures and indicators of monetary stance over the postwar period.

Figure 1
Monetary Indicators in Japan
Money Growth, Interbank Rate and Discount Rate



Note: Shaded areas indicate periods of rising discount rate

rates have almost always occurred during periods of declining discount and interbank interest rates. Using episodes of rising discount rates (shaded areas) to indicate monetary restraint, and episodes of falling discount rates (non-shaded areas) to indicate monetary ease, appears to be a reasonable summary measure of the stance of policy.

Figure 2 graphs the level (in logs) of Japanese land prices (LPALL: average of commercial, residential and industrial for all urban districts), stock prices (SP225: Nikkei Stock Average) and the general price level (GNPDEF: GNP deflator) against episodes of monetary restraint (shaded areas) and accommodation (non-shaded areas). Basic summary statistics are presented in Table 1. The table presents mean values, standard errors, minimum values and maximum values of the variables of interest (% changes from a year earlier).

Several features stand out from the figure and the table. First, the trend increase in land and equity prices has been much faster than the rise in the GNP price deflator. As a result, the relative price of land and equities (nominal values less the GNP deflator for goods and services) have grown at annual average rates of 6.4 and 5.9 %, respectively, between 1955-93. Second, the rapid climb in asset prices in the latter part of the 1980s was

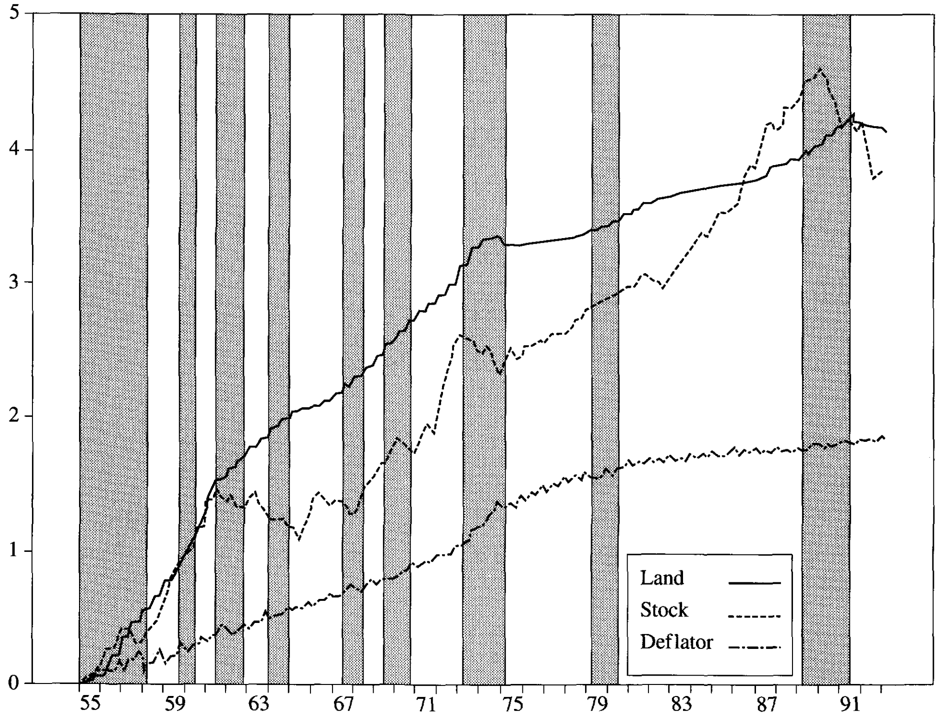
Table 1
Summary Statistics (Percent changes from a year earlier)

Series	Obs	Mean	Std Error	Minimum	Maximum
1956 1Q-1993 1Q					
GNPDEF	149	4.69	3.68	-3.68	19.20
RGNP	149	6.17	3.37	-1.57	14.86
M2CD	149	13.14	5.18	-0.25	22.70
SP225	149	10.27	18.82	-43.28	66.86
RSP225	149	5.58	19.39	-45.23	59.85
SPTOPIX	149	9.87	19.06	-45.45	66.13
RSPTOPIX	149	5.18	19.79	-47.40	59.12
LPALL	75	10.99	8.99	-5.69	35.31
RLPALL	75	6.35	8.33	-14.62	27.99
LPL6	75	12.81	13.33	-21.57	52.82
RLPL6	75	8.16	13.19	-23.26	44.66
1956 1Q-1969 4Q					
GNPDEF	56	5.16	2.46	-3.68	9.98
RGNP	56	9.22	2.49	4.34	14.86
M2CD	56	17.08	2.38	12.98	22.17
SP225	56	11.81	18.23	-20.93	44.91
RSP225	56	6.64	18.12	-26.64	37.36
SPTOPIX	56	10.87	17.17	-21.68	41.58
RSPTOPIX	56	5.70	17.22	-27.40	37.42
LPALL	28	17.64	7.80	4.65	35.31
RLPALL	28	12.49	7.44	-0.48	27.99
LPL6	28	19.13	13.13	1.83	52.82
RLPL6	28	13.97	12.58	-3.49	44.66
1970 1Q-1979 4Q					
GNPDEF	40	7.70	4.53	2.16	19.20
RGNP	40	5.09	3.10	-1.57	12.61
M2CD	40	14.83	4.11	9.70	22.70
SP225	40	11.67	17.56	-16.30	66.86
RSP225	40	3.96	19.80	-33.99	59.85
SPTOPIX	40	10.93	18.74	-20.82	66.13
RSPTOPIX	40	3.23	21.05	-38.15	59.12
LPALL	20	9.11	9.24	-5.51	28.38
RLPALL	20	1.41	8.45	-14.62	14.05
LPL6	20	9.13	10.30	-8.61	30.96
RLPL6	20	1.43	10.11	-18.79	17.58
1980 1Q-1989 4Q					
GNPDEF	40	1.90	1.49	-0.38	5.87
RGNP	40	3.97	1.17	2.16	6.56
M2CD	40	8.60	1.28	6.44	11.44
SP225	40	16.90	10.82	-8.98	40.13
RSP225	40	15.00	11.52	-10.92	40.52
SPTOPIX	40	17.40	12.66	-9.90	50.80
RSPTOPIX	40	15.50	13.23	-11.84	51.19
LPALL	20	5.95	2.60	2.63	10.08
RLPALL	20	4.04	2.72	0.45	10.23
LPL6	20	13.00	8.14	4.38	29.99
RLPL6	20	11.09	8.87	3.03	30.14
1990 1Q-1993 1Q					
GNPDEF	13	1.97	0.40	1.28	2.71
RGNP	13	3.15	1.83	0.07	5.64
M2CD	13	4.88	4.52	-0.25	12.11
SP225	13	-20.99	15.42	-43.28	11.03
RSP225	13	-22.96	15.26	-45.23	8.31
SPTOPIX	13	-20.86	15.70	-45.45	6.79
RSPTOPIX	13	-22.84	15.58	-47.40	4.08
LPALL	7	4.15	8.60	-5.69	15.05
RLPALL	7	2.47	8.05	-6.22	13.16
LPL6	7	-2.52	19.08	-21.57	26.26
RLPL6	7	-4.20	18.56	-23.26	23.68

GNPDEF = GNP Deflator
RGNP = Real GNP
M2CD = Broad money, M2+CD
SP225 = Nikkei 225 Stock Index
RSP225 = Nikkei Stock Index deflated by GNP Deflator
SPTOPIX = Tokyo Stock Price Index
RSPTOPIX = Tokyo Stock Price Index deflated by GNPDEF
LPALL = average Land Price in urban districts
RLPALL = average Land Price in urban districts deflated by GNPDEF
LPL6 = average Land Price in 6 Largest cities
RLPL6 = average Land Price in 6 Largest cities deflated by GNPDEF

*All data quarterly except for Land Prices (LPALL, RLPALL, LPL6, RLPL6), which are semiannual. The source for LPALL and LPL6 is the Japan Real Estate Institute. Other data are from the Bank of Japan data base. The Land Price is the average of commercial, industrial and residential land prices.

Figure 2
Asset Prices and The General Price Level
Nationwide Land Prices, SP225 and GNP Deflator



Note: Shaded areas indicate periods of rising discount rate

not unique: land and stock prices rose at a faster rate both in the late 1950s/early 1960s and in the early 1970s. For subsample periods shown in Table 1, land prices rose most rapidly during 1956-69 (17.6 % a.a.r.) and stock prices rose most rapidly during 1980-89 (16.9% a.a.r.). Third, the volatility of land and stock prices is much greater than the general price level, but stock prices are by far the most volatile. Over the full sample period, the standard errors of GNPDEF, SP225 and LPALL are 3.7, 18.8 and 9.0, respectively.

Fourth, important downward turning points in land and stock prices have centered around episodes of monetary restraint, but episodes of monetary restraint are not synonymous with falling asset prices. Land prices, in particular, have continued to rise during many periods of monetary restraint; indeed, significant declines were marked only in 1973-75 and 1991-93. Casual observation suggests that stock prices may be more sensitive to monetary conditions than land prices.

These summary statistics and graphs also suggest that the influence of trend inflation, and by implication monetary factors, may account for somewhat less than half of the trend increase in land and equity prices. The general price level was 6 times higher in

1993 than 1955 and over longer periods this should tend to increase land and equity prices by roughly similar amounts if long-run "neutrality" of inflation holds. However, since land and equity prices have grown much faster than the general price level, more than twice as fast on average over the 1955-93 period, other factors are seemingly at work.

Another indication that non-monetary factors are responsible for a significant fraction of the movement in land prices is that regional variation has been substantial. In the latter part of the 1980s, for example, the largest 6 urban areas grew at a much faster rate than smaller cities. Similarly, in certain areas with declining industries (Neuro, Yubari and Kamaishi), land prices declined in the latter 1980s (Bank of Japan, 1990, p. 75). Standard theory does not predict substantial regional variation in land price fluctuations associated with monetary factors.

IV. Model and Methodology

In this section we present a model designed to isolate and measure the influence of monetary factors, and more generally aggregate demand conditions, on land prices over the 1955-93 period. This allows us to more formally investigate the influence of monetary policy on the wide swings in land prices observed during the past four decades.

The multivariate system examined here is assumed to be driven by three fundamental types of disturbances: aggregate supply shocks, aggregate demand shocks, and market specific relative land price shocks. Our focus is on determining the relative importance of macroeconomic disturbances on land price movements, and estimating the dynamic effects of a given shock. In order to decompose the disturbances into their various components we must impose some restrictions on the multivariate dynamic system. Such identifying restrictions have taken a variety of forms in the recent literature. One approach achieves identification by imposing a priori restrictions on the contemporaneous interactions among the variables in the system. These restrictions normally take the form of exclusion restrictions, and in the context of VAR systems include the recursive structure popularized by Sims (1980) and the simultaneous equations approach used by Blanchard and Watson (1986), Bernanke (1986) and Walsh (1987).

An alternative approach to identification relies on restrictions on long-run effects implied by an underlying theoretical model. For example, long-run neutrality implies that aggregate demand disturbances should not have permanent effects on the levels of the real variables.[14] As shown by Blanchard and Quah (1989), this can be translated into a restriction on the dynamic system that may aid in the identification of model parameters.

[14]Variations in the stock of money generated via open market operations may be non-neutral due to the fiscal effects of the resulting changes in the government's interest payments (Sargent (1987)). We assume any such effects are of secondary importance empirically and view our assumption of long-run neutrality as a good approximation to the predictions of most theoretical frameworks in macro-economics.

We borrow from both these approaches to estimate sources of fluctuations in land prices.[15] The specific model can be represented by a $k \times 1$ vector of endogenous variables y_t (in this case a 3×1 vector comprising GNP, PRI and LAND) with Wold representation given by

$$y_t = B(L)\varepsilon_t, \tag{1}$$

where $B(L) = B_0 + B_1 L + B_2 L^2 + \ldots$ is a $k \times k$ matrix of polynomials in the lag operator L and ε_t is a $k \times 1$ vector of white noise disturbance terms. We assume that B_0 has 1's along its diagonal and that $E\varepsilon\varepsilon' = \Sigma_\varepsilon$ is a diagonal matrix. It will be convenient to define the diagonal matrix PP' such that $PP' = \Sigma_\varepsilon$; the diagonal elements of P are the standard errors of the elements of ε. The variables in y_t may be in the first difference form if necessary to ensure stationarity. The ε's are viewed as the fundamental structural disturbances, and we are interested in estimating the response of the elements of y to innovations in the elements of ε. For example, one element of ε represents the aggregate supply disturbance. We are interested in measuring the response of land prices arising from aggregate supply shocks and in their past contribution to total land price variation.

One way to summarize the sample information contained in our observations is to estimate the VAR representation of y_t:

$$H(L)y_t = u_t, \quad \text{where } H(O) = I.^{16} \tag{2}$$

Inverting the VAR representation yields $y_t = D(L)u_t$, where $D(L) = H(L)^{-1}$ and $D(O) = I$. In terms of equation (1), $D(L) = B(L)B(O)^{-1}$ and $u_t = B(O)\varepsilon_t$. Thus, in order to recover estimates of the structural disturbances, ε_t, from the estimated VAR residuals, u_t, it is necessary to estimate $B(O)$.

The covariance matrix of the VAR residuals, Σ_u, is related to $B(O)$ and Σ_ε by

$$\Sigma_u = B(O)\Sigma_\varepsilon B(O)' = B(O)PP'B(O)'. \tag{3}$$

We have $k(k+1)/2$ bits of sample information in Σ_u to estimate the k^2 unknown elements in $B(O)$ and P; in general, $k^2 - k(k+1)/2 = k(k-1)/2$ additional restrictions are required for identification.[17]

The lag polynomial $D(L)$ that is obtained by inverting the VAR representation is defined by

$$D(L)B(O) = B(L).$$

Since $D(L)$ may be estimated (it is just the lag polynomial obtained by estimating a standard VAR representation), a priori restrictions on $B(L)$ might allow $B(O)$ to be

[15]This technique has also been employed by Shapiro and Watson (1988), Judd and Trehan (1989) and Hutchison and Walsh (1992). Our methodology discussion draws heavily on Hutchison and Walsh.

[16]That is, $H(L) = H_1 L + \ldots$

[17]This is clearly an order condition and is only necessary, but not sufficient, for identification.

estimated. If $B(O)$ can be estimated, then estimates of the structural disturbances, ε_t, are given by $B(O)^{-1}u_t$, where u_t is the vector of VAR residuals.

As an example of the type of restrictions one might impose on $B(L)$, assume that economic theory implies that certain structural disturbances have no long-run impact on some elements of y. This imposes zero restrictions on the elements of $B(1)$. In this case, the restrictions imposed by

$$D(1)B(O) = B(1), \tag{5}$$

together with the restrictions implied by equation (3) may allow $B(O)$ to be estimated.

For the model we consider, the matrices in equation (3) are 3×3. Thus, $B(O)$ contains 6 unknown off diagonal elements while Σ_ε contains three unknown variances. The estimated VAR provides 6 bits of sample information (the number of unique elements in the 3 × 3 symmetric covariance matrix of the VAR residuals Σ_u). Three additional restrictions on $B(O)$ or $B(1)$ would be necessary to identify the remaining unknown elements of $B(O)$.

The model we estimate restricts the underlying joint moving average process in two ways. First, we assume that market-specific real land price shocks do not affect the macro economy, implying that $b_{13}(L)=b_{23}(L)=0$, where $b_{ij}(L)$ is the ijth element in $B(L)$. Second, we assume that aggregate demand shocks are neutral with respect to output and relative land prices in the long run. Evaluated at $L=1$, $B(L)$ gives the matrix of long-run multipliers ($B(1)=B_0+B_1+B_2+\ldots$). These two long-run restrictions therefore imply that $b_{12}(1)=0$ and $b_{32}(1)=0$. $B(1)$ in our model has the form

$$\begin{bmatrix} b_{11}(1) & 0 & 0 \\ b_{21}(1) & b_{22}(1) & 0 \\ b_{31}(1) & 0 & b_{33}(1) \end{bmatrix}. \tag{6}$$

We carry out our estimation using the two-step instrumental variable procedure suggested by Shapiro and Watson (1988). Once we have obtained consistent estimates of $B(O)$, and therefore ε_t, we report the properties of the moving average representation in terms of impulse response functions and variance decompositions.

V. Results

As a preliminary analysis, we test for the existence of nonstationarity in the log levels of the three variables of interest: real GNP, the GNP deflator and real land prices.

Table 2 reports Dickey-Fuller (Dickey, 1976) and Phillips-Perron (1986) statistics for testing that each variable contains a unit root. 4 lags were used in the Phillips-Perron tests. The "Levels" column presents tests on log levels of the base data and the "First Differences" column presents tests on the first difference of log levels. These statistics clearly reject the unit root null hypothesis for the data in first difference (log) form, but

Table 2

Unit root tests

						Levels	First Differences
Y	Dickey-Fuller	Test with	0	Lags	=	−3.98058	−205.22168
P	Dickey-Fuller	Test with	0	Lags	=	−1.47091	−262.73676
L	Dickey-Fuller	Test with	0	Lags	=	−3.04168	−43.35265
Y	Phillips-Perron	Test with	4	Lags	=	−2.10210	−155.11460
P	Phillips-Perron	Test with	4	Lags	=	−1.14752	−269.55516
L	Phillips-Perron	Test with	4	Lags	=	−3.21544	−57.34043

Y = Real GNP (log)
P = GNP Deflator (log)
L = Real Land Prices (log)

provide somewhat mixed results for the data in (log) level form.

We proceed therefore under the assumption that there exists a VAR representation in the first differences of the three variables. The model was estimated with 4 lags (two years using semiannual data) using the methodology described above. Using this approach we are able to identify three sources of disturbances: aggregate supply shocks, aggregate demand shocks and land-market specific shocks.

Before focusing on the determinants of land price fluctuations, we present in Figures 3 and 4 a check on the general plausibility of the model by considering the response of Japanese real GNP and price level to aggregate supply and demand shocks, respectively.[18] The aggregate supply disturbance considered is a one unit shock and its dynamic effects on both real GNP and the price level are consistent with standard theoretical predictions.

In particular, the positive aggregate supply shock causes an immediate 1 % rise in the level of real GNP which continues (at a reduced rate of increase) for several years before gradually levelling off at about 5%. The effect of the supply shock is to initially reduce the price level by about 1/2 – 1 %, but after about 1 1/2 years to gradually increase the price level so that the longer-term effect is to raise the price level by 1%. This could reflect a monetary response (reaction function) to an initially declining price level which "overcompensates" and causes a net increase.

The effects of aggregate demand shocks on real GNP and prices, shown in Figure 4, are also plausible. By construction (*i.e.* the long-run neutrality assumption which helps to identify the disturbances), the effect of the aggregate demand shock on the level of real

[18]The model is estimated in first differences but the impulse responses converted to levels for presentation purposes.

Figure 3
Dynamic Effects of Aggregate Supply Shocks
On Real GNP and Price Level

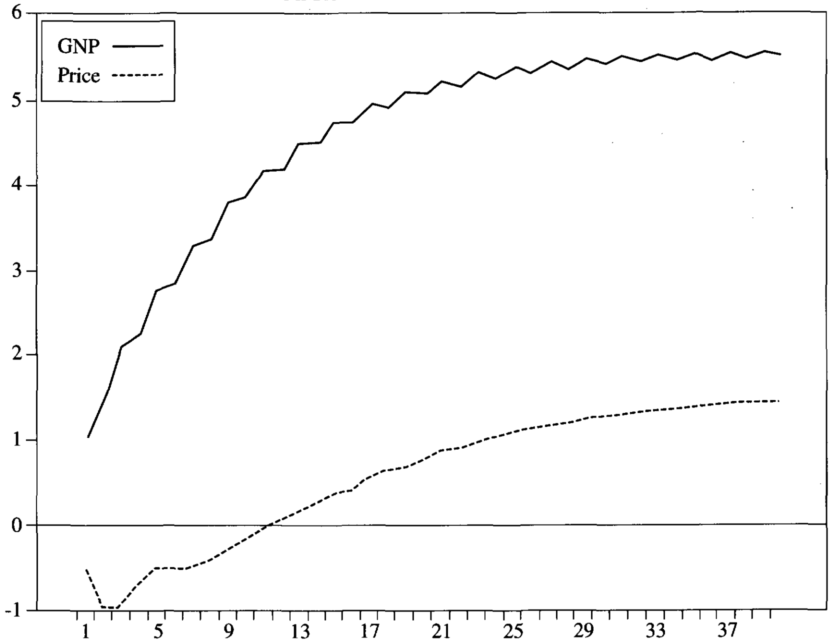
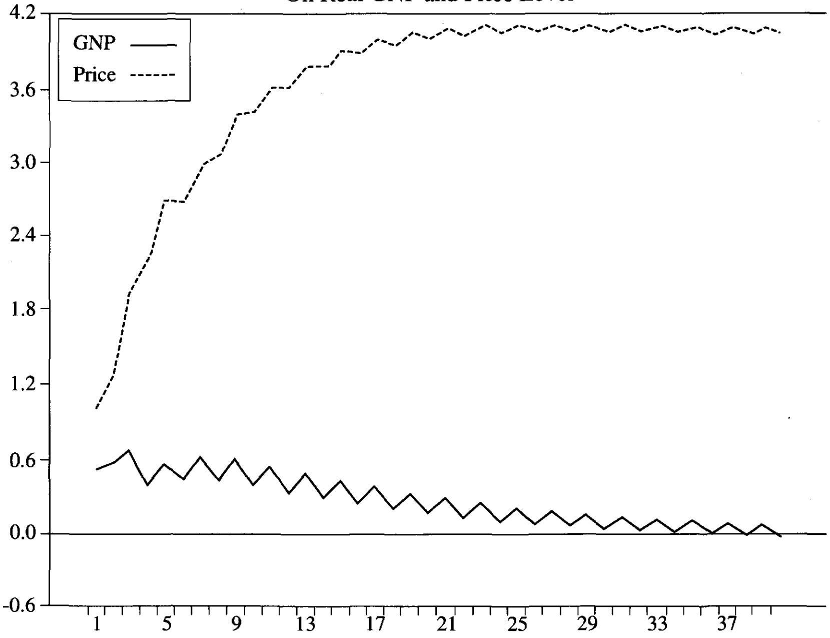


Figure 4
Dynamic Effects of Aggregate Demand Shocks
On Real GNP and Price Level



GNP eventually goes to zero. But the estimates indicate that the initial effect of the demand shock is to raise output by about 1/2 % and a considerable effect persists for a number of years.[19] The demand shock is estimated to raise prices by 1 % initially and continues to put upward pressure on the price level (at a reduced rate of increase) for several years. The total increase is about 4 %.

As a final check on the plausibility of the model at the macroeconomic level, we consider two episodes of slow or negative real GDP growth (1974-75 and 1986) to see if they were primarily attributable to the cumulative effects of contemporaneous and lagged demand or supply shocks. This "historical decomposition" (given in Table 3) asks what % of the real GDP change was forecast and divides the forecast error (unexpected weakness in real GNP) into supply and demand components.[20]

Following dual shocks of the Bretton Woods fixed exchange rate system collapse (February 1973) and the first oil shock (September 1973-March 1974), real GNP in Japan declined sharply in 1974 and the first half of 1975. The model estimates indicate that the cumulative unpredicted decline in real GDP during this period is 8.4 %; adverse supply shocks caused output to decline by 8.9 % and slightly positive demand shocks caused output to rise by 0.5 %.[21] This episode clearly follows the conventional wisdom about the dominance of supply shocks.

Following the sharp appreciation of the exchange rate, real GDP growth in 1986 is 2.9 % less than predicted. We estimate that past and current demand (supply) shocks dampened output growth in 1986 by 1.8 (1.1) %. The lion's share of the slowdown in growth is attributed to demand factors, reflecting conventional wisdom, but a sizable component is attributed to supply factors. This suggests that yen appreciation at the time (presumably the proximate cause of the real GDP slowdown) may reflect both demand and supply factors, where the latter encompasses all disturbances having a permanent effect on real output (*e.g.* high productivity growth in Japan relative to the US, new product development, and so on).

Given the plausibility of the model predictions at the macroeconomic level (*i.e.* aggregate supply and demand have the theoretically predicted dynamic effects on real output and prices, and the plausible historical decompositions), we now proceed to investigate the effects of these macroeconomic shocks, as well as market-specific shocks, on real and nominal land prices.

[19]The impact effects and the degree of persistence is unconstrained. The effect of the shock is only constrained to eventually go to zero at some indefinite point.

[20]Note that this is not the same as simply listing the contemporaneous supply and demand shocks. The historical decomposition is preferable because any given movement in real GDP is attributable to current as well as past supply and demand shocks. A demand contraction in the current period, for example, may not fully impact real GNP for several periods.

[21]Demand shocks (current and lagged) exerted a net positive effect on real GDP in 1974 (1.2 %) but a net negative effect in the first half of 1975 (- 0.7 %).

Table 3
Decomposition of Real GNP fluctuations
by Forecast values, Supply shocks and Demand shocks

Date	Real GNP	Forecast Real GNP	Error due to: Supply shock	Demand shock
1958:01	−0.1527	−0.1277	0.0015	−0.0266
58:02	0.2103	0.2061	−0.0033	0.0074
59:01	−0.1323	−0.1313	0.0012	−0.0022
59:02	0.2287	0.2010	0.0069	0.0207
60:01	−0.0997	−0.1297	0.0198	0.0101
60:02	0.2176	0.1940	0.0188	0.0047
61:01	−0.1039	−0.1251	0.0269	−0.0056
61:02	0.2098	0.1895	0.0168	0.0033
62:01	−0.1120	−0.1225	0.0164	−0.0059
62:02	0.1839	0.1826	0.0170	−0.0158
63:01	−0.1175	−0.1191	0.0000	0.0015
63:02	0.2101	0.1776	0.0173	0.0151
64:01	−0.0871	−0.1153	0.0178	0.0103
64:02	0.1805	0.1726	0.0151	−0.0071
65:01	−0.1244	−0.1117	−0.0009	−0.0118
65:02	0.1807	0.1678	0.0238	−0.0109
66:01	−0.0903	−0.1081	0.0025	0.0153
66:02	0.1961	0.1634	0.0230	0.0095
67:01	−0.0890	−0.1046	0.0136	0.0019
67:02	0.1912	0.1594	0.0373	−0.0055
68:01	−0.0810	−0.1012	0.0194	0.0008
68:02	0.1997	0.1557	0.0435	0.0004
69:01	−0.0740	−0.0980	0.0250	−0.0010
69:02	0.1793	0.1522	0.0267	0.0003
70:01	−0.0653	−0.0950	0.0282	0.0014
70:02	0.1486	0.1490	0.0008	−0.0011
71:01	−0.1054	−0.0921	−0.0019	−0.0113
71:02	0.1474	0.1460	0.0082	−0.0068
72:01	−0.0731	−0.0894	0.0068	0.0094
72:02	0.1588	0.1432	0.0009	0.0145
73:01	−0.0660	−0.0868	0.0067	0.0141
73:02	0.1231	0.1407	−0.0259	0.0083
74:01	−0.1333	−0.0845	−0.0529	0.0040
74:02	0.1269	0.1383	−0.0199	0.0086
75:01	−0.1058	−0.0822	−0.0161	−0.0073
75:02	0.1416	0.1361	0.0037	0.0017
76:01	−0.0922	−0.0801	−0.0128	0.0007
76:02	0.1266	0.1340	−0.0072	−0.0001
77:01	−0.0784	−0.0782	0.0045	−0.0048
77:02	0.1235	0.1321	−0.0105	0.0019
78:01	−0.0787	−0.0763	0.0010	−0.0034
78:02	0.1303	0.1304	0.0018	−0.0019
79:01	−0.0724	−0.0746	0.0110	−0.0088
79:02	0.1245	0.1287	−0.0003	−0.0038
80:01	−0.0846	−0.0730	−0.0051	−0.0064
80:02	0.1136	0.1272	−0.0195	0.0059
81:01	−0.0782	−0.0716	0.0007	−0.0073
81:02	0.1098	0.1258	−0.0170	0.0010
82:01	−0.0779	−0.0702	0.0038	−0.0116
82:02	0.1129	0.1244	−0.0112	−0.0002
83:01	−0.0858	−0.0689	−0.0058	−0.0110
83:02	0.1136	0.1232	−0.0125	0.0029
84:01	−0.0695	−0.0677	−0.0006	−0.0011
84:02	0.1103	0.1221	−0.0173	0.0055
85:01	−0.0622	−0.0666	0.0121	−0.0077
85:02	0.1148	0.1210	−0.0074	0.0012
86:01	−0.0880	−0.0656	−0.0130	−0.0094
86:02	0.1135	0.1200	−0.0044	−0.0020
87:01	−0.0786	−0.0646	−0.0075	−0.0064
87:02	0.1278	0.1191	0.0019	0.0067
88:01	−0.0652	−0.0637	−0.0004	−0.0010
88:02	0.1240	0.1182	0.0064	−0.0007
89:01	−0.0756	−0.0629	−0.0068	−0.0058
89:02	0.1215	0.1174	0.0014	0.0026
90:01	−0.0716	−0.0621	−0.0108	0.0013
90:02	0.1157	0.1167	−0.0007	−0.0003
91:01	−0.0683	−0.0614	−0.0068	0.0000
91:02	0.1013	0.1160	−0.0106	−0.0040
92:01	−0.0786	−0.0607	−0.0160	−0.0018

Real GNP is not seasonally adjusted. Semi-annual data is the average of quarterly data. Growth rates are the first difference of natural logarithms (of the semi-annual series).

Figure 5 (Figure 6) shows the response of nominal (real) land prices to aggregate supply and demand shocks. The estimates suggest that aggregate supply shocks, representing real increases in productive capacity and income, substantially increase asset prices, both in nominal and real terms. Most of the rise in land prices following a supply shock occurs within a three-year period, by which time land prices in nominal (real) terms increase by about 6 (7) %. The rate of increase slows considerably at that point, although land prices continue to increase at a reduced rate for a number of years before leveling off at about 12 % in nominal terms and 11 % in real terms.

Comparing these results with Figure 3, our estimates indicate that aggregate supply shocks ultimately raise real land prices by about twice as much as real GNP. This figure is the same order of magnitude as Ito (1993), who finds that a 1 % rise in real GNP leads to a 1.6 % rise in land prices. In our study, however, real GNP and land prices are endogenous variables, which in turn are determined by the fundamental disturbances.

The response of nominal land prices to aggregate demand shocks is substantially less than the estimated response to supply shocks. Of course, the long-run effect on real land prices is constrained to be zero, and hence the ultimate effect on nominal land prices simply reflects the rise in the general price level. However, the unconstrained short-run effect of the aggregate demand shock on land prices is also small in comparison with aggregate supply shocks. Specifically, nominal land prices (Figure 5) rise gradually following a demand shock until leveling off at about 4 %.

The model estimates suggest that real land prices decline in the short-run following a demand shock, indicating that the general price level rises faster than the nominal land price, but the response is not large and is fairly short lived. This result is also consistent with Ito (1993) who finds that high general price inflation tends to decrease the rate of land price growth after one year and hence, in our terms, lead to a fall in the real price of land.

These results suggest that a given aggregate demand shock, and by implication monetary shock, has a relatively modest effect on the real land price by comparison with a given supply shock. Nonetheless, the magnitude and frequency of aggregate demand and supply shocks could vary significantly. In this case, inferences about the contribution of these disturbances to the total variance of land prices cannot be directly uncovered from impulse response functions. To address this issue, we decompose the forecast error variance of land prices into its three separate component parts. This is shown in Table 4, where the upper panel represents nominal land prices and the lower panel real (relative) land prices.

The results in Table 4 indicate that relatively little of nominal or real land price variance is attributable to aggregate demand disturbances. By contrast, aggregate supply and land-market specific shocks account for around 90-95 % of the variance in nominal land prices (at all forecast horizons) and somewhat less of the variance in real land prices at short- to medium-term forecast horizons. This indicates the importance of

Figure 5
Response of Nominal Land Prices
To Aggregate Supply and Aggregate Demand Shocks

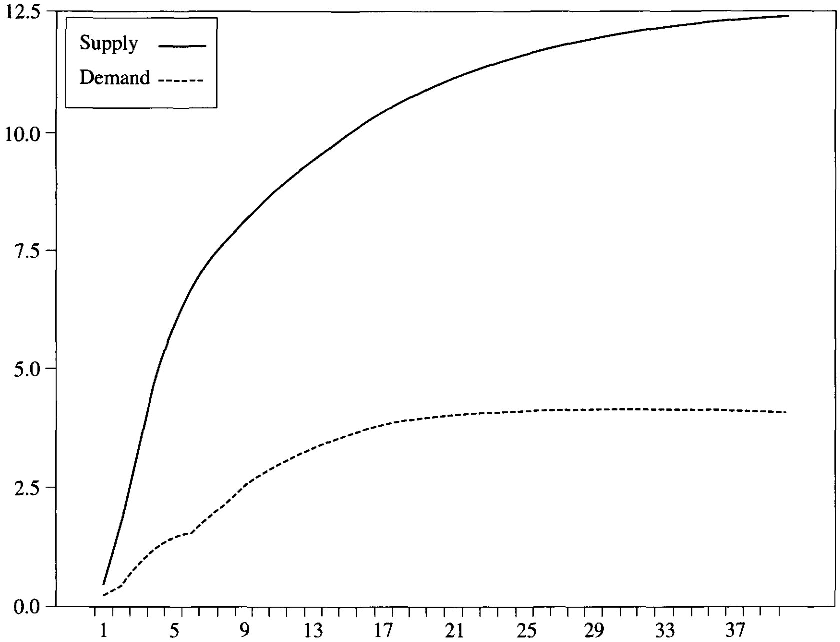


Figure 6
Response of Real Land Prices
To Aggregate Supply and Aggregate Demand Shocks

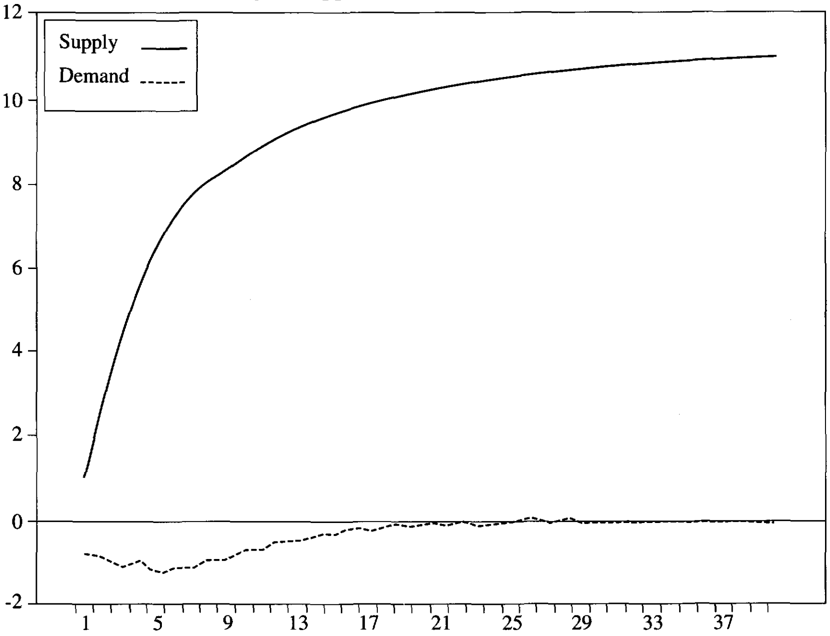


Table 4
Decomposition of variance for land prices

Periods ahead	Nominal land prices explained by: Aggregate supply	Aggregate demand	Market specific factors	Relative land prices explained by: Aggregate supply	Aggregate demand	Market specific factors
1	8.03	2.98	88.99	22.77	17.97	59.25
2	17.28	2.14	80.58	34.20	7.93	57.86
3	26.02	2.77	71.21	38.64	4.92	56.43
4	32.28	3.04	64.68	41.40	3.27	55.31
5	35.64	3.15	61.22	42.58	2.74	54.67
6	37.64	3.13	59.24	43.59	2.28	54.12
7	38.81	3.28	57.91	44.18	2.01	53.80
8	39.69	3.58	56.74	44.74	1.72	53.52
9	40.39	3.98	55.63	45.17	1.52	53.30
10	41.08	4.40	54.53	45.66	1.32	53.00
15	44.12	6.13	49.75	47.78	0.76	51.44
20	46.63	7.19	46.17	49.56	0.50	49.93
25	48.71	7.74	43.55	50.98	0.37	48.63
30	50.38	7.99	41.63	52.12	0.29	47.58
35	51.70	8.08	40.22	53.00	0.23	46.75
40	52.73	8.10	39.17	53.70	0.20	46.09

fundamental supply-side factors such as rapid productivity growth rates as well as land-market specific factors, including the possibility of speculative bubbles.

Specifically, the nominal land price variance decomposition indicates that aggregate supply shocks account for between 8-35 % of land price variance at short- to medium-term horizons (up to 3 years), but this increases to more than 50 % at longer-term horizons. Aggregate demand disturbances, by contrast, gradually rise from 2-3 % at short- to medium-term horizons to about 8 % at long-term horizons. Factors specific to the land market account for most of the short- to medium-term variance, between 60-90 %, and about 40 % of the long-term variance.

Similar results are obtained from the forecast error variance decomposition of real land prices. Depending on the forecast horizon, aggregate supply shocks account for around 20-50 % of the variance in real land prices. Aggregate demand shocks, however, account for a significant part of the very short-run variance (18 %) in real land prices. The % of real land price variance explained by aggregate demand shocks gradually falls, and by construction (an identifying restriction) goes to zero in the long run. Market specific factors explain about 60 % of the very short-run variance in real land prices, 50-55 % of the medium-term variance and 45 % of the long-term variance.

These results suggest that monetary factors have played a relatively small role in Japanese land price fluctuations. This is especially noteworthy because we have intentionally set up the model to allow monetary factors the largest possible role in explaining land prices within the context of the statistical model. That is, we have biased the tests in favor of rejecting the "no monetary effect" null hypothesis by not allowing land market specific shocks to influence the macroeconomic variables (real GNP and the price level). The covariance between the macroeconomic series and land prices is therefore entirely attributable to macroeconomic shocks.

Although somewhat unrealistic, this gives results which are more likely to indicate a large role for aggregate demand shocks and hence monetary policy. Since our aggregate demand measure includes both monetary and non-monetary demand factors, monetary disturbances alone are even less important than the limited effect found for the total aggregate demand component. However, statistical results are only as strong as the underlying model's assumptions: if some monetary disturbances have a permanent effect on real output, they are classified as supply shocks using this methodology. This misspecification of the disturbances would tend to understate the monetary influence on land prices.

VI. Conclusion

Several conclusions may be drawn from this study. Most important, we find little evidence that monetary factors have played a significant *systematic* role in land price fluctuations in Japan. The model indicates that a monetary stimulus, perhaps in the form of lower interest rates, raise nominal land prices but decrease real land prices in the short- to medium-term. The latter result obtains because a monetary shock feeds through faster to the general price level than the nominal land price. This finding is consistent with the large body of evidence indicating that inflation is associated with poor performance in other long-term asset markets, notably the real price of equity.

Second, we find that aggregate supply shocks and land-market specific disturbances dominate nominal and real land-price variance. Although our methodology is entirely different, this is consistent with studies finding a large role for high expected rent growth in Japan (in turn associated with high expected real growth rates combined with land-supply constraints). Our results indicate that a given aggregate supply disturbance causes a substantial rise in land prices over time. This strong response, combined with substantial aggregate supply shock variance, accounts for a major part of the variance in land prices.

Third, the most important factors moving nominal and real land prices in the short- to medium-term (1 to 5 years) are specific to that market and not macroeconomic in nature. We have identified a composite shock which is by construction independent of macroeconomic factors. These include changes in fundamental factors such as changes in tax laws and land-use policies, but also capture any speculative bubbles in the market. This research can not rule out short-term bubble elements, and the large short-term variance associated with land-market specific factors, relative to the long-term variance, indicates that they may be substantial.

Our methodology has attempted to identify the systematic effects of particular disturbances on land prices over the postwar period. Two important caveats should be noted in interpreting the results. Our identification of monetary disturbances relies on the assumption that monetary policy has no permanent effects on real output. If monetary policy has a first-order impact on the long-run real equilibrium of the economy,[22] then our methodology does not fully capture its effect on land prices (attributing it instead to aggregate supply disturbances). In addition, we can not rule out isolated episodes when monetary factors may have played a large role in land price movements such as the rapid rise in the 1980s.[23] Despite these caveats, at a minimum, our results shed doubt on the view that monetary factors are primarily responsible for the swings in Japanese land prices during the past four decades.

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[22]Most economists do not deny that monetary policy has some quantitatively small long-run effect on the real equilibrium of the economy (working through imperfections in credit markets, uncertainties in investment decisions, hysteresis effects, and so on). Most empirical evidence, however, suggests that monetary effects on real output dampen considerably after several years.

[23]However, the evidence suggesting a dominant monetary role during these episodes is not conclusive. Indeed, other factors such as financial and credit market liberalization, shifts in corporate flows of funds, strong economic growth and, perhaps, speculative activities, seemed to have played the most important roles.

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