Discriminating between Keynesian and Classical Theories of the Business Cycle: Japan 1967-1982*

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I. Introduction

This paper reports the results of a study of the time series behaviour of aggregate output in Japan. The central objective of the study is to discriminate between Keynesian and Classical theories of the business cycle. By Keynesian theories I mean that class of models proposed by Stanley Fischer (1977), and Edmund S. Phelps and John B. Taylor (1977). In such models, wages are contractually determined for several future periods. The formulation that I employ follows JoAnna Gray (1976) and supposes that wages are set at a level such that the labour market is *expected* to clear

* This paper is based on work undertaken during my tenure as "Visiting Scholar from Abroad" at the Institute for Monetary and Economic Studies, the Bank of Japan, Tokyo. I am grateful to Haruo Shimada (Keio University) and Kazuo Koike (Kyoto University) for educating me on the intricacies of the Japanese labour market; to Michio Hatanaka (Osaka University), Fumio Hayashi (Tsukuba University), Toshiyuki Mizoguchi (Hitotsubashi University), Katsuto Tanaka (Hitotsubashi University), Toshihisa Toyoda (Kobe University), Kazuo Ueda (Osaka University), and Taku Yamamoto (Yokohama National University) for extensive and helpful comments on an earlier draft of my work; to Barry Cozier (Concordia University) and Takatoshi Ito (University of Minnesota) for helpful discussions; to Akinari Horii (Bank for International Settlements) and Hiroo Taguchi (Bank of Japan) for helpful discussions on seasonality; to Yoshiaki Shikano for excellent research assistance as well as for thoughtful and constructive criticism; to Keiko Kimura for secretarial assistance. Work on this paper since returning to Canada has been supported by a grant from the Social Sciences and Humanities Research Council of Canada.

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but the *actual* level of employment (and of output) depends on the *demand* for labour. By Classical business cycle theory, I mean the model proposed by Robert E. Lucas Jr. (1972, 1973) and analyzed by Robert J. Barro (1976) and Thomas J. Sargent and Neil Wallace (1975). This is an equilibrium model in which the level of employment (and output) is the level that clears the labour market given the prevailing, but incomplete, state of information.[1]

There are two reasons why the Japanese economy provides a data base that is particularly well-suited to the task of discriminating between Keynesian and Classical theories of the business cycle. First, the institution of the "spring labour offensive", or "Shunto", provides a close empirical approximation to non-staggered labour market contracts.[2] This simplifies the specification of the Keynesian model compared with the case of staggered-contracts.[3] When contracts are staggered, Keynesian theory accounts for persistence in output fluctuations as a direct consequence of the timing structure of wage changes. When contracts are not staggered, persistence from one contract period to the next has to be treated as emanating from the same source as in the Classical theory. That source is the costly adjustment of factor inputs.[4] Allowing simultaneously for both staggered contracts and costly input adjustments is unlikely to lead to sharp inferences concerning the separate roles of these sources of inertia. If staggered wage setting can be ruled out *a priori* as the source of persistence, as it can in the case of Japan, then better inferences about persistence arising from costly input adjustments (or some other yet to be discovered source) may be made.

Second, the extensive use of bonus payments in Japan creates a potentially exploitable ambiguity concerning the importance of contractually predetermined wages. One view is that Japanese wage bonuses inject sufficient flexibility into real wages to ensure that the labour market is always cleared.[5] This corresponds to the

1. For an extensive nontechnical description of these alternative theories, as well as for a guide to the broader literature, see Michael Parkin (1984, Chs. 23-29).

2. Between 70% and 80% of all contracts are negotiated (early) in the second quarter of each year and approximately 20% are negotiated (late) in the first quarter (see Haruo Shimada, T. Hosokawa and A. Seike, <1982, pp. 49-51>). Thus, almost all contracts are negotiated within a few weeks of each other.

3. See John B. Taylor (1979, 1980).

4. In operational terms, this effect was captured by Lucas (1973) with the inclusion of an autoregressive term in the supply function. More recently, the almost equivalent assumption employed is a time lag in the production function—see, in particular, Finn E. Kydland and Edward C. Prescott (1980, 1982) and John B. Long Jr. and Charles I. Plosser (1983).

5. See especially Masanori Hashimoto (1979).

Classical model. Other students of the Japanese labour market, in contrast, emphasize the relative constancy of bonus payments over the cycle[6] and conclude that "wage fluctuations in Japan depend greatly on the wage rate decided on through collective bargaining".[7]

The models to be studied here will exploit these features of the Japanese economy in order to attempt to test and discriminate between a Keynesian and Classical interpretation of the Japanese business cycle. The performance of the Japanese economy, over this sample period, contains an unusual contrast of "failure" following the first oil shock (1974-75) and "success" following the second oil shock (1979-80). It is of considerable interest, therefore, to investigate the sources of those very different responses to a rather similar shock. Part of that difference is almost certainly attributable to monetary policy. There are, however, two views on how important monetary policy was. One view is that it was all important. The other view is that monetary policy only made a difference in performance because it was aided by fortunate institutional arrangements in the labour market.[8] The findings of this exercise will, if conclusive, be useful for resolving this policy dispute.

Although there is much that is novel in this paper, its point of departure is not a vacuum. There already exist several interesting, if inconclusive, studies of the macroeconomic behaviour of Japan, and the work reported here has benefitted enormously from, and in some respects represents an extension of, these. In particular the work of C. Piggot (1978), Yoshiharu Oritani (1981), Jun'ichiro Seo and Wataru Takahashi (1981), Mitsuru Taniuchi(1982), Koichi Hamada and Fumio Hayashi (1983) and Herschel I. Grossman and William S. Haraf (1983), form an invaluable starting point for this investigation.

The paper is organized in the following way. First, in the next section (Part II), the structures of two aggregate models—one Keynesian and one Classical—are set out and their predictions concerning the time series behaviour of aggregate output are derived. In Part III, the time series behaviour of output in the Japanese economy between 1965(1) and 1982(1) is examined and, in the light of the earlier studies, cited above, a variety of alternative models are proposed, some consistent with the Keynesian theory and some with the Classical theory. A large variety of alternative specifications of the deterministic trend and seasonal components of output has been proposed in the earlier literature and it is vital that these alternatives be discrim-

6. In the decade 1971-81, bonuses fluctuated between the equivalent of 2.4 and 3.3 months' earnings. (*Katsuyō Rōdō Tōkei,* Table C27, 1979, p. 79; 1983, p. 85; Japan Productivity Centre, Tokyo).

7. In particular, see Shimada *et al* (1983).

8. See R. Komiya and K. Yasui (1973).

inated amongst. This discrimination has to be conducted simultaneously with the attempt to discriminate between Keynesian and Classical theories of the cycle. This exercise is conducted on two levels: First, in terms of rather general distributed lag models and, subsequently, in terms of more specialized formulations.

The main conclusion reached is that, we may not reject the hypothesis that the cycle in aggregate output in Japan is well-described by a first order stochastic difference equation that is independent of influence from *past* values of the money stock and velocity. Earlier studies that have reached conclusions contrary to this were based on faulty procedures for handling the trends and seasonal components in output. The basic characterization of the cycle that emerges is one that does not reject the Classical theory of the business cycle but that does reject the Keynesian theory.

It remains to be seen whether these conclusions will be robust and whether they can survive more stringent tests in models that explore the deeper structure of the Japanese economy. It also has to be noted that the conclusion (like those that it challenges) is based on what has to be acknowledged as a "small sample".

II. Two Theories of the Business Cycle

In this section, two alternative theories of the business cycle are presented. The first is a Keynesian theory that has been heavily influenced by, though in some important respect differs from that proposed by, Grossman and Haraf (1983). The Classical model to be proposed here is one based directly on the work of Lucas (1973).

Each of the models will be specified at the level of market behaviour, or aggregate decision rules and no attempt will be made to penetrate the deeper structure of the preferences and technology that lie behind those decision rules. This is an acknowledged shortcoming of the study. It does, however, reflect the current state of the art. Although there are deeper models in the Classical vein available, no similarly deep general equilibrium models incorporating Keynesian rigidities appear to be available.[9]

1. A Keynesian Model

The starting point for, and chief distinguishing characteristic of, the Keynesian model of the business cycle is a specification of the behaviour of aggregate supply.

9. For an attempt to provide a general equilibrium model of "sticky prices", see Michael Parkin (1983).

The analysis begins with a short-run production function. Expressing all the variables in logarithms, such a production function may be written as:

$$Y^A_{t,\tau} = \alpha\, \ell_{t,\tau} + D_{t,\tau}\,,\quad 0 < \alpha < 1 \tag{1}$$

where Y^A = aggregate output
ℓ = aggregate employment
D = shifts in production function—constant, trends, seasonals, inertia, and noise
t = year
τ = quarter (1,2,3,4).

This is a quite general specification of the production function. Output varies directly with variations in labour input. In addition, however, the production function shifts over time. Capital accumulation and technological progress generate long-term trends in output. Climatic conditions and other fixed seasonal factors generate seasonal fluctuations. Nonlinear adjustment costs produce inertia and, finally, enumerable random events generate noise.

It is assumed that firms maximize profits so that, given the aggregate production function in (1), the demand for labour will be given by:

$$\ell_{t,\tau} = \frac{1}{1-\alpha}\{\log \alpha + D_{t,\tau} - (W_{t,\tau} - P_{t,\tau})\} \tag{2}$$

where W = money wage rate
P = price level.

The supply of labour (ℓ^S) is assumed to be given by:

$$\ell^S_{t,\tau} = N_{t,\tau} + r\,(W_{t,\tau} - E_i P_{t,\tau}),\quad r > 0 \tag{3}$$

where N = shifts in the supply of labour function—trends, seasonals, inertia and noise
E_i = expectations operator, conditional on information available at i
i = $t, \tau - 1$ for $\tau = 2, 3, 4$
$t - 1, 4$ for $\tau = 1$.

Like the production function, the supply of labour function is presumed to be subject to trends, seasonals and random fluctuations. The supply of labour is specified as depending upon the *expected* real wage, reflecting the idea that, at the time of committing themselves to a labour-supply decision, households do not have complete information on the prices of the products that they will be purchasing with the proceeds from their labour. This contrasts with the demand for labour which is specified as depending upon the actual real wage. This reflects the idea that firms know the prices of the outputs that they are selling at the time at which they make decisions on the volume of labour to employ. There is no asymmetry of information being assumed here. Rather, it is that the demand for labour represents the aggregation of individual demands, each of which depends upon a "local" known, real wage, whereas the supply of labour represents an aggregation of individual labour supplies, each of which depends upon a known money wage and an expectation of the *general* price level.

The essential characteristic of the Keynesian model of the labour market is that wages are set once a year and are fixed for the entire year. That is:

$$W_{t,\tau} = W_t \quad , \quad \tau = 1, \cdots, 4. \tag{4}$$

In setting wages at a fixed level for the succeeding four quarters, the objective (of both sides of the labour market) is the achievement of a labour market which, on the average, clears. That is:

$$\sum_\tau E_W \ell_{t,\tau} = \sum_\tau E_W \ell^s_{t,\tau} \tag{5}$$

where

$$E_W \equiv E_{t-1,4}.$$

In order to determine the wage level (W_t) that achieves an expected clearing of the labour market, substitute equations (2) and (3) into (5) and then solve for W_t in accordance with (4). This gives:

$$W_t = \frac{1}{4}\sum_\tau E_W P_{t,\tau} + \frac{1}{1+\gamma(1-\alpha)} [\log \alpha$$
$$+ \frac{1}{4}\sum_\tau \{ E_W (D_{t,\tau} - (1-\alpha) N_{t,\tau})\}]. \tag{6}$$

The money wage is set at a level that is homogeneous of degree one in the expectation of the average price level for the forthcoming four quarters. This implies, of course, that what is determined in the wage negotiations is an expected real wage. That expected real wage depends on expectations of production function and labour supply shocks. The higher is the expected level of marginal product, the higher will be the real wage and the higher is the expected supply of labour, the lower will be the real wage.

The next essential feature of the Keynesian model is that it is the demand for labour curve that determines the amount of employment. The labour supply curve, having been used (in an *ex ante* sense) to determine the money wage rate, no longer is relevant. Workers, in accepting a money wage offer, also implicitly accept the right of the employer to determine the total level of employment. Thus, to calculate the level of employment, the money wage rate may be used in conjunction with equation (2) above to give the actual level of employment as:

$$\ell_{t,\tau} = \frac{r}{1+r(1-\alpha)} \log\alpha + \frac{1}{1-\alpha} D_{t,\tau} - \frac{1}{(1-\alpha)\{1+r(1+\alpha)\}} \cdot \frac{1}{4}\sum_{\tau} E_W \{D_{t,\tau} - (1-\alpha)N_{t,\tau}\} + \frac{1}{1-\alpha}(P_{t,\tau} - \frac{1}{4}\sum_{\tau} E_W P_{t,\tau}). \quad (7)$$

Equation (7) tells us that the level of employment will vary in accordance with the trends, seasonals and inertial factors underlying the production function and also will fluctuate directly with deviations between actual and expected average prices. Using equation (7) in the production function gives the behaviour of aggregate output as:

$$Y^A_{t,\tau} = \frac{\alpha r}{1+r(1-\alpha)} \log\alpha + \frac{1}{1-\alpha} D_{t,\tau} - \frac{\alpha}{(1+\alpha)\{1+r(1-\alpha)\}} \cdot \frac{1}{4}\sum_{\tau} E_W \{D_{t,\tau} - (1-\alpha)N_{t,\tau}\} + \frac{\alpha}{1-\alpha}(P_{t,\tau} - \frac{1}{4}\sum_{\tau} E_W P_{t,\tau}). \quad (8)$$

In what follows I shall assume that $E_W(D_{t,\tau} - N_{t,\tau})$ is collinear with $D_{t,\tau}$. Also, the constant term in equation (8) will be collinear with the constant term in $D_{t,\tau}$. Redefining all these sources of shocks as S, and with $\delta \equiv \alpha / (1-\alpha)$, equation (8) may be rewritten as:

$$Y^A_{t,\tau} = S_{t,\tau} + \delta (P_{t,\tau} - \frac{1}{4}\sum_{\tau} E_W P_{t,\tau}) \quad (9)$$

where S captures all the shift terms in the production function and labour supply function.

Next, define aggregate output as being decomposable into a trend part ($Y^T_{t,\tau}$), a systematic seasonal component ($Y^S_{t,\tau}$), and a cyclical component ($Y_{t,\tau}$), so that

$$Y^A_{t,\tau} = Y^T_{t,\tau} + Y^S_{t,\tau} + Y_{t,\tau}. \tag{10}$$

Additionally, specify the shocks to equation (9) as:

$$S_{t,\tau} = Y^T_{t,\tau} + Y^S_{t,\tau} + \lambda Y_i + \varepsilon_{t,\tau}$$
$$\varepsilon \sim N(0, \sigma^2_\varepsilon). \tag{11}$$

What this says is that the shocks affecting aggregate supply consist of trends and systematic seasonal components, inertia in the form of an autocorrelated cyclical component and white noise. Using (11) in (9) gives

$$Y^A_{t,\tau} = Y^T_{t,\tau} + Y^S_{t,\tau} + \delta\left(P_{t,\tau} - \frac{1}{4}\sum_\tau E_W P_{t,\tau}\right) + \lambda Y_i + \varepsilon_{t,\tau}. \tag{12}$$

Equivalently, using (10), cyclical output is given by:

$$Y_{t,\tau} = \delta\left(P_{t,\tau} - \frac{1}{4}\sum_\tau E_W P_{t,\tau}\right) + \lambda Y_i + \varepsilon_{t,\tau}. \tag{13}$$

Each of these alternative formulations will be used in the subsequent empirical work.

This completes the derivation of the aggregate supply function in the Keynesian model of the business cycle. Attention is now turned to the aggregate demand side. The simplest conceivable—though in fact quite general—specification of aggregate demand will be employed. Specifically:[10]

$$Y_{t,\tau} = M_{t,\tau} + V_{t,\tau} - P_{t,\tau} \tag{14}$$

where M = money supply
V = velocity of circulation.

The generality of this specification of aggregate demand arises from the possibility of V capturing all the possible influences on aggregate demand other than those of the

10. Aggregate demand is specified here as cyclical aggregate demand so that velocity and money may be thought of as net of these same seasonal and trend factors. Nothing of substance is affected by this and it permits the development of the analysis in a manner that focuses on the cycle.

money stock itself. The money supply and velocity will be treated as being exogenous stochastic processes, generated by the vector autoregressive scheme:

$$\begin{pmatrix} M_{t,\tau} \\ V_{t,\tau} \end{pmatrix} = \begin{pmatrix} A'(L) & B'(L) \\ C'(L) & D'(L) \end{pmatrix} \begin{pmatrix} M_i \\ V_i \end{pmatrix} + \begin{pmatrix} \eta_{t,\tau} \\ \zeta_{t,\tau} \end{pmatrix} \tag{15}$$

$$\eta \sim N(0, \sigma_\eta^2), \zeta \sim N(0, \sigma_\zeta^2).$$

Equations (13) (aggregate supply), (14) (aggregate demand) and the processes generating the variables that have been treated as exogenous, constitute a model of output and price behaviour. The system will be used to generate predictions about the behaviour of output.

First, from (13), it is apparent that:

$$\frac{1}{4}\sum_\tau E_W Y_{t,\tau} = \lambda \frac{1}{4}\sum_\tau E_W Y_i . \tag{16}$$

This is a fifth-order difference equation in expected cyclical output, which has the solution:

$$\frac{1}{4}\sum_\tau E_W Y_{t,\tau} = \phi Y_{t-1,4} \tag{17}$$

where $\phi = \frac{\lambda}{4} \frac{(1-\lambda^4)}{(1-\lambda)}$.

From (14), we know that:

$$\frac{1}{4}\sum_\tau E_W P_{t,\tau} = \frac{1}{4}\sum_\tau E_W M_{t,\tau} + \frac{1}{4}\sum_\tau E_W V_{t,\tau} - \phi Y_{t-1,4} . \tag{18}$$

Using (15), the expectations of the money stock and velocity formed at the time of wage determination (E_w) may be calculated as:

$$\frac{1}{4}\sum_\tau E_W M_{t,\tau} + \frac{1}{4}\sum_\tau E_W V_{t,\tau} = A''(L) M_i + B''(L) V_i \tag{19}$$

where $A''(L)$ and $B''(L)$ are defined implicitly between (15) and (18).

Using (19) in (18) and the result in (13) gives:

$$Y_{t,\tau} = \delta (P_{t,\tau} - A''(L) M_i - B''(L) V_i + \phi Y_{t-1,4}) + \lambda Y_i + \varepsilon_{t,\tau} . \tag{20}$$

Using (14) in (20) gives:

$$Y_{t,\tau} = \frac{\delta}{1+\delta}\{M_{t,\tau} + V_{t,\tau} - A''(L)M_i - B''(L)V_i + \phi Y_{t-1,4}\}$$

$$+ \frac{\lambda}{1+\delta} Y_i + \frac{1}{1+\delta} \varepsilon_{t,\tau} \qquad (21)$$

and, finally, using (15) to eliminate M and V from (21) gives:

$$Y_{t,\tau} = \frac{\delta}{1+\delta}\{A(L)M_i + B(L)V_i\} + \frac{\delta\phi}{1+\delta} Y_{t-1,4} + \frac{\lambda}{1+\delta} Y_i + \xi_{t,\tau} \qquad (22)$$

where A(L) and B(L) are defined implicitly between (15) and (21) and where:

$$\xi_{t,\tau} = \frac{1}{1+\delta}\{\varepsilon_{t,\tau} + \delta(\eta_{t,\tau} + \zeta_{t,\tau})\} \sim N(0, \sigma_\xi^2).$$

It is worth pausing and reflecting on what has been established. Using this Keynesian contract model to capture the Shunto arrangements, it has been established, as shown in equation (22), that cyclical output will be influenced by—to be precise Granger-caused[11] by—both the money stock and velocity. In addition, cyclical output will follow an autoregression (AR) process that has a seasonal order. In the first quarter following Shunto, output will be AR1. In the second quarter, it will be AR2. In the third quarter, output will be AR3, but with a zero on the second lag. Finally, in the fourth quarter, output will be AR4, but with zeros on both the second and third lags.

Equation (22) provides one of the inputs that will be used in order to attempt to test and discriminate between the Keynesian and Classical theories of the business cycle. Before going on to explore in greater detail how that equation will be used, the Classical alternative will be set out.

2. A Classical Theory of the Business Cycle

The only difference between the Classical and Keynesian theories of the business cycle being proposed here lies in the theory of aggregate supply. The production function (equation (1)), the demand for labour function (equation (2)) and the supply of labour function (equation (3)) all apply to the Classical as well as the Keynesian model. The key difference between the two models concerns the way in which wages are determined. In the Classical model, in contrast to the Keynesian model, it is assumed that wages are determined in each time period to clear the labour market.

11. See Clive W. J. Granger (1969).

That is:

$$\ell_{t,\tau} = \ell^{S}_{t,\tau} . \tag{23}$$

In effect, what is being asserted in equation (23) is that there is sufficient flexibility in the payments of bonus wages to effectively negate the money wages determined at Shunto. On this view, Shunto is a charade. The wages that matter are those determined by market forces as a result of the operation of the bonus payments. To avoid misunderstanding, this is not being asserted as a fact. It is a hypothesis. The implications of this hypothesis will be worked out and whether this or the alternative hypothesis embodied in the Keynesian model yields predictions that better accord with the facts will be established on the basis of an empirical investigation.

Using equation (23) together with the labour market demand and supply equations (2) and (3) determines the money wage rate as:

$$W_{t,\tau} = \frac{1}{1+(1-\alpha)\gamma} \{ P_{t,\tau} + (1-\alpha)\gamma E_i P_{t,\tau} + \log\alpha + D_{t,\tau} - (1-\alpha) N_{t,\tau} \} . \tag{24}$$

Unlike in the Keynesian case, the money wage rate is not determined exclusively by price level expectations. The money wage is homogeneous of degree one in the actual and expected price levels. In the limiting case of a zero elastic labour supply function, the money wage rate would respond one for one to movements in the actual price level. At the other extreme in the event of a perfectly elastic supply of labour, the money wage rate would respond one for one to the expected price level and would be independent of the actual price level. Other things equal, the higher is the marginal product of labour (the larger is D), the higher is the money wage rate, and the larger is the supply of labour (the larger is N), the lower is the money wage rate. This solution for the money wage rate may be used in either the supply or demand equation in the labour market to obtain the actual level of employment (and equilibrium level of employment):

$$\ell_{t,\tau} = \frac{1}{\{1+(1-\alpha)\gamma\}} N_{t,\tau} + \frac{\gamma}{1+(1-\alpha)\gamma} \{ \log\alpha + D_{t,\tau} + P_{t,\tau} - E_i P_{t,\tau} \} . \tag{25}$$

Further, using this in the production function (equation (1)) gives:

$$Y^A_{t,\tau} = \frac{1+r}{1+(1-\alpha)r} D_{t,\tau} + \frac{1}{\{1+(1-\alpha)r\}} N_{t,\tau}$$
$$+ \frac{\alpha r}{1+(1-\alpha)r}(\log \alpha + P_{t,\tau} - E_i P_{t,\tau}) . \tag{26}$$

Equation (26) is telling us that output will be larger, the larger is the marginal product of labour (D), the larger is the supply of labour (N), and the higher is the actual price level relative to the expected price level.

Making use of the assumption that the shift variables underlying the production function and labour supply function as well as the constant in the labour demand function are collinear and subsuming all these factors under the variable S defined above and furthermore, using equation (11) to define the decomposition of S gives the aggregate supply function:

$$Y_{t,\tau} = \phi (P_{t,\tau} - E_i P_{t,\tau}) + \lambda Y_i + \varepsilon_{t,\tau} . \tag{27}$$

This Classical aggregate supply function corresponds to equation (13), the Keynesian aggregate supply function. Note that the key difference lies in the price expectations term that enters the Classical aggregate supply equation. It is simply the contemporaneous price level surprise that influences cyclical output in the Classical model.

The Classical model is completed by using equation (14) to determine aggregate demand and (15) for the process generating the money supply and velocity. Equations (14), (15) and (27), together with the assumption that expectations are formed rationally, solve for the equilibrium levels of output, prices, the money supply and velocity. The solution for output is:

$$Y_{t,\tau} = \lambda Y_i + u_{t,\tau} \tag{28}$$

where

$$u = \varepsilon + \frac{\phi}{1+\phi}(\eta + \zeta) \sim N(0, \sigma_u^2) . \tag{29}$$

The contrast between (28) and the output solution for the Keynesian model (equation (22)) is striking. In the Classical case, output is predicted to follow a fixed autoregressive process of order 1 independently of the season. Recall that this contrasts with the Keynesian model in which the autoregressive order is seasonal. In addition, in the Classical model money and velocity do not Granger-cause output. The first autoregressive process for output is disturbed only by a white noise residual that itself incorporates the random disturbances to the production function, the money supply and velocity processes.

Now that the predictions of both the Keynesian and Classical models have been generated, it is possible to turn to an examination of how these two alternatives may be discriminated between.

3. Discriminating between the Two Explanations

Equations (22) and (28) provide a potentially sharp way of discriminating between the Keynesian and Classical explanations of the business cycle. Two features of these equations provide the discriminating power. First, according to the Classical theory, output should follow an AR1 process. According to the Keynesian theory, it should follow a seasonal AR process. Thus, if an AR1 specification for output cannot be rejected then the Keynesian explanation for the cycle is rejected and the Classical explanation is not. If an AR1 specification is rejected then the Classical explanation (or at least this particular Classical explanation) is rejected. Whether or not the Keynesian explanation is rejected would require a further investigation of the particular AR structure of output.

The second feature of the behaviour of output concerns its Granger-causal relation with money and velocity. If the hypothesis that money and velocity Granger-cause output is not rejected, the Classical explanation of the cycle is rejected and the Keynesian explanation is not. Conversely, if Granger-causality from money and velocity to output is rejected, then the Classical explanation of the business cycle is not rejected and the Keynesian explanation is rejected.

Notice that it is possible for both theories to be rejected. If output is AR1 and if money and/or velocity Granger-cause output then both the Keynesian and Classical theories presented here are inconsistent with the facts.

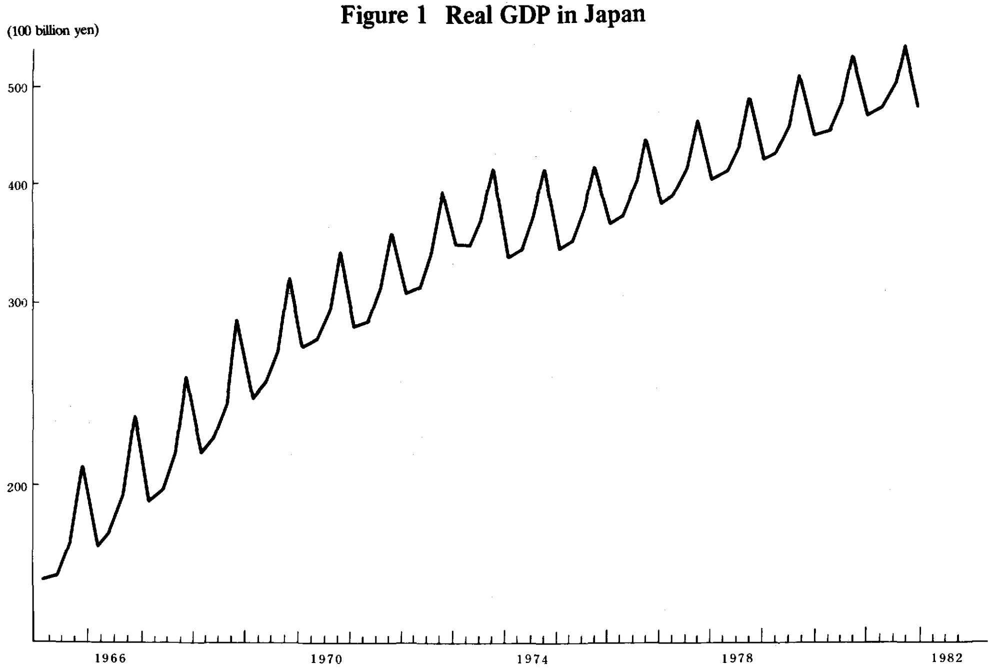
Testing these alternative theories and estimating the output process is the task of the next part of the paper.

III. Discriminating between the Alternative Theories

It is instructive to begin this attempt to discriminate between Keynesian and Classical explanations of the business cycle by visually examining the raw time series for real GDP. The sample period available begins in 1965(1) and ends in 1982(1). This is the longest available run or quarterly data on real GDP measured on a consistent basis.[12] These 69 observations of quarterly real GDP (in 100 billions of

12. The data for 1982(2) to 1983(3) are only available in preliminary form and those prior to 1965 are based on a different system of national accounting (SNA). For a description of the change in SNA in 1965, see *A System of National Accounts in Japan,* Economic Planning Agency, 1980.

Figure 1 Real GDP in Japan



1975 yen) are shown on a logarithmic scale in Figure 1. Three features of these data are note-worthy.

First, there is the appearance of a slowdown in the average growth rate of real GDP in the second half of the sample compared with the first half. Second, there is a strong seasonal pattern in the data. Real GDP rises by increasing amounts in each successive quarter. (There is one trivial exception to this pattern in 1973 when real GDP fell between the first and second quarters.) It is also evident, however, that the seasonal pattern has not been constant. The fourth quarter surge in output is apparently greater in the 1960's than in the 1970's. Recognizing and adequately modelling this feature of the time series turns out to be crucial. Third, though less striking than the trend and seasonal patterns, the data display obvious cyclical activity. Upswings occur in 1966-69, 1971-73 and 1975-79 and downswings occur in 1970-71 and 1974-75.

Although the central objective of this study is to discriminate between alternative theories of this last feature of the data—the business cycle—it is, of course, necessary to model the trend and seasonal aspects of real GDP simultaneously with the cycle. Previous studies of the behaviour of aggregate output in Japan have, as noted in the introduction, used a variety of alternative methods of modelling the trend and seasonal components of output. Table 1 summarizes these previous treatments. There are three different models of the trend. One study uses a quadratic

Table 1 Summary of Previous Studies

Study	Period	Basic Series	Differencing Filter	Trend Specification	Seasonal Specification	Other Variables (and Lag Lengths)	Conclusion Reached
Piggot (1978)	1960(1) 1977(3)	GNP SA(Q)	1−L	t	SA data	LDV(4), AM(7), UM(7)	AM and UM cause GNP
Oritani (1981)	1956(1) 1979(3)	GNP (Q)	$1-L^4$	t	Seasonal Difference	LDV(5), M(5), DP(5)	M causes GNP
Seo and Takahashi (1981)	1965(1) 1980(4)	GNP SA(Q)	Level	t, Shift in 1974(1)	SA data	Price of oil, AM(9), UM(9)	AM and UM cause GNP
Taniuchi (1982)	1960(1) 1980(2)	GNP SA(Q)	Level	t, t^2	SA data	LDV(3), UMS(4), G, X	UMS causes GNP
Hamada and Hayashi (1983)	1965(J) 1982(D)	IP SA(M)	Level	t, Shift in 1974(1)	SA data	UM(12m), AM(12m)	AM and UM cause IP
Grossman and Haraf (1983)	1959(4) 1982(2)	IP(Q)	1−L	—	Linear shifts	LDV(4), DP(4)	Inflation causes IP

Notes:
GNP = real Gross National Product
IP = Index of Industrial Production
SA = Seasonally adjusted
(Q) = quarterly
(M) = monthly
L = lag operator
t = linear time trend
t, t^2 = quadratic time trend
LDV = lags of dependent variable
AM = anticipated money stock
UM = unanticipated money stock
UMS = unanticipated changes in money stock since last shunto
DP = inflation rate
G = Government Expenditure
X = Exports

formulation, the coefficient on the squared time variable being negative. Two studies allow for a change in the level and the growth rate in 1974(1) and two use a constant growth trend. There are also three different models of seasonality. Four of the studies assume (implicitly) that the official seasonal adjustments give the correct seasonal model. The other two studies use the unadjusted data—one with seasonal differencing and the other with deterministic linear seasonal shifts.

Table 1 also summarizes the other variables used in the previous studies and the conclusions reached. Inspection of the final column of Table 1 quickly creates the impression that those conclusions are extremely unfavourable to the Classical explanation of the business cycle set out in the preceding section. In every case the conclusion reported is that money (or inflation) Granger-causes real GDP. Though these findings are not necessarily consistent with all the details of the predictions of the Keynesian theory of the cycle presented above, they certainly, if correct, constitute a rejection of the Classical explanation.

In view of the variety in the treatment of trends and in seasonality, it is of some importance to investigate the implications of the alternative models employed for the inferences made concerning the cyclical variations in output. It is also important that the validity of each of the alternative trend in seasonal models be tested.

In order to undertake these tasks in a systematic way, two alternative approaches were adopted. One approach, close to that followed in most of the earlier studies, decomposes output into its trend, seasonal and business cycle components using a variety of alternative models and then studies the properties of the revealed business cycle. The other approach studies the behaviour of output using rather general distributed lag models with a variety of alternative deterministic trend and seasonal formulations. In the next section the second of these exercises will be described and its results reported. The subsequent section will deal with the first of these exercises.

1. A General Distributed Lag Approach

The starting point for this investigation is the specification of a time series model of real income that has sufficient generality to incorporate each of the alternative models of trends and seasonality employed in earlier studies as special cases. Also the model needs to be sufficiently general to incorporate the obvious shift in the fourth quarter seasonal pattern that occurred in 1970. The following is such a model:

$$Y_t^A = a_0 + a_1 t + \sum_{i=2}^{4} a_i s_{it} + a_5 d_{1t} + a_6 d_{1t} t + a_7 t^2 + a_8 d_{2t} s_{4t}$$

$$+ \sum_{i=1}^{5} a_{8+i} Y_{t-i}^A + \sum_{i=1}^{5} a_{13+i} M_{t-i} + \sum_{i=1}^{5} a_{18+i} V_{t-i} + \varepsilon_t \qquad (30)$$

where:

t = integer sequence, 1,...,64
s_i = 1 in quarter i
= 0 elsewhere
d_1 = 0, 1967(1)-1973(4)
= 1, 1974(1)-1982(1)
d_2 = 0, 1967(1)-1969(4)
= 1, 1970(1)-1982(1)

and the remaining variables are the same as defined previously.[13]

The first three terms in equation (30) represent a linear trend and linear seasonal shifts. The next four terms model the changing trend and seasonal patterns. The once-and-for-all change in the growth rate and level of income is allowed for in 1974(1) following the first oil shock and, in addition, a gradually declining growth rate (the t^2 term) is permitted. The possibility of a change in the seasonal pattern, suggested by visually inspecting the real GDP series shown in Figure 1, is also allowed for. The final three terms represent the business cycle together with the possibility of stochastic seasonality. Persistence in the business cycle, together with possible stochastic seasonality, is captured both in the lags of real GDP and in the lags of the money supply and velocity. Also, the lags in the money supply and velocity represent the possibility of Granger-causation running from money and velocity to real GDP. The disturbance, ε_t, represents the current period (identically and independently distributed) random shock that displaces real GDP and which, possibly together with shocks from the money supply and velocity, drives the business cycle.

Five lags were employed on output, the money supply and velocity to represent a flexible version of the four previous quarters' growth rates of these variables. Lags of this order are indicated by earlier Japanese studies and by most other works using data for other countries. No pretesting was undertaken in order to determine these lag lengths and no explicit criteria other than conformity with earlier studies were employed in order to determine the "best" lag length.

The deterministic trend and seasonal specifications employed in previous studies may be recognized as special cases of (30). Table 2 sets out those special cases. A more comprehensive and systematic list of special cases of the trend and seasonal part of (30) is represented by the 16 models shown in Table 3. These 16 models divide into four blocks. Blocks 1 and 3 (models 1-4 and 9-12) allow for a shift in seasonality after 1970. Blocks 2 and 4 (models 5-8 and 13-16) do not allow for such a shift. Also

13. The time notation involving t for the year and τ for the quarter is *not* employed in the empirical section. The sequence t now indexes time measured in quarters.

Table 2 Previous Specifications as Special Cases of Equation (30)

Study	Zero Restrictions on Coefficients									
	a_0	a_1	a_2-a_4	a_5	a_6	a_7	a_8	a_9-a_{13}	a_{14}-a_{18}	a_{19}-a_{23}
Piggot (1978) (SA)			○	○	○		○			○
Oritani (1981)			○	○	○		○			
Seo and Takahashi (1981) (SA)			○			○	○	○		○
Taniuchi (1982) (SA)			○	○	○		○			○
Hamada and Hayashi (1983) (SA)			○			○	○	○		○
Grossman and Haraf (1983)				○	○	○	○		○	

a_0 = constant
a_1 = linear trend
a_2-a_4 = linear seasonal shifts
a_5 = change in *level* of GDP in 1974(1)
a_6 = change in trend after 1974 (1)
a_7 = quadratic trend
a_8 = change in 4th quarter seasonal after 1970(1)
a_9-a_{13} = persistence effects
a_{14}-a_{18} = money stock effects
a_{19}-a_{23} = velocity effects
(SA) = seasonally adjusted data used
○ represents zero restirctions implicit in previous studies.

Table 3 Sixteen Restricted Models of Deterministic Trends and Seasonal Variations

Model	Zero restrictions on coefficients					Previous Study
	$(a_2\text{-}a_4)$	a_5	a_6	a_7	a_8	
1						
2				O		
3		O	O			
4		O	O	O		
5					O	
6				O	O	
7		O	O		O	
8		O	O	O	O	Grossman and Haraf (1983)
9	O					
10	O			O		
11	O	O	O			
12	O	O	O	O		
13	O				O	
14	O			O	O	Seo and Takahashi (1981) (SA), Taniuchi (1982) (SA), and Hamada and Hayashi (1983) (SA)
15	O	O	O		O	Piggot (1980) (SA), and Oritani (1981)
16	O	O	O	O	O	

blocks 3 and 4 (models 9-16) do not permit any deterministic seasonal effects (other than the change in seasonal pattern in block 3). Within each of the four blocks, there are four models; the first (1, 5, 9 and 13) are the most general and permit a 1974 trend and level change as well as a continuous trend change. The second (2, 6, 10 and 14) do not allow for a continuous trend change and the third (3, 7, 11 and 15) do not allow for the 1974 trend and level change. Finally (4, 8, 12 and 16) impose the restriction of a fixed linear trend.

Of these 16 models, 4 (13-16) may be regarded as applying to the seasonally adjusted data. That is, if the seasonally adjusted data adequately, correctly, and completely remove all systematic seasonal influence from the data then no linear seasonal shifts should be required. Thus, in total, there are 20 alternative models.

Three sets of questions may be addressed with these models. They are: (1) maintaining each trend and seasonal hypothesis, does either money or velocity Granger-cause income?; (2) is the answer to question (1) independent of the trend and seasonal hypothesis maintained? And, especially important if the answer to (2) is negative; (3) which deterministic specification(s) is(are) not rejected by the data?

Establishing the answer to question (3) and, for that(those) and only that(those) specification(s) answering question (1), provides a description of the Japanese business cycle and a potential way of discriminating between alternative explanations for that phenomenon. Recall that if the hypothesis that money and velocity do not Granger-cause output and that output follows a first-order autoregressive process is not rejected by the data, then the Classical explanation for the cycle is not rejected. If, on the other hand, it is not possible to reject the hypothesis that either money or velocity causes output or that output follows a more complicated (seasonal) AR process, then the Classical explanation of the cycle is rejected but the Keynesian explanation is not.

To proceed with answering the above questions and discriminating between alternative cycle theories, the model set out in equation (30) was estimated[14] using the quarterly data for Japan between 1967(1) and 1982(1).[15]

The detailed parameters estimated are not of major intrinsic interest and, to economize on space, are not reported. What is of interest are the answers to the three questions posed above.

Questions (1) and (2) are answered in Table 4. With raw data, money Granger-causes real GDP in models 7 and 15. Velocity Granger-causes real GDP in models 3 and 4. These four models represent three different models of seasonality and two different models of the time trend. Using seasonally adjusted data, the hypothesis that money causes real GDP is not rejected in the case of three of the four models and is on the edge of nonrejection for the fourth case as well.

Question (3) is answered in Table 5. For the seasonally unadjusted data, models that do not contain a deterministic seasonal component are rejected (see hypotheses 1,2 and 3 in Table 5). Both seasonal dummies and a shift in the seasonal pattern after 1970 are required. The data reject models that do not contain this feature, even when seasonal lags (equivalent to a flexible form of seasonal differencing) are included. Thus, for the raw data, models 5 to 16 may be rejected.

14. All the estimation and data manipulation were performed using RATS 4.1 written by and described in Thomas A. Doan and Robert B. Litterman (1981).

15. The data employed are listed in the Appendix. Velocity was calculated using the identity M+V=P+Y. Data on the money supply only became available in 1967 and restrict the length of run of this empirical exercise. Data for 1967 were employed in the study but have not been published by the Bank of Japan and, therefore, are not listed in the Appendix.

Table 4 Does Money or Velocity Cause Real GDP?

Model	Degree of Freedom	Money Causes Real GDP	Velocity Causes Real GDP
1	5,32	0.85	1.78
2	5,33	1.21	1.85
3	5,34	2.00	2.80*
4	5,35	1.64	2.58*
5	5,33	1.30	0.70
6	5,34	1.46	0.50
7	5,35	2.56*	1.04
8	5,36	1.80	0.60
9	5,35	1.33	1.40
10	5,36	2.16	1.42
11	5,37	2.40	1.82
12	5,38	2.06	1.65
13	5,36	1.48	1.08
14	5,37	2.10	0.98
15	5,38	2.57*	1.51
16	5,39	2.08	1.21
13SA	5,36	2.44	1.54
14SA	5,37	3.13*	1.06
15SA	5,38	3.49*	1.62
16SA	5,39	2.93*	1.12

Notes: $F_{.05}(5,30) = 2.53$
$F_{.05}(5,40) = 2.45$
* Indicates rejection of the null hypothesis at the .05 level

Next consider the alternative trend specifications. For the non-rejected models (1-4) and for the seasonally adjusted models (13SA-16SA), the relevant test statistics are reported under hypothesis 4 in Table 5. Evidently, these tests do not discriminate amongst the four alternative trend specifications. Each could be true.

The consequence of these findings is that there is ambiguity as to whether money and velocity cause output. If a quadratic trend or a fixed linear trend adequately characterizes the data, then, according to the seasonally unadjusted results, velocity Granger-causes output (though money does not.) If the seasonally adjusted data are

Table 5 Tests of Alternative Deterministic Models

Hypothesis:

1. There is no deterministic seasonal variation ($a_2 - a_4$, $a_8 = 0$)							F-Value
Model	13	compared with model	1	(4,32)			5.36
"	14	"	2	(4,33)			5.21
"	15	"	3	(4,34)			6.88
"	16	"	4	(4,35)			6.62
$F_{.05}$ (4,30) = 2.69; $F_{.05}$ (4,40) = 2.61						Reject	
2. There is no shift in deterministic seasonality ($a_8 = 0$)							
Model	5	compared with model	1	(1,32)			17.05
"	6	"	2	(1,33)			17.64
"	7	"	3	(1,34)			19.92
"	8	"	4	(1,35)			20.93
$F_{.05}$ (1,30) = 4.17; $F_{.05}$ (1,40) = 4.08						Reject	
3. The only deterministic seasonal is the shift in 1970 ($a_2 - a_4 = 0$)							
Model	9	compared with model	1	(3,32)			6.35
"	10	"	2	(3,33)			5.91
"	11	"	3	(3,34)			8.38
"	12	"	4	(3,35)			7.76
$F_{.05}$ (3,30) = 2.92; $F_{.05}$ (3,40) = 2.84						Reject	
4. There is a constant time trend ($a_5, a_6, a_7 = 0$)							
Model	4	compared with model	1	(3,32)			1.72
"	16SA	"	13SA	(3,36)			2.05
$F_{.05}$ (3,30) = 2.92; $F_{.05}$ (3,40) = 2.84						Accept	

the appropriate ones to use, then almost regardless of the way in which the trend is modelled, the hypothesis that money Granger-causes real GDP is not rejected.

What do these results say about the Keynesian and Classical theories of the business cycle set out in the previous part of the paper? First, for the seasonally adjusted data, the results are most unfavourable to the Classical explanation. If money does indeed Granger-cause real GDP, the Classical explanation (or at least the particular version of the Classical explanation presented above) has to be rejected. Whether the Keynesian explanation set out above is not rejected would require further investigation. Second, if the seasonally unadjusted data are the appropriate ones to use, then the conclusions are mixed. Regardless of the trend specification money does not Granger-cause real GDP and that is favourable to the Classical theory and unfavourable to the Keynesian theory. Velocity, however, does cause real GDP in the two cases of either a fixed linear trend or a quadratic trend. Only in the case where the trend and level of real GDP are permitted to change after the first oil shock do the results reject the Keynesian theory and favour the Classical theory.

In an attempt to narrow down the area of uncertainty and also to provide a closer examination of the relationship between the findings of this paper and those of earlier studies, an alternative method of examining the business cycle and the trends and cycles in output was undertaken and the results of that exercise will now be reported.

2. Decomposing Real GDP into Trends, Seasonals and Cycles

Almost all of the earlier studies of Japanese output fluctuations have proceeded by way of a prior decomposition of real GDP into its trend and seasonal components on one hand and its business cycle component on the other. This approach was pursued in order to check the conformity of the results obtained by that procedure with those obtained using a general distributed lag approach. In keeping with the earlier studies, a two variable (real income and money) environment is studied here rather than the three variable (income, money and velocity) environment employed in the previous section. In the present exercise, seven alternative time series models, chosen for their conformity with earlier studies and for their conformity with the informal description of the behaviour of real GDP given above, were examined. They are set out in Table 6.

Models 1 and 3 are formal representations of the informal description of output contained in Table 1 and are formulations that are not inconsistent with the findings of the previous section. They differ between each other in that the deterministic trend in model 1 changes, in both slope and level, in 1974(1) following the first oil shock while model 3 has a continuously declining (quadratic) trend. Each has deterministic seasonal shifts, the pattern of which changes in 1970. Models 2 and 4 are like 1 and 3 but do not allow the deterministic seasonal pattern to change in 1970. In effect, they force any such shift into the business cycle. The treatment of the trends in output in models 1 and 2 is identical to that of Seo and Takahashi (1981) and Hamada

Table 6 Alternative Time Series Models of Real GDP

Model	Real GDP	=	Trend	+	Seasonal	+	Change in Trend	+	Change in Seasonal	+	Business Cycle
1	Y_t^A	=	$a_0 + a_1 \dot{t}$	+	$\sum_{i=2}^{4} a_i s_{it}$	+	$a_5 d_{1t} + a_6 d_{1t} t$	+	$a_7 d_{2t} s_{4t}$	+	y_{1t}
2	Y_t^A	=	$b_0 + b_1 t$	+	$\sum_{i=2}^{4} b_i s_{it}$	+	$b_5 d_{1t} + b_6 d_{1t} t$			+	y_{2t}
3	Y_t^A	=	$c_0 + c_{1t}$	+	$\sum_{i=2}^{4} c_i s_{it}$	+	$c_5 t^2$	+	$c_7 d_{2t} s_{4t}$	+	y_{3t}
4	Y_t^A	=	$d_0 + d_{1t}$	+	$\sum_{i=2}^{4} d_i s_{it}$	+	$d_5 t^2$			+	y_{4t}
5	$(1 - L) Y_t^A$	=	e_1	+	$\sum_{i=2}^{4} e_i s_{it}$					+	y_{5t}
6	$(1 - L^4) Y_t^A$	=	f_1			+	$f_5 (1 - L^4) d_{1t} + f_6 (1 - L^4) d_{1t} t$			+	y_{6t}
7	$(1 - L^4) Y_t^A$	=	g_1			+	$g_5 t^2$			+	y_{7t}

Note: L is the backward shift or lag operator.

and Hayashi (1983) and models 3 and 4 are equivalent to the way in which Piggot (1978), Oritani (1981) and Taniuchi (1982) dealt with the trend. Model 5 (formulated as a first difference of real GDP with no trend or intercept shifts and with a constant seasonal pattern) is equivalent to the formulation of Grossman and Haraf (1983). Finally, models 6 and 7 deal with seasonality in the manner chosen by Oritani (1981), by using seasonal differences in the data. Model 6 (like 1 and 2) allows a trend and level shift in 1974(1) while model 7 (like 3 and 4) allows the trend to decline continuously (as in Oritani).

The consequences of using the official seasonally adjusted data are investigated by specifying 5 of the 7 models set out in Table 6 as models of the official seasonally adjusted values of real GDP. When specified for the seasonally adjusted data, seasonal shift terms are excluded so that models 2 and 4 become identical to models 1 and 3 respectively.

This exercise yields 12 alternative time series models of real income and, in effect, 12 alternative representations of the Japanese business cycle. Four of these representations have featured in the earlier literature and have provided the basis for conclusions favourable towards the Keynesian interpretation of the cycle. They are models 1 and 3 using seasonally adjusted data and models 5 and 7 using unadjusted data.

The stochastic processes yit represent alternative *descriptions* of the business cycle. How those descriptions differ among themselves and what the implications of those differences are for inferences about the properties and sources of the business cycle may be determined by analyzing their behaviour. In particular, as we have seen, if the yit follow a first-order autoregression and are not Granger-caused by money or velocity, then a Classical interpretation of the cycle is consistent with the facts. If money and/or velocity do Granger-cause yit and/or if a more complex and seasonal autoregressive process is required to characterize its behaviour, then a Keynesian interpretation is favoured.

Ordinary least squares estimation of the 7 models set out in Table 6, treating the yit terms as the residuals, gave the results set out in the columns headed "annual growth rates"and "seasonal shifts" in Table 7 for unadjusted data and in Table 8 for seasonally adjusted data. The residuals from these OLS regressions were studied in two ways. First, their autocorrelations were examined in order to determine and estimate their ARMA properties. Second, the causal relationships between the money supply and the residuals were investigated. In selecting the appropriate ARMA model, a certain element of subjectivity was employed. The results of the causality relationship between the business cycle and the money supply were, however, checked for reasonable alternative models and the results reported here seem not to be influenced by the final model selected.

The results of the first of these exercises, estimating the trend and seasonal patterns, are set out in the columns headed "cycle" in Tables 7 and 8. The test statistics in the final 4 columns of Tables 7 and 8 refer to this latter exercise so that the Box-Pearce Q statistic refers not to the behaviour of yit but to the residuals in the ARMA process describing yit.

Consider first the seasonally unadjusted results in Table 7. All the models of the cycle have residuals that produce Box-Pearce Q statistics that are less than the value of χ^2 for the 5% significance level. Hence, the hypothesis that the residuals (ε_t) are not autocorrelated is not rejected.

The deterministic part of model 2 is nested in 1 and that of 4 is nested in 3. The restrictions in 2 and 4 that the linear seasonal pattern be constant may, therefore, be tested directly. These restrictions are rejected. This agrees with the results of the exercise reported in the previous section; namely that there is a significant change in the fourth quarter surge in output appearing after 1970.[16] Comparing models of 1 and 3 is a less clean-cut exercise. Model 1 has a slightly lower standard error. Also its residuals have a much simpler structure than those of model 3(AR(1) compared with ARMA(2,1)). Thus, it is clear that if the trend is treated as continuously declining, a rather complicated residual is "revealed" as the business cycle. If, in contrast, output is treated as having a change in both the level and trend after the first oil shock, then a very simple business cycle emerges.

Model 5, although estimated in first difference form, is, in its deterministic part, a restricted version of model 1. It is strongly rejected by the data. Further, it alone still possesses seasonal residuals, requiring an AR(4) process to characterize it.

Models 6 and 7 parallel models 1 and 3 in the way they treat the trend, but model seasonality as a seasonal difference rather than as a linear shift. Whilst both of these models deliver similar and simple first-order autoregressive cycles, each is slightly inferior, on the standard error criterion, to its linear seasonal counterpart. Further, the constantly falling growth rate (version 7) is decidedly inferior to the once-and-for-all shift in level and trend (version6).

Taking all the above considerations together, it is evident that model 1 is the best, though 1, 3, 6 and 7 cannot be discriminated amongst by classical inference

16. Various suggestions were made to me concerning the source of this seasonal shift. Akinari Horii suggests that it may arise from a change in the seasonality of consumption resulting from the increasing share of non-seasonal services in the consumption bundle and from a change in the seasonal pattern of new housing starts resulting from a change in the timing of government decisions on grants and subsidies to home buyers. Hiroo Taguchi suggests that changes in the corporate financial year may be responsible. Investigation of the seasonal pattern of disaggregated output shows the shift in seasonality occurring at the end of the 1960's to be a dispersed phenomenon that is present in all the main expenditure categories of GDP. An independent study that confirms the change in the seasonal pattern of output, but that does not regard a simple model such as that employed here as adequate, is Shoji Tahara (1983). I am grateful to Toshiyuki Mizoguchi for drawing my attention to this work.

Table 7 Alternative Time Series Models of Real GDP Seasonally Unadjusted

Model	Dependent Variable	Annual Growth Rates				Seasonal Shifts				Cycle				Test Statistics			
		1965–1973	Change in 1974(1)	1965(1)	Annual Change	Quarter 2	Quarter 3	Quarter 4	Shift in Q4, 1970	ρ_1	ρ_2	θ	σ^2_ϵ	ϵ_t Q	ϵ_t D of F	Money Causality F	Money Causality D of F
1	Level	9.68 [63.3]	-5.02 [23.1]	–	–	0.12 [0.2]	5.65 [7.7]	22.31 [19.2]	-6.38 [5.0]	0.77 [9.7]	–	–	1.30	23.5	24	1.86	6,47
2	Level	9.41 [55.7]	-4.77 [19.1]			0.03 [0.0]	5.60 [6.5]	17.79 [20.5]	–	-0.30 [2.1]	0.55 [6.9]	0.82 [5.6]	1.78	22.7	21	(a) 1.88	7,44
3	Level	–	–	11.27 [30.1]	-0.15 [14.4]	0.01 [0.0]	5.80 [4.7]	41.46 [31.1]	-4.56 [2.2]	0.10 [2.6]	0.73 [20.5]	0.97 [23.9]	1.37	18.2	21	(a) 1.91	7,44
4	Level			11.03 [30.0]	-0.14 [13.9]	0.05 [0.0]	5.75 [4.6]	18.22 [14.5]	–	0.91 [9.1]	–	-0.22 [1.2]	1.92	27.6	21	1.74	6,47
5	First Difference	6.53 –				18.65 [23.3]	24.09 [30.5]	30.72 [38.9]	–	0.57 [5.5]	– –	– –	1.59	18.1	21	2.52*	9,38
6	Seasonal Difference	9.35 [24.7]	-4.87 [9.0]	–	–	–	–	–	–	(b) 0.73 [8.1]	–	–	1.47	15.0	21	6.08*	6,43
7	Seasonal Difference	–	–	11.43 [14.8]	-0.14 [7.2]	–	–	–	–	0.81 [10.7]	–	–	1.66	21.2	21	6.16*	6,43

Notes: (a) Causality test is based on an AR (2) Model; ARMA (2,1) encountered a non-invertible MA parameter when money was included.
(b) ρ_4, fourth order AR with coefficients of zero for lags 1 to 3.

$\chi^2_{.05}(24) = 36.4$ $F_{.05}(6,43) = 2.33$
$\chi^2_{.05}(21) = 32.7$ $F_{.05}(6,47) = 2.31$
$F_{.05}(7,44) = 2.24$
$F_{.05}(9,38) = 2.10$

* Indicates rejection of the null hypothesis that money does not cause real GDP at the .05 level.

Table 8 Alternative Time Series Models of Real GDP Seasonally Adjusted

Model	Dependent Variable	Annual Growth Rates				Cycle			Test Statistics			
									ϵ_t		Money Causality	
		1965 – 1973	Change in 1974(1)	1965(1)	Change	ρ_1	ρ_2	σ^2_ϵ	Q	D of F	F	D of F
1	Level	9.44 [59.9]	–4.80 [13.4]	–	–	0.77 [9.7]	–	1.34	12.5	24	0.94	6,47
3	Level	–	–	10.96 [29.8]	–0.14 [14.1]	0.93 [20.2]	–	1.26	25.6	24	2.71*	6,47
5	First Difference	6.37 [9.2]	–			0.17 [1.4]	0.27 [2.2]	1.35	22.1	24	4.86*	7,42
6	Seasonal Difference	9.32 [25.0]	–4.86 [9.1]	–	–	0.73 [8.2]	–	1.43	15.9	21	7.19*	6,43
7	Seasonal Difference	–	–	11.39 [14.9]	–0.13 [7.2]	0.82 [11.1]	–	1.60	24.2	21	6.38*	6,43

$\chi^2_{.05}(24) = 36.4$
$\chi^2_{.05}(21) = 32.7$

$F_{.05}(6,47) = 2.31$
$F_{.05}(6,43) = 2.33$
$F_{.05}(7,42) = 2.25$

* Indicates rejection of the null hypothesis that money does not cause real GDP at .05 level.

procedures. Models 2, 4 and 5 may, however, be rejected.

Next, consider the relationship between the business cycle and the money supply. The hypothesis that money causes cyclical output was tested in the following way. First, the money supply was regressed on exactly the same trend and seasonal variables specified in models 1 through 7. In other words, both real GDP and the money stock were orthogonalized with respect to the same set of fixed trend and seasonal regressors. Second, in order to test for Granger-causality between money and output, the following equation was estimated:

$$y_{it} = \rho(L)\, y_{it-1} + \theta(L)\varepsilon_t + \sum_{i=1}^{5} k_i M^r_{t-i} \tag{31}$$

where

$\rho(L)$ is a polynomial in L of order p(AR),
$\theta(L)$ is a polynomial in L of order q(MA), and
M^r is the orthogonalized value of the money stock.

The hypothesis that the coefficients k_i are zero was tested and the relevant F statistics and degrees of freedom are reported in the final two columns of Tables 7 and 8.

Using this test, the hypothesis that money causes output is rejected for models 1 to 4 and accepted for models 5 to 7 (cf. statistics in Table 7). Each of the models, however, for which the hypothesis that money Granger-causes output is not rejected, has an important defect. All of the models impose a constant seasonal pattern on output—a restriction that is strongly rejected by the data. Thus, money *appears* to cause output only in models that are inappropriately specified. In models whose specifications are not rejected (1 and 3), money does not cause output.

Thus, on the basis of alternative decompositions of output into its trend, seasonal and cyclical components, using data that have not been previously seasonally adjusted, the conclusions reached in the previous section may be sharpened up. In those models, money does not Granger-cause output. Furthermore, in the case where a shift in both the level and trend growth rate following the first oil shock is allowed, the cycle in output follows a simple first-order autoregressive process.

Next, consider the results for seasonally adjusted data (Table 8). Again, every model passes the Box-Pearce test for non-autocorrelated residuals. The only nested comparison available in the case of seasonally adjusted data is between model 5 and models 1 and 3. Model 5 is a restricted version of each of these models and clearly, on the basis of the t-statistics on the trend change variables, those restrictions are rejected. On the basis of standard errors comparisons, however, model 5 looks similar to model 1 though inferior to model 3. Model 5 does, however, have a more complicated error structure (AR(2)) than the other models. None of the other models may be discriminated against by classical procedures and all look very similar in terms of their implications for the business cycle. They each give rise to a cycle that is well described by a first-order autoregressive process. The two models with continuously changing growth rates (3 and 7) display more persistence, however, with an autoregressive coefficient somewhat closer to unity than in the version with a once-and-for-all trend change (1 and 6).

The results of the money-output Granger-causality tests using seasonally adjusted data are most revealing. In the case of four of the models (3, 5, 6 and 7), the hypothesis that money causes cyclical output is not rejected. Only in the case of model 1 is the hypothesis rejected. This finding parallels that of the previous general distributed lag exercise. Thus, regardless of the procedures employed, when seasonally adjusted data are used, the hypothesis that money Granger-causes output is almost uniformly not rejected.

Why do the seasonally adjusted data point to the conclusion that money Granger-causes output while the raw data reject that conclusion? The answer almost certainly is that the seasonal adjustment procedures induce spurious causality.

The seasonal adjustment method employed to generate the official seasonally-adjusted real GDP series is similar to the Census X-11 method.[17] Relying, as it does, on (among others) moving average methods, the official seasonal adjustments give rise to problems long known to statisticians and econometricians.[18] In the present context, the problem can be illustrated very simply. Suppose that the business cycle is in fact generated by a Classical mechanism so that:

$$y_t = \lambda\, y_{t-1} + u_t\ . \tag{32}$$

The seasonally adjusted data may be thought of as being partly a moving average of the actual unadjusted series S(L) and in part as incorporating other adjustments (z). Thus, the seasonally adjusted series for real GDP (y^{SA}) may be represented as:

$$y^{SA} = S(L)\, y_t + z_t\ . \tag{33}$$

Using the seasonal adjustment on equation (32) yields:

17. The Census X-11 method uses a mixture of trading-day adjustments, moving averages and modification or removal of extremes. It is described by Julius Shiskin, Allan H. Young and John C. Musgrave (1967).

18. See, for example, Lovell (1963), Kenneth Wallis (1974) and Christopher Sims (1974).

$$y^{SA} = \lambda\ y^{SA}_{t-1} + S(L)u_t + z_t\ . \tag{34}$$

Clearly, what the seasonal adjustment does to the Classical business cycle equation is to convert a white noise error into a moving average error. This might not matter much were it not for the fact that, as is made clear in equation (29), part of the white noise disturbance in equation (32) represents innovations in the money supply itself. By passing those innovations through a moving average filter, lagged innovations in the money stock appear as Granger-causal variables of seasonally adjusted output. In an empirical investigation, therefore, the actual lagged money supply would appear as having a Granger-causal relation with seasonally adjusted output.

What this line of reasoning reveals is that, if the business cycle is a Classical phenomenon, then money will Granger-cause seasonally adjusted real output. The reverse deduction may not, of course, be made. That is, the finding that money does Granger-cause seasonally adjusted output does not lead to the conclusion that the business cycle is a Classical phenomenon. It does not, however, rule out that possibility.

The conclusion of the foregoing is that the use of seasonally adjusted data gives misleading answers to the crucial causality questions and the correct inferences (albeit subject to the usual caveats) are obtained from the seasonally unadjusted data. The conclusions reached from an analysis of the unadjusted data are that, when the trend and seasonal components of real GDP are modelled in an adequate manner, money does not Granger-cause output. Further, if the hypothesis that there was a shift in the level and trend of real GDP following the first oil shock in 1974 is maintained, the conclusion that cyclical output is characterized by a first-order autoregressive process is not rejected. Thus, the Classical explanation of the business cycle is not rejected by the Japanese data.

Since this conclusion stands in sharp contrast to that of almost all the previous studies on this topic, it seems appropriate to return to those earlier studies to see whether it is possible to discover the sources of their (incorrect) conclusions. First, those studies that used seasonally adjusted data are flawed for the reasons just discussed. There is, however, a remaining puzzle in this regard. Model 1, using seasonally adjusted data, has the same trend formulation as used by Seo and Takahashi and by Hamada and Hayashi. They found causality but none is found here. What is the explanation for this? One possibility is that the error processes have been modelled in different ways in the two studies. A second possibility is that different revisions of the seasonally adjusted data have been used in the different studies. A third difference is that Hamada and Hayashi used industrial production rather than GDP. These and other possibilities would reap a deeper investigation.

The earlier studies that used unadjusted data and found Granger causality from money (or prices) to output correspond to models 5 and 7 in Table 7. Causality is also found here. Those models are, however, rejected by the tests reported here.

The major ambiguity in the findings reported here arises from the interaction between the trend model employed and the money (or, in the previous section, velocity) causality relations. That is, the answers concerning causality questions depend on the trend employed. A possible explanation for this is the following: "Suppose a permanent change in the growth rate of money changes the growth rate of real GDP for a long period of time and suppose that such a change occurred around 1974. This will show up as a change in the trend, so the trend specification that allows for a change in trend will completely miss the effect of a change in the growth rate of money on real GDP. If no change in the trend is allowed for, then the effect of money on real GDP will show up in the output equation...as a slowly declining lag distribution for past money" (Fumio Hayashi).[19] A similar line of reasoning could be conducted concerning velocity and real GDP since money supply growth and velocity interact in a well-known way (captured in my system of equations (15)) above.

The implication of the above interpretation of the interaction between trend specifications and money (or velocity) causality is that there may well be a super non-neutrality that this study is failing to properly identify. Super non-neutralities are not, of course, inconsistent with Classical economics and certainly not inconsistent with Classical business cycle theory. Thus, regardless of whether the correct model is taken to be the one that does allow for a trend change, the consequence of which is the appearance that money does not cause income, or whether the specification in which there is the appearance of money causing income where the causation arises from trend rather than cycle considerations, one is led to the conclusion that Classical business cycle theory is not rejected by this body of data.

A final remaining point on which the conclusions reached here may be thought to be vulnerable arises from the shift in seasonality that was detected in 1970. Since the essence of the Keynesian model of the cycle involves a seasonal autoregression, could it be the case that this change in the seasonal pattern is, in fact, a consequence of some aspect of Shunto? Such a conclusion does not appear to be promising. The average value of the fourth-quarter seasonal surge in output is remarkably constant in both the pre- and post-1970 periods. It is, however, a different constant in those two subperiods. This is the only feature of the change in the seasonal pattern. It is hard to see how that change could be interpreted as representing the effects of fourth-quarter random events not foreseen during the first quarter of the year when wages were being negotiated. Indeed, in view of the regularity of the seasonal pattern, visible to the naked eye in the raw time series, the Keynesian model, with its

19. Fumio Hayashi made this suggestion to me in a written comment on an earlier version of this paper. I am extremely grateful to Professor Hayashi for this suggestion.

emphasis on seasonal autoregression, looks most unconvincing.

IV. Conclusions

The main positive conclusion reached by this study is that we may not reject the hypothesis that the Japanese business cycle is well-described by a stochastically disturbed difference equation at first order that is independent of influence from past values of the money stock. Earlier studies that have reached conclusions contrary to this were based on faulty procedures for handling trends and seasonality. The implication of this conclusion is that the Classical explanation of the business cycle is not inconsistent with the Japanese data. The Keynesian explanation is inconsistent with the data.

The implication of this finding for the interpretation of Japan's inflation "failure"of 1974-75 and "success" of 1979-81 is that monetary policy was all important and labour market arrangements incidental.

It remains to be seen whether the conclusion reached here will be robust and whether it can survive more stringent tests in models that explore the deeper structure of the Japanese—and other—economies.

APPENDIX

DATA LISTING

Year Quarter	Raw Data: Real GDP (billion ¥)	Raw Data: GDP deflator (1975=100)	Raw Data: Money Stock (billion ¥)	Seasonally Adjusted Data: Real GDP (billion ¥)	Seasonally Adjusted Data: GDP deflator (1975=100)	Seasonally Adjusted Data: Money Stock (billion ¥)
1965. 1	15635.9	46.07				
1965. 2	15825.0	47.16		17116.1	47.22	
1965. 3	17092.7	46.73		17532.3	47.59	
1965. 4	20636.2	49.04		17506.9	47.78	
1966. 1	16870.6	48.00		18283.2	48.41	
1966. 2	17561.1	49.26		19029.6	49.40	
1966. 3	19094.8	49.23		19476.9	50.11	
1966. 4	22994.2	51.79		19713.7	50.58	
1967. 1	18750.0	51.31		20282.1	51.64	
1967. 2	19320.6	51.85		20760.9	51.99	
1967. 3	21262.7	51.74		21593.5	52.60	
1967. 4	25432.9	54.89		22054.0	53.71	
1968. 1	21047.6	53.89	32686.5	22651.7	54.24	32661.9
1968. 2	21828.6	54.63	33753.5	23377.9	54.75	33818.3
1968. 3	23667.8	54.57	34854.4	23976.7	55.47	34974.9
1968. 4	29046.1	57.53	36487.9	25460.6	56.33	36312.9
1969. 1	23897.4	55.80	37837.1	25603.4	56.23	37826.3
1969. 2	24848.9	57.10	39368.1	26499.4	57.17	39446.8
1969. 3	26664.2	57.74	41080.2	26915.6	58.63	41188.8
1969. 4	31906.6	60.52	43267.9	28136.6	59.25	43069.2
1970. 1	26900.4	60.14	44977.3	28671.4	60.65	44991.8
1970. 2	27322.1	61.58	46754.4	29135.5	61.51	46850.8
1970. 3	29683.0	61.54	48555.7	29883.2	62.53	48635.5
1970. 4	33938.8	65.03	50800.0	30056.1	63.58	50583.7
1971. 1	28415.0	63.81	52802.0	30185.4	64.47	52859.9
1971. 2	28603.5	65.18	55563.3	30615.3	64.90	55661.1
1971. 3	30892.4	64.56	59078.8	31059.8	65.80	59125.1
1971. 4	35361.4	67.79	62730.9	31334.7	66.13	62493.2
1972. 1	30739.2	66.11	66254.9	32547.7	66.91	66367.8
1972. 2	30801.7	68.40	70071.7	33035.1	67.89	70139.3
1972. 3	33675.5	68.03	74902.8	33742.6	69.51	74940.1
1972. 4	38923.7	72.13	80020.7	34610.5	70.45	79774.6
1973. 1	34203.3	71.31	83869.7	36180.8	72.22	84048.7
1973. 2	34139.2	75.37	88521.2	36587.3	74.71	88514.8
1973. 3	36561.0	76.07	91177.2	36513.4	77.74	91215.5
1973. 4	41041.5	84.24	93779.6	36569.9	82.13	93588.4
1974. 1	33269.0	86.10	95837.6	35437.6	87.11	96028.2
1974. 2	33836.8	91.87	98623.2	36046.6	91.40	98547.0
1974. 3	36592.3	92.45	101174.3	36520.1	94.43	101217.1
1974. 4	40732.0	99.94	104292.4	36365.6	97.14	104151.0

APPENDIX DATA LISTING

Year Quarter	Raw Data			Seasonally Adjusted Data		
	Real GDP (billion ¥)	GDP deflator (1975=100)	Money Stock (billion ¥)	Real GDP (billion ¥)	GDP deflator (1975=100)	Money Stock (billion ¥)
1975. 1	33811.8	97.06	107361.7	36065.2	98.34	107547.9
1975. 2	34645.8	100.07	111047.7	36809.2	99.40	110947.4
1975. 3	37260.6	98.16	114808.2	37192.3	100.46	114811.2
1975. 4	42096.9	104.71	119114.9	37704.2	101.81	119021.7
1976. 1	35955.4	102.18	123799.9	38351.7	103.52	124006.2
1976. 2	36694.0	106.51	128414.1	38777.0	105.76	128316.1
1976. 3	39232.9	105.39	132312.2	39191.2	107.71	132227.1
1976. 4	43770.2	111.51	136169.0	39303.2	108.83	136107.1
1977. 1	37917.4	108.98	139355.2	40408.7	110.27	139650.7
1977. 2	38691.8	112.56	142809.2	40797.0	111.73	142702.1
1977. 3	41038.3	111.05	147049.9	41042.7	113.35	146825.7
1977. 4	46188.7	117.24	150734.6	41596.5	114.67	150711.7
1978. 1	39908.9	114.59	154374.1	42385.1	115.82	154830.1
1978. 2	40378.5	118.27	159685.2	42704.0	117.23	159489.7
1978. 3	43143.1	116.26	164897.5	43182.1	118.57	164554.2
1978. 4	48645.4	121.59	169121.1	43779.7	119.25	169134.4
1979. 1	41830.0	118.76	173320.1	44291.1	120.02	173956.2
1979. 2	42572.5	121.77	179316.7	44969.3	120.78	179004.9
1979. 3	45397.7	118.91	184209.0	45451.8	121.09	183794.4
1979. 4	51106.3	123.82	188047.0	46050.5	121.20	188074.1
1980. 1	44174.2	119.85	191775.2	46766.4	121.36	192541.1
1980. 2	44741.6	124.57	197431.0	47059.0	123.90	197033.7
1980. 3	47556.9	123.18	199610.6	47668.4	125.43	199190.1
1980. 4	53378.4	128.95	202669.5	48236.0	126.06	202662.0
1981. 1	46172.8	125.33	206269.9	48738.2	126.78	207094.2
1981. 2	46866.2	127.57	213009.7	49308.7	126.80	212611.0
1981. 3	49639.0	125.39	218739.7	49753.4	127.73	218300.5
1981. 4	54817.9	131.51	224087.1	49637.9	128.59	224034.9
1982. 1	47111.6	128.09	228125.2	49709.9	129.62	229019.9

Source: Real GDP : Economic Planning Agency, Japanese Government
GDP Deflator : Economic Planning Agency, Japanese Government
Money Stock : M_2+CD, Average Outstanding, The Bank of Japan

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