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Implicit Estimates of the Natural and Cyclical Components of Japan's Real GNP

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This paper studies measurement of the business cycle from an economic rather than purely statistical perspective. Since the natural level of output is associated with price stability it should be possible to infer its behavior from relative movements of inflation and output, given a model of price dynamics. For example, if inflation accelerates when output slows it seems clear that the natural level has declined. While long-term growth is due to the natural level, short-term fluctuations will be generated by both nominal demand shocks and real shocks to the natural level. Results for Japan's real GNP are presented.

I. Introduction

Traditionally the problem of separating an economic time series into trend and cyclical components has been viewed as essentially a statistical one. Little thought seems to have been given to whether statistical methods measure these components in a way that is useful to economists. A key feature of these approaches has been to assume a priori that the trend and cycle components are statistically independent. This assumption is useful to the statistician because it is sufficient to identify (allow estimation of) the two components. However, it may or may not result in a decomposition that is useful to economists. Sir John Hicks (1965) made this point very clearly when he wrote:

> "...The distinction between trend and fluctuation is a statistical distinction; it is an unquestionably useful device for statistical summarizing. Since economic theory is to be applied to statistics, which are arranged in this manner, a corresponding arrangement of theory will (no doubt) often be convenient. But this gives us no reason to suppose that there is anything corresponding to it on the economic side which is at all fundamental. We have no right to conclude, from

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the mere existence of the statistical device, that the economic forces making for trend and for fluctuation are any different, so that they have to be analyzed in different ways."

The basic motivation for trend-cycle decomposition begins with the observation that measures of economic output such as real GNP exhibit both long-term growth and short-term fluctuation. Economists tend to think of the processes generating the two components as quite different. Long-term growth is due to growth in labor force and capital stock and to technological change. Short-term fluctuations are though of as arising largely from monetary disturbances which in principle can be offset by the monetary authority but in practice may originate with or be aggravated by actions of the monetary authority. Economic theory suggests that monetary policy can have a large short-term effect on output but will be neutral in the long run. It is therefore important to the understanding and conduct of monetary policy that we be able to measure the deviation of real GNP from its long run path. The burden of monetary and fiscal policy-making is to render these deviations as small as possible.

Statistical procedures for measuring trend and cycle components incorporate the definitional concept that the trend component accounts for long-term growth while the cycle is transitory. Until recently econometricians have assumed that the trend is a deterministic function of time, generally an exponential growth curve. This specification left no scope for stochastic variation in the trend component, for example shocks due to changing energy prices, because all variation around the trend curve was attributed to cyclical variation. The results of Nelson and Plosser (1982) and numerous subsequent papers suggest that the trend component of real GNP and other U.S. time series are better modeled as nonstationary processes akin to a random walk with positive drift.

A recent series of papers seeks to relax the assumption of a deterministic trend by casting the problem in the context of the state space model and Kalman filter in which the trend component is assumed to be a random walk with positive drift and the cycle a stationary autoregression. Harvey (1985), Watson (1986), and Clark (1987) apply the Kalman filter approach to U.S. data. Horiye, Naniwa and Ishihara (1987) have studied the behavior of Japanese business cycles using a smoothness-priors state space model. Their approach allows for a stochastic trend component in the growth rate rather than level of real GNP and related variables, thereby offering more flexibility in modeling the transition to slower growth in the Japanese economy since 1975.

The state space model underlying the Kalman filter assumes that the trend and cycle components are statistically uncorrelated because without this assumption the two components are not identified. That is, there is not sufficient information in the time series of real GNP itself to allow estimation of its components. (Further discussion of this identification problem can be found in Nelson and Plosser.) The resulting trend and cycle are uncorrelated by assumption. For U.S. post-war quarterly real GNP data the estimated trend component reported by Watson and Clark is much like a trend line, with almost all variation attributed to the cyclical component which exhibits swings lasting 10 to 17 years. One reservation I have about the Kalman filter approach concerns its statistical properties; a Monte Carlo study reported in Nelson (1988) shows that it tends to estimate a very smooth trend and variable cycle when in fact the data contain no cycle. Another is that the assumption of statistical independence between the trend and cycle components is not motivated by economic considerations but is a "statistical device" to render the underlying state space model identified. Beveridge and Nelson (1981) proposed the long horizon forecast of a time series as a concept of trend which does not require independence of the components and is nevertheless always computable. More fundamentally, however, these statistical constructions are not entirely satisfactory because they are not the components of GNP which policy-makers should be concerned with.

Surely the fluctuations of interest to policy-makers are deviations from the natural level of real GNP. The natural level of output is generally defined as the rate at which the economy would operate if all agents correctly perceived relative prices and could adjust prices and wages costlessly. Actual real GNP will deviate from the natural rate if either of these conditions is absent, that is if agents do not fully perceive the aggregate price level or face costs in adjusting their own prices. The natural level of real GNP will grow over time with growth in labor force, capital accumulation and improvements in technology, and in the long run it accounts for of all the growth in real GNP. Deviations of actual from the natural level of output will be transitory in nature, their persistence depending on the speed with which agents change their perception of relative prices and the costs of adjusting prices and wages. This cyclical component of real GNP may arise as the result of a shock to nominal demand, or because of a shock to the natural component which we will call a "real shock." Either type of shock sets in motion a change in the price level which generates a transitory discrepancy between the actual and natural level of output while the price level adjustment takes place. Since real shocks will in general affect both the natural and cyclical components of GNP the two components must be correlated, contrary to the customary statistical assumption.

The natural level of real GNP is unobservable, but we should be able to make inferences about its movements from the relative behavior of the price level and actual real GNP. For example, if we observe an acceleration in inflation accompanied by a slowing of real GNP this suggests a decline in the natural level of real GNP which we can think of as a negative real shock. On the other hand, if inflation does not accelerate in spite of faster growth in real GNP then one infers the occurrence of a positive real shock which has raised the natural level of real GNP. However, if price level adjustment is not instantaneous then the dynamics of the adjustment process will play an important role in making inferences about the timing and size of real shocks. This is the basic idea underlying the approach to measuring the natural level of real GNP and the cyclical deviations from it which was introduced in Nelson (1987) and is extended in this paper to the behavior of the economy of Japan.

II. An Empirical Model of Aggregate Output Dynamics in Japan

We can think of the natural level of real GNP as an index of the production possibilities frontier facing the economy, reflecting the stocks of human, physical and technological capital as well as the terms of trade the economy faces with the rest of the world. This natural level may be subject to both temporary and permanent shocks, collectively called real shocks. Actual real GNP at time t, denoted Q_t, will be a function of the paths of both nominal variables such as monetary aggregates and the natural level. This relationship can be expressed as monetary aggregates and the natural level. This relationship can be expressed as

$$Q_t=Q(.., Y_{t-1}, Y_t;.., QN_{t-1}, QN_t), \tag{1}$$

where Y is a vector of nominal variables and QN denotes the natural level of Q. If we know the distributed lag function Q(.) then we can use the observed values of Q and Y to infer recursively the path of QN. Following Lucas (1973), Nelson (1979), and Gordon (1982), I make the simplifying assumption that nominal demand is summarized by nominal GNP, denoted Y. Equation (1) then describes how a given change in nominal spending is divided between a change in output and a change in the price level through the identity $Y=Q+P$ (variables expressed in natural logs).

This recursive structure in which nominal income is considered to be causally prior to the division of nominal spending between quantity and price is a characteristic of monetary models in which exogenous movements in money determine nominal income through an interest inelastic money demand function. Recursive structure breaks down if the velocity of money or the quantity of money depends on how Y is divided between P and Q in which case the system becomes simultaneous. Some evidence that the hypothesis of recursive structure is not at odds with U.S. quarterly data is presented in Nelson (1979) and Fama (1981). The hypothesis provides an explanation of why U.S. stock prices react negatively to news of higher inflation, since a higher price level would signal lower productivity associated with a negative real shock. Whether recursive structure is also appropriate for Japan remains to be seen.

The specific form of the Q(.) function will depend on how the price level adjusts to discrepancies between the actual and natural levels of real GNP. If economic agents incur costs in adjusting prices, for example menu costs of various types, then the current price level will depend both on the prior price level and on the inflationary or deflationary gap. The basic idea that lags in adjustment of prices and wages are the source of economic fluctuations is a very old one, going back at least to Hume (1752), and still constitutes the driving mechanism of macroeconomics. The simplest specification of this process is the partial adjustment equation

$$P_t=\lambda P_{t-1}+(1-k)PN_t; \quad 0<\lambda<1, \tag{2}$$

where PN is defined as the price level which would equate actual real GNP, Q, to its natural level, QN, given nominal GNP, Y. Equation (2) could alternatively arise as the reduced form expression for the price level in a model where information lags under rational expectations are the source of the adjustment lags. For example, Nelson (1979) discusses how it can be the reduced form of the rational expectations model of Lucas (1973). Subtracting the prior price level from both sides of (2) and substituting (Y_t-QN_t) for PN_t we have an expression for the rate of inflation in terms of the difference between Q_t and QN_t namely

$$P_t-P_{t-1}=((1-\lambda)/\lambda)(Q_t-QN_t). \qquad (2)'$$

This says that the rate of inflation is proportional to the gap between that actual and natural levels of real GNP. This gap is also the cyclical component of real GNP. One implication of price stickiness which is evident from equation (2)′ is that persistent inflation will be associated with a persistently positive cycle component, that is a long run Phillips curve.

The implied Q(.) function is then obtained by solving (2) for Q_t which gives us

$$Q_t=((\lambda-\lambda L)/(1-\lambda L))Y_t+((1-\lambda)/(1-\lambda L))QN_t, \qquad (3)$$

where L is the lag operator. The first term in this equation gives the part of Q which is due to nominal demand and the second term the part due to the natural level. Note that the long run multiplier for the former is zero while for the latter it is unity. The strategy will be to use observed Y to calculate the first term given the parameter λ, with the second term being the remainder. From this remainder one can then calculate the implied series for QN.

Equation (3) can be viewed as a transfer function relating Y to Q with a particularly simple relationship among the parameters. The first term is a distributed lag function for Y with values at lags zero and one determined by two numerator parameters, values at subsequent lags decaying geometrically at the rate given by the denominator parameter. Each of these parameters is equal to λ which, according to the partial adjustment model, measures the stickiness of the price level. The noise process added to the transfer function is due to unobserved movements in QN which will form the error term (not serially random) of an ARMA process with autoregressive parameter which is also equal to λ.

To estimate equation (3) by least squares we need to assume that the process of nominal shocks is uncorrelated with the process of real shocks. This is a strong assumption that clearly may not be true. There is no free lunch in econometrics as well as economics, and in order to get rid of the assumption of uncorrelatedness of trend and cycle we need another uncorrelatedness assumption. If the model and this assumption are correct, or roughly so, then we would expect unconstrained values of the model parameters to be close to one another and the residuals to be uncorrelated with Y at leads and lags.

To estimate the model we take first differences since all of the variables are presumably nonstationary and these are denoted by lower case letters. Using quarterly GNP series for Japan 1957 I through 1988 I, transforming to natural logs, and first differencing one obtains the estimated transfer function model

$$q_t = \left(\left(\underset{(.04)}{.67} - \underset{(.10)}{.57}L\right)/\left(1 - \underset{(.15)}{.76}L\right)\right)y_t + \left(\left(1 - \underset{(.14)}{.37}L\right)/\left(1 - \underset{(.09)}{.76}L\right)\right)u_t \tag{4}$$

R-sq=.722; F(5,116)=60.11; Log Likelihood=434.8

Q(12)=13.4 with 10 df and p-value=.203
S(0,12)=12.8 with 10 df and p-value=.234
S(−1,−12)=14.75 with 12 df and p-value=.255

where standard errors appear in parentheses under coefficients, u_t is a residual, Q is the Box-Pierce-Ljung portmanteau test statistic for autocorrelation, and the S are Box-Pierce test statistics for crosscorrelation between u and y lags and leads (negative lags) respectively. These diagnostics for model specification are satisfactory.

The range of estimates of λ in this model is from .57 to .76. In my paper using U.S. data (Nelson 1987) I obtained corresponding estimates around .9 which suggests that the price level is considerably stickier in the U.S. than in Japan. This difference between the two economies is more apparent in the amount of adjustment of the price level that occurs in four quarters. As the estimated adjustment rate for the U.S. economy only 35% takes place within a four quarter span, while for Japan the comparable figure is 75%, using .7 as the value for lambda. In this sense the economy of Japan appears to be more classical than that of the U.S. Suzuki (1985) has argued that greater price level flexibility in Japan relative to the U.S. is due to differences in their labor markets. He points in particular to annual wage negotiations, the importance of bonuses and overtime in the wage package, and the rapid growth of labor productivity in Japan.

The denominator and AR parameters of the model agree closely, both about .76, and the numerator parameters of the distributed lag are not significantly different which tells us that the long run multiplier for y is not significantly different than zero as expected. Nevertheless, I would suggest taking the parameter estimates as suggestive of the rate of price adjustment based on a model that at best is an approximation to reality. There are several reasons why the model may produce biased estimates; for example the quarterly time interval is only an artifact of the way data is collected and not an economic constant. The actual price level adjustment process presumably goes on continuously and in Japan may vary in speed seasonally due to the annual shunto wage negotiations in the spring. The focus on this paper will be to explore the characteristics of the decompositions of real GNP that are implied by plausible values of λ rather than on model testing.

The assumptions underlying the recursive structure of the model would be called into question if the inflation rate were an important determinant of the velocity of money; a higher inflation rate presumably tending to increase velocity. If that were the case, then an increase in inflation due to negative real shocks would tend to accelerate the growth of nominal GNP because of rising velocity. The model would then tend to attribute the increase in inflation to the apparent nominal shock rather than to the real shock that caused it. The regression of the velocity of quasi-money (M_2+CDs) on the CPI inflation rate has an R-square of .01 and is not significant. The behavior of this velocity measure for Japan is dominated by a steady negative trend which persisted in spite of the surge of inflation of the 1970s.

Finally, while the empirical model is consistent with the partial adjustment model, most economists would like to see inflation expectations play a role in the price adjustment equation. Having experimented with some simple specifications which proved unsatisfactory, I feel that progress will be made in this direction only by modeling carefully the particular wage negotiation process associated with the annual shunto.

III. The Behavior of the Implied Natural and Cyclical Components of Japan's Real GNP

By definition the cyclical component of real GNP is the actual level minus the natural level

$$C_t = Q_t - QN_t. \tag{5}$$

Using the price adjustment model to substitute for Q_t in terms of Y and QN we obtain

$$C_t = (\lambda/1-\lambda L)y_t + (-\lambda/1-\lambda L)qn_t \tag{6}$$
$$= Cy_t + Cqn_t, \tag{6$'$}$$

where again lower case letters indicate changes in the natural logarithms of the variables which are continuous rates of change. This equation shows that the cyclical component consists in turn of two symmetric components: one due to nominal shocks (represented by the growth rate of nominal GNP) denoted Cy and the other to real shocks (represented by the growth rate of the natural level of real GNP) denoted Cqn. Note that the cyclical component is not uncorrelated with the natural component as in a statistical decomposition of real GNP but rather depends directly on it.

A positive nominal shock raises the cyclical component and this effect persists while the price level adjusts upward. A positive real shock reduces the cyclical component while the price level adjusts downward. To illustrate the latter, suppose there is a fall in international oil prices when initially $Q_t = QN_t$. This would correspond to a positive real shock, raising QN and creating a deflationary gap so that then $Q<QN$ and $QC<0$. As the price level falls output rises given the level of nominal GNP. During this adjustment process the cycle component is negative although output is rising unusually rapidly. The example makes clear that the cycle component implied by the adjustment model is not to be confused with simply rising or falling output. Rising output may be associated with a positive cycle component if it is due to a positive nominal shock or with a negative cycle component if it is due to a positive real shock.

The value of the natural level of real GNP implied by the model is easily calculated after solving equation (3) for QN_t in terms of the observable histories of Q and Y. The resulting expression may be written

$$QN_t=(1-\lambda L)(Q_t-Cy_t)/(1-\lambda), \tag{7}$$

which shows that the natural component is a distributed lag on the part of Q that is not due to nominal shocks.

To explore the kind of results that come out of this approach to decomposition and their sensitivity to the value of λ, I have chosen 0.55 and 0.8 as representing the ends of a range of plausible values of λ suggested by the estimated distributed lag model. This also reflects my view that an informed user of the approach may not wish to take the econometric point estimate as the best value of λ, both because it is likely to be subject to biases of various kinds and because other sources of information available to the user may suggest a better estimate. Thus the values used here are meant to be illustrative and suggestive, but no claim is made that they are optimal. Figures 1 and 2 plot the respective estimates of the natural level of real GNP (dot line) and the actual level (line) over the full sample period 1957-88. To make the comparisons more readily apparent and highlight the mid-1970s period Figures 3 and 4 present the same series for the period since 1972. A number of points should be noted from these figures.

a. Over long periods of time the natural level accounts for all of the growth in real GNP and the marked change in its growth rate after 1974.

b. Over shorter periods the natural level differs from the actual. The implied cyclical component, the difference between the two, is both larger in amplitude and longer in duration for the larger value of k (corresponding to slower price adjustment).

c. The natural component is more variable than the actual, the latter being smoothed by the price adjustment process.

d. The mid-1970s energy crisis corresponded to a fall of several percent in the natural level while the actual level fell more moderately from an unusually high level associated with a boom that had preceded the energy crisis. The natural level recovered about half of the decline from the initial shock, but has subsequently grown more slowly than it did prior to 1974.

e. The recent unusually rapid growth of Japan's real GNP during the 1987-88 period is accounted for by rapid growth in the natural component. This may be due to improved terms of trade arising from the strong yen as well as lower crude oil prices.

The implied cyclical component is the difference between Q_t and the calculated value of QN_t and the resulting series for both values of k are plotted in Figures 5 and 6

Figure 1. Natural and Actual Japan Real GNP

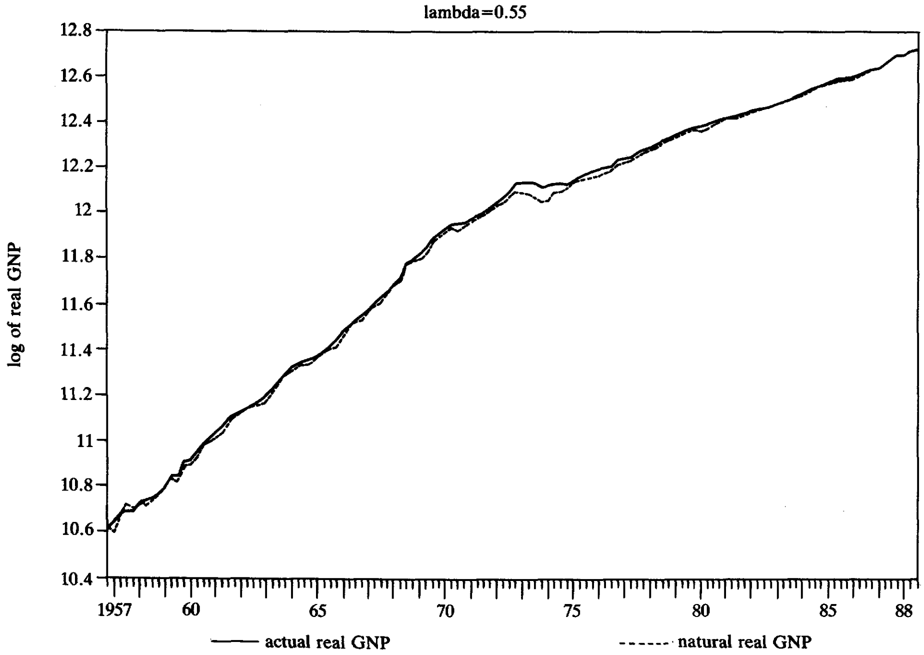


Figure 2. Natural and Actual Japan Real GNP

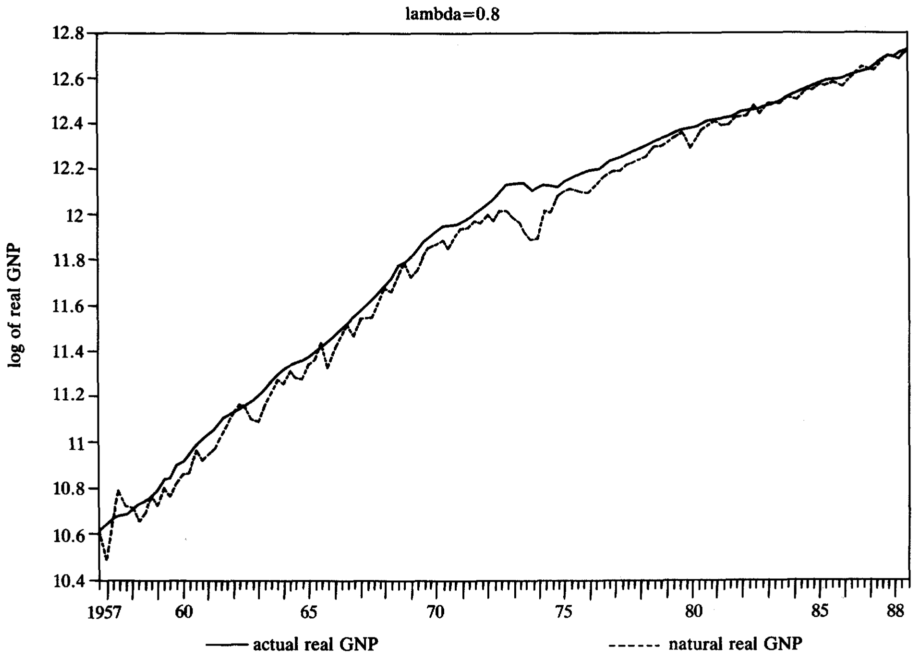


Figure 3. Natural and Actual Japan Real GNP

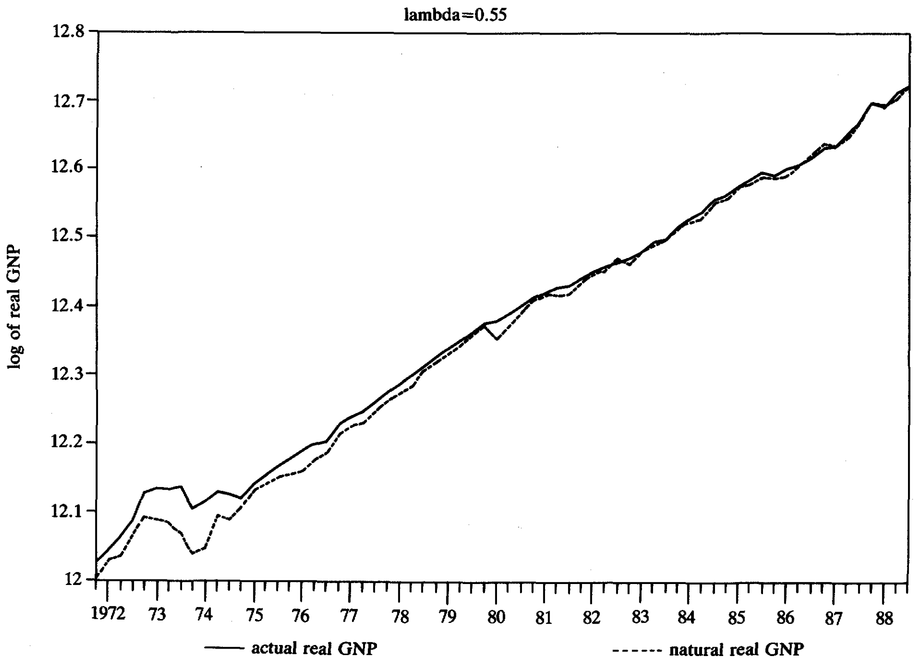


Figure 4. Natural and Actual Japan Real GNP

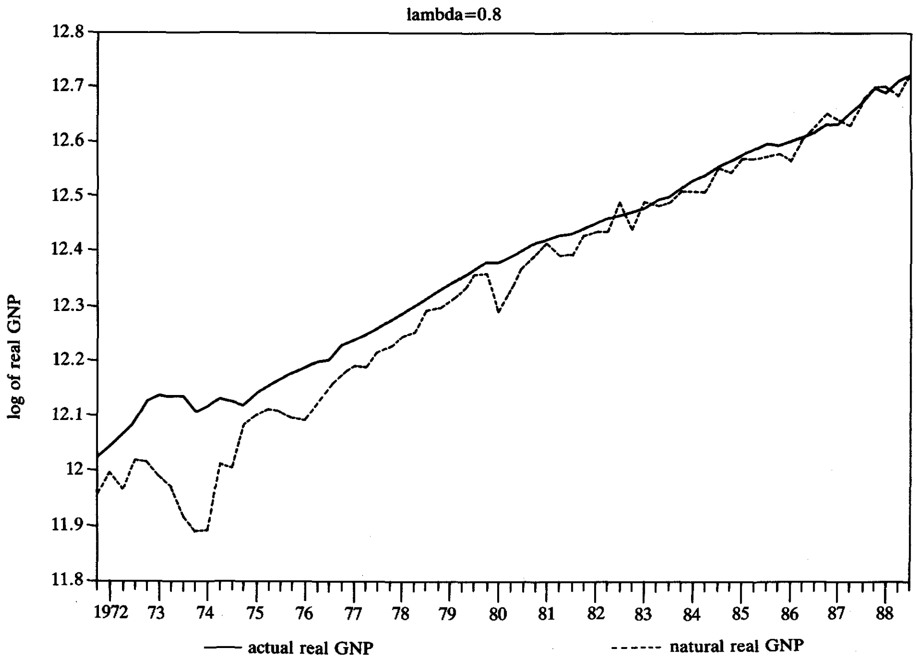


Figure 5. Cycle Component of Japan Real GNP

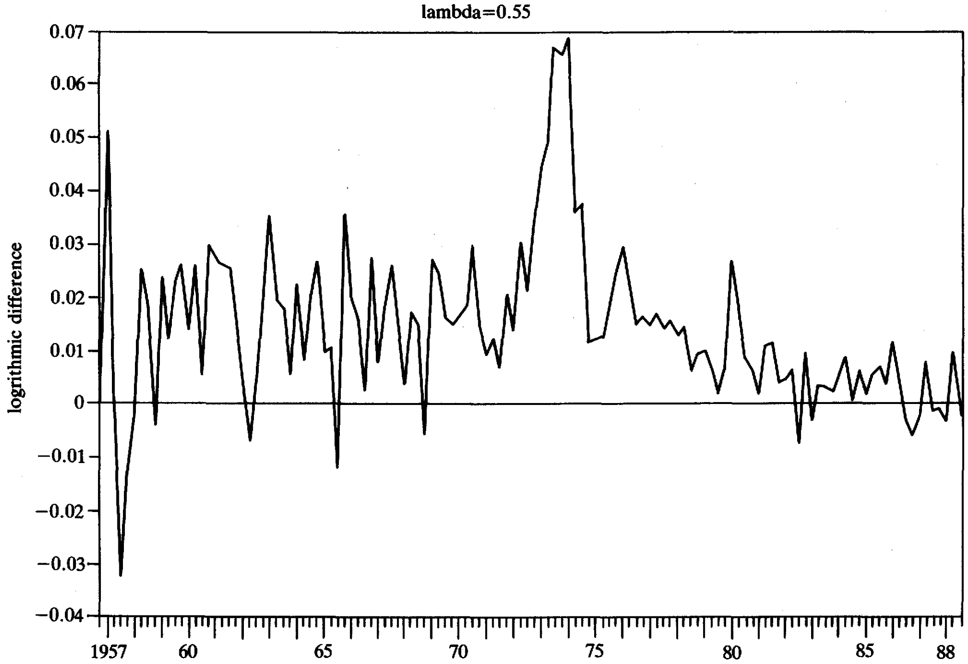


Figure 6. Cycle Component of Japan Real GNP

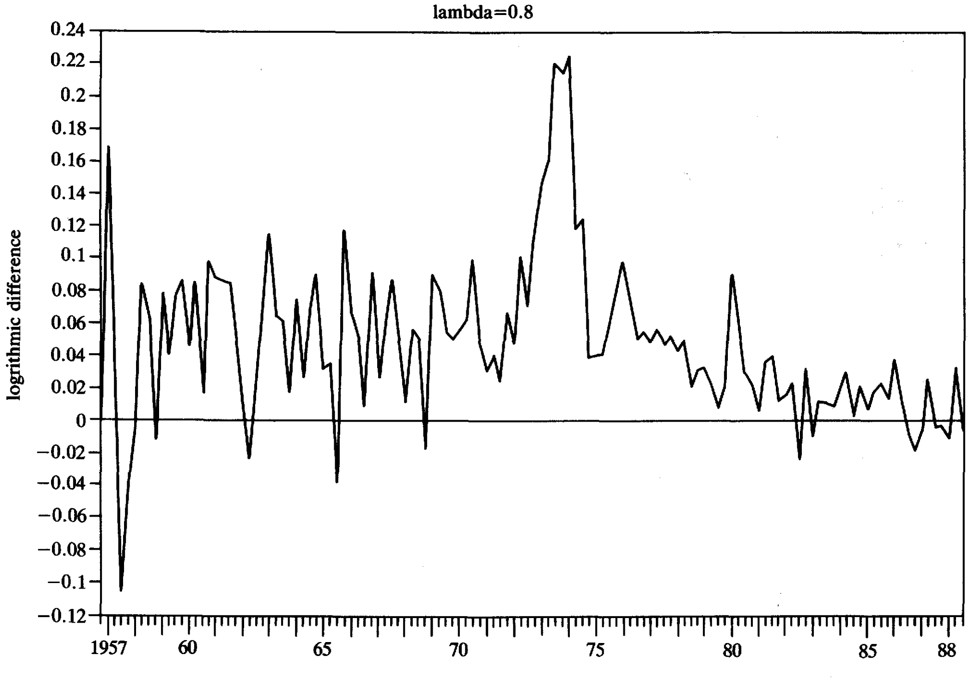


Figure 7. Cycle Component due to Nominal Shocks

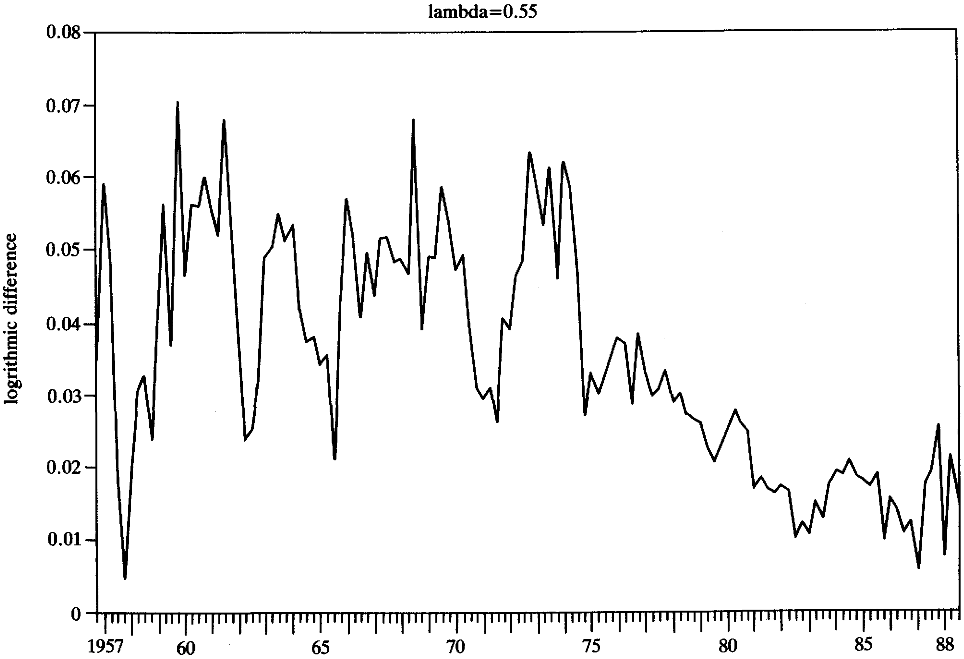
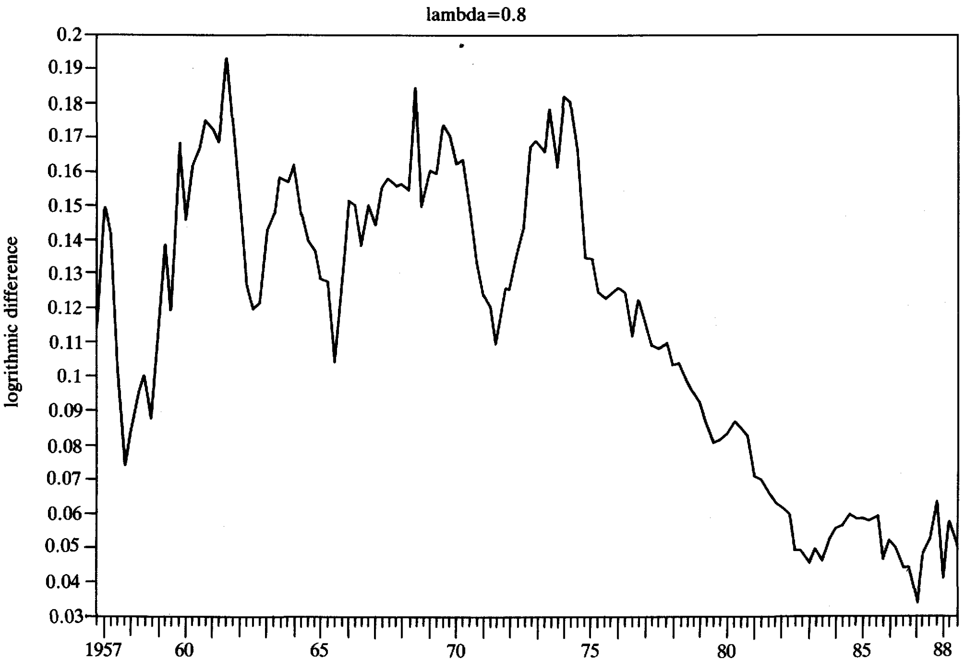


Figure 8. Cycle Component due to Nominal Shocks



respectively. Note that:

f. The cyclical component has diminished in both mean value and volatility since 1975. After the mid-1970s inflation pressure gradually eased until it became virtually absent after 1982. However prior to the energy crisis the predominantly positive cyclical component put steady upward pressure on the price level. The amplitude of the cycle depends on the value of k, varying between 7% and 20% of real GNP as k changes from 0.55 to 0.8. The positive bias of the cycle reflects the persistence of inflation until recent years.

g. The years 1973-74 were marked by a surge in inflationary pressure that was much stronger than any other episode in the series and its beginning predates the energy crisis of 1974.

Variation in the cyclical component will be due to both nominal shocks and real shocks as shown above in equation (6). By calculating these two components of the cycle separately we get a picture of how each factor has contributed to business cycles in Japan since 1957. The portion of the cycle component due to nominal shocks is plotted in Figures 7 and 8 for each value of k. Note that:

h. The contribution of nominal shocks to the business cycle and therefore inflationary pressure has diminished in both mean value and volatility since 1975, reflecting a deliberate change in monetary policy designed to reduce inflation and increase stability. Prior to the oil crisis monetary policy was largely driven by balance of payments considerations under fixed exchange rates; see Suzuki (1980).

i. The sharp increase in inflation in Japan in the mid-1970s was evidently due in part to nominal stimulus during 1973 which was reinforced in 1974 by the oil shock.

j. In recent years this nominal component of the cycle has diminished to the point where it is only accommodating the long run real growth rate of the economy. There is some suggestion that it has become more volatile again during 1987 and 1988, perhaps related to operations to stabilize the U.S. dollar.

These changes in the behavior of the cyclical component due to nominal shocks is consistent with the differences between monetary policy before and after the mid-1970s as described by Suzuki (1980, 1985) and Ito (1989). Money growth rates (measured by M_2+CDs) declined dramatically in both mean and variance after 1975. The wide swings of the earlier period were usually associated with the response of the Bank of Japan to fluctuations in the balance of payments, but after 1975 the BOJ put greater emphasis on stability in monetary aggregates although the extent is debated (Ito 1989). Moves to tighten monetary policy in 1957, 1961-62, and 1964 and the loosening of policy in 1971-72 are evident in the figures. Monetary policy had set the stage for a burst of inflation when the energy crisis hit in 1974 by raising demand pressure and keeping it high the prior three years.

Figure 9. Cycle Component due to Real Shocks

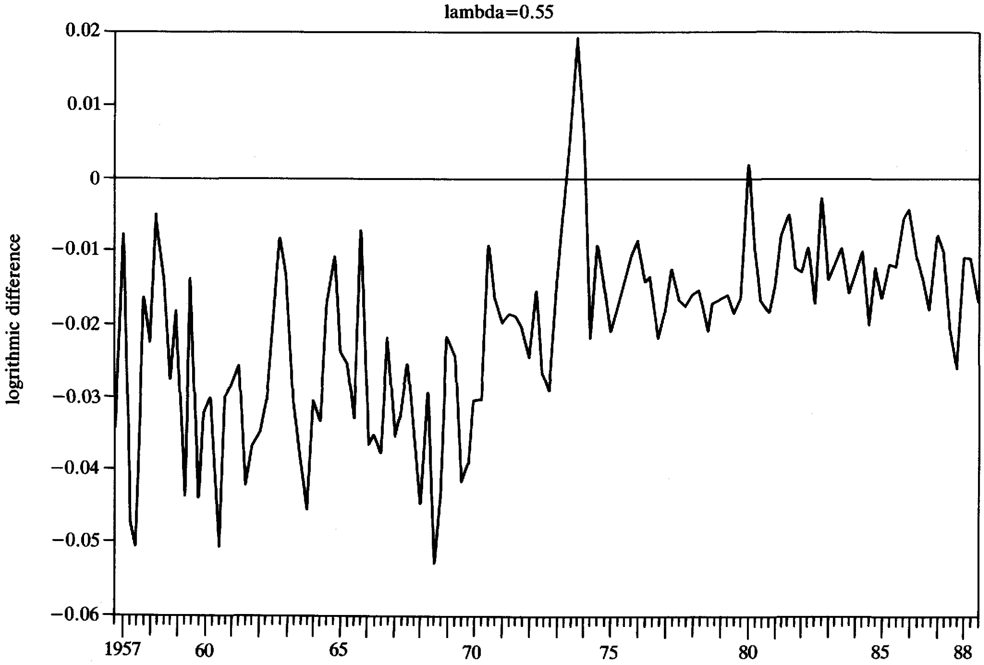
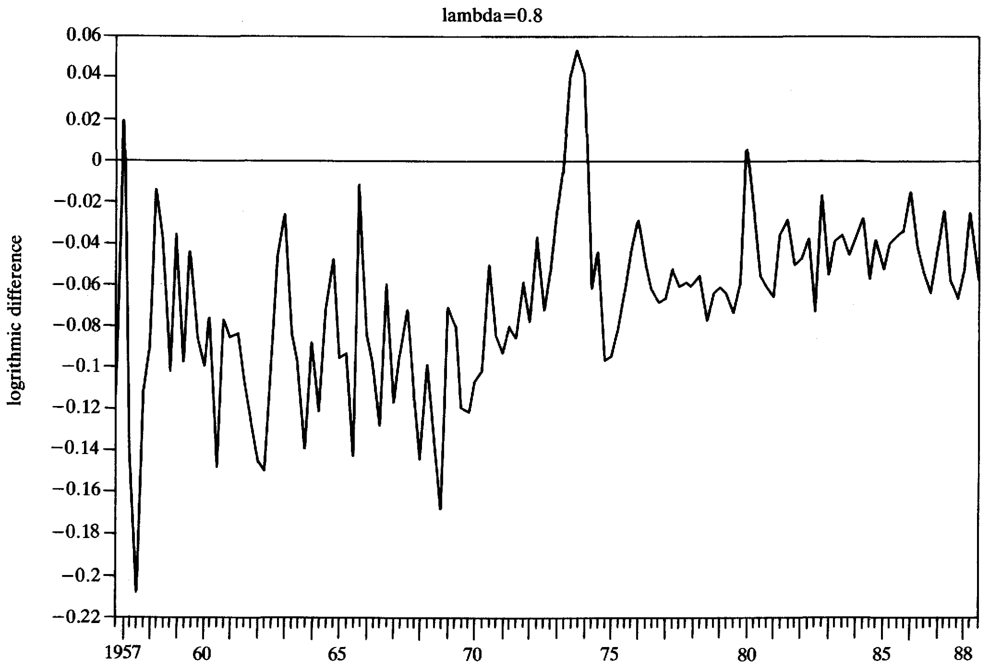


Figure 10. Cycle Component due to Real Shocks



The part of the cycle not due to nominal shocks is attributed in this framework to real shocks. Recall from equation (6) that a positive shock to the natural level of real GNP will reduce the size of the cycle. This inverse relation is because an increase in QN reduces the difference between Q and QN and correspondingly reduces inflationary pressure. The calculated cycle component due to real shocks is presented in Figures 9 and 10 for the two values of k. Note that:

k. The long-term growth of the natural level exerts a drag on the inflation rate which is reflected in a negative mean value for this cycle component. This drag has been less since 1975 due to slower growth in the natural level of real GNP. The smaller value of k suggests that real shocks have also been less volatile since 1975, although this difference is less striking for the larger value of λ.

l. Only for three quarters during the 1974 oil crisis and for one quarter during the second oil crisis was the decline in the natural level severe enough to make a positive net contribution to inflation pressure.

m. During 1987 and 1988 positive real shocks exerted somewhat more drag on the inflation rate, although this is less apparent for the larger value of k. Lower oil prices may have been the primary factor acting in this direction.

n. The two parts of the cycle have roughly cancelled each other out during most of the 1980s, producing relative stability in the price level in the Japanese economy.

The decomposition of Japan's real GNP into its natural and cyclical components and the latter into the parts due to nominal and real shocks highlights a number of trends in the economy since 1957. The natural level of real GNP has grown more slowly since the mid-1970s, but business cycles have become smaller in magnitude. Since that time nominal shocks have become less variable, contributing to a smaller cycle, and less inflationary.

IV. Decomposition of the Inflation Rate in Japan

Changes in the price level are due both to changes in nominal demand and to changes in the natural level of output. Using the framework of the price adjustment equation, one can separate these two components of inflation to see the separate contributions of nominal shocks and real shocks over time. Rearranging the model one has:

$$p_t=((1-\lambda)/(1-\lambda L))y_t+(-(1-\lambda)/(1-\lambda L))qn_t, \tag{8}$$

where again lower case letters indicate rates of changes. The two components are generated by the same distributed lag function, differing only in sign because changes in nominal demand and the natural level of real GNP have symmetric effects on inflation. Figures 11 and 12 present the inflation rate as measured by the GNP deflator and its two components using the two values of λ respectively. Inflation is expressed as an annualized

Figure 11. Inflation in Japan and Its Components

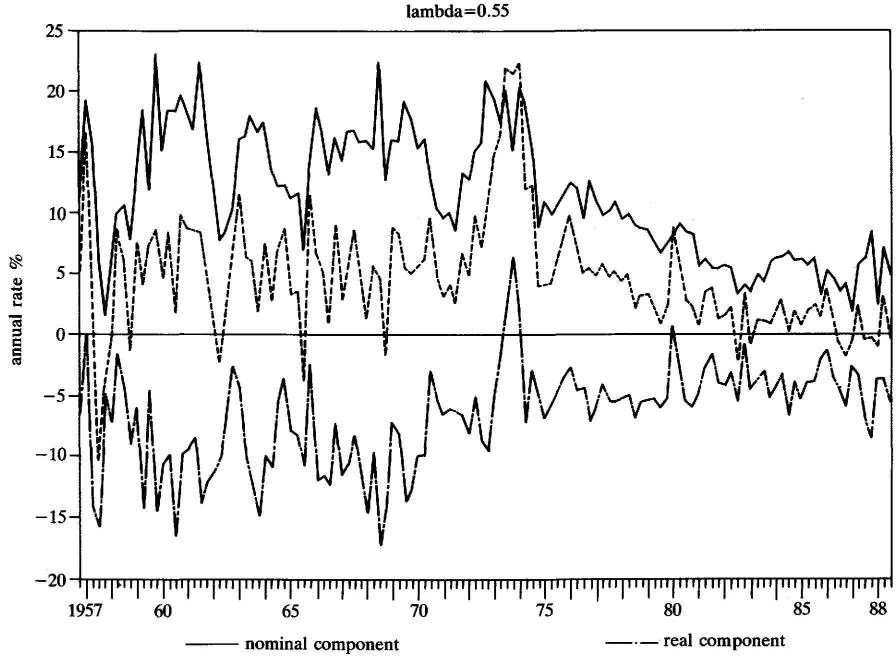
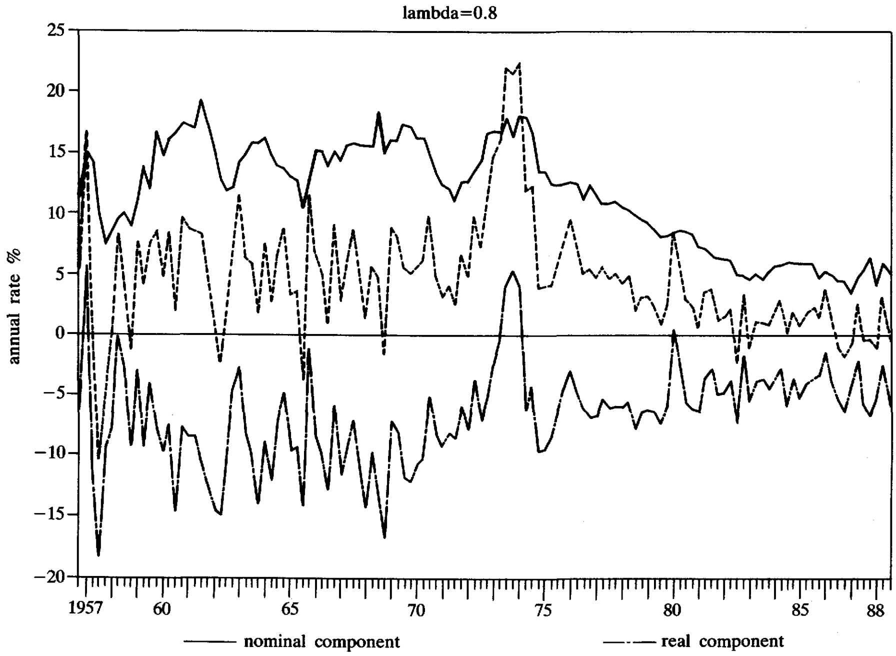


Figure 12. Inflation in Japan and Its Components



percentage rate. Note that:

o. The actual inflation rate was higher and more variable before the mid-1970s than after. It reached a peak of about 20% during 1974, followed by a gradual decline until virtual price stability was achieved in the 1980s.

p. Both nominal and real shocks have contributed to both short-term variation in the inflation rate and to the decline in its level that occurred after the mid-1970s. The smaller value of k implies roughly equivalent short-term variability in the two components while the larger value of l implies that nominal shocks have been responsible for less short-term variation.

q. The surge in inflation in the mid-1970s was due to both components. The component due to nominal shocks increased rapidly in 1972 and 1973 and remained high in 1974, while the component due to real shocks rose sharply in 1974 when the first oil crisis struck. In contrast, the smaller surge in inflation in 1980 was primarily due to the real shock associated with the second oil crisis and was only reinforced slightly by a small nominal shock.

r. Growth in the natural level of real GNP has exerted a drag on the inflation rate because higher output reduces the equilibrium price level given money supply and velocity. This drag has been less since the mid-1970s as the secular growth rate of the economy of Japan has been smaller. Only during three quarters of 1974 and one quarter of 1980 was the contribution of real shocks to the inflation rate positive. In the last few years more rapid growth in the natural level of real GNP has again exerted a more significant drag on Japan's inflation rate.

s. The secular decline in the inflation rate from the roughly 5% level of the years prior to 1973 to the price stability of the 1980s is entirely due to the slower growth of nominal demand. From a level of around 10% in the earlier period this component of inflation has declined to the point where it roughly offsets the drag from real growth. It is also striking that the variability of this component of inflation has also diminished, contributing to the diminished variability of the actual inflation rate. In the last two years there has been some renewed inflation pressure from nominal demand, albeit of modest proportions compared to the earlier period. Nevertheless, this could be the source of renewed inflation if it does not continue to be offset on the real side and therefore should be a source of concern to policy-makers.

t. One again sees the change in monetary policy after 1975 reflected in the declining level and variability of the component of inflation due to nominal shocks. The inflationary impulse that preceded the 1974 oil crisis is particularly apparent. The reader is referred to the discussion of changes in Bank of Japan monetary policy in Section III. above.

This decomposition of the inflation rate implies that inflation is not entirely and always a monetary phenomenon. Real shocks do play an important role in both short-term fluctuations in inflation and long-term inflation rates. The latter at least can be offset by monetary policy and indeed it would appear that the inflation effects of slower growth after 1975 were countered by monetary policy which also sought to reduce and stabilize the inflation rate.

V. Summary and Conclusions

A model of the price adjustment process in response to nominal and real shocks allows us to infer the natural level of real GNP and the cyclical deviations from that level. This decomposition differs from statistical decompositions into trend and cycle because it does not assume the two components are uncorrelated, rather it implies in general that they are correlated. It attempts to measure the level of GNP that represents a target for monetary policy, namely the natural level, and also estimates the amount of the deviation from that target that is due primarily to monetary policy and the amount that is due to real disturbances. It leads naturally to a corresponding decomposition of the inflation rate into the part due to nominal shocks and the part to real shocks.The empirical results suggest that both types of shocks have played a role in long- and short-term fluctuations in the business cycle and in inflation.

In a number of broad respects the empirical results agree with the conclusions of Horiye, Naniwa, and Ishihara based on the state space model. Both reveal the secular decline in the real growth rate since the mid-1970s and the reduced amplitude of the cycle. Horiye et al. also report a reduced amplitude of cycles in plant and equipment investment which is consistent with the smaller amplitude of the part of the cycle due to real shocks as shown in Figures 9 and 10. I interpret this agreement on the major changes in the economy as a check on the reasonableness of the price adjustment methodology.

Finally, the role played by nominal shocks in the changing behavior of the business cycle and inflation in Japan since the mid-1970s is consistent with our understanding of changes in the direction of monetary policy over the same period. In particular the wide swings in monetary policy prior to the mid-1970s as it attempted to respond to fluctuations in the balance of payments, the contribution of monetary policy to the burst of inflation in the mid-1970s, and then the decision by the Bank of Japan to pay more attention to the stability of monetary aggregates after that are reflected in the estimates of the component of the business cycle and of the inflation rate attributed to nominal shocks. Estimates for 1987-88 suggest that the BOJ may be risking renewed inflationary pressure and higher variance in its most recent policy posture.

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