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DETERMINANTS OF THE 1991-93 JAPANESE RECESSION: EVIDENCE FROM A STRUCTURAL MODEL OF THE JAPANESE ECONOMY

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ABSTRACT

The objectives of this paper are to determine the extent to which various factors contributed to the current recession in Japan and to assess whether the recent behavior of the Japanese economy differs from that in previous recessions. Toward that end, we develop a small, structural macroeconometric model of the Japanese economy and estimate it using data from 1971 Q1 through 1991 Q1, the period just prior to the recent downturn. The important results can be summarized as follows. First, the severity of the current recession probably does not reflect structural economic changes. Second, the poor economic performance in 1991-1993 period was to some extent predictable, reflecting the unwinding of imbalances that developed during the preceding expansion. Finally, unpredictable movements in exchange rates, land and stock prices occurring after 1991 played an important, but not predominant, part in accentuating the downturn, while unusually stimulative fiscal and monetary policies appear to have contributed substantially to GDP during the recession.

Determinants of the 1991-93 Japanese Recession: Evidence from a Structural Model of the Japanese Economy

Allan D. Brunner and Steven B. Kamin[1]

I. Introduction

The current recession in Japan is the deepest and longest since the early 1970s. From the official peak of the most recent expansion in early 1991 to the end of 1993, real GDP grew at an average annual rate of 0.7 percent (see Figure 1).[2] This falls well short of the 4 percent average annual growth rate over the past two decades, and it is exceeded in severity only by the negative growth rates experienced in the 1973-75 recession.

There are several factors that have been cited by economic analysts to explain the weakness in economic activity, many of them associated in one way or another with the unwinding of the economic expansion -- the so-called "bubble economy" -- of the late 1980s. The most widely-cited explanation is the collapse of asset prices in the early 1990s, which has been associated with reduced business and consumer confidence, declines in household wealth, corporate financial weakness, and severe non-performing loan problems at banks. In addition, the rapid build-up of the capital stock during the investment boom of the late 1980s has probably contributed to much of the recent weakness in investment. A third possible explanation is that the downturn was triggered by a tightening of monetary policy in 1989, which was designed to contain the swift rise in asset prices and economic activity at that time. Finally, the appreciation of the yen since 1990 has exerted downward economic pressure as well, but its effects probably

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[2] The trough of the most recent recession has not been officially designated. However, strong GDP growth in 1994 Q1 and a recent upturn in business confidence suggest that the recession may have ended in the 1993 Q4.

did not take hold until well after the recession started.

The exceptional depth and prolonged nature of the current downturn, along with unprecedented declines in asset prices and resultant financial problems, have also raised concerns that the current recession might differ fundamentally from previous downturns, perhaps reflecting significant structural changes in the Japanese economy. These concerns are reinforced by the relatively widespread incidence of the slowdown in economic activity. Unlike in previous recessions, both the private domestic and external sectors of the economy have been depressed, with government spending representing the sole source of strength in the last few years.

The primary objectives of this paper are to determine the extent to which various factors contributed to the current recession and to assess whether the recent behavior of the Japanese economy differs significantly from that in previous recessions. Toward that end, we develop a small, structural macroeconometric model of the Japanese economy and estimate it using data from 1971 Q1 through 1991 Q1, the period just prior to the current downturn. We then use the structural model to conduct several exercises. First, we calculate out-of-sample one-step-ahead forecast errors for each of the model's structural equations from 1991 Q2 through 1993 Q4. Assuming that the model equations are stable and have good predictive accuracy within the estimation period, the out-of-sample forecast errors can be used to gain a sense of which sectors of the economy may have undergone structural changes in recent years. Second, we use the model forecasts to gauge whether the recession was in any way predictable. That is, were there underlying economic forces at work that lead to the decrease in economic activity, or does the recession reflect unexpected developments in the Japanese economy.

Finally, we use the model to assess the relative importance of various factors in causing Japan's latest recession. In particular, we decompose the observed values of real GDP over the forecast period into three components -- an *exogenous* component, an *anticipated stochastic* component, and an *unanticipated stochastic* component. The exogenous component reflects constants, deterministic trends, and other variables exogenous to the model. The stochastic components are composed entirely of structural shocks to model equations, either shocks that were experienced prior to the recession and were working their way through the economy during the recession (anticipated) or shocks that were experienced during the recession itself (unanticipated).

The results of these analyses can be summarized as follows. First, the timing and the severity of the recent recession probably do not reflect structural changes in the Japanese economy. For nine of the model's twelve structural equations, one cannot reject the null hypothesis that the out-of-sample one-step-ahead forecast errors were drawn from the same distribution as the in-sample residuals. The only private-demand-type equation showing even marginal statistical evidence of instability over the last few years -- that for consumption -- on balance underpredicted rather than overpredicted consumption throughout most of the forecast period. On the other hand, the model predicts a rapid recovery in 1993 compared to the flat performance that actually occurred, suggesting that certain special factors may have inhibited spending in the latter phase of the recession and thereby contributed to its unusual duration.

Second, part of the poor performance in the Japanese economy in the 1991-1993 period was predictable, based on information available prior to the recession itself. This supports our view that the downturn did not reflect novel and unpredictable structural changes in the economy. It also suggests that the recession in part reflected the unwinding of various imbalances developed during the preceding expansion. Based on our model, we estimate that the erosion of factors keeping GDP above its trend during the expansion would, by itself, have accounted for about a 3/4 percent drop in GDP over 1991. Additionally, the drop in land and stock prices that occurred in 1990 probably exerted strong downward pressure on the economy during the subsequent initial phase of the recession.

Third, there were several unpredictable developments that exacerbated the decline in GDP during the 1991-1993 recession. Unpredictable movements in exchange rates, land and stock prices occurring after 1991 played an important, but not predominant, part in accentuating the downturn. The model predicted much, but not all, of the rise in the yen that took place over the forecast period. However, the model predicted little of the further decline in land and equity prices that followed the onset of the recession. This unexpected decline in asset prices, which we interpret as an overshooting of the market correction that occurred in 1990 and early 1991, served to lower aggregate demand and deepen the recession, although a downturn probably would have occurred in any event. In addition, negative shocks to consumption, investment and net exports during 1993 acted to prolong the recession.

Finally, there were several unexpected factors that worked to offset declines in economic activity. In particular, government spending grew much more quickly over the course of the recession than it would have based on its pattern over previous business cycles. Had government spending maintained its traditional relationship to the output gap, real GDP would have been 1-1/4 percent lower in 1993 and the recession considerably more severe. In addition, monetary policy was more stimulative than might have been expected, based on its behavior over previous business cycles; lower-than-predicted interest rates are estimated to have raised GDP by almost 3/4 percent in 1993. Finally, there is some evidence that positive consumption and investment shocks boosted GDP in 1991 and 1992. This result lends support to the view that, although these components were weak during the early phases of the recession, they were stronger than we would have expected given the deterioration in both household and corporate balance sheets during that time.

The paper is organized as follows. Section II briefly outlines various factors believed to have played a role in causing or deepening the 1991-93 recession. Section III describes our econometric model of the Japanese economy. Section IV analyses out-of-sample forecasts of the model to determine whether the behavior of the Japanese economy was predictable, and Section V describes how the model is used to decompose GDP into its various components in order to isolate some of the factors contributing to the current downturn. Section VI provides some concluding remarks.

II. Possible Causes of the Downturn

Unlike previous recessions in Japan, the 1991-93 downturn cannot be attributed to a single factor. Indeed, given the widespread incidence of the recent recession, more than one factor has likely operated to depress Japanese economic activity. This section of the paper reviews four widely cited causes of the 1991-93 downturn in Japan -- asset price deflation, excess physical capital, monetary policy, and the appreciation of the yen. The econometric evidence for these factors will be assessed in Section V.

Asset Price Deflation. As shown in Figure 2, the drop in stock and land prices in the early 1990s was considerably more pronounced than during any of Japan's previous post-war recessions. Importantly, it is necessary to determine whether these declines reflected a genuine change in the economic outlook of investors or an unwinding of speculative increases in asset prices during the "bubble economy" of the late 1980s. To the extent that asset price deflation merely reflected perceptions of excess capital or the impact of future yen appreciation on profitability, it is these latter factors that may be said to have depressed economic activity rather than the resultant asset price declines *per se*. On the other hand, to the extent that the declines represented a market correction, the crash might be expected to have exerted an independent effect on aggregate demand through various channels.

Most analyses of recent asset price movements in Japan appear to support the latter view -- for example, see Ueda (1990), French and Poterba (1991), the Economic Planning Agency (1991b, 1993), Noguchi (1993), and Ogawa and Kitasaka (1993). In that case, there are several ways in which asset price deflation could be expected to have influenced economic activity. First, the crash in stock and land prices probably had important psychological effects, depressing consumer, business and investor confidence. Second, diminished investor interest in equity markets made it costlier for firms to raise funds.

Third, the recent asset deflation probably had substantial wealth effects. That is, the decline in asset prices weakened the balance-sheet positions of households and firms -- raising debt/asset ratios and lowering net worth -- and caused these sectors to reduce consumption and investment. There is no consensus in the literature on the importance of asset price deflation to consumption. Dekle (1994) identified positive effects of land prices on consumption using cross-sectional prefecture data. In contrast, the Economic Planning Agency (1991b), using annual data, found that land prices do not affect consumption although financial wealth does. Regarding the recent downturn, Ito (1994) cited the role of wealth effects, but Noguchi (1993) and Schinasi and Hargraves (1992) argued that such wealth effects should have little impact, since households hold few stocks and rarely sell land. Although the financial condition of households did not deteriorate markedly, certain firms -- particularly smaller firms or those in real estate-related industries -- were weakened considerably as a consequence of heavy borrowing in the 1980s and the collapse of asset values in the 1990s; see the discussions of Ogawa and Kitasaka (1993) and the Economic Planning Agency (1993).

Finally, there may have been some disruptions in other financial markets as a result of the collapse of asset prices in the early 1990s. Several observers, including the Economic Planning Agency (1991b), Schinasi and Hargraves (1992), Ogawa and Kitasaka (1993), and

Mieno (1993), have noted that lower collateral values likely reduced firms' access to bank lending. Moreover, some analysts have further argued -- see Fries (1993) and Ito (1994) -- that the weakened financial condition of some nonfinancial corporations reduced their ability to service debt, causing a substantial number of bankruptcies and, possibly, reducing economic output.

In addition, these bankruptcies have lead to an increase in the share of nonperforming loans at banks. In combination with a reduction of capital due to asset price declines, this factor may have induced a tightening of credit, although the evidence in support of this hypothesis is inconclusive. Kim and Moreno (1994) identified a strong statistical relationship between stock prices and bank lending, although they failed to establish a direct link between bank balance sheets and bank lending. Okina and Sakuraba (1993) and Ito (1994) found somewhat more direct (although relatively weak) evidence supporting this hypothesis.

Excess Physical Capital. A substantial portion of the decline in growth since 1991 can be associated with a plunge in real private investment spending; see Mieno (1993) and OECD (1993). The drop in investment spending, shown as a percent of real GDP in the upper panel of Figure 3, in part reflects the consequences of the investment boom of the late 1980s, when low interest rates and soaring stock and real-estate prices lowered the cost of funds to firms. As a result, by the early 1990s the ratio of the private non-residential capital stock to potential GDP, shown in the lower panel of Figure 3, was well above its historical trend. An important question to ask is whether this excess capital stock contributed significantly to the recent fall in investment or, conversely, whether other factors (such as asset price deflation) have caused investment to fall relative to the capital stock.

Monetary Policy. Figure 4 indicates the path of nominal and real short-term interest rates over the past 2-1/2 decades. While it is difficult to assess causality, it is evident that the rise in asset prices during the "bubble economy" period, as well as a significant acceleration of output growth, took place contemporaneously with a marked loosening of monetary policy. Symmetrically, the collapse of asset prices in 1990 and the slowing of growth starting in early 1991 appear to be preceded by a sharp tightening of monetary policy beginning in 1989. This reversal of monetary policy could be a proximate cause of the subsequent recession. However, as monetary policy has loosened considerably since 1991, the prior tightening is unlikely to explain why the recession has been so deep and prolonged compared to previous downturns.

Yen Appreciation. The failure of net exports to play their traditional stabilizing role in this downturn largely reflects the appreciation of the yen. As shown by the dashed line in Figure 5, since its recent low point in 1990, the CPI-adjusted, bilateral-trade-weighted value of the yen has increased by almost 40 percent. Real net exports, the solid line, after rising through 1992 in response to the yen's earlier depreciation and a recession-induced decline in imports, began to turn down in early 1993 and have declined significantly since. This suggests that the rise in the yen, while not representing a proximate cause of the recession, certainly could have made it deeper than it would have been otherwise.

III. The Econometric Model

In order to assess the relative weight of the factors cited above, we developed a simple macroeconometric model of the Japanese economy. This section of the paper provides a summary overview of the model and its dynamic properties, and a more detailed description of the model is provided in a supplementary appendix. In analyzing the sources of Japan's recent downturn, the model has two distinct advantages relative to other macro models, such as the Japanese module in the EPA World Econometric Model -- Economic Planning Agency (1991a). First, our model focuses more attention on financial variables and relationships between those variables and economic activity than most other models. Second, our model is much more parsimonious and, therefore, better suited to our objective of identifying the sources of shocks to the Japanese economy.

<u>Structure and Estimation of the Model</u>

The model is essentially a structural error-correction model, permitting both long- and short-run relationships between model variables. It is comprised of 12 estimated behavioral equations and various additional identities, organized into four main blocs. The first bloc consists of equations determining the primary components of private aggregate demand -- consumption, investment, and net exports -- as well as various subsidiary equations determining explanatory variables for the primary expenditure components. The second bloc consists of an aggregate supply curve, relating inflation to aggregate output. The third bloc determines the primary instruments of government fiscal and monetary policy -- government expenditures and the nominal short-term interest rate. A final bloc determines the value of key asset prices in the economy -- the exchange rate, a stock market index, land prices, and long-term real interest rate.

The short- and long-term relationships embedded in the model's estimated equations are based on standard macroeconomic theory, amended as needed to take into account the special characteristics of the Japanese economy. Private consumption depends on household wealth in the long-run, and is influenced in the short-run by changes in disposable income, the expected real interest rate, and conditions in the labor market. The capital stock is cointegrated with the level of output, and net investment is influenced by the user cost of capital -- negatively due to changes in real long-term real interest rates and positively due to changes in the real price of land. Net exports are determined in the long-run by the real exchange rate and foreign and domestic output. Government spending responds counter-cyclically to movements in the output gap, while a monetary reaction function links the nominal short-term rate of interest positively to the level of inflation and to the gap between actual and potential output, and negatively to increases in the value of the yen. The value of the exchange rate is determined by the size of Japan's trade surplus and the Japan-U.S. real interest rate differential. Equations also are estimated for the long-term real interest rate, land prices, and stock prices, although these relations are less well-informed by economic theory.

Because theory is often uninformative about the dynamic adjustment of aggregate demand to shocks, most equations were estimated using a (loose) general-to-specific methodology to identify lag lengths for the explanatory variables. The equations were estimated using quarterly, seasonally adjusted data over the period from 1971 Q1 through 1991 Q1. The latter date represents the peak of the "bubble economy" surge in output growth, and hence excludes observations occurring during the subsequent downturn.

Model Performance

Measured against various criteria, the estimated model performs relatively well. First, the model's predicted responses to various shocks are reasonable, are generally consistent with economic theory, and tend to dampen out over time. Figure 6 presents the "impulse response functions" depicting the response of real GDP to one-standard-deviation shocks in each of the structural equations. As shown in the top panel, shocks to the main spending components raise the level of real GDP for about a year before the increase dampens down; the effects of a shock to investment wear off more rapidly, since increases in the capital stock sharply depress subsequent real investment. The middle panel indicates that GDP initially responds negatively to a shock to the real short-term interest rate, reflecting both its direct negative effect on consumption and to its indirect effect in depressing investment by lifting the long-term real interest rate. A shock to the inflation rate produces nearly an opposite GDP path, since the nominal interest rate responds less than proportionally to changes in inflation, thereby inducing opposite movements in the real interest rate. Finally, the bottom panel shows that GDP initially responds positively to unexpected increases in stock and land prices, but negatively to positive shocks in long-term real interest rates and to real exchange rate shocks.

Second, most of the equations in the model are relatively stable; that is, their forecasting performance does not break down outside the sample period. Table 1 presents the results of chi-square tests of the null hypothesis that the out-of-sample one-step-ahead forecast errors (from 1991 Q2 through 1993 Q4) are drawn from the same distribution as the in-sample residuals (from 1971 Q1 through 1991 Q1). Using a 5 percent confidence region, the null hypothesis can be rejected for 3 of the 12 estimated equations; these equations determined asset-based wealth, the real price of land, and the real stock market index. Of these, the instability of the stock and land price equations is not surprising, given the unprecedented nature of the price declines and the possibility that the crash was a market correction rather than a fundamental adjustment. The asset-based wealth equation relates capital gains on household wealth to changes in land and equity prices. While estimated, it does not represent a behavioral relation per se, but rather an approximation of the complex accounting relationships linking household wealth holdings to asset prices; it is understandable that the recent large movements in asset prices should reduce the accuracy of this approximation. Finally, the consumption function represents the only major demand relationship to exhibit even marginal evidence of structural instability; the hypothesis of stability can be rejected at the 9 percent significance level. As discussed below, however, the consumption function does not appear to shift consistently in a single direction during the forecast period.

Finally, the model exhibits surprisingly good dynamic stability. Charts 7a and 7b depict the actual and simulated path of various variables over the period 1985 Q1 through 1993 Q4; this time span includes both in-sample observations through 1991 Q1 and out-of-sample observations for the remainder of the simulation period. Notwithstanding the fact that the experiment involved a fully dynamic simulation starting in 1985, the simulated values of GDP exhibit no drift away from their actual value. As one would expect, however, the model does tend to underpredict growth during the bubble economy expansion from 1989 through 1991 and to overpredict growth during the subsequent recessionary period. This may be attributable to the model's failure to predict both the swift run-up in asset prices in the late 1980s and the crash in the 1990s. As shown on Figure 7b, because the TOPIX stock market index and the price of land were estimated to be relatively unresponsive to developments in the rest of the economy, the model projects relatively flat upward trends for the TOPIX and land prices, based on their history of strong growth throughout the estimation period. The predicted steady increases in asset prices, in turn, contribute to the predicted steady growth in output.

IV. Was the Recession Predictable?

We now turn to an analysis of the 1991-93 downturn in Japanese economic activity. The first issue that we address concerns whether the recession was in any way predictable. That is, was the recession the outcome of underlying forces at work before the economy turned down, or did the recession reflect unexpected developments or structural changes in the economy? Based on indications of our model's relative reliability, we used the model to compute dynamic forecasts over the period of the recession itself, from 1991 Q2 through 1993 Q4. We examine these forecast results in the remainder of this section. In the subsequent section, we will take a closer look at the sources of deviation between predicted and actual values of GDP.[3]

Figures 8a and 8b compare actual and predicted paths for the most important variables in the model for the period from 1991 Q2 through 1993 Q4. Based on these forecast results, several observations can be made. First, most aspects of Japan's most recent downturn do not appear to reflect unprecedented changes in the behavior of its economy, although the unprecedented duration of the downturn may have been unusual. Our model, based on parameters estimated over the period ending before the recession began, predicts a downturn that initially is sharper and deeper than the one that actually took place. The initial flattening of consumption was well predicted by the model, while the model predicts a somewhat sharper drop in investment spending initially than actually took place. Predicted net exports, shown in Figure 8a, rise more quickly than their actual value, perhaps because overall output is predicted to drop more than actually occurred initially.

In the last three quarters of 1993, predicted GDP grows well above actual. This deviation reflects predicted recoveries in consumption and investment that did not occur in actuality, as well as a plunge in actual net exports below its essentially flat predicted values in 1993. The fact that actual consumption and investment did not turn up as quickly as the model forecasts did could suggest that extraordinary factors, not captured by our model, restrained the economy from making the rapid recovery exhibited by most previous recessions in Japan. On the other hand, it should be cautioned that the three quarterly model errors under discussion are not sufficient to establish that the behavior of the economy has changed significantly.

Our second broad conclusion is that the recent decline in growth has taken place in the

[3] It is interesting to note that similar exercises have been conducted for the U.S. experience in 1990-91. Hall (1993) and Hansen and Prescott (1993) compared model forecasts with actual outcomes as we do in this section, while Blanchard (1993) used a structural VAR model to decompose forecast errors similar to our approach in the next section.

context of exceptionally strong government counter-cyclical policy. As shown in Figure 8a, actual government spending rose more rapidly than predicted, confirming our intuition that government spending was more counter-cyclically responsive in this downturn than in previous recessions. Monetary policy also appears to have been more counter-cyclically responsive than in previous downturns. Short-term interest rates, shown on Figure 8b, declined more rapidly than predicted, and, by the end of 1993, they were about 1-1/2 percentage points below their predicted level.

Third, the dramatic movements in asset prices that have taken place since 1990 are not well predicted by the model. As shown in Figure 8b, the real trade-weighted value of the yen is the best-predicted asset price, although it is not predicted to appreciate quite as much as actually occurred. Land prices are predicted to remain about flat over the forecast period. The predicted value of the TOPIX stock market index, after initially declining somewhat, bottoms out and recovers to well above its actual level. These considerations suggest that much of the movement in land and stock prices over the past three years has not been connected with fundamentals. Their paths more likely reflect the correction in the early 1990s of bubble-like behavior in the late 1980s, subsequently followed by an overcorrection (relative to the fundamentals) in 1992 and 1993.

In summary, based on the model's forecasts, it appears that at least part of the 1991-93 recession was predictable. However, the economy turned down more slowly and stayed depressed longer than historical relationships would have suggested. In the next section, ignoring the possibility of a structural change in the Japanese economy, we examine more closely the model forecasts and forecast errors in order to determine what made the 1991-93 recession different.

V. What Caused the Recession?

In this section of the paper, we attempt to assess the relative merits of several widely-cited causes of the 1991-93 economic downturn in Japan. We first describe a methodology for decomposing Japanese GDP into various components. This approach is analogous to the methods developed by Litterman (1981) and Doan, Litterman, and Sims (1984) for decomposing structural vector autoregressive (VAR) models. We then employ these methods to decompose Japanese GDP into components attributable to different shocks, thereby gauging the relative importance of these shocks.[4]

Methodology

As described in the introduction, we are interested in decomposing the model variables into three components: an *exogenous* component, an *anticipated stochastic* component, and an *unanticipated stochastic* component. The exogenous component consists of constants, deterministic trends, and other elements exogenous to the model; this component is essentially a long-range forecast similar to the ones shown in Figures 7a and 7b. By contrast, the stochastic components are due entirely to structural shocks to model equations, either shocks that were experienced prior to the recession and were working their way through the economy during the recession (anticipated) or shocks that were experienced during the recession itself (unanticipated).

Let X_{t+k} represent an nx1 vector of variables of interest. Using the structural model developed in Section III, X_{t+k} can be written in matrix form as follows:

$$A_0 \cdot X_{t+k} = G \cdot Z_{t+k} + A_1 \cdot X_{t+k-1} + A_2 \cdot X_{t+k-2} + \dots + \epsilon_{t+k} \qquad (1)$$

where Z_{t+k} represents a mx1 vector of exogenous variables, including constants, deterministic

[4] See West (1992) for a similar exercise based on a much smaller model of Japanese economic activity.

trends and other exogenous variables; G represents an nxm matrix of coefficients; A_i (i=0,p) represent nxn matrices containing the model's structural coefficients; and ε_{t+k} is a 12x1 vector of structural shocks (the one-step-ahead forecast errors) that are distributed with mean zero and variance-covariance Ω, a diagonal matrix.

The representation of X_{t+k} in equation (1) can be "inverted" to yield the moving-average representation:

$$\begin{aligned} X_{t+k} &= H_0 \cdot Z_{t+k} + H_1 \cdot Z_{t+k-1} + H_2 \cdot Z_{t+k-2} + \ldots \\ &+ C_0 \cdot \epsilon_{t+k} + C_1 \cdot \epsilon_{t+k-1} + C_2 \cdot \epsilon_{t+k-2} + \ldots \end{aligned} \tag{2}$$

where $H(L) = A(L)^{-1} \cdot G$ and $C(L) = A(L)^{-1}$. In other words, using the structure of the model, X_{t+k} can be written as the sum of an exogenous component (the Zs) and a linear combination of one-step-ahead forecast errors (the εs).

Now, consider the task of decomposing X_{t+k} as described earlier. X_{t+k} can be first be decomposed into an anticipated and an unanticipated component, based on information known at time t, as follows:

$$X_{t+k} = E_t X_{t+k} + FE_t(X_{t+k}) \tag{3}$$

where $E_t X_{t+k}$ denotes the predictable component of X_{t+k} and $FE_t(X_{t+k})$ represents the k-step-ahead forecast error for X_{t+k}, the unpredictable component of X_{t+k}. Using equation (2), $E_t X_{t+k}$ can be further decomposed as follows:

$$\begin{aligned} E_t X_{t+k} &= H_0 \cdot Z_{t+k} + H_1 \cdot Z_{t+k-1} + H_2 \cdot Z_{t+k+2} + \ldots. \\ &+ C_k \cdot \epsilon_t + C_{k+1} \cdot \epsilon_{t-1} + C_{k+2} \cdot \epsilon_{t-2} + \ldots. \end{aligned} \tag{4}$$

where the terms in the first line of equation (4) comprise the *exogenous* component of X_{t+k} and the terms in the second line comprise the *anticipated stochastic* component -- a linear combination of structural shocks that have hit the economy prior to the forecast date (dated t and earlier) and are working their way through the economy. Similarly, $FE_t(X_{t+k})$ can be written as a function of the one-step-ahead forecast errors that hit the economy subsequent to the forecast date (dated t+1 and later) and, therefore, comprise the *unanticipated stochastic* component:

$$FE_t(X_{t+k}) = C_0 \cdot \epsilon_{t+k} + C_1 \cdot \epsilon_{t+k+1} + \dots + C_{k-1} \cdot \epsilon_{t+1} \qquad (5)$$

Finally, it is often interesting to compute the portion of the stochastic components that can be attributed to a particular structural shock. For example, let $FE_t(X_{t+k})^{i,j}$ represent the portion of the k-step-ahead forecast error of the ith element of X_{t+k} that can be attributed to the jth element of ε_t (ε_t^j). Using equation (5), $FE_t(X_{t+k})^{i,j}$ can be calculated as follows:

$$FE_t(X_t)^{i,j} = C_0^{i,j} \cdot \epsilon_t^j + C_1^{i,j} \cdot \epsilon_{t-1}^j + \dots + C_{k-1}^{i,j} \cdot \epsilon_{t-k+1}^j \qquad (6)$$

where $C_m^{i,j}$ denotes the (i,j) element of C_m. A similar decomposition can be computed for the anticipated stochastic component using equation (4).

Decomposing GDP

Table 2 presents a decomposition of Japanese GDP during the 1991-93 period. Columns one and two of the table show the date and the actual values of GDP, respectively. Column three lists the model's forecast value for each period, which correspond to the values graphed in Figure 8a. This forecast, as described in equation (4), consists of an exogenous component plus an anticipated stochastic component, shown in columns four and five, respectively. The exogenous component, which consists of constants, deterministic trends, and other elements exogenous to the model, exhibits some initial variability before increasing steadily over the remainder of the forecast period. The anticipated stochastic component, which reflects the accumulation of shocks that occurred prior to 1991 Q2, is seen to be positive in 1991 and generally zero thereafter. This is, whatever shocks buffeted the economy prior to the economic downturn, their net effect on aggregate output was fully eroded by 1992 Q1, and the model's forecast for GDP thereafter largely consists only of the purely exogenous component. Note that the erosion of the anticipated stochastic component -- equal to about 3/4 percent of GDP in 1991 Q2 -- contributes to the forecast decline in output over 1991 and early 1992.[5] This lends support to the view that the recession was in part predictable and reflective of conditions that developed over the course of the preceding expansion.

Finally, the last column of Table 2 shows the unanticipated stochastic component of GDP for the forecast period, the component due to shocks that were experienced during the recession and, therefore, was unforecastable. As described in the previous section, these forecast errors are largely positive between 1991 Q3 and 1993 Q1, indicating that the model predicted a much quicker and deeper recession than actually occurred. By contrast, the forecast errors from 1993 Q2 through Q4 are negative as actual output fell below the forecasted values, suggesting that some factors (not included in the model) may have been operating to prolong the downturn.

While an examination of these components of GDP (or any other variable) can be informative, it does not reveal the ultimate source of movement in these components. For example, the GDP forecast errors may reflect shocks to any of the behavioral equations in the model. As illustrated in equation (6), these components can be decomposed into the contributing errors using the structure of the econometric model. Table 3 summarizes the results of such a decomposition for the forecast errors (the unanticipated stochastic components) of real Japanese

[5] While forecasted aggregate GDP returns to its exogenous (or trend) level by 1992, the gaps between forecasts and trend levels for the components of GDP -- not shown in Table 2 -- take much longer to close. Forecasted consumption and investment start out well above trend, while forecasted net exports starts out well below. Because these gaps largely offset each other, the anticipated stochastic component for GDP starts out relatively small and diminishes rapidly.

GDP.[6]

The first line of the table shows the decomposition of the unanticipated stochastic component (the average forecast error) in 1991, expressed as a percent of actual GDP. Our estimates indicate that actual GDP was 1.1 percent above its forecasted level during the last three quarters of 1991, reflecting effects of various shocks that occurred after 1991 Q1. Of this deviation, errors in the asset price equations contributed -.2 percent, errors in the consumption function contributed .3 percent, and so on.[7] Based on this decomposition, it is apparent that shocks to asset prices (land and stock values) and exchange rates were the only shocks consistently depressing output below its predicted value over the forecast period. The measured effect of these shocks on output is not great, but this in part reflects the fact that some of the deterioration in asset values was predicted; in particular, the rise of the yen was predicted moderately well. Additionally, the forecast exercise was started in 1991 Q1, after much of the decline in stock prices and some of the decline in land prices had already occurred; the lagged effects of these declines probably continued to depress output after 1991 Q1, but would not be reflected in the model's forecast errors. It is nevertheless true, however, that while the collapse of asset price was an important factor in the recession, Japanese growth probably would have slowed significantly even if asset prices had not fallen.

Second, echoing the conclusion voiced above, neither the fact that the recession occurred nor its severity appear to be attributable to significant changes in the economy's structure. None of the aggregate demand equations consistently exhibited negative errors -- that is, overpredicted

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[6] The relatively small size of the anticipated stochastic component of GDP makes its decomposition somewhat less interesting and, given the imprecision of our estimate, less easy to interpret.

[7] A few shocks did not make important contributions to forecast errors over the forecast period and were dropped from the analysis. As a result, the contributions shown may not sum exactly to the total forecast error.

spending -- over the course of the forecast period. Indeed, the decomposition indicates that unexpected strength in both consumption and investment boosted GDP in the early phases of the recession. Although some observers have frequently pointed to the weakness in these components as causes of the recession, others have been puzzled by their relative strength given the significant deterioration in household and corporate balance sheets in 1991 and 1992. Our results support the latter view given that shocks to these components in those years are estimated to have been positive.

Third, the prediction of output above its actual level in the final three quarters of 1993 most importantly reflects shocks to the investment equation, although consumption and net exports also exhibited negative shocks. It is possible that special factors not incorporated into the model may have inhibited investment more recently. These could be structural and long-lasting -- for example, due to the achievement of a capital-output ratio appropriate to a mature industrial economy after decades of high capital accumulation or to concerns that a permanently higher yen will restrict the future growth of the export sector. Alternatively, the decline in investment below predicted values could reflect more transitory factors such as the effect of recent political problems on business confidence or the impact of asset quality problems in the banking sector.

Fourth and finally, the decomposition analysis confirms that over the recession, government policy was more stimulative than its behavior in previous business cycles would lead one to predict. To begin with, government spending grew more rapidly than our fiscal reaction function would predict. This may have reflected the government's response to the unusually broad incidence of the downturn, as well as its association with unprecedented asset price declines and its spillover into financial sector problems. In any event, the acceleration in government spending relative to predicted growth is estimated to have caused output to be about

1-1/2 percent higher than it otherwise would have been in 1992 and 1993, thereby moderating the impact of the decline in private demand. Additionally, monetary policy was more stimulative than might have been expected, with downward shocks to the short-term nominal interest rate raising GDP by about 1/2 percent in 1992 and about 3/4 percent in 1993.

VI. Conclusion

The primary objectives of this paper were to determine the extent to which various factors contributed to the current recession and to assess whether the recent behavior of the Japanese economy differed significantly from that in previous recessions. Toward that end, we developed a small, structural macroeconometric model of the Japanese economy and estimated it using data from 1971 Q1 through 1991 Q1, the period just prior to the current downturn. We then used the structural model to conduct several exercises. First, we calculated out-of-sample one-step-ahead forecast errors for each of the model's structural equations from 1991:Q2 through 1993:Q4. In addition, we used the model to determine whether the recession was predictable, and to examine the relative importance of various factors in causing Japan's latest recession.

The results of this exercise can be summarized as follows. First, neither the timing nor the severity of the recent recession appear to reflect structural changes in the Japanese economy. For nine of the model's twelve structural equations, one cannot reject the null hypothesis that the out-of-sample one-step-ahead forecast errors were drawn from the same distribution as the in-sample residuals. The only private-demand-type equation showing even marginal statistical evidence of instability over the last few years -- that for consumption -- on balance under-predicted rather than overpredicted consumption throughout most of the forecast period. On the other hand, the model predicts a rapid recovery in 1993 compared to the flat performance that actually occurred, suggesting that certain special factors may have inhibited spending in the latter phase of the recession, thereby contributing to its unusual duration.

Second, part of the poor performance in the Japanese economy in the 1991-1993 period was predictable, suggesting both that the recession was in part the outcome of "normal" business cycle processes and that the origins of the downturn can be found in imbalances developed during the preceding expansion. Our estimates indicate that the "wearing off" of forces keeping GDP above its trend level through early 1991 probably contributed somewhat to the economy's weakness in 1991 and 1992. The lagged effects of the decline in asset prices during 1990 probably also helped to lower output in those years.

Third, there were several unpredictable developments that exacerbated the decline in GDP during the 1991-1993 recession. Unpredictable movements in exchange rates, land and stock prices played an important, but not predominant, part in accentuating the downturn. The model predicted much of the rise in the yen that took place over the forecast period, but much less of the decline in land and equity prices. The unexpected further decline in asset prices, which we interpret as reflecting an overcorrection, served to lower aggregate demand and deepen the recession, although a downturn would have occurred in any event. In addition, negative shocks to consumption, investment, and net exports during 1993 acted to prolong the recession.

Finally, there were several unexpected factors that worked to offset declines in economic activity. In particular, government spending grew much more quickly over the course of the recession than it would have based on its pattern over previous business cycles. Had government spending maintained its traditional relationship to the output gap, real GDP would have been 1-1/4 percent lower in 1993 and the recession more severe. In addition, short-term interest rates fell faster over the 1991-93 period than our model predicted; this more stimulative than normal stance is estimated to have added almost 3/4 percent to the level of GDP in 1993. Finally, there is some evidence that positive consumption and investment shocks boosted GDP in 1991 and

1992. This result lends support to the view that, although these components were weak during the early phases of the recession, they showed relative strength given the deterioration in both household and corporate balance sheets during that time.

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Table 1. χ^2 Tests for Equation Stability

Structural Equation	χ^2 Statistic	Significance Level
Consumption	17.5	.09
Investment	7.1	.79
Net Exports	7.9	.72
Government Spending	14.3	.21
Short-term Interest Rate	14.0	.23
Inflation	8.9	.63
Job-to-Applicant Ratio	8.3	.69
Asset-based Wealth	52.8	<.01
Real Long-term Interest Rate	11.6	.39
Real Exchange Rate	8.1	.71
Real Land Price	42.2	<.01
Real Stock Price	24.6	.01

Table 2. Decomposition of Japanese GDP, 1991-93
(per capita, millions of 1985 ¥)

Period (1)	Actual GDP (2)	Forecasted Value (3)	Exogenous Component (4)	Anticipated Stoch. Comp. (3)-(4)	Forecast Error (2)-(3)
1991:Q2	4.07	4.07	4.04	.03	.00
Q3	4.09	4.03	4.01	.02	.06
Q4	4.11	4.03	4.02	.01	.08
1992:Q1	4.12	4.03	4.03	.00	.09
Q2	4.10	4.00	4.00	.00	.10
Q3	4.08	4.04	4.04	.00	.04
Q4	4.06	4.04	4.04	.00	.02
1993:Q1	4.09	4.04	4.04	.00	.05
Q2	4.06	4.11	4.10	.01	-.05
Q3	4.06	4.14	4.13	.01	-.08
Q4	4.03	4.16	4.14	.02	-.13

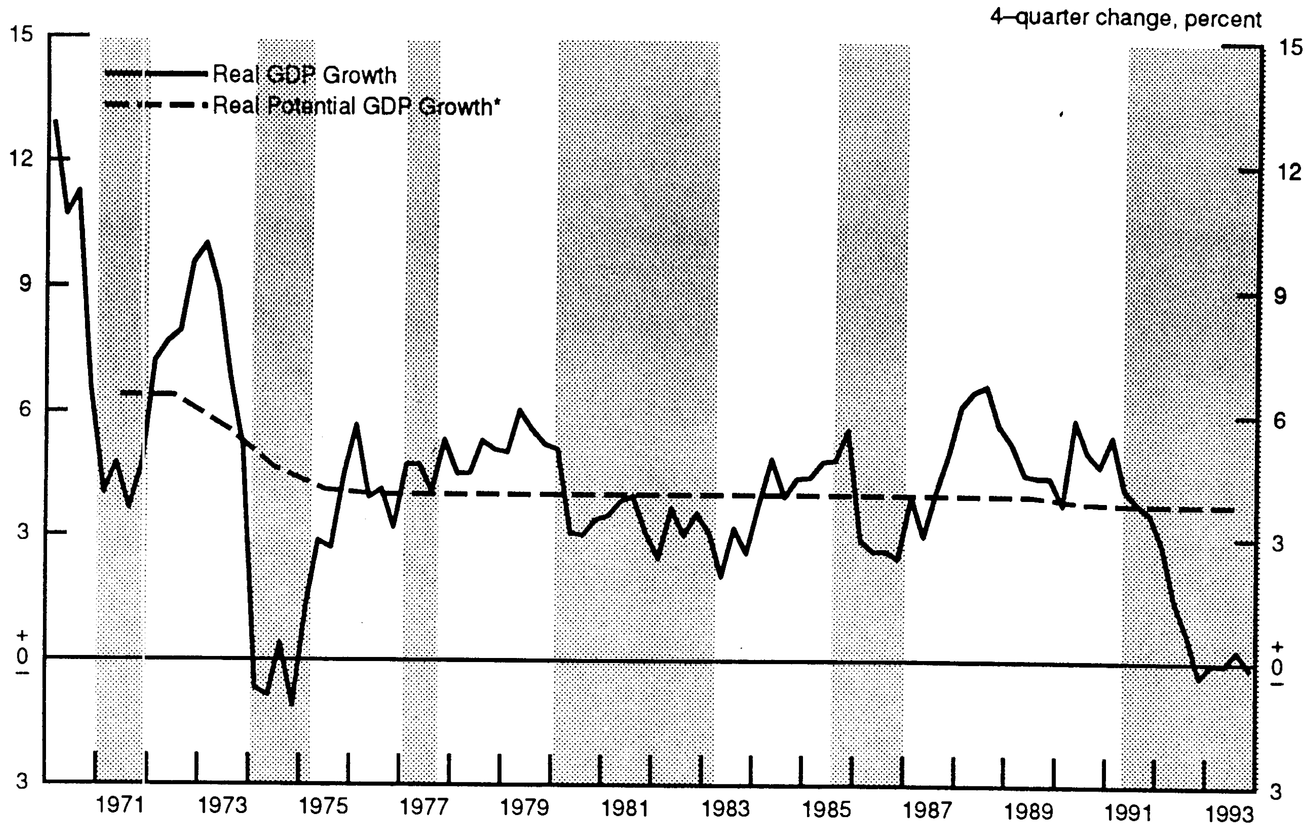
Note: Columns may not add due to rounding. The anticipated stochastic component is composed of shocks that occurred prior to 1991 Q2 and are working their way through the economy during the forecast period. The forecast error (unanticipated stochastic component) consists of shocks that occurred during the forecast period.

Table 3. Decomposition of Forecast Errors for Japanese GDP, 1991-93
(expressed as a percentage of actual GDP)

		Amount of Forecast Error Attributable to Shocks to:						
Period	Forecast Error	Asset Prices	Cons.	Inv.	Net Exports	Gov.	Nominal Short Rate	Exchange Rate
1991	1.1	-.2	.3	.8	-.2	.7	.1	.0
1992	1.6	-.7	.1	.2	.4	1.9	.5	-.3
1993	-1.1	-.4	-.3	-1.3	-.4	1.2	.7	-.5

Note: 1991 values are for 1991 Q2 through Q4, and "asset prices" category incorporates the effects of shocks to land and stock prices.

Figure 1. Real GDP Growth in Japan



* Based on authors' estimates and IMF, World Economic Outlook, October 1993.

Figure 2. Asset Prices

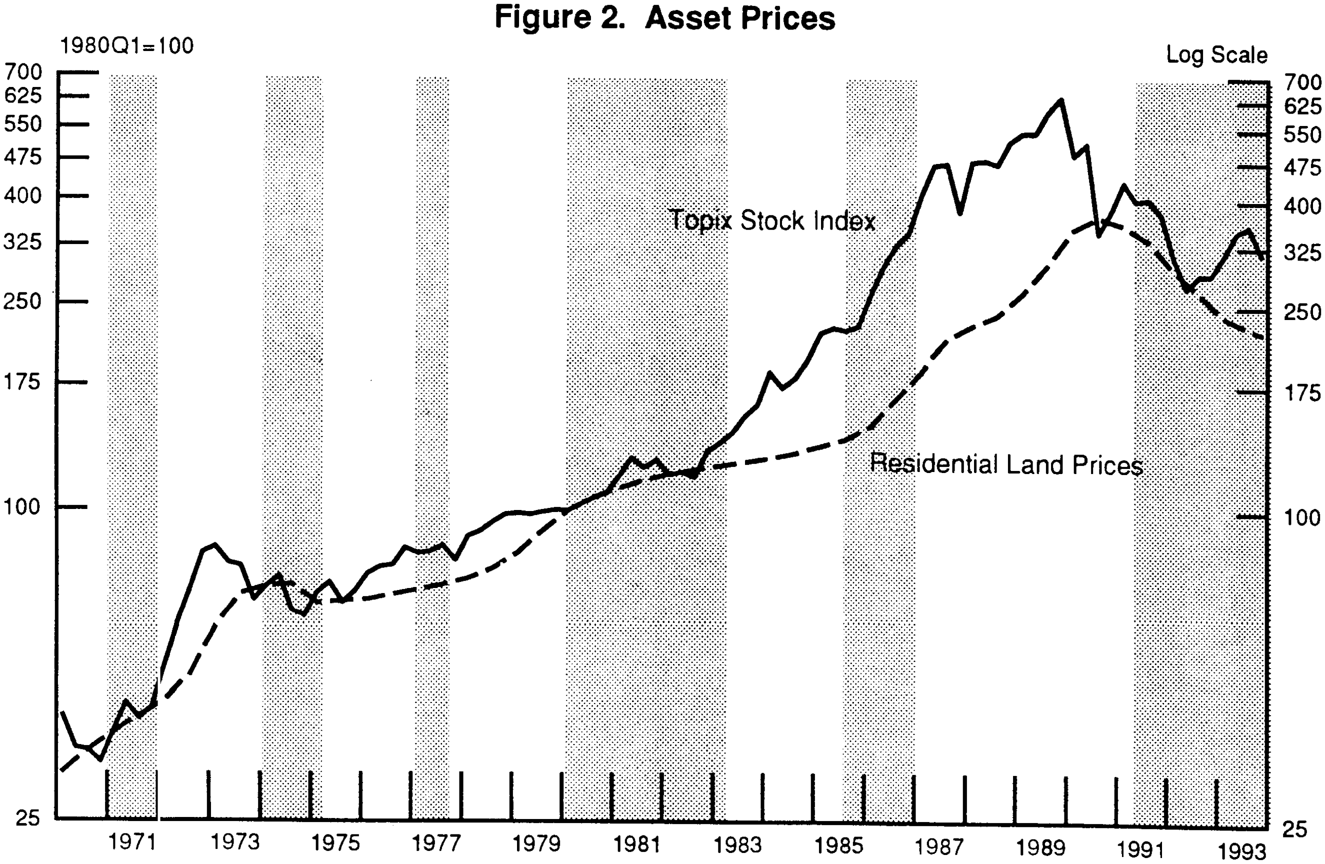


Figure 3. Trends in Private Investment Spending

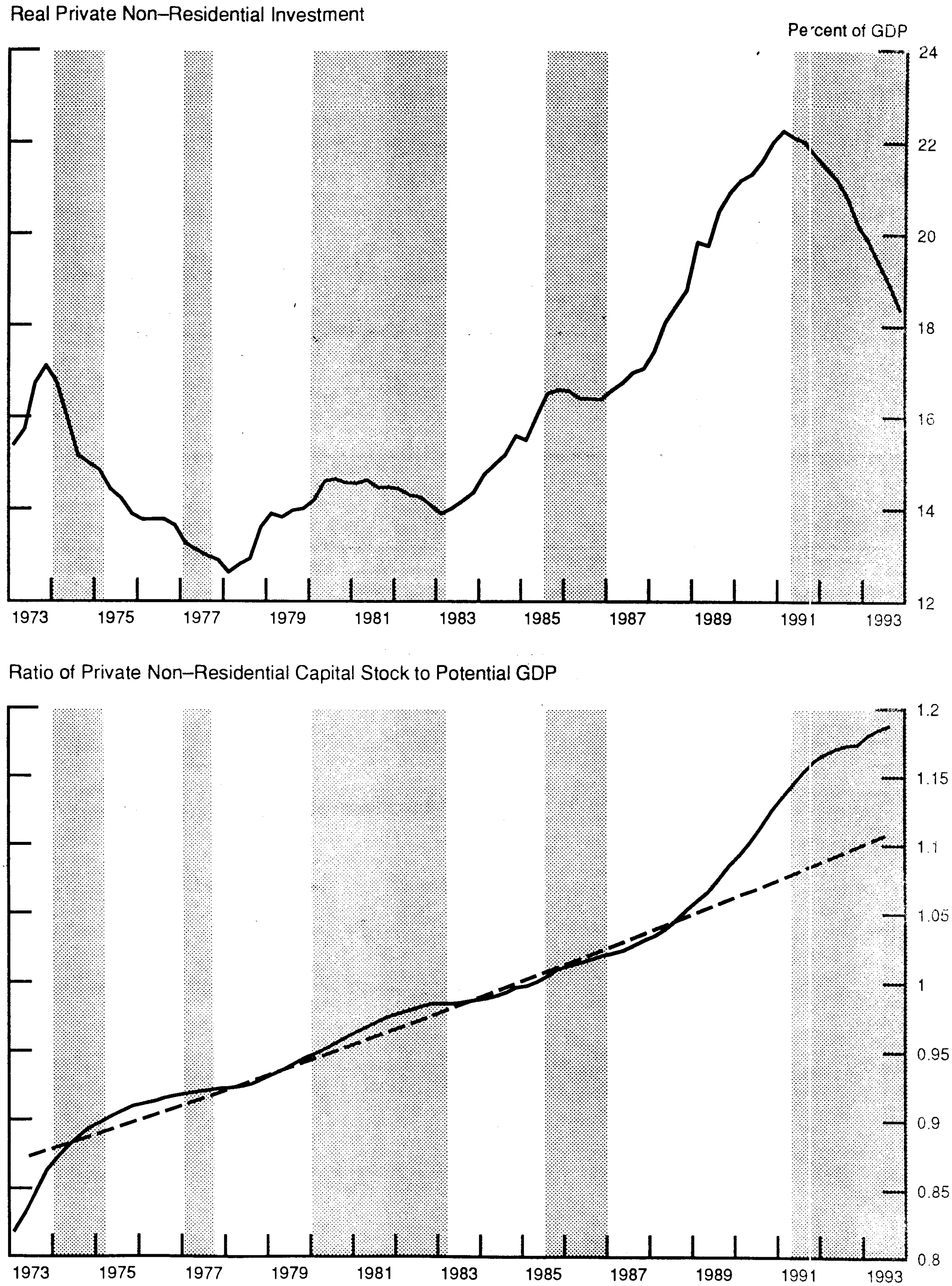
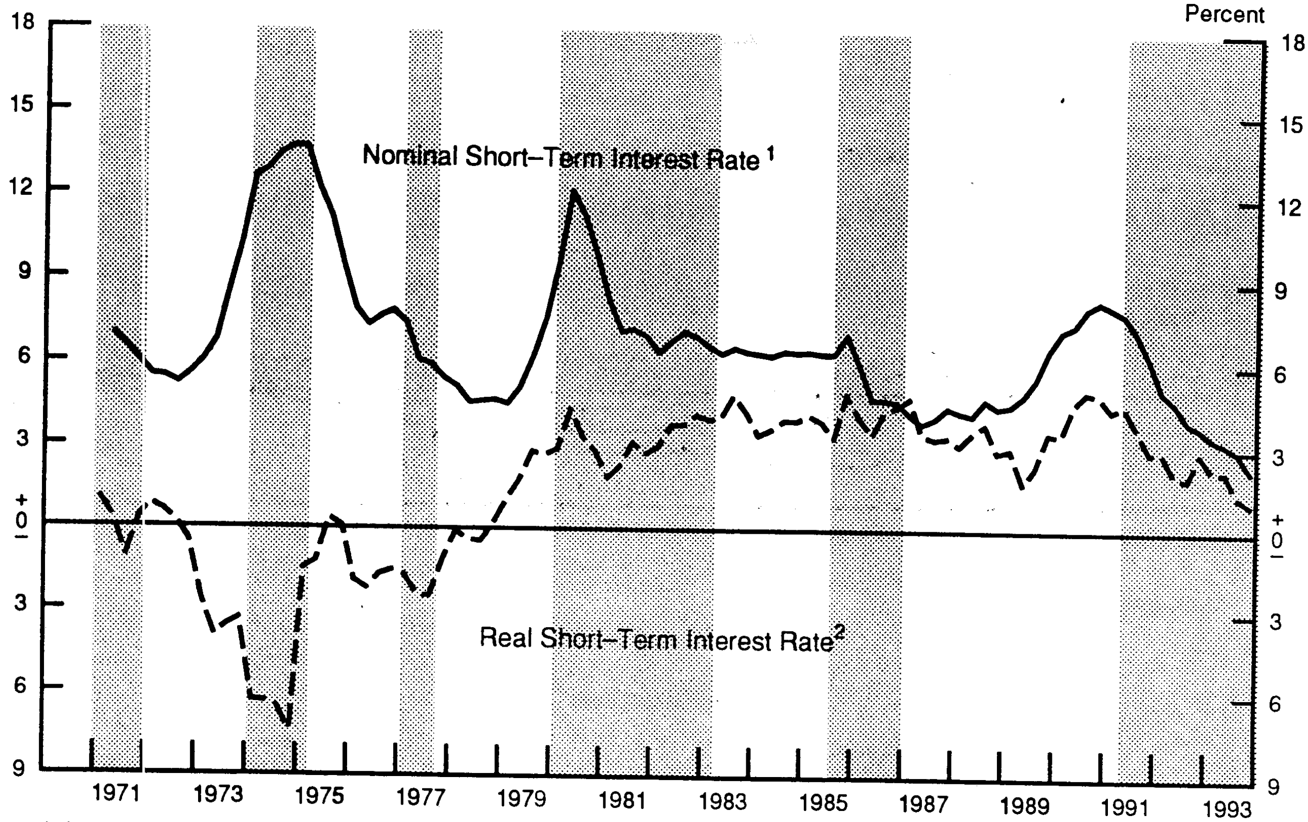


Figure 4. Measures of Monetary Conditions in Japan



1. 3–month CD rate 1984Q3–present, Gensaki rate 1979Q2–1984Q2, two month "ends" rate 1971Q1–1975Q1.
2. Nominal rate minus change in consumer prices over previous 12 months.

Figure 5. The Exchange Rate and Net Exports

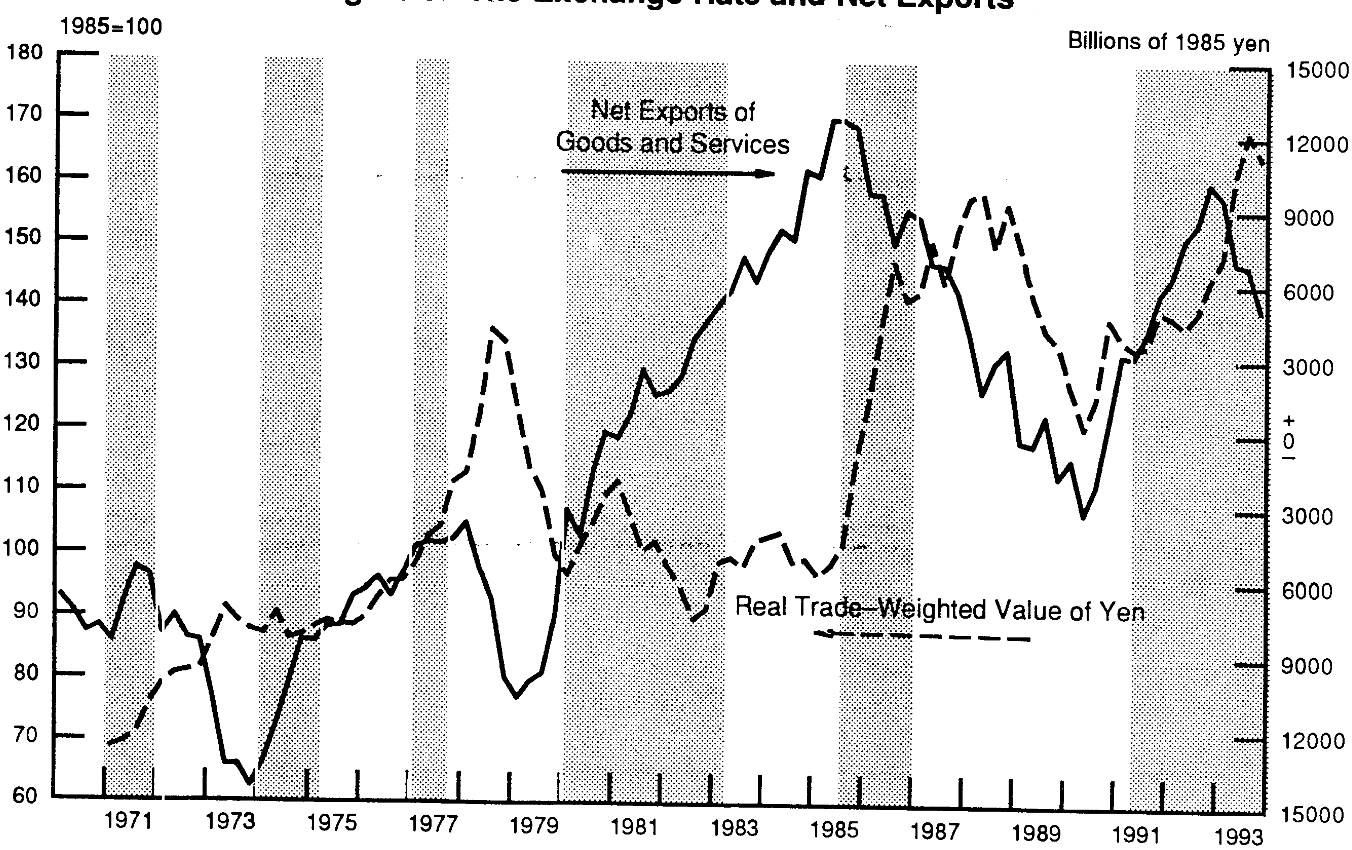


Figure 6. Response of GDP to Shocks

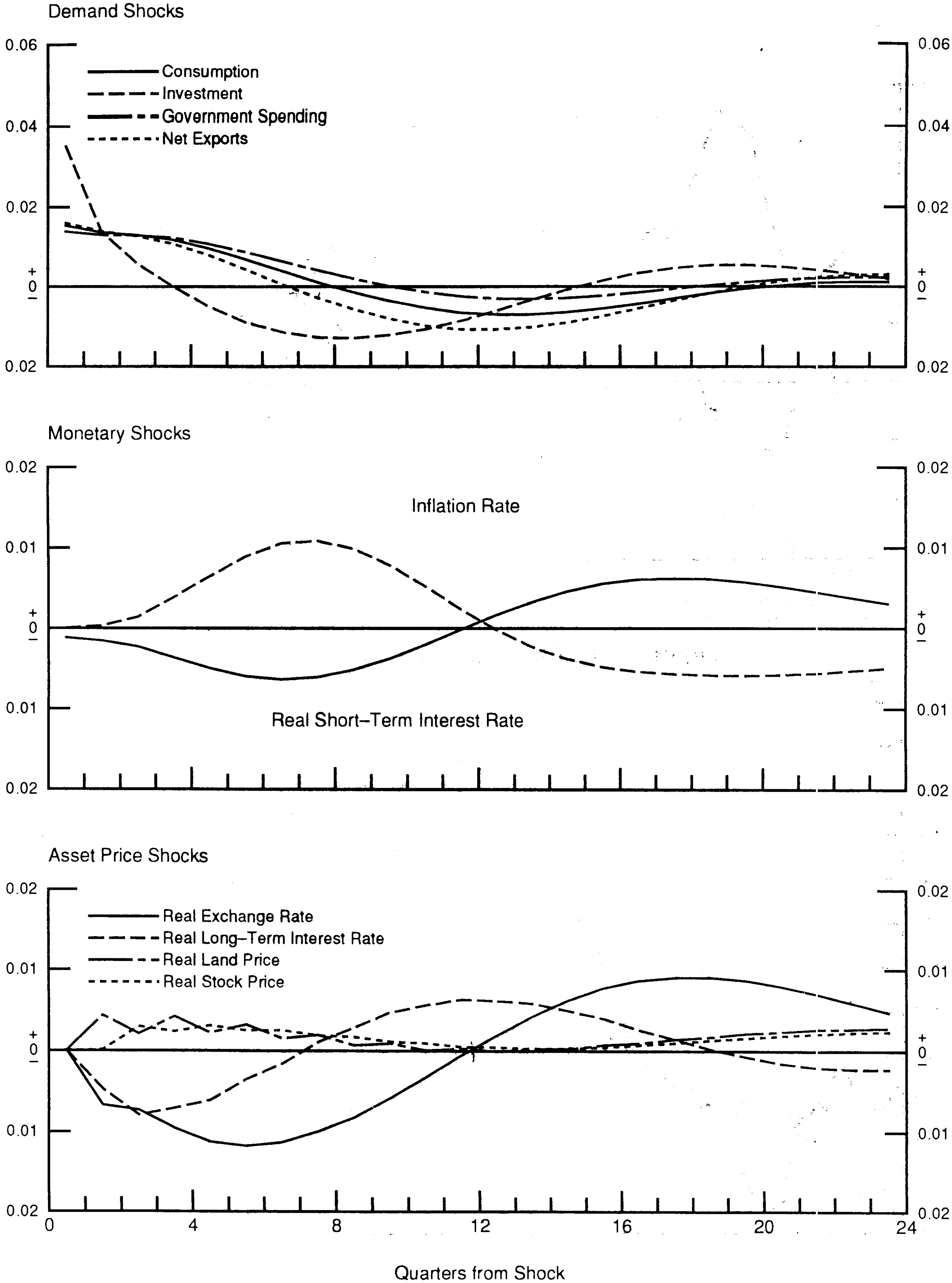
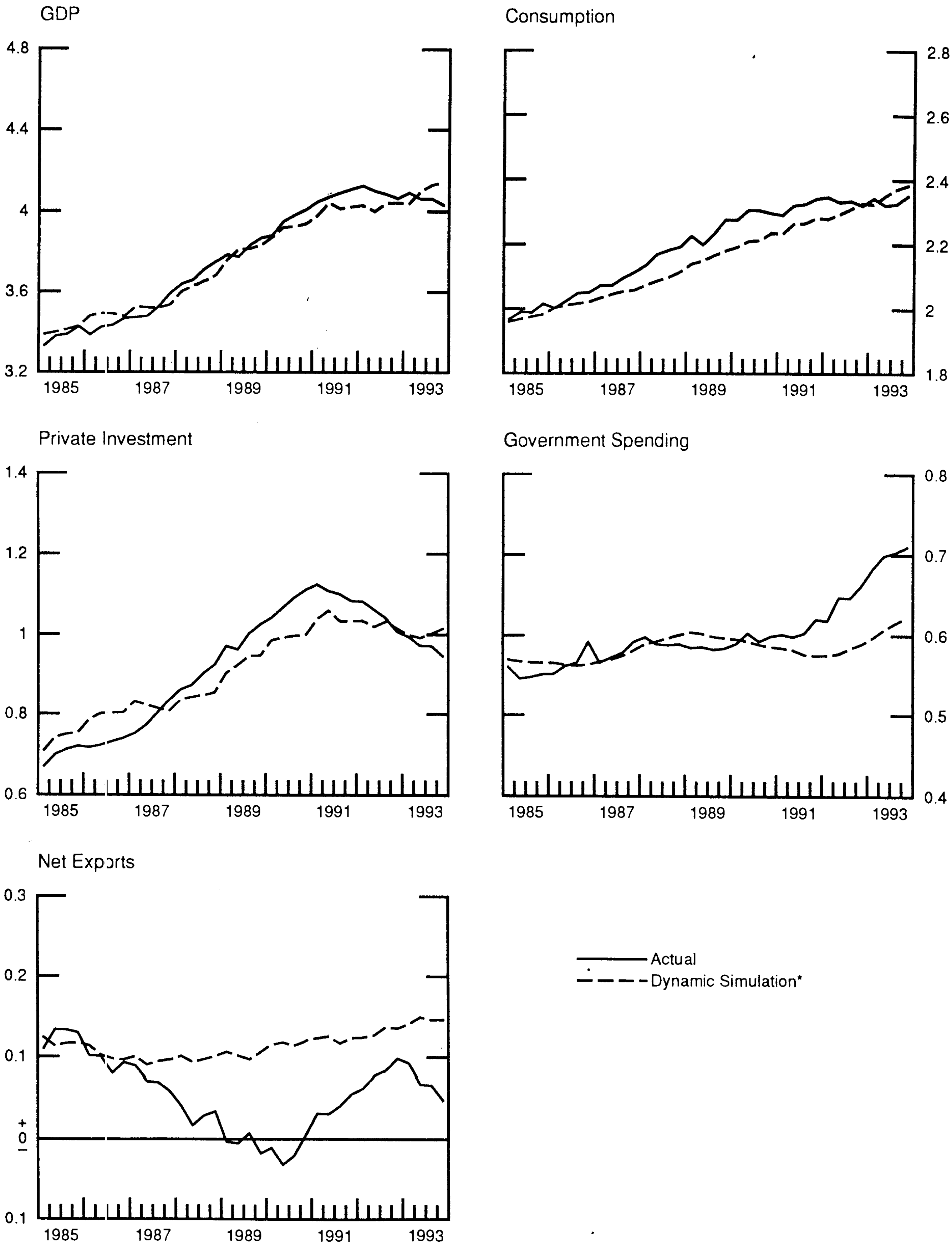


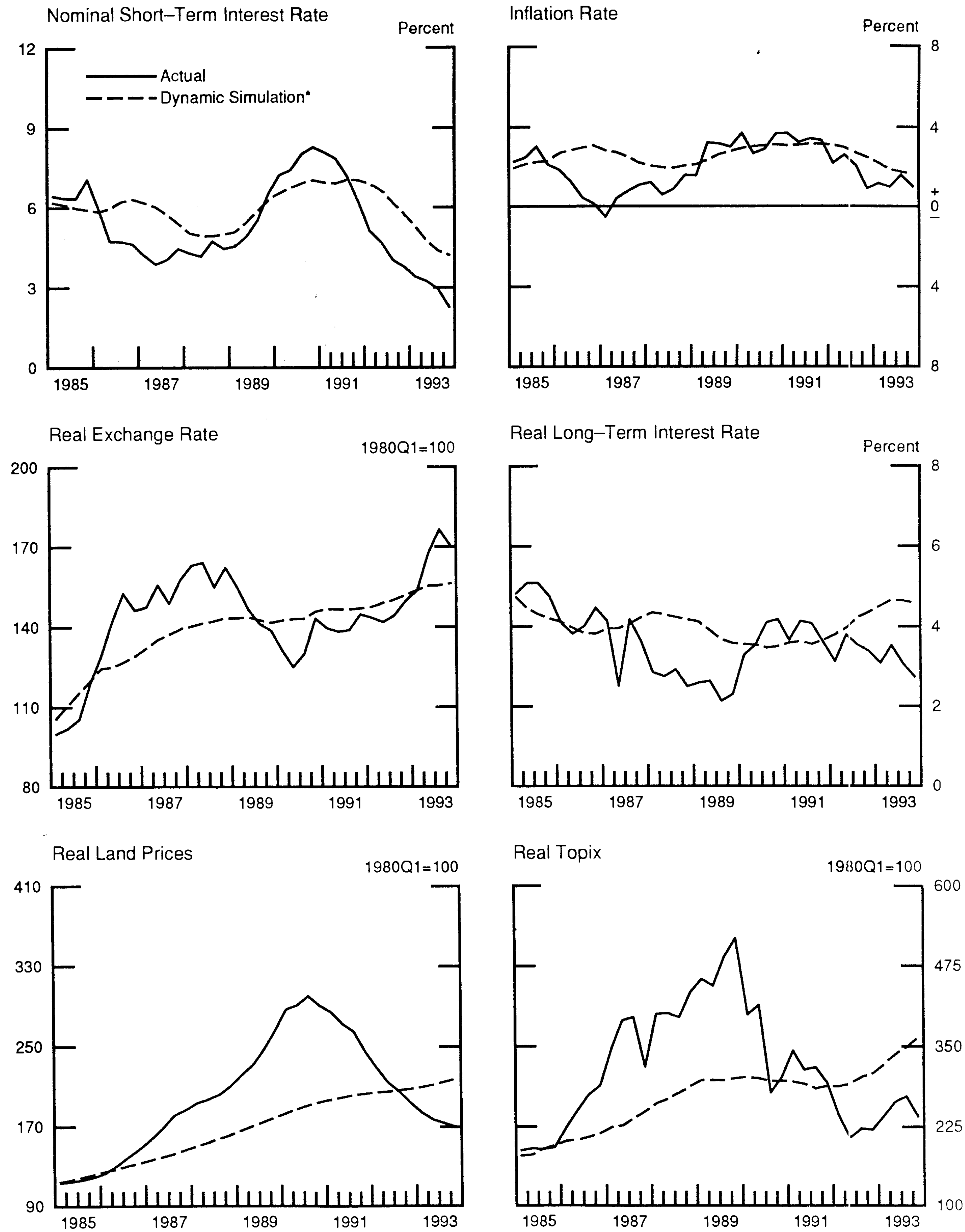
Figure 7A. Dynamic Simulations of Spending Components

(Millions of 1985 Yen per capita)



* Dynamic simulation starts in 1985Q1.

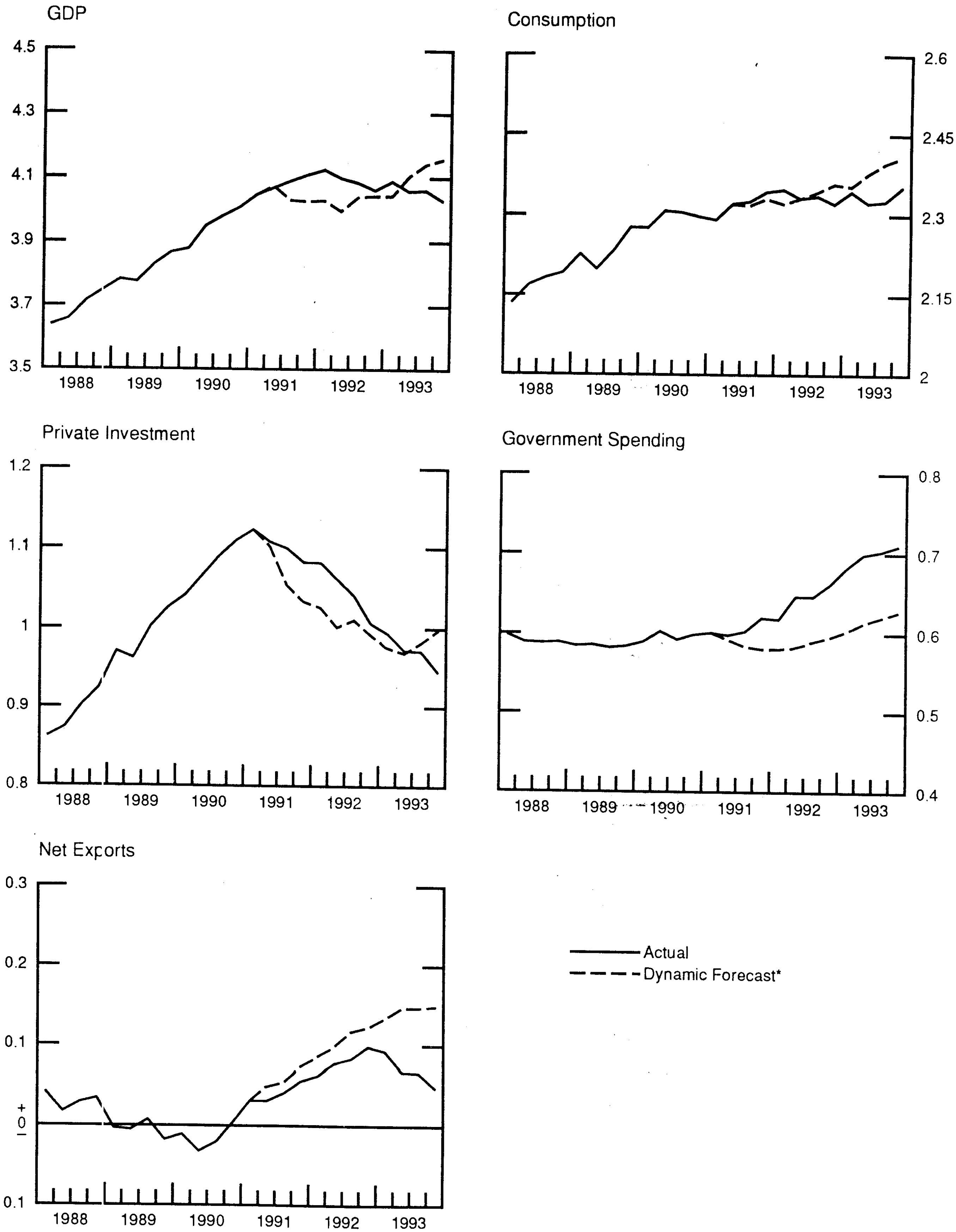
Figure 7B. Dynamic Simulations of Monetary Variables and Asset Prices



* Dynamic simulation starts in 1985Q1.

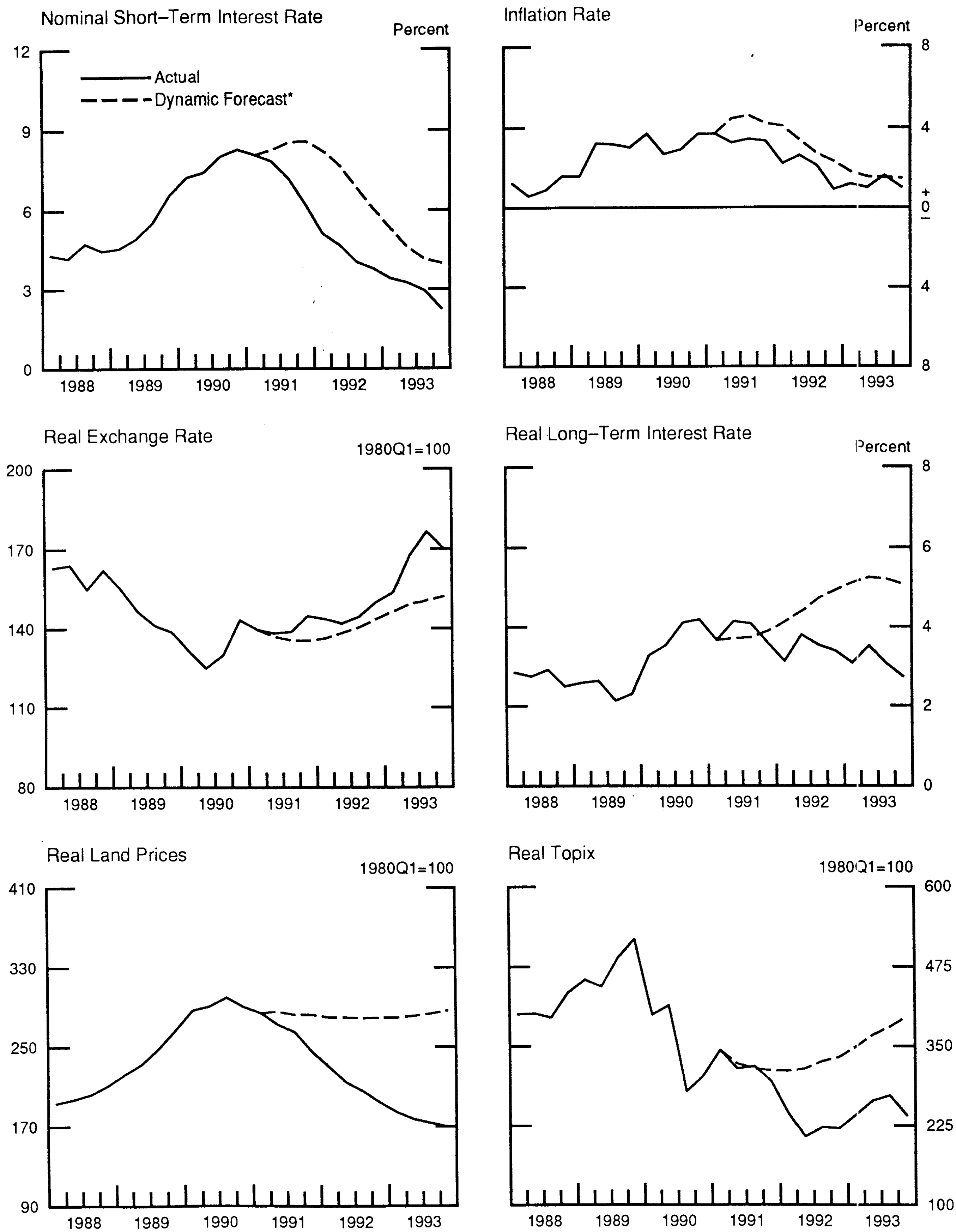
Figure 8A. Dynamic Forecasts of Spending Components

(Millions of 1985 Yen per capita)



* Dynamic forecast starts in 1991Q2.

Figure 8B. Dynamic Forecasts of Monetary Variables and Asset Prices



* Dynamic forecast starts in 1991Q2.

SUPPLEMENTAL APPENDIX

A Description of the Structural Econometric Model

This appendix provides a detailed discussion of the structural econometric model used in the paper, including a description of our data, our tests for long-run economic relationships, and the parameter estimates for our model equations.

Data Description

A list of the model variables is provided in Tables A1 and A2. The data extends from 1971:1 through 1993:4. In most cases, the data was obtained from the Bank of Japan's *Monthly Statistics*; the foreign income series (FGDP) and the trade-weighted yen (EXR) were constructed using data from Federal Reserve databases.

Time Series Properties of the Data

We investigated the time-series properties of the data using both Dickey-Fuller methods to test for the order of integration and Johansen-type methods to test for cointegration between nonstationary variables. The results of this exercise are summarized in Tables A3 and A4 and are discussed briefly in the following paragraphs.

The tests for integration are based on augmented Dickey-Fuller (ADF) test, where the first-difference of a variable (Δz_t) is regressed on its lagged level (z_{t-1}), on lagged first-differences, and (possibly) on a constant and a linear time trend as follows:

$$\Delta z_t = \mu + \tau \cdot TIME_t + \rho \cdot z_{t-1} + A(L) \cdot \Delta z_{t-1} + \epsilon_t$$

where L is the lag operator and $A(L) = A_0 + A_1 \cdot L + A_2 \cdot L^2 + ... + A_p \cdot L^p$, and where the null hypothesis is that $\rho=0$ (i.e., z_t is nonstationary). Table A3 presents ADF tests for the model variables, with variables listed in column one and the number of autoregressive lags (p) shown in column two. Columns three and four show the t-statistics for two ADF tests, a test that includes a constant term only (t_μ), and a test that includes both a constant and a time trend (t_τ).

The results for the macroeconomic variables indicate that the null hypothesis of a unit root cannot be rejected for most variables, although there is evidence that log GDP, log FGDP, and YD are trend stationary. In addition, ADF tests on the first-difference of these variables (not shown) reject the presence of two unit roots.

The tests for inflation and for nominal and real interest rates provide somewhat contradictory results. The nominal short rate and the inflation rate appear stationary. The results indicate that the real short rate, however, is nonstationary, although the real long rate is quite stationary. In addition, the cointegration tests, which will be discussed shortly, suggest that both the long and short real rates are stationary. Consequently, although these tests are somewhat open to interpretation, we will assume that these variables are stationary.

Finally, the ADF tests for the remaining asset prices (for land, equities, and foreign exchange) indicate that these variables are difference-stationary. Again, ADF tests on the first-differences of these variables (not shown) reject the presence of two unit roots.

The test for cointegration are based on the methods discussed in Johansen and Juselius (1990) and the asymptotic distributions provided by Osterwald-Lenum (1992). More specifically, for a nx1 vector of variables (z_t), we estimated the following regression:

$$\Delta z_t = \mu + \pi \cdot z_{t-1} + A(L) \cdot \Delta z_{t-1} + \epsilon_t$$

where π is an nxn matrix. The trace statistic was then used to establish the number of cointegrating vectors (r) in various subsystems; this statistic compares the null hypothesis of $r=r_0$ against the alternative r=n (i.e., all variables are stationary). The results of these tests are presented in Table A4. Column one lists the variables in each subsystem, the middle columns present the trace statistics for various hypotheses, and the last column shows the implied cointegrating vectors based on the test statistics.

Overall, the results suggest the presence of several cointegrating vectors in the Japanese data that are roughly consistent with economic theory. First, there appears to be a single cointegrating vector between consumption and household wealth. Second, the capital stock and output are also indicated to be cointegrated; the real long rate is shown to be stationary and does not enter the cointegrating vector. With respect to net exports, there also appears to be one cointegrating relationship between net exports, domestic and foreign output, and the real exchange rate. Interestingly, in a bivariate system with long and short rates, one can reject both the null hypothesis of zero cointegrating vectors (at the one percent level) and one cointegrating vector (at the ten percent level). This lends some support to our assumption that these variables are stationary. Finally, although we find strong evidence of a cointegrating relationship between stock and land prices, this relationship falls apart when we include other covariates such as those included in equations (11) and (12) discussed below. As a consequence, we do not include such a vector in our econometric model.

Model Estimation

The econometric model consists of 12 structural equations -- equations (1) through (12) below -- and several identities. In most cases, the structural equations were estimated in error-correction form, with differences of the endogenous variable regressed both on lagged levels of that variable and other explanatory variables -- the cointegrating relationship -- and on differences of other explanatory variables -- the dynamic relationships. In identifying the dynamic specification for the model equations, we used a (loose) general-to-specific methodology to determine lag lengths for the explanatory variables. In general, lags with t-statistics less than two were eliminated progressively from the estimated equations. However, variables with somewhat lower t-statistics were often retained if their inclusion was strongly supported by economic theory or by our own prior views.

The remainder of the appendix describes the estimation results for each equation. t-statistics are shown in parentheses below the estimated coefficients. Below each equation are the adjusted R^2 and the Q(20) statistic (and its significance level) that tests for serial correlation in 20 lags of the equation errors.

Private Aggregate Demand

Consumption. As discussed earlier, a long-run relationship exists between the log-levels of consumption and household wealth. This is somewhat different than the specifications advocated by either Hall (1978), who argued for a random walk in consumption, or Davidson, et al. (1978), who propounded a cointegrating relationship between consumption and disposable income. Both of these specifications appear to be rejected by data from several countries; for evidence on Japan, see Shintani (1994). Alternatively, our specification is consistent with Molana (1991) and others, who have proposed a cointegrating vector between consumption and wealth.

It was hypothesized that the expected real interest rate, changes in disposable income, and changes in labor market conditions also affect consumption in the short run. Additionally, a dummy variable was included to explain the unusually sharp decline in consumption in the first quarter of 1974:[1]

$$\begin{aligned}
\Delta \log C_t = & \underset{(-0.86)}{-.75} - \underset{(-2.11)}{.05} \log C_{t-1} + \underset{(2.29)}{.02} \log W_{t-1} \\
& + \underset{(3.18)}{.12} \Delta \log YD_t - \underset{(-2.00)}{.05} \Delta \log YD_{t-2} - \underset{(2.10)}{.11} ers_t \qquad (1) \\
& + \underset{(1.98)}{2.33} \Delta JOBS_t - \underset{(-9.40)}{5.94} D741
\end{aligned}$$

$$\bar{R}^2 = .63; \quad Q(20) = 26.0; \quad p = .16$$

The results in equation (1) imply that the estimated long-run elasticity of consumption with respect to

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[1] This equation was estimated using instrumental variables due to the inclusion of contemporaneous disposable income. The additional instruments were contemporaneous and four lagged values of log GOV, as well as four lagged values of log GDP, log W, and log TOPIX.

wealth is about .4, a somewhat higher figure than is believed to prevail in other industrialized countries.

Household Disposable Income and Wealth. Because the model predicts GDP while consumption is based on disposable income, the following identity links disposable income to GDP, using the actual, quarterly ratio of the two variables:

$$YD_t \equiv YDRATIO_t \cdot GDP_t$$

In addition, the following identity sums up changes in real household wealth (in levels) as (i) real saving plus (ii) changes in the valuation of existing assets:

$$\Delta W_t \equiv YD_t - C_t + \Delta WA_t$$

The two main assets held by households that are subject to valuation changes are stocks and land. Accordingly, equation (2) determines the change in real "asset" wealth as the sum of changes in stock and land prices, multiplied by estimated coefficients that implicitly represent the average holdings of those assets:

$$\Delta WA = \underset{(4.17)}{.09} + \underset{(3.40)}{.04}\ \Delta TOPIX_t + \underset{(11.42)}{4.66}\ \Delta PLAND \tag{2}$$

$$\bar{R}^2 = .63; \quad Q(20) = 39.8; \quad p = .01$$

Job Offers-to-Applicants Ratio. The job offers-to-applicants ratio is believed to be a more accurate indicator of cyclical conditions in the labor market than the unemployment rate. It is relatively well explained by past lags and by lags of the growth of real GDP:

$$JOBS_t = \underset{(-.06)}{-.00} + \underset{(14.30)}{1.47}\ JOBS_{t-1} - \underset{(-5.05)}{.52}\ JOBS_{t-2}$$

$$+ \underset{(2.02)}{.02}\ \Delta \log GDP_{t-1} + \underset{(3.41)}{.02}\ \Delta \log GDP_{t-2} + \underset{(2.87)}{.02}\ \Delta \log GDP_{t-3} \qquad (3)$$

$$\bar{R}^2 = .98; \quad Q(20) = 14.5; \quad p = .80$$

Private Fixed Capital Stock and Gross Investment. Based on the cointegration analysis, we modeled a long-run relationship between capital and output. In addition, net private fixed investment (changes in the fixed capital stock) were assumed to depend on short-run changes in the user cost of capital -- see Hoshi and Kashyup (1990) for firm-level evidence on the user cost of capital in Japan -- proxied here by the real long-term interest rate and the return on land:

$$\Delta \log K_t = \underset{(3.79)}{1.01} - \underset{(-4.20)}{.03}\ \log K_{t-1} + \underset{(3.94)}{.04}\ \log GDP_{t-1} - \underset{(-3.63)}{.04}\ rl_{t-1}$$

$$+ \underset{(3.60)}{.45}\ \Delta \log K_{t-1} + \underset{(1.67)}{.01}\ \Delta \log PLAND_{t-1} \qquad (4)$$

$$\bar{R}^2 = .95; \quad Q(20) = 19.0; \quad p = .52$$

The measured positive association between land price changes and net investment may reflect the inducement of speculative investments when real estate prices are rising. Alternatively, it may reflect the importance of land holdings in collateralizing bank loans in Japan; increases in land prices increased the value of collateral assets, thereby permitting firms and households to borrow more. Notably, inclusion of the stock market index did not add to the explanatory power of the equation, notwithstanding the long-held view that increases in the Japanese stock market significantly reduced the cost of funds to firms during the 1980s.

Gross investment is calculated by adding the amount of depreciated fixed capital to net investment:

$$I_t \equiv \Delta K_t + DEP \cdot K_{t-1}$$

Net Exports. Consistent with economic theory, net exports are estimated to be negatively related to the level of domestic GDP, positively related to foreign GDP, and negatively related to the real value of the yen:

$$\begin{aligned} \Delta\,(NX/GDP)_t = \underset{(3.56)}{19.23} - \underset{(-2.75)}{.07}\,(NX/GDP)_{t-1} - \underset{(-2.75)}{.07}\,\log GDP_{t-1} \\ + \underset{(3.04)}{.10}\,\log FGDP_{t-1} - \underset{(-3.56)}{.02}\,\log EXR_{t-1} \\ - \underset{(-2.35)}{.15}\,\Delta\log GDP_{t-1} - \underset{(-2.63)}{.21}\,\Delta\log FGDP_{t-2} - \underset{(-2.29)}{.02}\,\Delta^2\log EXR_{t-1} \end{aligned} \tag{5}$$

$$\bar{R}^2 = .30; \quad Q(20) = 16.2; \quad p = .71$$

The estimated negative response of net exports to lagged changes in foreign GDP is surprising, but it reflects the dynamics of net export adjustment rather than its long-term behavior, and therefore might not be expected to adhere as closely to the predictions of economic theory.

Aggregate Demand. Finally, total aggregate demand (in levels) is calculated using the following standard GDP identity:

$$GDP_t \equiv C_t + I_t + G_t + NX_t + RESIDUAL_t$$

The residual term in the GDP identity, which is treated as exogenous in the model, includes two items: (1) inventory changes, and (2) the negative of net factor receipts. Inventory changes have, with a few exceptions, played only a minor role in the current and previous Japanese recessions. Net factor receipts are subtracted because the export and import variables include factor receipts, which are included in

GNP but not in GDP.

Fiscal and Monetary Policy

Government Spending. Government spending is estimated to fall in response to an increase in GDP relative to a linear time trend, reflecting a counter-cyclical motive for fiscal policy:

$$\Delta \log G_t = \underset{(4.08)}{10.66} - \underset{(-3.68)}{.56} \log GDP_{t-1} + \underset{(3.51)}{.38} \; TIME \tag{6}$$

$$\bar{R}^2 = .15; \quad Q(20) = 20.7; \quad p = .42$$

Nominal Short-term Interest Rate. Since the Bank of Japan has targeted the short-term interest rate over much of the estimation period, the equation for the short rate is modeled as a central bank reaction function. In the long run, the level of the nominal short rate is modeled as linked positively to the rate of inflation -- in order to take into account the inflation premium -- and also positively to the output gap, the latter being proxied by inclusion of both output and the capital stock. Additionally, the short rate is modeled as falling in response to appreciations of the real exchange rate, reflecting Bank of Japan desire to prevent excessive swings in the value of its currency:

$$\begin{aligned} is_t = {} & \underset{(-.97)}{-1.04} + \underset{(10.84)}{1.15} \; is_{t-1} - \underset{(-3.14)}{.33} \; is_{t-2} + \underset{(3.62)}{.15} \; INFL_{t-1} - \underset{(-2.06)}{.09} \; INFL_{t-3} \\ & + \underset{(2.93)}{.14} \log GDP_{t-1} - \underset{(-3.00)}{.09} \; TIME - \underset{(-3.17)}{.04} \; \Delta \log EXR_{t-1} \end{aligned} \tag{7}$$

$$\bar{R}^2 = .95; \quad Q(20) = 12.8; \quad p = .89$$

Aggregate Supply

Inflation. Inflation is explained by the output "gap" -- proxied here by the inclusion of log real

GDP and log K:

$$
\begin{aligned}
INFL_t = \underset{(0.40)}{.62} + \underset{(2.59)}{.08} \log GDP_{t-1} - \underset{(-3.42)}{.06} \log K_{t-1} + \underset{(26.05)}{1.14} INFL_{t-1} \\
- \underset{(-7.04)}{.69} INFL_{t-4} + \underset{(5.56)}{.48} INFL_{t-5} + \underset{(5.91)}{5.13} D741
\end{aligned}
\tag{8}
$$

$$\bar{R}^2 = .97; \quad Q(20) = 37.9; \quad p = .01$$

Asset Prices

Real Exchange Rate. The real exchange rate is modeled as depending positively both on the ratio of net exports to GDP, a measure of the current account balance, and the Japan-U.S. short-term interest rate differential:

$$
\begin{aligned}
\Delta \log EXR_t = \underset{(3.58)}{47.11} - \underset{(-3.53)}{.10} \log EXR_{t-1} + \underset{(2.78)}{.53} (NX/GDP)_{t-1} \\
+ \underset{(1.81)}{.30} (rs_t - rs\_us_t) + \underset{(3.63)}{.36} \Delta \log REXR_{t-1}
\end{aligned}
\tag{9}
$$

$$\bar{R}^2 = .23; \quad Q(20) = 22.8; \quad p = .30$$

Real Residential Land Price. Although we found evidence of a cointegrating relationship between land and stock prices in a bivariate model, a multivariate analysis did not tend to support the existence of a contintegrating relationship between land prices and any of the other variables in the model. As a consequence, equation (10) links changes in the price of land positively to changes in stock prices, negatively to changes in real long-term interest rates, and positively to changes in real short-term interest rates:

$$\Delta \log PLAND_t = \underset{(-.02)}{-.00} + \underset{(8.69)}{.66}\ \Delta \log PLAND_{t-2} + \underset{(6.07)}{.13}\ \Delta \log TOPIX_{t-1}$$

$$+ \underset{(4.54)}{.08}\ \Delta \log TOPIX_{t-2} - \underset{(-2.77)}{.87}\ rl_{t-1} + \underset{(2.63)}{.87}\ rl_{t-2} \qquad (10)$$

$$+ \underset{(3.54)}{.53}\ rs_t - \underset{(-2.90)}{.46}\ rs_{t-2}$$

$$\bar{R}^2 = .79; \quad Q(20) = 20.7; \quad p = .42$$

Real Long-term Interest Rate. Our analysis indicated the real long-term interest rate to be essentially stationary, but with short-term dynamics influenced by both the output gap and the short-term real interest rate -- see Cambell and Hamoa (1990):

$$rl_t = \underset{(.10)}{.07} + \underset{(16.11)}{.77}\ rl_{t-1} + \underset{(2.16)}{.10}\ rs_{t-2}$$

$$- \underset{(-5.12)}{.11}\ \log GDP_{t-1} + \underset{(6.11)}{.08}\ \log K_{t-1} \qquad (11)$$

$$\bar{R}^2 = .97; \quad Q(20) = 18.6; \quad p = .55$$

In the long run, a 100 basis point increase in the short-term real interest rate is estimated to lead to a 46 basis point increase in the long rate. Additionally, the real long-term interest rate is estimated to respond negatively to increases in the output gap, proxied by the level of GDP and of the capital stock. While this latter result may seem counter-intuitive, it must be borne in mind that the short rate is being held constant. Implicitly, the equation is reflecting the fact that the yield curve tends to steepen during recessions, when the output gap widens.

Topix Stock Market Index. As with land prices, we were not able to identify cointegrating relationships between the real level of the stock market and other variables in the model. Consequently, equation (12) relates changes in the TOPIX stock market index to the output gap, proxied by real GDP and a time trend, to the real long-term interest rate, and to the real short-term interest rate; for similar specifications for Japan, see Cambell and Hamao (1992):

$$\Delta \log TOPIX_t = \underset{(4.23)}{62.21} - \underset{(-3.68)}{.39}\ \Delta \log TOPIX_{t-1} - \underset{(-3.72)}{2.71}\ \log GDP_{t-1} + \underset{(3.42)}{1.71}\ TIME$$

$$- \underset{(-5.21)}{5.29}\ rl_t + \underset{(4.75)}{5.49}\ rl_{t-2} + \underset{(2.08)}{1.47}\ rs_{t-2} \tag{12}$$

$$\bar{R}^2 = .40; \quad Q(20) = 8.3; \quad p = .99$$

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Table A1. A List of the Model's Endogenous Variables

Variable	Description
C	Real private consumption; per capita; millions 1985 yen.
G	Real government expenditures (consumption and investment); per capita; millions 1985 yen.
GDP	Real gross domestic product; per capita; millions 1985 yen.
ers	"Expected" real short term interest rate; equal to isn in given quarter less lagged INFL.
EXR	Real bilateral trade-weighted exchange rate; CPI-adjusted; 1980 Q1 = 100.
I	Real gross private fixed capital investment; per capita; millions 1985 yen.
INFL	Four-quarter percentage change in consumer price index.
is	Nominal short-term interest rate; two-month "ends" rate 1971 Q1 - 1979 Q1, Gensaki rate 1979 Q2 - 1984 Q2, three-month CD rate 1984 Q3 - 1993 Q4.
JOBS	Ratio of job offers to applicants.
K	Real private fixed capital stock; per capita; millions 1985 yen.
NX	Real net exports; per capita; millions 1985 yen.
PLAND	Real price of residential land; index of residential land prices deflated by personal consumption expenditures deflator; 1980 Q1 = 100.
rl	Real long-term interest rates; 10-year bellweather Treasury bond rate minus 36-month centered moving average of CPI inflation.
rs	Real short-term interest rate; is - INFL.
TOPIX	Real stock market index; TOPIX stock market index deflated by personal consumption expenditures deflator; 1980 Q1 = 100.
W	Real household wealth; per capita; millions 1985 yen.
WA	Real "asset" wealth; per capita; millions 1985 yen.
YD	Real disposable income; per capita; millions 1985 yen.

Table A2. A List of the Model's Exogenous Variables

Variable	Description
DEP	Rate of depreciation of the capital stock.
FGDP	Real bilateral trade-weighted index of foreign real GDP; 1985 = 100.
POP	Total population 15 years and older; millions.
rs_us	United States real short-term interest rate; three month Treasury bill minus quarterly CPI inflation rate.
TIME	Linear time trend; 1971 Q1 = 1.
RESIDUAL	Net inventory change minus net factor receipts; per capita; millions 1985 yen.
D741	Dummy variable; 1974 Q1 = 1, zero otherwise.

Table A3. Unit Root Tests on Model Variables

Variable	Number of Lags	$t_{\mu}(\rho)$	$t_{\tau}(\rho)$
log GDP	4	-0.77	-3.73**
log C	8	-1.09	-2.07
log K	8	-0.82	-3.00
log G	4	-0.29	-1.58
NX/GDP	4	-0.86	-1.77
log YD	8	-0.41	-3.12*
log W	8	-0.61	-2.85
log FGDP	2	-0.89	-3.31**
is	2	-3.24**	-4.03***
INFL	4	-2.75*	-2.97
rs	8	-1.71	-1.43
rl	8	-3.42**	-2.02
log PLAND	8	-0.71	-3.60**
log TOPIX	1	-0.95	-1.41
log EXR	8	-1.20	-2.25

Notes: *** indicates significance at the 1% level,
** indicates significance at the 5% level, and
* indicates significance at the 10% level.

Table A4. Cointegration Tests for Selected Subsystems

Variables	Trace Statistic r=0	r≤1	r≤2	r≤3	Implied Cointegrating Vector(s)
log C, log YD, log W	39.2^{***}	12.8	1.7		log C = .2 logW
log K, rl, log GDP	38.9^{***}	15.9^{**}	0.1		rl, log K = 1.2·log GDP
NX/GDP, log GDP, log FGDP, log EXR	55.3^{***}	23.1	7.6	2.1	NX/GDP = -10.5 · log GDP + 11.3 · log FGDP - .7 · log EXR
rs, rl	25.9^{***}	3.4^{*}			none
log PLAND, log TOPIX	17.7^{**}	0.4			log PLAND = .7·log TOPIX

Notes: All subsystems include eight autoregressive lags and include a constant term, except the interest rate subsystem, which does not include a constant term.

*** indicates significance at the 1% level,
** indicates significance at the 5% level, and
* indicates significance at the 10% level.

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