NBER WORKING PAPER SERIES

SHUNTO, RATIONAL EXPECTATIONS, AND OUTPUT GROWTH IN JAPAN

Herschel I. Grossman

William S. Haraf

Working Paper No. 1144

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

June 1983

Prepared for presentation at the International Seminar on Macroeconomics, Paris, June 1983, and at the NBER Conference on Macroeconomics, Cambridge, July 1983. This research was assisted by a grant from the Joint Committee on Japanese Studies of the Social Science Research Council and the American Council of Learned Societies with funds provided by the National Endowment for the Humanities and the Ford Foundation. Michael Parkin made useful comments on an earlier draft. The research reported here is part of the NBER's research program in Economic Fluctuations and the project in Productivity in the World Economy. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #1144
June 1983

Shunto, Rational Expectations, and Output Growth in Japan

ABSTRACT

This paper describes a theoretical and empirical study of the Japanese macroeconomy that focuses on the role of predetermined nominal wages in the relation between monetary policy and aggregate output. The main features of the model are that nominal wage rates set at Shunto are equal to rational expectations of the nominal wage rates that would be consistent with target levels of real output and that firms determine employment and output by equating marginal productivities to real wage rates. The essential implication of the model is that the current deviation of aggregate output from its target level depends only on innovations in inflation and productivity since the last Shunto. The equation derived to implement the model empirically relates current aggregate output growth in a precise way to past values of output growth and inflation since the last Shunto and includes an explicit specification of a white noise error term. The results of econometric analysis of this restricted model equation are consistent with the hypothesis that nominal wages predetermined according to Shunto with rational expectations are important for the determination of real aggregates. The empirical analysis, however, also suggests that the assumptions about monetary policy used to close the model are not adequate, a result that leads to directions for further research.

Herschel Grossman
Department of Economics
Brown University
Providence, RI 02912

(401) 863-2606

William Haraf
Council of Economic Advisors
Washington, D.C. 20500

Historical experience and economic data both suggest that monetary policy has an important effect on the cyclical behavior of aggregate real variables, such as employment and output. Identification of the characteristics of market economies that account for this apparent connection between nominal causes and real effects presents a difficult challenge to economic analysis. Keynesian models attribute this linkage of nominal and real aggregates to the failure of labor markets to clear. This approach, for reasons discussed in Grossman (1983), remains the most popular framework for the analysis of macroeconomic fluctuations.

The key assumptions of Keynesian models are that nominal wage rates are at least partly predetermined and that employment adjusts to equate marginal productivities to contemporaneous real wage rates. A standard motivation for these assumptions is the observation that actual labor contracts involve multiperiod setting of future nominal wage rates, with only incomplete, if any, indexation of nominal wages to prices and other variables, and allow firms proximately to decide on short-run changes in employment. The essential argument is that this arrangement allows monetary policy to influence the decisions of firms about aggregate employment and aggregate output by causing the price level to change relative to the predetermined level of nominal wage rates.

A seminal paper by Fischer (1977) generates more precise predictions about the relation between monetary policy and real aggregates by incorporating into the Keynesian framework two further assumptions about the nature of wage determination. One assumption is that the objective of agents who make labor contracts is to set future nominal wage rates such that future employment and output will equal given target levels, usually described as those levels that would be consistent with "market clearing". The other assumption is that this process of wage determination reflects rational expectations. Specifically, the agents who set nominal wages behave as if they understand the economy's relevant stochastic structural relations, which, in this context, include the processes governing monetary policy.

These two assumptions imply that the wage setting process employs all available information to determine the future nominal wage rates that are likely to be consistent with the target levels of the real variables. In particular, rational wage-setting agents take fully into account any aspects of future monetary policy that they can predict. This behavior implies that monetary policy can affect real aggregates only if monetary policy responds to a larger information set than is available to wage-setting agents. Actual experience, of course, suggests that the monetary policy process reacts to new information more frequently than nominal wages are adjusted. In this way a critical difference in information sets results from a systematic response of current monetary policy to events that occur after the wage-setting process has predetermined current nominal wages.

The main theoretical objection to models in which predetermined nominal wages play a critical role in determining real aggregates is that analysis of efficient labor contracts suggests that employment should adjust to equate marginal productivities to the marginal values of alternative uses of time, but not necessarily to contemporaneous real wage rates. Even if nominal wage rates are predetermined, the actual short-run employment changes that firms select actually might satisfy this efficiency criterion. This efficiency argument is theoretically appealing, especially from the perspective of neoclassical economic analysis, and, as explained in Hall (1980), creates a tension between Keynesian macroeconomic analysis and the standard neoclassical approach to other economic phenomena. Nevertheless, the Keynesian approach has retained its popularity primarily because efficient employment determination, especially given the availability of accurate contemporaneous monetary data, seems inconsistent with the apparent effect of monetary policy on the cyclical behavior of real aggregates. Grossman (1983) and Boschen and Grossman (1982) provide extensive discussions of this point.

Although Keynesian models that use Fischer's assumptions about wage setting can generate a number of potentially testable hypotheses, empirical analysis of them as yet has not gotten far, mainly because the specification of relevant information sets requires dating of the formation of the expectations on which the current level of nominal wages is based. For the United States and most other countries, this dating is difficult because wage setting is not synchronized. Specifically, given the prevalent pattern of overlapping contracts with differing origination dates and durations, the present nominal wage level in most countries presumably reflects expectations that were taken at many dates in the past over horizons of many different lengths and, hence, that were based on many different information sets. Neither theoretical nor empirical analysis readily generates hypotheses about the relevant weighting of this past information.

Japan in this regard is exceptional because, since 1955, Japanese wage setting increasingly has conformed to a synchronized pattern that results from the annual "spring labor offensive" (Shunto) and the associated process of collective bargaining. In Shunto, all of the major labor unions and managements negotiate wage settlements for the next fiscal year, which begins April first. The outcome of these negotiations is also influential in determining wage adjustments for members of smaller unions and for non-unionized and government employees. Given rational expectations, the critical implication of this synchronized annual wage setting is that the present nominal wage level reflects only expectations based on information available at the time of the last Shunto. Thus, as suggested by Taniuchi (1982), the Shunto arrangement presents a unique opportunity to implement empirically a model based on the work of Fischer and, thereby, to study the role of predetermined nominal wages in the relation between monetary policy and macroeconomic fluctuations.

Although the Shunto arrangement of annual wage setting appears to fit the story of predetermined nominal wage rates, the widespread Japanese practice of semi-annual bonus payments, which apparently average about a quarter of total labor compensation, complicates the picture. It seems clear that these bonus payments introduce flexibility into Japanese compensation arrangements, and one might conjecture that they make actual compensation sufficiently sensitive to current economic conditions that decisions made at Shunto are unimportant for determining real outcomes. At the least, the practice of bonus payments means that the importance of multiperiod nominal-wage setting for Japanese macroeconomic fluctuations is not obvious and, hence, requires empirical substantiation.

In what follows, Section 1 sets up a model of the determination of aggregate output in Japan. The main features of this model are that nominal wage rates set at Shunto are equal to rational expectations of the nominal wage rates that would be consistent with clearing of labor markets, and that firms determine employment and output by equating marginal productivities to real wage rates. Section 2 closes the model in a provisional way by deriving a stochastic process that generates the price level. The key assumption in this section is that the Bank of Japan attempts to achieve a fixed target inflation rate. Section 3 derives the implications of the model, on which the empirical analysis focuses, for the relation between growth in aggregate output during the current quarter and the pattern of output growth and inflation since the last Shunto. Section 4 describes the empirical analysis. Section 5 summarizes the results of this provisional study and outlines a program for further research.

1. Wage-Setting and Aggregate Output

Consider a Shunto that takes place at the end of the fourth quarter of Japanese (fiscal) year t-1 and determines nominal wages for the four quarters of (fiscal) year t. Following Fischer, assume that the wage-setting process conforms to

$$(1) \qquad W_{t,\tau} = E_w W^*_{t,\tau}, \quad \text{for} \quad \tau = 1,2,3,4$$

where the index (t,τ) denotes quarter τ of year t,

$W_{t,\tau}$ is the log of the actual nominal wage level in (t,τ),

$W^*_{t,\tau}$ is the log of the nominal wage level that would be consistent with clearing the labor market in (t,τ),

and E_w is an operator that denotes a rational expectation conditional in information available at the end of quarter $(t-1,4)$.

To analyze the determination of $W^*_{t,\tau}$ and $E_w W^*_{t,\tau}$, assume that, both for the representative firm and in aggregate, output has the following log-linear relation to employment:

(2) $$Y_{t,\tau} = \alpha N_{t,\tau} + \beta(4t+\tau) + s_\tau + \eta_{t,\tau}, \quad 0 < \alpha < 1,$$

where $Y_{t,\tau}$ is the log of aggregate output in (t,τ),

α is a parameter restricted such that the marginal productivity of labor is positive and diminishing,

$N_{t,\tau}$ is the log of aggregate employment in (t,τ),

β is the deterministic trend in productivity,

s_τ is the deterministic seasonal effect on productivity in all quarters τ,

and $\eta_{t,\tau}$ measures other effects on productivity in (t,τ).

The analysis assumes, importantly, that the wage-setting agents know the entire history through quarter $(t-1,4)$ of all of the variables in equation (2).

Disturbances to productivity play an important role in the model. For maximum generality, assume that, for any quarter i, η_i follows a moving average process of infinite order,

(3) $$\eta_i = \varepsilon_i + h_1\varepsilon_{i-1} + h_2\varepsilon_{i-2} + \ldots.$$

where ε_i is a normally distributed random variable, with zero mean, uncorrelated serially and uncorrelated with other random variables

and $h_1, h_2, \ldots$ are parameters. The disturbance η_i need not be stationary and, consequently, the series of h parameters need not converge. Equation (3) implies that

$$(4) \qquad \eta_{t,\tau} - E_w \eta_{t,\tau} = \varepsilon_{t,\tau} + \sum_{i=1}^{\tau-1} h_i \varepsilon_{t,\tau-i}.$$

Equation (4) says that the forecast error made at Shunto for productivity in (t,τ) equals a linear combination of the innovations in productivity during quarters $(t-1)$ through (t,τ).

The empirical implementation of this model focuses on aggregate output rather than aggregate employment because Japanese employment and unemployment data suffer from severe conceptual problems. For example, the data count as employed workers who are in a government-financed "employment adjustment" program that pays part of their usual earnings while they wait to be recalled to work. See Komiya and Yasui (1984) for a fuller discussion of these issues.

The essential Keynesian assumption is that firms determine employment and output by equating marginal productivities with real wage rates. This assumption, together with the production function given by equation (2), implies that aggregate output satisfies

$$(5) \qquad Y_{t,\tau} = (1-\alpha)^{-1}[\alpha(P_{t,\tau} - W_{t,\tau}) + \alpha \ln \alpha + \beta(4t+\tau) + s_\tau + \eta_{t,\tau}],$$

where $P_{t,\tau}$ is the log of the price level in (t,τ).

Equation (5) says that aggregate output depends positively on the realized price level relative to the predetermined nominal wage level and on productivity variables.

To calculate $W^*_{t,\tau}$, substitute for $Y_{t,\tau}$ in equation (5) the target value of output denoted by $Y^*_{t,\tau}$, that would be consistent with clearing of labor markets, and solve for the nominal wage rate. This calculation yields

$$(6) \qquad W^*_{t,\tau} = P_{t,\tau} + \ln\alpha + \alpha^{-1}[\beta(4t+\tau) + s_\tau + \eta_{t,\tau} - (1-\alpha)Y^*_{t,\tau}].$$

The specification of $Y^*_{t,\tau}$ is discussed below. To determine the actual nominal wage rate, apply the rational expectations operator E_w to equation (6) and substitute into equation (1), which gives

$$(7) \qquad W_{t,\tau} = E_w W^*_{t,\tau} = E_w P_{t,\tau} + \ln\alpha$$
$$+ \alpha^{-1}[\beta(4t+\tau) + s_\tau + E_w\eta_{t,\tau} - (1-\alpha)Y^*_{t,\tau}].$$

Equation (7) indicates that the nominal wage level determined at Shunto for quarter (t,τ) equals a linear combination of the rational expectation of the price level in (t,τ), the rational expectation of productivity in (t,τ), and the target for output in (t,τ).

The final step in this part of the analysis is to calculate actual aggregate output in (t,τ) by substituting equation (7) into equation (5) to get

$$(8) \qquad Y_{t,\tau} = Y^*_{t,\tau} + (1-\alpha)^{-1}[\alpha(P_{t,\tau} - E_w P_{t,\tau}) + \eta_{t,\tau} - E_w\eta_{t,\tau}].$$

Equation (8) indicates that the difference between actual aggregate output in (t,τ) and its target level, $Y^*_{t,\tau}$, equals a linear combination of the forecast errors made at Shunto for the price level and productivity. Specifically, unanticipated increases in prices and productivity both tend to raise aggregate output. Equation (4) gives the forecast error in productivity. The forecast error in the price level remains to be analyzed.

2. The Inflation Process

Keynes and Fischer assume that the price level adjusts each period to equate aggregate demand to aggregate output, as given by equation (5). A general specification of the determination of aggregate demand is

$$(9) \qquad Y_{t,\tau} = k(M_{t,\tau} - P_{t,\tau}) + v_{t,\tau},$$

where k is a positive parameter,

$M_{t,\tau}$ is the log of the money stock in (t,τ),

and $v_{t,\tau}$ represents all other factors influencing aggregate demand in (t,τ).

For present purposes, the precise specification of the stochastic process that generates $v_{t,\tau}$ is not important because in equation (13) below only the current innovation in $v_{t,\tau}$ turns out to be consequential for the inflation rate in (t,τ). The critical factor determining the price level is the monetary policy of the Bank of Japan, which is discussed presently.

Equating equations (5) and (9) gives as the solution for the price level,

$$P_{t,\tau} = [\alpha + k(1-\alpha)]^{-1}[(1-\alpha)(kM_{t,\tau} + v_{t,\tau}) + \alpha W_{t,\tau} - \alpha \ln \alpha - \beta(4t+\tau) - s_\tau - \eta_{t,\tau}],$$

and as a corresponding expression for the inflation rate,

$$(10) \qquad \Delta P_{t,\tau} = [\alpha + k(1-\alpha)]^{-1}[(1-\alpha)(k\Delta M_{t,\tau} + \Delta v_{t,\tau}) + \alpha\Delta W_{t,\tau} - \beta - \Delta s_\tau - \Delta\eta_{t,\tau}],$$

where Δ is an operator that denotes the difference between the value of a variable in (t,τ) and its value in the preceding quarter.

Assume provisionally that the Bank of Japan attempts to stabilize inflation at a fixed rate, and that to accomplish this objective the Bank revises its policies quarterly using rational expectations. In this context, rational expectations means that the Bank behaves as if it knows not only the structure of the economy and the past realizations of all stochastic variables but also the path of nominal wage rates determined at the preceding Shunto. Specifically, the Bank sets policy such that

(11) $$E_m \Delta M_{t,\tau} = \Delta M^*_{t,\tau}$$

where E_m is an operator that denotes a rational expectation conditional on information available at the end of the preceding quarter,

$\Delta M^*_{t,\tau}$ is the value of $\Delta M_{t,\tau}$ that is consistent with $E_m \Delta P_{t,\tau} = \pi$.

and π is the Bank's fixed inflation target.

The use of this model of monetary policy in the empirical analysis assumes that the basic objective of the Bank was unchanged over a sample period that includes major changes in the conduct of monetary policy, including the ending of a fixed yen-dollar exchange rate and the beginning of announced monetary targets. This assumption involves no inconsistency. A fixed policy objective--more generally, policy derived from constant preferences over outcomes--does not imply an unchanged policy regime relating policy instruments to predetermined variables. On the contrary, constant preferences suggest evolution of the conduct of policy in response to external events.

The discussion by Susuki (1981) of the evolution of Japanese monetary policy suggests that the Bank actually has constant preferences, which, however, involve real variables in addition to inflation, although the operating targets and conduct of monetary policy have changed over time. Specifically, Susuki indicates that since 1975, because of the perceived difficulty of juggling multiple operating targets, the Bank has focused on low inflation both as an objective and as a link to other objectives.

The strategy underlying equation (11) is to derive restrictions from theoretical analysis that takes monetary policy to be a rational process, rather than from merely descriptive specifications of policy regimes, in order to close the model and to implement empirically its testable implications. As Cooley, LeRoy, and Raymon (1982) cogently argue, the idea of rational expectations seems to dictate treating the preferences of the Bank as exogenous and the evolution of its policy regime as endogenous. Both the comments of direct observers like Susuki and the empirical results discussed below, however, suggest that a more complex specification of the Bank's preferences and decision making than that embodied in equation (11) would improve significantly the ability of the model to fit the data.

Applying the rational expectations operator, E_m, to equation (10) and using equation (11) gives

$$(12) \qquad E_m \Delta P_{t,\tau} = \pi = [\alpha + k(1-\alpha)]^{-1} [(1-\alpha)(k\Delta M^*_{t,\tau} + E_m \Delta v_{t,\tau}) + \alpha \Delta W_{t,\tau} - \beta - \Delta s_\tau - E_m \Delta n_{t,\tau}].$$

Subtracting equation (12) from equation (10) yields, as the stochastic process generating the price level,

$$(13) \qquad \Delta P_{t,\tau} = \pi + [\alpha + k(1-\alpha)]^{-1} [(1-\alpha) u_{t,\tau} - (\Delta n_{t,\tau} - E_m \Delta n_{t,\tau})]$$

where $u_{t,\tau} \equiv k(\Delta M_{t,\tau} - \Delta M^*_{t,\tau}) + \Delta v_{t,\tau} - E_m \Delta v_{t,\tau}$.

Denote $u_{t,\tau}$ as the unanticipated nominal disturbance. The analysis assumes that $u_{t,\tau}$ is a normally distributed random variable, with zero mean, uncorrelated serially and uncorrelated with past values of other random variables. Also, note that, from equation (3),

$$\Delta\eta_{t,\tau} - E_m\Delta\eta_{t,\tau} = \varepsilon_{t,\tau}.$$

Equation (13) says that the deviation of inflation from its target value is a random variable that is a linear combination of unanticipated shifts in the relation between policy instruments and the money stock and in other factors influencing aggregate demand, both captured by $u_{t,\tau}$, and the current innovation in productivity, $\varepsilon_{t,\tau}$. Note that an unanticipated positive nominal disturbance tends to increase prices, whereas an unanticipated positive productivity disturbance tends to decrease prices. Applying the rational expectations operator E_w to equation (13) yields

$$E_w\Delta P_{t,\tau} = \pi,$$

and subtracting from equation (13) gives

$$(14) \qquad \Delta P_{t,\tau} - E_w\Delta P_{t,\tau} = [\alpha+k(1-\alpha)]^{-1}[(1-\alpha)u_{t,\tau} - \varepsilon_{t,\tau}].$$

These equations indicate that the rational expectation of wage-setting agents at Shunto is that inflation will equal rate π for the next four quarters, and their forecast error of inflation is white noise.

To calculate the forecast error in the price level, which is critical for the determination of aggregate output, expand equation (14) to obtain

$$(15) \qquad P_{t,\tau} - E_w P_{t,\tau} = [\alpha+k(1-\alpha)]^{-1} \sum_{i=0}^{\tau-1} [(1-\alpha)u_{t,\tau-i} - \varepsilon_{t,\tau-i}].$$

Equation (15) indicates that this forecast error equals a sum of the innovations in the inflation rate during quarters (t,1) through (t,τ).

The final step in obtaining a solution for aggregate output is to substitute into equation (8) the expression for the forecast error in productivity from equation (4) and the expression for the forecast error in the price level from equation (15). This substitution yields

$$(16) \quad Y_{t,\tau} = Y^*_{t,\tau} + (1-\alpha)^{-1}\{\alpha[\alpha+k(1-\alpha)]^{-1} \sum_{i=0}^{\tau-1} [(1-\alpha)u_{t,\tau-i} - \varepsilon_{t,\tau-i}] + \varepsilon_{t,\tau} + \sum_{i=1}^{\tau-1} h_i \varepsilon_{t,\tau-i}\}.$$

The most noteworthy feature of equation (16) is that the deviation of aggregate output in (t,τ) from its target level depends only on innovations in inflation and productivity occurring during quarters $(t,1)$ through (t,τ)--that is, since the last Shunto. Innovations that occurred before the last Shunto are irrelevant. Moreover, the specification of past innovations that affects aggregate output differs by quarter. For example, for $\tau = 1$, current innovations are relevant, whereas, for $\tau = 2$, innovations in the current and preceding quarter are relevant, and so forth. These distinctive properties of the model follow from incorporating the synchronized setting of nominal wages at Shunto and the assumption that the wage setters form rational expectations using all information available at Shunto into the Keynesian framework. Note that, if bonus payments actually make nominal wages effectively determined only one period in advance, all quarters would be like the first quarter.

3. Testable Implications

The final component needed for empirical implementation of the model is the specification of the target level of aggregate output, $Y^*_{t,\tau}$, that the wage setters at Shunto try to achieve. In Fischer's formulation, the object of wage setting is to clear the labor market--that is, to make actual employment equal the quantity of labor supplied. This reasonable assumption by itself is not adequate for empirical implementation because the quantity of labor supplied is not directly observable.

A possible approach, which unfortunately is well beyond the scope of the present paper, would be to develop an explicit model of labor supply as a function of observable variables. A simpler alternative way to obtain an operational specification is to assume that the Shunto wage-setters aim for output to grow at a constant rate net of predictable seasonal effects. Specifically,

$$(17) \qquad Y^*_{t,\tau} - s_\tau = Y_{t-1,4} - s_4 + \tau g,$$

where g is the fixed target quarterly growth rate. The setting of the base for the target as output in quarter (t-1,4) reflects the timing of Shunto. If bonus payments actually make nominal wages effectively determined only one period in advance, the base would adjust every period. Given an appropriate story about labor supply, we can regard the target given by equation (17) as a proxy for clearing of the labor market. In any event, this specification seems to work well in the empirical implementation.

Substituting equation (17) into equation (16) completes the theoretical specification of the model. Empirical implementation, however, requires converting the moving average representation for the level of output relative to the target level given by equation (16) into a tractable autoregressive representation relating current output growth to past output growth and past inflation.

For $\tau = 1$, using equation (17), equation (16) becomes

$$(18) \qquad \Delta Y_{t,1} = g + s_1 - s_4 + [\alpha + k(1-\alpha)]^{-1}(\alpha u_{t,1} + k\varepsilon_{t,1}).$$

Thus, $\Delta Y_{t,1}$ equals the sum of the constant growth target, a seasonal effect, and a linear combination of unanticipated current nominal and productivity disturbances.

For $\tau = 2$, using equation (17) and subtracting equation (18) from equation (16) gives

$$(19) \qquad \Delta Y_{t,2} = g + s_2 - s_1 + [\alpha + k(1-\alpha)]^{-1}(\alpha u_{t,2} + k\varepsilon_{t,2}) + (1-\alpha)^{-1}(h_1 - 1)\varepsilon_{t,1}.$$

Thus, $\Delta Y_{t,\tau}$ equals the sum of the constant growth target, a seasonal effect, the same linear combination of unanticipated current nominal and productivity disturbances, plus a multiple of the unanticipated productivity disturbance in $(t,1)$.

To deal with this lagged disturbance, $\varepsilon_{t,1}$, note that for $\tau = 1$ equation (13) becomes

$$(20) \qquad \Delta P_{t,1} = \pi + [\alpha + k(1-\alpha)]^{-1}[(1-\alpha)u_{t,1} - \varepsilon_{t,1}].$$

Solving equations (18) and (20) simultaneously gives the following expression for the unanticipated productivity disturbance in $(t,1)$ in terms of output growth and inflation in $(t,1)$:

$$(21) \qquad \varepsilon_{t,1} = (1-\alpha)(\Delta Y_{t,1} - g - s_1 + s_4) - \alpha(\Delta P_{t,1} - \pi).$$

Substituting equation (21) into equation (19) and carrying out analogous procedures for $\tau = 3$ and $\tau = 4$ gives the required complete autoregressive representation:

$$(22) \qquad \Delta Y_{t,\tau} = g + \Delta s_\tau + H_1 D_1 Z_{t,\tau-1} + H_2 D_2 Z_{t,\tau-2} + H_3 D_3 Z_{t,\tau-3} + [\alpha + k(1-\alpha)]^{-1}(\alpha u_{t,\tau} + k\varepsilon_{t,\tau}),$$

where $H_1 = h_1 - 1$,
$H_2 = h_2 - h_1 - (h_1 - 1)^2$,
$H_3 = h_3 - h_2 - (h_2 - h_1)(h_1 - 1) + (h_1 - 1)^3$,

$$D_1 = \begin{cases} 0 & \text{for } \tau = 1 \\ 1 & \text{for } \tau = 2,3,4, \end{cases}$$

$$D_2 = \begin{cases} 0 & \text{for } \tau = 1,2 \\ 1 & \text{for } \tau = 3,4, \end{cases}$$

$$D_3 = \begin{cases} 0 & \text{for } \tau = 1,2,3 \\ 1 & \text{for } \tau = 4, \end{cases}$$

and $$Z_{t,i} = \Delta Y_{t,i} - g - \Delta s_i - \alpha(1-\alpha)^{-1}(\Delta P_{t,i} - \pi).$$

Equation (22), which we denote as "the model equation", represents aggregate output in (t,τ) as the sum of the constant growth target, a seasonal effect, a linear combination of current nominal and productivity innovations, and a linear combination, given by $Z_{t,i}$, of past deviations of output growth from its target and of inflation from its target during quarters $(t,1)$ through $(t,\tau-1)$, weighted by combinations--H_1, H_2, and H_3--of the coefficients of the moving average process generating the stochastic productivity disturbance. Note that if bonus payments actually make nominal wages effectively determined only one period in advance, the $Z_{t,i}$ variables would not appear in the equation and deviations in output growth from its target in all quarters would be white noise. Notice also that if $h_1 = h_2 = h_3 = 1$, a specification that would obtain if the productivity process were a random walk, the coefficients of the $Z_{t,i}$ variables would equal zero. In this special case, the model equation would be indistinguishable from the case in which nominal wages are determined only one period in advance. In general, however, the model equation reflects the implications of the peculiar timing of wage setting associated with Shunto.

The empirical analysis focuses on three features of the model equation. Each of these features reflects both the essential implication of incorporating Shunto and rational expectations into the Keynesian framework--namely, that deviations in aggregate output from its target level depend on innovations in inflation and productivity since the last Shunto--and the auxiliary assumptions about the targets of monetary policy and wage setting used to close the model.

First, the variables in the model equation include past values of output growth and inflation since the last Shunto. Specifically, in the first quarter after Shunto, no past values enter, whereas in the second quarter after Shunto, one set of past values enter, and so forth. Second, lagged values of output growth and inflation enter only as deviations from target values and only in the linear combination given by $z_{t,i}$. Third, given the growth target, seasonal effects, and the forecast error effects captured by past output and past inflation, the only remaining effects on current output growth are from current stochastic innovations. Because there are no data that directly measure these innovations, regression analysis must treat them as random errors. The model equation, however, fully describes the components of this error term and specifies that the error term is white noise.

4. Empirical Analysis

The empirical analysis begins with estimation of the parameters of the model subject to the restrictions incorporated in the model equation. The calculation of the estimates uses the nonlinear least-squares procedure LSQ from the computer program TSP (Hall and Hall, 1980). The data are from fiscal quarter (1959,4), which is the first quarter of calendar year 1960 and is the earliest date for which consistent data are available, to fiscal quarter (1982,2). All data are seasonally unadjusted. The index of industrial production serves as a proxy for aggregate output. National income accounts data do not seem suitable because they apparently measure final sales rather than production and do not include a reliable measure of net inventory investment. In the results reported below, the measure of the Bank's inflation target is the mean rate of change in the consumer price index over the sample period, 1.7% per quarter, and changes in the consumer price index also serve as the measure of actual inflation. Results obtained using the index of wholesale prices for manufacturing industry products instead of the consumer price index are essentially the same. The calculations normalize the seasonal effects on productivity by setting Δs_1 equal to zero.

Table 1 gives the results of the estimation of the model parameters within the specified model equation. The model equation seems to fit the data well. Most importantly, although examination of the residuals indicates some evidence of residual autocorrelation at four and five lags, the Box-Pierce test for serial correlation in the residuals strongly indicates that the data do not reject the hypothesis that the disturbance term is white noise. As noted above, this hypothesis is a strong implication of the model equation, which includes an explicit specification of the error term.

In addition, the individual parameter estimates accord with the theory and seem reasonable. The restriction imposed by the production function is easily satisfied as the estimated value of α differs by more than five standard errors from both zero and unity. The estimated target growth rate for $\tau = 1$, given by g, is 3.0%. The estimated target growth rates for the other quarters, given by $g + \Delta s_\tau$, are 1.8% for $\tau = 2$, 3.7% for $\tau = 3$, and -1.3% for $\tau = 4$. The estimated average target growth rate is 1.8% per quarter.

The estimated values of the coefficients of the moving average process generating the stochastic productivity disturbance--h_1, h_2, h_3--all exceed unity by more than four standard errors. This result suggests that the productivity process is not stationary. Importantly, the fact that the implied coefficients of the $Z_{t,i}$ variables are significantly different from zero is consistent with the hypothesis that nominal wages set at Shunto are important for real outcomes and implies that the actual flexibility in compensation associated with bonus payments is limited.

From an historical perspective, it is interesting to calculate the actual time paths of the nominal innovation and the productivity innovation implied by the model and the data. Let $x_{t,\tau}$ denote the estimated residuals from the model equation. Equation (22) specifies that

$$x_{t,\tau} = [\alpha + k(1-\alpha)]^{-1}(\alpha u_{t,\tau} + k\varepsilon_{t,\tau}),$$

and equation (13) specifies that

$$\Delta P_{t,\tau} - \Pi = [\alpha + k(1-\alpha)]^{-1}[(1-\alpha)u_{t,\tau} + \varepsilon_{t,\tau}].$$

Solving these equations gives

$$u_{t,\tau} = x_{t,\tau} + k(\Delta P_{t,\tau} - \Pi)$$

and $$\varepsilon_{t,\tau} = (1-\alpha)x_{t,\tau} - \alpha(\Delta P_{t,\tau} - \Pi).$$

Thus, the implied current nominal innovation equals the sum of the current estimated residuals and the current deviation of inflation from its mean, weighted by k. The implied current productivity innovation equals the difference between the current estimated residual, weighted by $1-\alpha$, and the current deviation of inflation from its mean, weighted by α.

Calculations of these innovations, using the estimated value of α and a value for k of unity, which seems plausible, reveal the standard deviation of the nominal innovations to be almost twice as large as the standard deviation of the productivity innovation. The correlation coefficient for the innovations is .35. For each innovation, most of the absolute values larger than one standard deviation are isolated events or occur in sequences that sum to approximately zero over a few quarters. The notable exceptions are large positive nominal innovations in every quarter of fiscal year 1973 and negative productivity innovations that are large but of decreasing magnitude in quarters (1973,4), (1974,1), and (1974,4). These productivity innovations are presumably associated with the first oil-price shock, but, interesting, no stochastic innovations, either productivity or nominal, are associated with the second oil-price shock.

A key aspect of the model equation is that the effects of both nominal innovations and productivity innovations persist only through the current fiscal year. A dramatic example of the phenomenon occurs between 1974 and 1975. As the apparent result of the large negative productivity innovations in quarters (1974,1) and (1974,4), reinforced by nominal disturbances that on net for the year were also negative output growth was negative throughout fiscal year 1974, averaging almost seven percent per quarter less than the target growth rates and reaching a low of over eleven percent below the target growth rate for quarter (1974,4). In accord with the absence of inter-annual persistence, however, output growth recovered dramatically to exceed the target growth rate by almost two percent in quarter (1975,1), aided only by an apparently small positive nominal innovation in that quarter, and averaged slightly more than the target growth rate for fiscal year 1975.

A related, if somewhat less dramatic, example occurs a year earlier. The largest negative productivity innovation during the sample period apparently was in quarter (1973,4), and output growth was over four percent less than the target growth rate for that quarter, despite large positive nominal innovations in every quarter of fiscal year 1973. Another large negative productivity innovation apparently occurs in the next quarter (1974.1), together with a small negative nominal innovation. Output growth in quarter (1974,1), however, declines no further relative to the target growth rate for that quarter, reflecting the failure of the effects of the first negative productivity innovation to persist into the next fiscal year.

More generally, the model implies that the variance of the difference between actual and target output growth, denoted by V_τ, increases with τ. Specifically, from the model equation,

$$V_\tau = [\alpha+k(1-\alpha)]^{-2}(\alpha^2\sigma_u^2 + 2\alpha k\sigma_{u\varepsilon} + k^2\sigma_\varepsilon^2) + (1-\alpha)^{-2}\sigma_\varepsilon^2\sum_{i=1}^{\tau-1} H_i^2.$$

The differences between actual output growth and the estimated target growth rates, however, have the following variances:

$$\hat{V}_1 = .54, \quad \hat{V}_2 = .43, \quad \hat{V}_3 = .64, \quad \hat{V}_4 = 1.38.$$

Given the above formula for V_τ and the estimated values of the H_i coefficients, the calculated values for $\hat{V}_1$ and $\hat{V}_4$ seem too large relative to the calculated values of $\hat{V}_2$ and $\hat{V}_3$. A possible explanation for this result is the existence of significant seasonality in the variance of the productivity disturbance, from which the model equation abstracts.

The restricted set of past values of output growth and inflation that appear in the model equation is apparently highly correlated with alternative specifications in which all past values enter in each quarter. Table 2 gives the results of estimating a regression equation in which current output growth in all quarters depends on four lagged values of output growth and inflation and on seasonal dummies. Some of the estimated coefficients in this equation are statistically significant or nearly so and the standard error of this regression is only slightly higher than the standard error of the regression reported in Table 1 for the model equation.

If the model equation is true, the regression in Table 2 fits the data almost as well as the model equation only because the fuller set of past values in Table 2 are good proxies for the restricted set of past values in the model equation. An alternative conjecture, however, is that the model equation fits the data well only because its restricted set of past values are good proxies for a fuller set of past values, which perhaps is the true specification.

To evaluate these alternative explanations, it is necessary to compare the fit of the regression given in Tables 1 and 2 with the fit of a regression equation that includes both the restricted set of past values from the model equation and the fuller set of past values. Table 3 gives the results of estimating such an expanded regression equation. The standard error of this regression is only slightly less than the standard error of the regression for the model equation. The appropriate likelihood ratio, however, computed as twice the difference between the logs of the likelihood functions from the expanded equation and the model equation, is 16.6, which exceeds the relevant critical value of $\chi^2_{.95}(8) = 15.5$. This result indicates that the improvement in the fit of the expanded equation over the model equation is statistically significant.

The finding that the fuller set of past values adds statistically significant explanatory power implies that the model equation involves some misspecification. Notice that in the expanded regression the estimated value of α, which multiplies the past values of inflation in the model equation, is not significantly different from zero and that, among the fuller set of past values, the added explanatory power seems to come from past inflation. These observations suggest that the provisional assumptions underlying the specification of monetary policy and the inflation process, rather than the basic Keynesian specification with Shunto and rational expectations, may be leading the model equation astray.

A comparison of the estimated expanded equation in Table 3 with the estimated equation in Table 2 is also interesting. In this case, the appropriate likelihood ratio is 24.8, and also exceeds the relevant critical value of $\chi^2_{.95}(5) = 11.1$. This result indicates that the improvement in fit of the expanded equation over the equation without the restricted set of past values from the model equation is also statistically significant. Thus, it appears that the model equation, although suffering from some misspecification, captures an important aspect of reality. Specifically, the finding that the restricted set of past values from the model equation adds statistically significant explanatory power implies that a simple specification of output growth in which the same set of past values enters in each quarter with fixed coefficients is not realistic. In other words, the data support the prediction of the model that coefficients of a distributed lag equation for output growth for Japan are not time invariant.

5. Conclusions and Extensions

The conclusions that follow from the provisional analysis reported here are mixed. The positive results are that the Japanese data seem to be consistent with the hypothesis that the setting of nominal wages more than one period in advance is important for the determination of real aggregates, but that, because of Shunto and rational expectations, only innovations in inflation and productivity since the last Shunto cause aggregate output to differ from its target level. Specifically, the restricted set of past values of output growth and inflation implied by the model has significant explanatory power and the estimated residuals from the model equation conform to the white noise process implied by the model. The estimates of the structural parameters also accord with the theory.

The conclusion that the Keynesian framework as extended by Fischer is relevant for Japan accords with what Taniuchi (1982) concluded from studying somewhat different implications of the role of Shunto. Except for the Shunto arrangements, the factors that determine aggregate output in Japan do not differ in any obvious ways from other market economies. Thus, both the present study and Taniuchi's work suggest that Fischer's model is also relevant in other market economies, for which direct testing of its implications is more difficult than in Japan.

The negative finding from the analysis reported here is that the effect of past values of output growth and inflation on current output growth seems not to be limited to the restricted set of past values implied by the model. The results suggest, however, that the auxiliary assumptions about monetary policy used to close the model are mainly at fault. In any event, it is clear that accounting adequately for the relation between nominal and real aggregates in Japan requires more ambitious modelling.

Further research along these lines will involve additional analysis of the wage-setting process, of the factors influencing aggregate output, and of monetary policy. One extension is to consider other targets for the wage-setting process. Another useful set of possibilities involves extension of the specification of the production function to include more than one input and more than one stochastic process generating the observed productivity disturbance. Allowing for additional inputs would permit explicit consideration, for example, of the effect of historical changes in relative fuel prices. Allowing for additional stochastic processes would require more ambitious theoretical analysis, but also would introduce potentially relevant inference problems and dynamic considerations into the formation of rational expectations.

The specification of monetary policy seems to be the weakest part of the existing model. In this regard, two new directions are worth exploring. One possibility is to try to determine the process generating monetary policy empirically, in the spirit of Barro's work, rather than by deriving restrictions from theoretical analysis. The other possibility is to extend the analysis of rational monetary policy to include more complex goals than merely stabilizing inflation. Both direct observation and preliminary examination of data suggest that the Bank of Japan worries at least about aggregate output growth and the real exchange rate of the yen, in addition to inflation.

Table 1

Estimation of Model Equation

Parameter	Estimated Value	Standard Error
g	.03	.01
α	.49	.09
h_1	1.69	.14
h_2	2.46	.30
h_3	2.34	.31
Δs_2	-.012	.005
Δs_3	.007	.006
Δs_4	-.043	.007

Log of likelihood function: 212.4

Standard error of the regression: .0215

Residual autocorrelations:

$r_1 = -.04$	$r_5 = -.23$
$r_2 = .04$	$r_6 = -.02$
$r_3 = .05$	$r_7 = .06$
$r_4 = .15$	$r_8 = -.03$

Box-Pierce Q statistic: 6.7 $\chi^2_{.95}(8) = 15.5$

The coefficients of the linear combination, $z_{t,i}$, of past output growth and past inflation, given in equation (22), are estimated as follows:

Coefficient	Estimated Value	Standard Error
H_1	.69	.14
H_2	.30	.17
H_3	-.33	.21

Table 2

Regression of ΔY on Four Lags of ΔY and ΔP and on Seasonal Dummies

Coefficient of	Estimated Value	Standard Error
Constant	.05	.01
ΔY_{i-1}	.19	.11
ΔY_{i-2}	-.05	.11
ΔY_{i-3}	-.13	.11
ΔY_{i-4}	.22	.10
DP_{i-1}	-.26	.22
DP_{i-2}	-.21	.23
DP_{i-3}	-.41	.23
DP_{i-4}	-.41	.25
DUMMY 1	.04	.01
DUMMY 2	.02	.01
DUMMY 3	.04	.01

Log of likelihood function: 208.3

Standard error of the regression: .0232

Table 3

Estimation of Model Equation Supplemented with Four Unrestricted Lags of ΔY and ΔP

Parameter	Estimated Value	Standard Error
G	.05	.01
α	.22	.27
h_1	1.68	.19
h_2	2.41	.40
h_3	2.10	.43
Δs_2	-.002	.011
Δs_3	.032	.016
Δs_4	-.006	.024
Coefficient of		
ΔY_{i-1}	-.12	.13
ΔY_{i-2}	-.09	.11
ΔY_{i-3}	-.02	.11
ΔY_{i-4}	.13	.10
ΔP_{i-1}	-.23	.23
ΔP_{i-2}	-.17	.21
ΔP_{i-3}	-.18	.21
ΔP_{i-4}	-.44	.22

Log of likelihood function: 220.7

Standard error of the regression: .0206

The coefficients of $z_{t,i}$ in the model equation are estimated as follows.

Coefficient	Estimated Value	Standard Error
H_1	.68	.19
H_2	.26	.21
H_3	-.49	.24

References

J.F. Boschen and H.I. Grossman, "Tests of Equilibrium Macroeconomics Using Contemporaneous Monetary Data," Journal of Monetary Economics, 8, November 1982.

T.F. Cooley, S.F. LeRoy, and N. Raymon, "Modeling Policy Interventions," unpublished, December 1982.

S. Fischer, "Long-term Contracts Rational Expectations, and the Optimal Money Supply Rule," Journal of Political Economy, 85, February 1977.

H.I. Grossman, "The Natural-Rate Hypothesis, the Rational-Expectations Hypothesis, and the Remarkable Survival of Non-Market-Clearing Assumptions." in K. Brunner and A. Meltzer eds., Carnegie-Rochester Conference Series on Public Policy, Volume 19 (New York: North-Holland, 1983).

B.H. Hall and R.E. Hall, Time Series Processor: Version 3.5, User's Manual (Stanford, California: 1980).

R.E. Hall, "Labor Supply and Aggregate Fluctuations," in K. Brunner and A. Meltzer, eds., Carnegie-Rochester Conference Series on Public Policy, Volume 12 (New York: North-Holland, 1980).

R. Komiya and K. Yasui, "Japan's Macroeconomic Performance Since the First Oil Crises: Review and Appraisal" in K. Brunner and A. Meltzer, eds., Carnegie-Rochester Conference Series on Public Policy, Volume 20 (New York: North-Holland, 1984).

Y. Susuki, "Monetary Control and Anti-Inflation Policy: The Japanese Experience Since 1975," Bank of Japan Discussion Paper No. 8. September 1981.

M. Taniuchi, "Prior Monetary Expectations and Output Determination: A Study of the Japanese Economy," unpublished dissertation, Brown University, 1982.