
Kenneth D. West

This paper studies the sources of the business cycle in Japan, 1972–90, focusing on the role played by money supply shocks. A secondary aim is to get a feel for whether the effects of Japanese monetary policy are roughly similar to those that would result if the Bank of Japan were operating under a simple, stylized rule or objective function.

For my analysis, I use a simple open economy aggregate demand–aggregate supply model, estimated on monthly data, January 1973 to August 1990. The six variables in the model are output, price, money supply, oil prices, foreign (U.S.) output, and the real yen-dollar exchange rate. The reduced form of the model is an unrestricted vector autoregression, and identification of the underlying linear simultaneous equations system is achieved in part with covariance restrictions of the sort first suggested by Blanchard and Watson (1986).

The model yields a decomposition of movements in the variables in the system into five underlying shocks: demand, cost, money supply, oil, and a residual foreign shock. It is found that movements in output are mainly attributable to demand and foreign shocks, movements in foreign output and the real exchange rate to foreign shocks; movements in prices are not driven overwhelmingly by any one kind of shock. For no variable apart from growth in the money supply itself are monetary shocks a particularly important source of variability; a conclusion also reached in some studies of the U.S. economy cited below. But unlike such studies, which typically find a major role for

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More generally, some readers will be skeptical about estimates of an aggregate demand-aggregate supply model, with or without rational expectations. I hope that such readers will still find in this paper two results that will be useful to keep in mind in future, and perhaps more highly structured, work. I state these now, since in the body of the paper I will assume the validity of the model in interpreting the empirical results.

The first result is that at conventional significance levels the broad measure of money used here (M4) Granger causes the real variables in the model, Eichenbaum and Singleton (1986) and Christiano and Ljungqvist (1988), among others, suggest that such a finding is inconsistent with a strict real business cycle theory. A small amount of experimentation suggests that, in possible contrast to U.S. data (e.g., Eichenbaum and Singleton 1986), this finding is robust to the method used to detrend the data.

Second, while the technique used to orthogonalize shocks relies on the assumed model for its validity, one can to a limited extent think of it in terms of the atheoretical approach exemplified by Sims (1980). In this context, the procedure can be interpreted as putting oil price shocks first, the residual foreign shock last, with demand, cost, and money supply shocks in between (and no simple Sims-style statement of the order of these three shocks is possible).

The fact that oil price shocks nonetheless play a small role and foreign shocks a big role in output fluctuations suggests that the results for these two shocks may be robust to alternative procedures for orthogonalizing the disturbances.

The dependence of the model described in section 6.2, the data, section 6.3 the estimated, section 6.4 the sensitivity of the results to minor changes in specification, and section 6.5 the behavior of the economy under hypothetical alternative money supply rules. An appendix available on request contains some additional results omitted from the body of the paper to save space.

6.1 The Model

The variables in the model, all of which are in logs, are:

- \( \chi \) = output (corporational production)
- \( p_r \) = price level (WPI)
- \( m_r \) = money supply (M4 + CD)
- \( o_r \) = oil prices (WPI for petroleum and coal)
- \( y_r \) = foreign output (U.S. industrial production)
- \( a_r \) = real exchange rate (yen/dollar)

1. On the other hand, the finding is not robust to the measure of money used. High-powered money does not Granger cause any of the three sets of real variables just listed. I believe that, in contrast to the argument Eichenbaum and Singleton (1986) and Christiano and Ljungqvist (1988), the argument in Princer (1990) would suggest that the overall pattern of Granger causality is therefore consistent with a real business cycle view.

Let \( x = (x_1, x_2, a_r, y_r, \alpha) \) be the \((k+1) \times 1\) vector of endogenous variables, with \( \alpha = (\alpha_r, \alpha_r, \alpha_r, \alpha_r, \alpha_r) \) the corresponding vector of reduced-form innovations (one-step-ahead prediction errors), \( x = x_1, x_2, \ldots, x_k \).

Six linear simultaneous equations determine the \( k \) endogenous variables in \( x \). On the right-hand side of each of the six endogenous variables \( x_i \). Together with a constant term, this set of \( k \) by \( k+1 \times 1 \) vector \( x_r \) and \( 1, x_2, \ldots, x_k \), the structural equations are:

\[
\begin{align*}
1. & \quad y_1 = \alpha_r (m_r - p_r) + \alpha_r \alpha_r + \alpha_r \alpha_r + \Gamma_{r+1} \alpha_r + \alpha_r
\end{align*}
\]

Equation (1) is an aggregate demand curve, \( u_r \) a demand shock. The demand curve may be obtained by combining IS and LM curves, substituting out for the nominal interest rate. The dependence of a standard IS curve on the real rate rather than the nominal rate is implicitly allowed, since \( \Gamma_{r+1} \lim \rightarrow \alpha_r \) will absorb any term in expected inflation.

The term in real balances \( m_r - p_r \) is (1) comes from the LM curve, and \( \alpha_r \) a term in the real exchange rate \( a_r \) and foreign output \( y_r \) come from the IS curve. These terms capture the effect that \( a_r \) and \( y_r \) have on the trade balance. If the J-curve is operative, so that depreciation (increase in \( a_r \)) has a perverse negative effect on the trade balance in the short run, \( \alpha_r \) be negative under some conditions on the foreign output terms, and thus the trade balance and aggregate demand, positively.

Equation (2) is an aggregate supply curve, \( u_r \) a cost (supply) shock. Both \( \beta_r \) and \( \beta_r \) are positive: quantity supplied depends positively on output and negatively on oil prices. The terms in expected prices or output are absorbed in \( \Gamma_{r+2} \).

Equation (3) is the money supply rule. I assume that, at the beginning of month \( t \), the monetary authority chooses an expected value for the period \( t \) money supply \( m_r \). The difference between \( m_r \) and \( m_r \) (the variable \( u_r \)) might or might not depend on inamonth attempts by the Bank of Japan to influence the path of nonmonetary variables. Output and price, and perhaps the real exchange rate, are present to allow for the possibility of such intra-month attempts to target these variables (Bryant 1990). A second reason that month-output and price are present is that the measure of money used in the empirical work is a broad one whose real value cannot be perfectly controlled at
time \( t = 1 \), but instead will depend on surpluses in money demand (velocity), even if the bank makes no such intramonth attempts. A second reason that the real exchange rate is present is that its value may affect intramonth decisions about whether or not to sterilize exchange rate operations, and thus affect the value of the money supply.

The monetary rule of course might also depend in part on interest rates. Equation (3) allows for this implicitly: use the LM curve to write the nominal interest rate in terms of money, output, and prices, and possibly lagged values of these and other variables, and then substitute out for the interest rate in the monetary rule.2 The resulting disturbance will then depend in part on velocity shocks and thus be correlated with the aggregate demand shock \( \psi \). The estimation procedure described below well, however, yield a shock to the money supply that is uncorrelated with demand shocks by construction. This is interpreted as the component of money supply shocks uncorrelated with velocity shocks. Under this interpretation, the estimation procedure is attributing entirely to demand shocks a component shared by both demand and money shocks.

In related literature (Blaug and Watson 1986), the money supply rule is written in terms of levels rather than surpluses (e.g., \( \psi \)). In the present setup, the specifications are observationally equivalent: estimates of the parameters in (3)–(6), and the implied variance decompositions, impulse response functions, and so on, are the same whether levels or surpluses are used. I write (3) as a function of surpluses in accord with my interpretation of monetary policy as a rule for setting \( \psi \), in simulations below on the hypothetical effects of alternative rules over the sample period, I take both the \( \psi \)'s and the \( \psi \)'s as structural and invariant to the policy rule.

Equation (4) says that the period \( t \) oil price is a predetermined variable, which in the present setup means that its innovation is contemporaneously uncorrelated with the other innovations in the model. Shapiro and Watson (1985) argue that this is reasonable because movements in oil prices are dominated by a few sharp swells. Note that the oil price being predetermined is perfectly consistent with it being Granger caused by other variables.

Equations (5) and (6) are vacuous identities, simply stating that the period \( t \) surprise in each of these variables can be written as a linear combination of other surprises, plus a term orthogonal to these surprises. The idea is that foreign output, while not modeled explicitly, is determined by a set of equations similar to those determining Japanese output. Since demand, cost, money, and oil shocks plausibly are correlated across countries, the period \( t \) surprise in foreign output will be correlated with all these shocks, as well as with any shocks to the exchange rate. The estimation procedure will attribute

2. If the interest rate targeted by the Bank of Japan is different from that in the LM curve (e.g., cell rate varies geographically, one may also use an equation relating the two rates to eliminate interest rate shocks from the system. The only reason I have not explicitly used interest rates is to avoid increasing the dimensionality of an already complicated system of equations.

this common element of foreign and Japanese demand shocks, for example, to \( \psi \) and similarly for other shocks. The residual \( \psi \) is thus the idiosyncratic component on foreign cycles after all common components have been absorbed by \( \psi \), \( \psi \), \( \psi \), and \( \psi \).

Similarly, the exchange rate is often thought to be set by forward-looking behavior of the sort generally presumed to determine asset prices, so, like

Once again, an observationally equivalent model would result if the sur-

in levels, \( \psi \), however, will be different in the two specifications.

As written above, the reduced form equations for \( \psi \) and \( \psi \) will not change with a change in the rule for setting \( \psi \), \( \psi \), while these equations would change with a change in the rule for setting \( \psi \). Contemplating below will much affect the coefficients in the reduced-form stochastic process for foreign output and the real ex-

In equations (5) and (6), putting foreign output \( \psi \) before the real exchange rate \( \psi \) is arbitrary; the variance decompositions reported below simply report a contribution from "foreign terms" that is the sum of contributions of \( \psi \), \( \psi \), \( \psi \), and \( \psi \).

To solve the model, tentatively replace the surprises in (3)–(6) with levels (e.g., replace \( \psi \) in (3) with \( \psi \)). Write (1)–(6) in matrix form as

\[
B_x \psi = k + B_{x1} \psi_1 + \ldots + B_{x6} \psi_6 + \epsilon_x
\]

where \( B_x \) are 6 by 6 matrices, \( k \) is a 6 by 1 vector of coefficients on constant terms, and \( \psi_1, \psi_2, \psi_3, \psi_4, \psi_5, \psi_6 \) are 6 by 1 vectors of mutually and serially uncorrelated disturbances. Premultiplying both sides of (1)–(6) by \( B_x^\dagger \) yields a vector autoregressive reduced form,

\[
\psi = B_y \psi + B_y B_{y1} \psi_1 + \ldots + B_y B_{y6} \psi_6 + \epsilon_y
\]

where \( \psi = (\psi, \psi, \psi, \psi, \psi, \psi, \psi) \), \( \epsilon_y \) is the 6 by 1 vector of reduced-form innovations. Even though surpluses rather than levels appear in equations (1)–(6), one can similarly deduce that the reduced form of (1)–(6) follows an \( n \)-order vector autoregression, with a similar mapping from reduced form to structural disturbances; I omit the algebra for simplicity.

Given \( B_x \) and \( B_y \), variance decompositions and impulse response functions.
can be calculated in the usual way. \( \Pi \), may be obtained by OLS. \( B_j \) may then be obtained from the variance-covariance matrix of \( \nu \), as follows. This matrix has twenty-one distinct elements. These must determine twenty-three parameters: six variances, one for each of the elements of \( \nu \), and the seventeen coefficients on contemporaneous variables or surprises in equations (13-46).

Without additional information, the system is not identified. Given the wealth of studies on the determinants of the Japanese trade balance, which have produced some consensus estimates of relevant elasticities, it seems likely to be uncontrovertial to impose values for \( \alpha \), \( \alpha_{0} \), and \( \alpha_{00} \), the instantaneous elasticities of aggregate demand with respect to the real exchange rate and foreign output, and so I used these studies to impose such values. This leaves twenty-one parameters to be determined from the twenty-one elements of the variance-covariance matrix of \( \nu \).

The structure of the system is such that the information in these twenty-one elements can be exploited by standard instrumental variables techniques. The residual from estimating the oil equation (4) \( u_{o} = \nu_{o} \) can be used to instrument the aggregate demand equation, to obtain \( \delta_{0} \). The aggregate demand and oil residuals \( u_{o} \) and \( u_{o} \) can then be used as instruments in the price equation; \( u_{0} \), \( u_{0} \), and \( u_{0} \) can then be used as instruments in the money supply equation; \( u_{0} \), \( u_{0} \), and \( u_{0} \) can then be used as instruments in the foreign output equation; and the entire set of structural disturbances can be used in the real exchange rate equation.

6.2 Data

The data are monthly, January 1973 to August 1990, for a total of 212 observations, with pre-1973 data used for initial lags. The ending point of the sample was determined by data availability. The starting point was determined, first, by the evident fact that the Japanese economy has behaved quite differently post-1973 than pre-1973 and, second, by the presumption that monetary policy was rather different in the era of fixed exchange rates than in the era of floating exchange rates. The exact date January 1973 was chosen in accord with Hamada and Hayashi (1985, 109), who concluded that January 1973 is the likeliest date for a concordant shift in monetary policy in the early 1970s. Results of estimates with two other subsamples, January 1976 to August 1990 and January 1973 to March 1990, are very similar, as noted below.

Data for both the United States and Japan through mid-1988 were obtained from the OECD's Main Economic Indicators (MEI) as supplied on PC diskettes by VAR Econometrics, and updated by published sources as indicated below. The MEI indices of Japanese industrial production, seasonally adjusted, and the WPI for mining and manufacturing, all 1980 = 100, were converted to 1985 = 100, and together with seasonally adjusted data on monthly averages of \( M \) + \( CD \) were then linked with post-1988 data published in various issues of the Bank of Japan's Economic Statistics Monthly.

(6.3.1) Preliminaries

The empirical work began with tests for unit roots. Standard univariate- and multi-variate-augmented Dickey-Fuller tests suggested that one difference sufficed to induce stationarity in each of the variables; a version of the Johansen (1983) test for cointegration, extended to include trend as well as constant terms, found, as expected, that the variables are cointegrated. Results are reported in Table 6.1. This analysis is consistent with the hypothesis that the exchange rate is determined by a set of demand and supply forces, with the exchange rate being the point of intersection of the demand and supply curves.
Fig. 6.1 Basic data
twelve, and twenty-four-furlong lags of each right-hand-side variable, plus a constant term. All regressions began in January 1973, with the twenty-four-lag regression, for example, reaching back to January 1971 for lags to put on the right-hand side. Likelihood ratio tests using the degrees of freedom adjustment suggested by Sims (1980) rejected the null of six lags in favor of the alternative of twelve (χ²(216) = 274.2, p-value = 0.003), but did not reject the null of twelve lags in favor of the alternative of twenty-four (χ²(432) = 311.4, p-value = 0.100). In addition, both Q-statistics (reported below) and the individual autocorrelations of the residuals suggested that a lag length of twelve sufficed to reduce the residuals in each equation to white noise. I thus set the lag length to twelve.

6.3.2 Reduced Form

The model suggests that, except in special cases, anything that Granger causes money, oil prices, foreign output, and the real exchange rate ought to Granger cause output and prices as well (though of course there may be such Granger causality in some output and prices even in the absence of Granger causality to the right-hand-side endogenous variables in equations (1) and (2)).

Table 6.2, panel A, presents F-statistics suggesting that this is essentially the case at conventional significance levels, at least one of money, oil prices, and foreign output is Granger caused by each of the six variables (rows 3–5), and, indeed, all six variables Granger cause output (row 1), and all but foreign output Granger cause prices (row 2). The standard errors for sums of distributed lags reported in table 6.2, panel B, yield comparable implications for when movements in one variable help predict movements in another.

Note that money Granger causes both output and prices (table 6.2, panel A, rows 1 and 2, column 3), suggesting the possibility that policy may be used to influence the path of these two variables. If the monetary authority

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**Table 6.1**

<table>
<thead>
<tr>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Autocorrelations</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) y</td>
<td>0.304</td>
<td>1.444</td>
</tr>
<tr>
<td>(2) p</td>
<td>0.274</td>
<td>1.000</td>
</tr>
<tr>
<td>(3) m</td>
<td>0.845</td>
<td>0.410</td>
</tr>
<tr>
<td>(4) e</td>
<td>0.599</td>
<td>0.900</td>
</tr>
<tr>
<td>(5) r</td>
<td>0.211</td>
<td>0.897</td>
</tr>
<tr>
<td>(6) o</td>
<td>-0.130</td>
<td>3.367</td>
</tr>
</tbody>
</table>

**Table 6.2**

<table>
<thead>
<tr>
<th>Table 6.2</th>
<th>Reduced Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Granger Causality Tests</td>
<td></td>
</tr>
<tr>
<td>(1) y</td>
<td>2.702</td>
</tr>
<tr>
<td>(2) p</td>
<td>0.000</td>
</tr>
<tr>
<td>(3) m</td>
<td>1.131</td>
</tr>
<tr>
<td>(4) e</td>
<td>0.000</td>
</tr>
<tr>
<td>(5) r</td>
<td>0.796</td>
</tr>
<tr>
<td>(6) o</td>
<td>2.022</td>
</tr>
<tr>
<td>B. Summary Statistics</td>
<td></td>
</tr>
<tr>
<td>Left-hand-side:</td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Sums of Log Coefficients</td>
</tr>
<tr>
<td>(1) y</td>
<td>0.470</td>
</tr>
<tr>
<td>(2) p</td>
<td>0.702</td>
</tr>
<tr>
<td>(3) m</td>
<td>0.658</td>
</tr>
<tr>
<td>(4) e</td>
<td>0.465</td>
</tr>
<tr>
<td>(5) r</td>
<td>0.128</td>
</tr>
<tr>
<td>(6) o</td>
<td>0.571</td>
</tr>
</tbody>
</table>

**Notes:** Panel A: The F-statistics in rows 1–6 test the null that the coefficients are zero for all lags of the variables in a given column. When the variable in a given row is on the left-hand side, p-values are given in parentheses. The standard errors of the regression in column 9 of the p-values for the Granger causality tests.
is following a program of targeting or stabilizing output and/or prices, in general it should adjust the money supply \( y \) in response to whatever variables influence the path of the two variables (see, e.g., Chow, 1983, chapter 12). In light of the results in rows 1 and 2, this means in response to all the variables in the system. To a stationary world (one in which the objective function of the monetary authority and parameters of the model are unchanged), this would lead to money being Granger caused by all the variables in the system.

It appears, however, that money is Granger caused only by itself and output (row 3, columns 1 and 7). Even on sums of distributed lag coefficients reported in table 6.2, panel B, find some predictive power in foreign output as well. But overall there is no reduced-form evidence that the money supply responds to prices, oil prices, or the real exchange rate.

One possible reason for the lack of Granger causality is that, while there is indeed a stable feedback rule consistent with targeting of output and prices, the sample is too small to accurately reflect this fact, a distinct possibility given that I am using a profitably parameterized model. But while it would not be wise to interpret the lack of Granger causality as sharp evidence against the simple textbook model of output and price targeting, it seems equally foolish to expect the estimates of this model to yield sharp implications about what the price and output targets of the Bank of Japan are, even if one's priors are that such targets are central to the bank's decision making (e.g., Bryden 1990).

Also, the fact that both output and foreign output help predict the money supply suggests that the bank does have its eye on the economy when it determines the money supply. That this money growth is exogenous has been argued by many, including in particular Hutchison (1986), who uses Granger causality tests such as those applied here. Once again, it would be foolish to expect the estimates of this model to yield a clear statement that the bank follows a money-targeting rule, even if one's priors are that this is essentially the case.

One final note on the reduced form: the evidence that money Granger causes real variables is quite strong. Consider rewriting the system so that money is the only nominal variable, with \( m_t = \rho \) (real balances) and \( \rho = \rho \) (real oil prices) joining \( y_t, m_t, \) and \( \rho \) as real variables. As reported in rows 7 and 8 of table 6.2, panel A, the null that money does not Granger cause any of these variables is strongly rejected, as is the null that money does not Granger cause the set of domestic variables \( y_t, m_t, \) and \( \rho = \rho \).

### 6.3.3 Structural Equations

Table 6.3, panel A, has estimates of equations (1)–(6). The coefficients on \( y_t \) and \( \rho_t \) in the aggregate demand equation were imposed rather than estimated: Noland (1989) estimated a long-run elasticity of Japanese exports with respect to foreign output of about 1.4. Since exports are about 10 to 15% of GNP, and the short-run effect is presumably less than the long-run, this suggests an upper bound of about 0.2 for the short-run elasticity of aggregate demand with respect to foreign output. Krugman and Obstfeld (1988, 554) report that Artus and Knight (1986) found that the six-month elasticity of the Japanese current account with respect to the real exchange rate was about 0.25, and Noland (1989) found a one-quarter elasticity of about 1 (the negative signs being consistent with a J-curve), again suggesting an aggregate demand elasticity about 10 to 15% of those figures: hence the 0.03. Some alternative imposed values for these short-run elasticities led to very similar results, as noted below.

The remaining parameters in table 6.3 were estimated by instrumental variables, as described above. The three freely estimated parameters in the aggregate demand and aggregate supply equations are all correctly signed. I do not know of estimates for Japanese data to which the estimates can be directly compared, but comparison with U.S. studies suggests that they are plausible.
Although the estimate of the instantaneous elasticity of aggregate demand with respect to real balances in fancy language is the 0.512 value is bracketed by estimates from very worthy U.S. data. On the one hand, the 0.15 quarterly figure for the MFS model for the United States (Blanchard 1989, 1150) is somewhat lower. On the other hand, if one combines the Japanese money demand estimates in Hamada and Hayashi (1985, table 4.5, income elasticity = 0.2 to 0.5, interest elasticity = -0.01 to -0.03) with tax range of interest elasticities of the IS curve found in U.S. studies (e.g., Friedman, 1977), the implied value of the elasticity is about 2-5, somewhat higher than the estimated value of 0.512. The estimated price elasticity of supply of d 4 (= 1.0.255) is bracketed by the quarterly U.S. estimates of 0.81 (Blanchard and Watson 1986, 132) and 10-12 (Blanchard 1989, 1152). The 0.094 figure on oil prices is consistent with the monthly estimate in Blanchard (1987, 68) that a 1% increase in crude materials prices causes a 0.026 increase in consumer prices. The three negative signs on the variables in the money supply equation are consistent with the possibility that the intra-month response of the Bank of Japan to shocks is one of "leaning against the wind"; on the other hand, the signs could as well simply reflect factors beyond the control of the authority, such as interregional shocks to the money multiplier: In any case, none of the three estimates is significantly different from zero, so, in the absence of any a priori theoretical bounds on plausible values, it is probably not advisable to read much into the signs or magnitudes of the estimates. As noted above, theory does not restrict the signs or values of the coefficients on the foreign output and real exchange rate equations. Table 6.3, panel B, has estimates of sums of distributed lag coefficients in the aggregate demand and supply equations. (The sums for the other equations are exactly as presented in table 6.2, panel B.) Coefficients on contemporaneous right-hand-side variables (e.g., m in 131) are included in these sums. By and large, the significance of the sums of these distributed lag coefficients is consistent with the Granger causality tests reported above. The long-run response of a given left-hand-side variable to a permanent increase in a given right-hand-side variable can be inferred from the estimates in the table. The long-run elasticity of aggregate demand with respect to money is about 4 (-0.728/.23), with respect to prices about -1.1 (-1.524/.408), which is probably consistent with a long-run elasticity of aggregate demand with respect to real balances of about 1, a point estimate suggested by Hamada and Hayashi (1985, 101). The long-run elasticity of aggregate demand with respect to the real exchange rate is about 0.13 (-0.189/1.408), comparable to the figures of about 0.15 and 0.05 implied by Artus and Knight (1984, cited in Krugman and Obstfeld 1984, 484) and Noland (1989, 177). The elasticity with respect to foreign output is about 0.8 (= 1.190/1.408), somewhat higher than the 0.14 figure implied by Noland (1989). (The stated figures for Artus and Knight and Noland were obtained by

multiplying their reported elasticities by 0.10, approximately the share of imports and exports in Japanese GNP.)

The long-run price elasticity of supply is about 0.13 (= [1 - 0.821] (1 + 0.615 - 0.255)). Figure 6.2 plots impulse response functions (dynamic multipliers), that is, one-to-six-month response of the levels of output, prices, and money to demand, cost, money, and oil shocks. (The responses to s, and s are not given, since the breakdown of the residual foreign shock into these two components is arbitrary; plots of responses of oil prices, U.S. output, and the real
Table 6.4  Variance Decompositions

<table>
<thead>
<tr>
<th>Month</th>
<th>( \alpha_1 )</th>
<th>( \alpha_2 )</th>
<th>( \gamma )</th>
<th>( \epsilon_1 )</th>
<th>( \epsilon_2 )</th>
<th>( \omega )</th>
<th>( \epsilon )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
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<tr>
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<td>0.00</td>
<td>2.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Apr</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>May</td>
<td>4.00</td>
<td>0.00</td>
<td>0.00</td>
<td>4.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Jun</td>
<td>5.00</td>
<td>0.00</td>
<td>0.00</td>
<td>5.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Notes:
- \( \alpha_1, \alpha_2 \): growth rates
- \( \gamma \): short-run factor
- \( \epsilon_1, \epsilon_2 \): shocks
- \( \omega \): permanent factor
- \( \epsilon \): error term

Movements in inflation and prices are roughly equally attributable to supply, demand, and money factors (table 6.4); the U.S. studies cited above tend to find demand factors more important. The contribution of money supply shocks is quite small and increases gradually over time, as one might expect in a sticky price framework.

Most of the variance of the growth and level of the money supply is due to money supply shocks (table 6.4); U.S. studies find that figures are smaller (Blanchard and Watson 1986; Gali 1990). Fluctuations in oil prices are not dominated by any single shock, at least at long horizons (recall that the 100% figure for one month holds by construction). Fluctuations in U.S. output and the real exchange rate are dominated by foreign shocks. The
result for output is as in West (1992), but not for the exchange rate, whose movements West found to be dominated by cost shocks.

Money supply shocks, then, do not account for a large share of the variance in any of the variables in the model, except the money supply itself. It is nonetheless possible that such shocks are important at cyclical turning points: Gall (1990), tables 4, 5), for example, finds that money supply shocks account for less than 15% of the variance of U.S. output at business cycle horizons, but attributes to such shocks the leading role in the 1981–82 recession. Table 5.5, however, suggests that this is not the case for Japan.

Table 6.5 computes causes of peak to trough changes in the (log) levels of output and prices.1 To read the table, consider row 1. The peak (November 1973) to trough (March 1975) fall of the index of industrial output was 19.32% in this contraction (column 1). The estimates of the model indicate that as of November 1973 the index was predicted to be only 11.71% lower in March 1975 (column 2), implying that the index fell 7.62% more than predicted (column 3). Of this forecast error, 4.5% (i.e., about — 3.43 of the — 7.62 that appears in column 3) is accounted for by demand shocks, 23% by cost shocks, 15% by money shocks, 5% by oil shocks, and 12% by foreign shocks. In columns 4–8, negative signs mean that the indicated shock was of the opposite sign of the forecast error in column 3. One contraction involved such a small (in absolute value) forecast error for output (row 2, column 3) that the estimates in columns 4–8 are very sensitive to small changes in the estimate of column 3. The estimates in rows 1, 3, and 4 are not as sensitive, and the figures in column 6 in these rows indicate that money supply shocks have not played a dominant role in movements in output over any of the contractions in the sample (and, more generally, contractions are not attributable to a simple type of stock). Row 7 does indicate that money supply shocks had a substantial impact on the unexpected component of the change in the price level in the contraction of February 1980 to March 1982. (I ignore row 5, again because the figure in column 3 that row that is so small that small changes in it lead to large changes in the estimates in column 4–8.)

I conclude, then, that money supply shocks have not played a dominant role in output fluctuations, either over the sample as a whole or over any of the contractions that have occurred in the sample; they have been somewhat more prominent in accounting for price and inflation fluctuations.

6.4 Sensitivity of Results

In this section, I briefly summarize the results of a set of experiments under- taken to see whether the results are sensitive to minor changes in specification. The experiments are listed in panel A of table 6.6. Specification A is the one used in previous tables and is repeated here solely to facilitate comparison. Specifications B and C impose different values for the short-run elasticities of aggregate demand with respect to foreign output and the real exchange rate (see equations [1]). Specification D imposes a random walk on the real ex-

3. Since the growth rate rather than the level of output appears to be a coincident indicator in Japan, there might be a choice of subperiods that would be more revealing about the effects of monetary shocks on the level of output, but I know of no source for cyclical shifts in the level of output in Japan.

Table 6.4 Growth Rates and Log Levels

<table>
<thead>
<tr>
<th>Months</th>
<th>( \Delta y_t )</th>
<th>( \Delta y_{t-1} )</th>
<th>( \Delta y_{t-2} )</th>
<th>( \Delta y_{t-3} )</th>
<th>( \Delta y_{t-4} )</th>
<th>( \Delta y_{t-5} )</th>
<th>( \Delta y_{t-6} )</th>
</tr>
</thead>
</table>
| 3      | 4.8           | 7.7           | 5.5           | 0.8           | 0.6           | 2.3           | 3.7           | 7.2           | 0.5           | 81.3
| 6      | 5.8           | 8.9           | 7.4           | 0.9           | 0.7           | 2.5           | 3.9           | 7.7           | 0.4           | 45.2
| 12     | 5.2           | 10.5          | 7.7           | 1.0           | 0.8           | 2.9           | 3.7           | 7.9           | 0.4           | 23.9
| 24     | 7.3           | 10.5          | 10.5          | 2.1           | 0.8           | 5.2           | 5.5           | 5.5           | 0.4           | 23.9
| 60     | 9.3           | 10.5          | 10.8          | 2.4           | 0.7           | 6.1           | 6.2           | 4.5           | 3.2           | 31.6

Notes: Standard errors are not available. Coefficients are described in text.
<table>
<thead>
<tr>
<th>Sample Period</th>
<th>Period</th>
<th>Levels,</th>
<th>Trend</th>
<th>Other</th>
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</tr>
<tr>
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<tr>
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<td>03, 05</td>
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<tr>
<td>1973-1990</td>
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<td>03, 20</td>
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<td>8</td>
<td>03, 20</td>
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<td>8</td>
<td>03, 20</td>
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<tr>
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<td>03, 20</td>
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### B. Granger Causality

<table>
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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
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<tbody>
<tr>
<td>0.05 (1) Level</td>
<td>&amp; *</td>
<td>p</td>
<td>m_i</td>
<td>p</td>
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<tr>
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<td>0.00</td>
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<td></td>
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<td>0.21</td>
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<tr>
<td>0.01</td>
<td>0.00</td>
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### C. Variables Decompositions of Levels at Twenty-Four Month Horizon

<table>
<thead>
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<th>Components</th>
<th>0.05 (1)</th>
<th>0.05 (2)</th>
<th>0.05 (3)</th>
<th>0.05 (4)</th>
<th>0.05 (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 (1)</td>
<td>0.05 (2)</td>
<td>0.05 (3)</td>
<td>0.05 (4)</td>
<td>0.05 (5)</td>
<td></td>
</tr>
</tbody>
</table>

### Notes

5. The model was estimated by the instrumental variables technique described above, since α is not exactly orthogonal to past data in the sample, slightly different estimates would be obtained if β had used a different method of extracting parameter estimates from the variance-covariance matrix of the reduced form residuals.

6. 5 Effects of Alternative Money Supply Rules

A number of authors have suggested that the Bank of Japan uses its operating instruments with its eyes focused on "final" (as distinct from intermediate) targets. The targets have been proposed, at least for the post-OPEC-I era, include: control of inflation, "as above, with avoidance of pronounced cyclical swings in output and aggregate demand", and targeting of the real exchange rate and balance of payments (Bryan 1990, 32), "price stability and change rate α, a result consistent with the reduced-form evidence presented above. Specification C substitutes high-powered money for M₄. Specification H assumes trend stationarity of all variables, and estimates with a trend term and twelve lags of the levels of all variables in all equations. Specification I assumes trend stationarity of all variables, allowing for the possibility of cointegration. In this specification, all equations had thirteen lags of all variables; the hypothesis tests were performed on the first twelve lags, so that an asymptotic normal distribution could be used in the hypothesis tests in panel B (see Sims, Stock, and Watson 1990).
the maintenance of an adequate level of demand" (Hamada and Hayashi, 1985, 83); "price stability" and "a high and stable exchange rate" (Fukui 1986, 110). Bryan (1990, 33-34), Hamada and Hayashi (1985, 116), and Ito (1989) seem to doubt that the bank places much weight on deviations of any given monetary aggregate from its targeted value. On the other hand, Fukui (1986, 110-111) and Suzuki (1985, 9) seem to view the money supply as an intermediate target that gets considerable weight. And Friedeman (1985, 27) lauds the bank for a "fairly consistent" policy of keeping money growth "relatively steady for the States and Great Britain".

What does the money supply rule estimated above reveal about such description? The reduced-form and structural evidence presented so far is strongly suggestive of neither a simple story of money supply targeting nor the simple textbook one of straightforward targeting of output and prices (perhaps with secondary weight placed on the money supply). I therefore doubt the wisdom of attempting to invert the estimated rule, to deduce an underlying objective function that maps one-to-one into the seventy-three parameters of the rule. Instead, to maintain a focus on simple and easy-to-understand objective functions, I simulate the behavior of the economy over the sample period under the apparently counterfactual assumption of a simple objective function.

This objective function is consistent with constant expected money growth. I assume that the monetary authority can perfectly control \( m \), but not \( M \). For simplicity, I abstract from the Lucas critique. I take as given the set of shocks and assume that the estimates of the parameters of equations (1)-(6) are invariant to such a change in regime. (In footnote 7, I briefly speculate on the possible biases from this simplification.) The coefficients in the reduced-form equations for \( m, p, \) and, of course, \( M \), will change; those for \( n, y, \) and, \( \alpha \), will not. The simulated time series process for all six variables of course is different from the actual.

The objective function corresponding to constant expected money growth aims to minimize the variance of money growth, since under this set of assumptions it is easy to see that minimizing the variance of \( M \) means setting \( \alpha = \alpha^{*} \) to a constant. This constant was set to the estimated sample mean of money growth.

Table 6.7 has the sample means and standard deviations for the growth of nominal output and for each of the six endogenous variables from the actual (columns 1 and 4) and simulated (columns 2 and 5) data, as well as correlations between the actual and simulated data (column 7). Columns 3, 6, and 8 will be described in a moment. Some may be seen in columns 1 and 2. The sim-ulated and actual data have nearly identical means. Perhaps surprisingly, they also have very similar standard deviations (columns 4 and 5) and, with the

<table>
<thead>
<tr>
<th>Table 6.7</th>
<th>Effects of Alternative Money Supply Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) ( \alpha )</td>
<td>0.106</td>
</tr>
<tr>
<td>(2) ( p )</td>
<td>0.274</td>
</tr>
<tr>
<td>(3) ( m )</td>
<td>0.845</td>
</tr>
<tr>
<td>(4) ( u )</td>
<td>0.199</td>
</tr>
<tr>
<td>(5) ( y )</td>
<td>0.711</td>
</tr>
<tr>
<td>(6) ( \alpha )</td>
<td>-0.130</td>
</tr>
<tr>
<td>(7) ( a )</td>
<td>0.066</td>
</tr>
<tr>
<td>(8) ( \beta )</td>
<td>0.066</td>
</tr>
</tbody>
</table>

Notes: Money supply rule 1 is the one actually estimated. Rule 2 is an expected money growth rule. Rule 3 is a constant expected money growth rule. Rule 4 is a constant expected money growth rule. Rule 5 is a constant expected money growth rule. Rule 6 is a constant expected money growth rule. Rule 7 is a constant expected money growth rule. Rule 8 is a constant expected money growth rule. The figures reported in the remaining columns are computed from a simulation under the indicated rule.

predictable exception of the money supply, are very highly correlated (column 7). Moreover, the actual and simulated data are so close that it is difficult to tell one from the other when they are plotted. See figure 6.3, in which the actual data are represented by the solid line, the simulated by a dashed line; when the software that generated the graph decided that the simulated and actual were too close to be distinguished by eye (as happens especially for output growth), it plotted only a dashed line.

According to the estimated model, then, whether or not the Bank of Japan was concerned above all else with stability of money growth, its policies had effects on the economy quite similar to those that would have occurred had the bank followed a rule of constant expected money growth. To interpret this tentative conclusion, let us begin by considering the possibility that the effects of anticipated monetary policy are so small that a wide range of money supply rules will lead to qualitatively similar behavior of output and prices.

Consider, then, performing the same counterfactual simulation with a different alternative policy, similar in spirit though very different in detail to one proposed by McCallum (1988) for U.S. monetary policy. Let expected money growth be determined by

\[
\ldots \dot{m} = \mu_{m} + \lambda y + \mu_{\alpha},
\]

where \( \mu_{m} \) and \( \mu_{\alpha} \) are constants, \( \mu_{\alpha} \) is a target rate for the growth of nominal output, and \( \lambda \) is a negative parameter. I set \( \mu_{m} \) to the sample mean of money growth, \( \mu_{\alpha} \) to the sample mean of nominal output growth, and \( \lambda = -0.25 \) (a value that McCallum (1988) found worked well for the United States in her more sophisticated feedback rule).

Columns 3, 6, and 8 have the resulting sample means, standard deviations,
and correlations with the actual data. As may be seen, the means are, once again, largely unchanged, but now the standard deviations are slightly and the correlations greatly different, not only for money growth but for output, inflation, and nominal output growth as well. Anticipated monetary policy, then, does have effects sufficiently large that the estimates suggest that at least one alternative policy would have led to very different behavior.

3. Even if rational expectations had been modeled explicitly, as in, for example, Taylor (1989), my aggregate demand-aggregate supply model might well suggest that a hypothetical switch to constant money growth rule would little change output and price behavior. The expectations that are relevant are of future prices and output. That the path of these variables is essentially unchanged under the new rule, when expectation effects are ignored, indicates that rational forecasts of these variables are similarly unchanged—that is, if we were to write the equations as distributed lags on the variables in the model, the coefficients in these distributed lags would not change much. This suggests (to me, at least) that a rational expectations version of the model may also have no equilibrium in which the distributed lag coefficients are not much different. This means that the coefficients on lagged variables in equations (13)-(16) will change little, which is exactly the assumption required to validate the exercise above. Such an argument does apply to the second money supply rule, which for well-known

References


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