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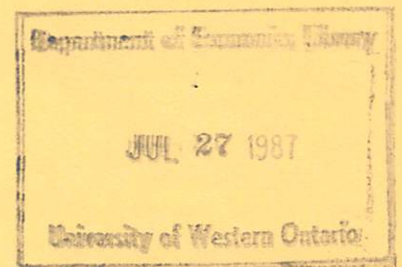
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Michael Parkin

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

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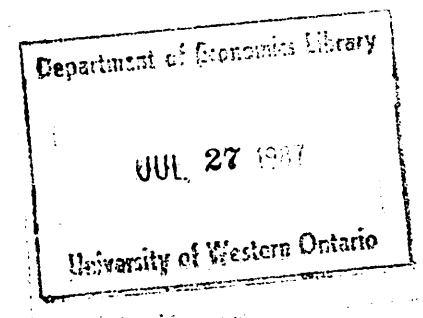


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MONETARY POLICY AND AGGREGATE FLUCTUATIONS

by

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This paper investigates the fluctuations of aggregate real output and the price level in the world¹ economy and in the national economies of the seven major industrial countries (Canada, France, Germany, Italy, Japan, United Kingdom, and United States) over the period 1958 to 1985.² The main goal of the investigation is to establish the contribution of monetary policy to output and price level fluctuations. In particular, it seeks to discover the extent to which monetary policy contributed to aggregate economic performance in the era of floating exchange rates since 1973.

The decision to study the world aggregate economy as well as the economies of the seven major industrial countries was based on two considerations. First, closed economies are simpler than open economies and the world aggregate economy is the best empirical entity available to us that approximates a closed economy.³ Second, before trying to understand the sources of variability in the aggregate performances of individual countries it seems useful to establish the patterns in the average performance of all countries.

The paper begins by describing the cycles in output and inflation and examining the changing cyclical patterns in the mid-1970s. It then examines a descriptive macroeconomic model that is consistent with a variety of alternative deeper structures and that provides an interpretation of the data on output, prices, and monetary policy. Though the model is descriptive, it contains enough structure to enable us to discriminate between sticky price Keynesian and rational expectations, market-clearing, explanations of aggregate fluctuations. It does not enable us to distinguish, at the world

aggregate level, between real business cycle theories on the one hand and monetary theories on the other hand.

Three main conclusions emerge from this study of world aggregate macroeconomic performance. First, the sticky price theory of the cycle is rejected while the class of theories based on market-clearing assumptions is not. Second, the major source of increased variability in output growth in the second half of the 1970s is an increased variability of real shocks hitting the supply side of the economy. Third, the rise in inflation in the 1970s had its origin in increased money supply growth rates in the late 1960s and early 1970s. Real, supply-side, shocks as well as financial innovations and changes in velocity made virtually no contribution to the rise in inflation.

The next section studies the individual countries, examining differences in their output and inflation performances. The main purpose in studying the individual countries is to reveal whether differences in national monetary policies can account for differences in national macroeconomic performances. It turns out that they can.

The seven countries fall into three groups: Canada and the United States whose aggregate real fluctuations have increased in amplitude since the mid-1970s; Japan, and to a lesser extent Germany and the United Kingdom, the amplitude of whose cycles has decreased in recent years; and France and Italy for whom the amplitude of aggregate fluctuations has remained constant. There are clear differences in the monetary policies pursued in these three country groups. In the first monetary policy has become more volatile under floating exchange rates. In the second and in particular in Japan, monetary policy has become more stable and predictable; while in the third (and to some degree in

Germany and the U.K.) the relevant parameters of monetary policy have not changed much under flexible exchange rates compared with the earlier fixed exchange rate period.

The main conclusion reached is that the major sources of fluctuations in world and national aggregate real economic activity are real shocks. But, monetary shocks have also been important in some countries and in particular in Canada and the United States where they have accentuated the fluctuations of output and inflation. Stable and highly predictable monetary policies, in particular in Japan, have contributed to the stabilization of real output even in the face of larger shocks emanating from the supply side of the world economy.

I. THE WORLD ECONOMY

The growth rate of world aggregate real Gross Domestic Product (as computed by the International Monetary Fund) is set out in Figure 1(a). Two features of the data shown in that figure are striking. First, there is a clear slowdown in real output growth in the late 1970s and 1980s compared with the 1960s and early 1970s. The average growth rate from 1960 to 1969 was 4.9 percent while from 1970 to 1984 it was 3.2 percent. The growth rate was apparently falling, though, even in the 1960s with the trough growth rates of 1967 and 1970 being successively lower than that of 1963. The second and perhaps more dramatic feature of the data is the increased volatility of growth in the 1970s and 1980s. The variance of output growth in the decade to 1969 was 0.8 percent while from 1970 onwards that variance was 3.4 percent.

The growth rate of world output is quite well described as a random walk. Figure 1(b) adopts this interpretation and plots the innovations in world output (measured as the absolute change in the percent growth rate). The increased volatility of output is more strongly visible at this level of differencing. The variance of the innovations from 1960 to 1970 was 1.5 percent while from 1971 to 1984 it was 4.7 percent.

Figure 2 shows world inflation (measured as the rate of change in the Gross Domestic Product deflator). The strong rising trend in the 1960s and early 1970s and much increased volatility in the 1970s and 1980s are clearly visible in these figures. The variance of inflation in the 1960s was 1.1 percent while in the 1970s and 1980s it increased to 7.8 percent. The variances of the innovations (measured as the absolute changes in the percent inflation rate) for those two same periods are 0.6 and 7.5 percent respectively.

Why have fluctuations to aggregate output and prices increased in amplitude in the 1970s and 1980s compared with the 1960s? Is the increased volatility in the world averages attributable primarily to real shocks, especially those associated with commodity and energy prices in the early and middle 1970s? Or, has the increased volatility in output and prices arisen as a consequence of the abandonment of the Bretton-Woods gold exchange standard and adoption of fiat money standards with flexible exchange rates with a consequential rise in the variability of money supply growth rates?

An attempt at answering these questions will begin by an examination of the contemporaneous relations between the growth rates of output, prices, and the money supply and then by an analysis of the causality (in the sense of

Granger) relations among the variables.

Contemporaneous Relations

In addition to producing data on world aggregate real GDP and the price level, the IMF produces five world aggregate money series--reserve money, narrow money, broad money (defined as money plus quasi-money), the income velocity of money plus quasi-money, and the ratio of reserve money to money plus quasi-money (the inverse of the broad money multiplier).

Two identities help us organize these data and, as it turns out, provide a partial answer to the questions posed above. The first is the income expenditure identity which, in growth rates is:

$$(1) \quad \Delta y + \Delta p = \Delta m + \Delta v$$

where all the variables are logarithms and y is real output, p is the price level, m is the money supply, v is velocity, and Δ is the difference operator. The second identity is that relating the money supply to the monetary base and is:

$$(2) \quad \Delta m = \Delta mb + \Delta mm$$

where again the variables are logarithms and mb is the monetary base and mm the money multiplier.

Figures 3, 4, 5 and 6 plot the monetary variables in a manner comparable with the data for output and the price level in Figures 1, 2 and Table 1 summarizes data for all six variables organized in terms of the two identities.

First consider the means. The rise in inflation from 4.2 percent in the 1960s to 11.5 percent in the 1970s and 1980s is associated with a rise in the growth rate of the money supply and with an approximately constant rate of change of velocity. The rise in the growth rate of the money supply is associated with a rise in the growth rate of the monetary base and with virtually no change in the rate of change of the money multiplier. Thus, despite massive financial deregulation and innovation, in the world aggregate data, the rate of change of velocity and of the money multiplier was little different in the 1970s and 1980s from what it had been in the 1960s and the higher inflation rate of the later period is associated exclusively with a higher growth rate of the money supply and of monetary base.

Next, consider the variances. The most striking differences between the two sub-periods are in output growth and inflation. The variance of output growth increased four-fold and that of inflation almost eight-fold. Where did this increased variability come from? What are the associated changes in the variances of nominal aggregate demand and the monetary variables? First, the variability of the money supply and the monetary base is virtually identical in the two sub-periods. The money multiplier and velocity each became more variable. The money multiplier rather more than tripled in variability and velocity somewhat more than doubled. Negative covariation, however, (not visible in the table) between money base growth and the multiplier resulted in the aggregate growth rate of the money supply being no more variable in the 1970s and 1980s than it had been in the 1960s. Further, negative covariation between velocity and money growth resulted in a smaller rise in the variability of aggregate nominal demand than in velocity itself. In fact, the variance of nominal aggregate demand was only 2 1/2 times larger in the 1970s and 1980s than it had been in the 1960s.

The data in Table 1 are consistent with the hypothesis that the increased variability of output and prices in the 1970s and 1980s was generated by increasingly severe supply and velocity shocks. The data are not consistent with the hypothesis that increased output and inflation variability were generated by increased variability in money supply growth. The data in Table 1 are also consistent with the hypothesis that the increase in inflation arose from an increase in the money supply growth rate and not from an increase in the growth rate of velocity. They are also, though, consistent with the hypothesis that the increase in inflation was caused by supply shocks which in turn were accommodated by increased money supply growth. It is to discriminate between these two possible directions of causation and to shed further light on the underlying sources of aggregate fluctuations that I now turn to an examination of the causality relations among the variables.

Causality

The contemporaneous relationships among real output, inflation, and the monetary variables are revealing but a deeper understanding of the processes at work can only be obtained by specifying and testing models that have some temporal structure. A model that is consistent with a variety of alternative deeper structures and one that conveniently specializes to three well-known models of the business cycle is the following.

First, aggregate demand, which is restricted to have unit elasticity, is given by:

$$(3) \quad y_t^d = m_t + v_t - p_t \quad (\text{aggregate demand})$$

where m is now the monetary base and v is the velocity of circulation of the monetary base.

Aggregate supply is given by:

$$(4) \quad y_t^s = y_t^* + \gamma(p_t - \alpha(L)E_{t-\tau}p_t) + u_t \quad (\text{aggregate supply})$$

where y_t^* is "natural" output, $E_{t-\tau}$ is an expectation conditional on information available at $t-\tau$; $\alpha(L)$, with $\sum a_i = 1$, is a polynomial L that operates on τ , and u is an unforecastable real technology shock. Aggregate supply shocks are in part real and in part arise from price level forecast errors. The price level forecast errors have been written in what appears to be a complicated and cumbersome way to accommodate two alternative theories of aggregate fluctuations. If $\alpha(L) = 1$ and $\tau = 1$, the aggregate supply function is that suggested by Lucas (1972, 1973). The more general case is the aggregate supply function proposed by Fischer (1977), and is in the spirit of theory not identical to, those of Phelps and Taylor (1977) and Taylor (1979, 1980).

If γ is zero so that price level forecast errors have no effect on aggregate supply, the specification is consistent with that proposed by the proponents of real business cycle theory such as Kydland and Prescott (1982), Long and Plosser (1983), and King and Plosser (1984).

The goods market clears to determine actual output

$$(5) \quad y_t^d = y_t^s = y_t \quad (\text{equilibrium})$$

The monetary sector is described by the two stochastic processes:

$$(6) \quad \Delta v_t = \lambda \Delta m_{t-1} + x_t \quad (\text{financial technology})$$

$$(7) \quad \Delta m_t = \alpha - \beta \Delta p_{t-1} + z_t \quad (\text{monetary policy})$$

The evolution of financial technology (6) reacts to recent changes in monetary base and incorporates a univariate process x_t . Money base growth, (7), reacts to the most recently observed inflation rate and, aside from that reaction, follows a stochastic process z .

It will be convenient to decompose the stochastic processes x and z into the component which is forecastable on information available at $t - 1$ and that which is unforecastable. Specifically let's define that decomposition as:

$$x_t = \hat{x}_t + \xi$$

$$z_t = \hat{z}_t + \epsilon$$

The random variables u , ξ and ϵ are distributed independently of each other. They are not identically distributed over time, however. Indeed, a principal purpose of this investigation is to explore sources of increased variance in output and inflation.

These five equations may be solved for the paths of output, inflation and money growth (with velocity growth being given as a linear combination of those three). The solution set out below is for the case in which $a(L) = 1$ and $\tau = 1$. The restrictions implied by that special case solution will be tested subsequently. The more general solution incorporating the Keynesian sticky-wage approach would incorporate distributed lags of all the innovations associated with the lag operator polynomial $a(L)$.

The solution for the special case is:

$$(8) \quad y_t = y_t^* + \frac{\gamma}{1+\gamma}(\varepsilon_t + \xi_t) + \frac{1}{1+\gamma}u_t$$

$$(9) \quad \Delta p_t = \alpha + \hat{x}_t + \hat{z}_t - \beta \Delta p_{t-1} + \lambda \Delta m_{t-1} + (y_{t-1} - y_t^*) \\ + \frac{1}{1+\gamma}(\varepsilon_t + \xi_t - u_t)$$

$$(10) \quad \Delta m_t = \alpha + \hat{z}_t - \beta \Delta p_{t-1} + \varepsilon_t$$

Equation (8) says that fluctuations in output around its natural rate are random. The variance of output deviations is:

$$\text{Var}(y_t - y_t^*) = \left(\frac{\gamma}{1+\gamma}\right)^2 (\sigma_\varepsilon^2 + \sigma_\xi^2) + \left(\frac{1}{1+\gamma}\right)^2 \sigma_u^2$$

Notice that money affects output in the sense that innovations in both financial technology (ξ) and money supply growth (ε) generate innovations in output. Output is not, however, caused (in the Granger sense) by money or velocity. The variance of output is higher the higher is the variance of the growth rate of nominal aggregate demand (with a weight $[\gamma/(1+\gamma)]^2$ and is greater the greater is the variance of the real shocks (with a weight of $1/(1+\gamma)^2$). In the case of the real business cycle with $\gamma = 0$, output variability is simply σ_u^2 , the variance of real supply shocks.

The inflation rate is autocorrelated and is also correlated with the previous period's money supply growth rate. The variance of the unforecastable component of inflation is given by:

$$\text{Var}(\Delta p) = \frac{1}{1+\gamma} (\sigma_\varepsilon^2 + \sigma_\xi^2 + \sigma_u^2)$$

Even if $\gamma = 0$ (real cycle theory), price variability is related one-for-one with the variability of both nominal demand and aggregate supply. Notice also that regardless of the value of γ (because of the assumption of unit elasticity of aggregate demand) supply shocks have an identical (but opposite sign) effect on output and prices. The money supply evolves according to equation (7) and is correlated with previous-period inflation.

Covariations between inflation and output fluctuations are of ambiguous sign and given by:

$$\text{Cov}(y - y^*), \Delta p = \frac{\gamma}{(1+\gamma)^2} (\sigma_\epsilon^2 + \sigma_\xi^2) - \frac{1}{(1+\gamma)^2} \sigma_u^2$$

Clearly,

$$\text{Cov}(y - y^*), \Delta p > 0 \text{ as } \gamma > \frac{\sigma_u^2}{\sigma_\epsilon^2 + \sigma_\xi^2}$$

The Keynesian formulation of the model, not explicitly written above, involves distributed lags of the random variables ϵ , ξ and u and a more complex distributed lag (based on the lag polynomial $a(L)$) in the interaction of inflation and money growth. In the Keynesian model, the lagged money innovations in the output equation imply that money Granger causes output.

To estimate and test the model whose solutions are set out as equations (8), (9) and (10). It is necessary to introduce some additional hypotheses about the stochastic processes y^* (the evolution of natural output) and \hat{x} and \hat{z} , (the stochastic processes governing velocity and money supply growth). The solutions can be written more compactly in the following form:

$$(8a) \quad y_t = z_{1t}$$

$$(9a) \quad \Delta p_t = \alpha - \beta \Delta p_{t-1} + \lambda \Delta m_{t-1} + z_{2t}$$

$$(10a) \quad \Delta m_t = \alpha - \beta \Delta p_{t-1} + z_{3t}$$

where

$$z_{1t} \equiv y_t^* + \frac{\gamma}{(1+\gamma)} (\varepsilon_t + \xi_t) + \frac{1}{(1+\gamma)} u_t$$

$$z_{2t} \equiv \hat{x}_t + \hat{z}_t + (y_{t-1} - y_t^*) + \frac{1}{(1+\gamma)} (\varepsilon_t (\varepsilon_t + \xi_t))$$

and $z_{3t} \equiv z_t$

Two alternative assumptions are made about the stochastic processes z_i ($i = 1, 2, 3$). Assumption 1 is that Δz_1 , z_2 and z_3 are independently and unidentically distributed random variables. Assumption 2 is that $\Delta^2 z_1$, Δz_2 and Δz_3 are identically and independently distributed. With these alternative assumptions and using the formulations written as (8a), (9a), and (10a), vector autoregressions using either the first differences (assumption 1) or the the second differences (assumption (2) the output, prices and money were run and the restrictions implied by (8), (9) and (10) imposed and tested.

One further modification, however, was made to the equations. We know from the above examination of the variables that there was a large rise in the variance of output and prices in the 1970s. We also know that there was virtually no change in the variance of money supply growth (monetary base growth in this case). In terms of the model set out above the increased variance of output and prices would have to be interpreted as an increase in the variance of either u or ξ . Both u and ξ are technological variables

and so each could, in principle, be affected by the same underlying shocks.

To permit variability in u (and possibly ξ) two variables were constructed, designed to capture the major sources of real shocks. The first is the rate of change of the relative price of commodities and the second is the rate of change in the relative price of petroleum. These two variables are shown in Figure 7. It turns out that the relative price of commodities on the average (which average incidentally excludes petroleum prices) performs better than the relative price of petroleum itself. Notice that the sharp rise in relative quality prices occurred a year earlier than that in petroleum prices and was associated primarily with the prices of food and beverages.

Defining the change in relative commodity prices as Δr and treating that relative price change as a proxy for unobservable real shocks to technology and endowments, the equations describing the evolution of output, prices and the money supply become:

$$(11) \quad \Delta^d y_t = \delta \Delta r_{t-1} + w_{1t}$$

$$(12) \quad \Delta^d p_t = \alpha - \beta \Delta^d p_{t-1} + \lambda \Delta^d m_{t-1} + \mu \Delta r_{t-1} + w_{2t}$$

$$(13) \quad \Delta^d m_t = \alpha - \beta \Delta^d p_{t-1} + w_{3t}$$

for $d = 1, 2$, and where w_i assumed to be i.i.d. random disturbances.

Estimation of (11), (12), and (13) as a general vector autoregressive system gave the estimates set out in Table 2a for the first difference case and in Table 3a for the second difference case. The estimates of the restricted systems are in Tables 2b and 3b. The F-statistic reported against each equation in Tables 2b and 3b is the one relevant for the restrictions imposed.

Choosing between the first and second difference formulation is not easy on the basis of the small samples with which we are dealing. On one critical issue, though, the two sets of results give the same answer. That is the directions of causation. In neither formulation does money growth Granger-cause output. Under both formulations money growth does Granger-cause inflation. There are, though, some contradictions between the two formulations. In the growth rates form lagged inflation has a strong and significant but negative effect on output growth. In second differences that effect is not present. Second in the first difference form inflation is autoregressive with a positive coefficient while in the second difference form inflation is autoregressive with a negative coefficient.

The effects of the real shocks, proxied by the rate of change in the relative price of commodities, has an effect of correct sign in both cases. It also corroborates the unit elasticity assumption in aggregate demand since, in each case, the positive effect on the price level is equal to the negative effect on output. In the first difference case that effect is small and not significant (at the 5% level) while in the second difference formulation the effect is larger and strongly significant.

In broad terms it seems to me that the second difference formulation of the model hangs together better and makes more sense than the first difference form. In the case of the money growth equation the first difference form almost certainly has a unit root and imposing that root in the second difference form appears appropriate both in terms of the goodness of fit and the plausibility of the counterinflationary effect found in that form. The output equation makes more sense in the second difference form with lagged inflation not playing a significant role. Interpreting the lagged inflation term in the first difference form is just about impossible. There are plenty

of models that predict such an effect but not in the absence of a lagged money growth effect. The presence of a lagged inflation effect and the absence of the lagged money growth effect suggest an inappropriate statistical formulation of the equation and favours the second difference case. It is less easy to choose between the two inflation equations. Consistency with the output of money growth equations though again points in favour of the second difference form.

What is clear is that this extremely parsimonious second difference representation of the time series behaviour output, prices, and the money supply, is a remarkably good one. It also enables us to interpret the data on means and variances presented in Table 1. According to this model, world aggregate output became more variable in the 1970s and 1980s as a result of being hit by real shocks that were of much larger amplitude than those experienced earlier. Aggregate output fluctuations were not of higher variance as a result of more variable monetary policy.

Monetary policy produced the inflation of the 1970s. The growth rate of the money supply is itself a random walk with slight drift--notice that the intercept in the money growth equation is positive and significant. Monetary policy reacts to inflation but does not fully offset inflationary shocks (coefficient of -0.7).

The effect of real shocks on output and the price level, particularly in 1973, were important. According to the estimated coefficient a 1% rise in the relative price of raw materials has about a one tenth of 1% effect on output (negative and the price level positive). The actual rise in the relative price of raw materials in 1973 was close to 50% so this single shock produced a 5% rise in prices and fallen output.

The conclusion to which we are led by this characterization of the world aggregate economy reinforces the conclusion based on contemporaneous correlations. The data are not consistent with a Keynesian sticky price model but are consistent with equilibrium models of both the real and monetary varieties. Are these conclusions borne out by the data describing national aggregate performance?

II. COUNTRY FLUCTUATIONS

The aggregate fluctuations of the seven major industrial countries (growth rates and changes in growth rates) are set out in Figures 8 through 14. In common with the world aggregate the growth rates of all seven countries declined over the sample period. Unlike the world aggregate, however, the amplitude of the cycle did not increase in each and every country. In France and Italy (with the exception of the 1974-1976 episode) the variability of output appears to have been roughly constant. Canada and the United States had a much higher degree of variability in the late 1970s and 1980s than earlier. Germany and the United Kingdom, and more strikingly, Japan experienced lower variability.

The average growth rates and their variances as well as the average innovations and variances are set out for three sub-periods in Table 4. Three sub-periods have been used to allow for the ambiguous period during which the Bretton-Woods system was collapsing but prior to which the flexible exchange rate system had settled down. The data in Table 4 give a more precise measure of the changed volatility in the individual countries than the pictures just considered.

Table 5 sets out similar data for inflation. The country variability of inflation is less striking than that of real output growth and there is a much less than perfect correlation between these two variables across the seven countries. Tables 6, 7 and 8 set out the national variances of the growth rates of the three definitions of the money supply--monetary base, narrow money and broad money (money plus quasi-money).

What can we learn from the cross-country variations in output, inflation and money growth?

A country model

Each country's aggregate fluctuations can be described by a model similar to that for the world as a whole but one that recognizes the openness of the individual economies. Each country has an aggregate demand function given by:

$$(14) \quad y_{it}^d = m_{it} + v_{it} - p_{it} \quad (\text{aggregate demand})$$

and an aggregate supply function given by:

$$(15) \quad y_{it}^s = y_{it}^* + \gamma(p_{it} - E_{t-1}p_{it}) + u_{it} \quad (\text{aggregate supply})$$

Equilibrium determines output as:

$$(16) \quad y_{it}^d = y_{it}^s = y_{it} \quad (\text{equilibrium})$$

Purchasing power parity holds in each country so that:

$$(17) \quad p_{it} = p_t + s_{it} - \rho_{it} \quad (\text{purchasing power parity})$$

where ρ is a stochastic process describing the real exchange rate, and s is the nominal exchange rate. Notice that I am not asserting that purchasing power parity is associated with constant international relative prices. I am suppressing all the detail of the determination of international relative prices such as that between traded and nontraded goods and capturing such features in the stochastic process ρ_{it} .

Financial technology evolves in accordance with:

$$(18) \quad \Delta v_{it} = \lambda \Delta m_{it-1} + x_{it} \quad (\text{financial technology})$$

Monetary policy depends on the exchange rate regime. Under flexible exchange rates the money supply is controlled to achieve domestic objectives and is assumed to follow:

$$(19) \quad (a) \quad \Delta m_{it} = \alpha - \beta \Delta p_{it-1} + z_{it} \quad (\text{monetary policy under flexible rates})$$

Under fixed exchange rates the change in the exchange rate is zero. That is,

$$(19) \quad (b) \quad \Delta s_{it} = 0 \quad (\text{monetary policy under fixed rates})$$

A reasonable assumption on the real exchange rate is that it follows a random walk so that:

$$(20) \quad \Delta p_t = \zeta_{it}$$

The solution to the country model depends on the exchange rate regime. Under fixed exchange rates output, prices and the money supply evolve according to:

$$(21) \quad y_{it} = y_{it}^* + \gamma(p_t - E_{t-1} p_t + \zeta_{it}) + u_{it}$$

$$(22) \quad \Delta p_{it} = \Delta p_t + \zeta_{it}$$

$$(23) \quad \Delta m_{it} = \Delta p_t - \gamma \Delta m_{it-1} + (y_{it}^* - y_{it-1}^*) + (1 + \gamma)\zeta_{it} + u_{it} - x_{it}$$

Output is a random process and driven by real domestic supply shocks and world price shocks. The inflation rate is tied to world inflation and departs from it in a random fashion and money supply growth is demand driven.

Under flexible exchange rates the solutions are:

$$(24) \quad y_{it} = y_{it}^* + \frac{\gamma}{1+\gamma}(\varepsilon_{it} + \xi_{it}) + \frac{1}{1+\gamma}u_{it}$$

$$(25) \quad \Delta p_{it} = \alpha + \hat{x}_{it} + \hat{z}_{it} - \beta \Delta p_{it-1} + \lambda \Delta m_{it-1} + (y_{it-1} - y_{it-1}^*) + \frac{1}{1+\gamma}(\varepsilon_{it} - u_{it})$$

$$(26) \quad \Delta m_{it} = \alpha + \hat{z}_{it} - \beta \Delta p_{it-1} + \varepsilon_{it}$$

Again output is determined by domestic technology shocks and also by domestic money and velocity shocks. Inflation is now generated by domestic monetary policy and by the random shocks to the money supply, velocity, and technology. The money supply is determined by the monetary policy actions of the central bank.

The relative variability of output under the fixed and flexible exchange rate regimes depends on the relative magnitudes of the domestic supply shocks and also on the relative magnitudes of domestic money supply and velocity shocks under flexible rates compared with world price level shocks and fixed rates. Output could be more or less variable under flexible rates depending on how domestic monetary policy is conducted. If that policy is conducted in an erratic fashion it is likely that output will be more variable under flexible rates than under fixed rates while if policy is highly stable, flexible rates make it possible to achieve greater stability in output.

Comparing price level fluctuations under fixed and flexible exchange rates is less clear cut. Under fixed rates domestic price level fluctuations are independent of domestic supply shocks, unless those shocks affect the real exchange rate, while under flexible rates the price level is influenced by domestic supply shocks. Also, under flexible rates the domestic price level is independent of the real exchange rate while under flexible rates the real exchange rate has a one-for-one effect on the domestic price level. As a result of this larger number of relevant shocks determining the price level there is no clear prediction of how countries' price level variability should rank based on variability in monetary policy.

Money supply growth variability under fixed rates depends on the variability in the demand for money while under flexible rates it depends on monetary policy.

The model set out above to describe an individual country is a good deal more complicated than that for the world aggregate economy. It has to take account of two exchange rate regimes as well as take account of international linkages through prices in markets for goods. (The markets for assets which also, of course, provide additional linkages have been suppressed.)

With the number of observations available we clearly cannot hope to estimate country models that are comparable to the one that was estimated for the world aggregate. What we can do, however, is to examine the cross-section data for the countries and see whether there is any evidence that variability across countries is associated with monetary variability. The central prediction of the above model is that the variability of output is directly related to the variability of money supply growth. This proposition does not imply causality between money growth and output growth. The model predicts contemporaneous correlation rather than causality. It also predicts a contemporaneous correlation regardless of exchange rate regime. Under fixed exchange rates the innovations that produce output fluctuations also produce demand-induced fluctuations in money growth. Under flexible exchange rates policy-induced variability in money growth also produces variability in output growth.

To test the predictions concerning output variability and money supply growth I constructed a pooled cross-section and regime data set based on the numbers set out in Tables 4 (for real output growth) and 6, 7 and 8 (for money supply growth). I then examined the relationship between the variability of output and the variability of money supply growth (looking at both the growth rates and their changes) controlling for country and regime.

There is virtually no cross-country association between growth rates of reserve money or growth rates of narrow money and growth rates of output.

(The same is true for the relation between the second differences among these variables.) There is, however, a significant relationship across countries between variability of real output growth and the variability of broad money growth. That relationship is summarized in the regressions set out in Table 9. Evidently the variance of output growth is reasonably well described as a constant plus 0.4 times the variance of money supply growth. Exactly that same coefficient (0.4) turns up when we look at changes in output growth and changes in money supply growth. The coefficient is quite well determined. The only country dummies that are significant are those for Canada and France in the growth rates. None of the country dummies is significant in the changes in the growth rates.

What do the cross-section correlations shown in Table 9 mean? Do they tell us that monetary variability is, in part, responsible for real output variability or are they a reflection of the fact that broad money is essentially an endogenous variable determined by the demand for it?

A definitive answer to this question would require the formulation of some further detailed hypotheses concerning national monetary policies that would have to be tested on finer disaggregations of national data. It is clear, however, that most countries in this sample did regard the targeting of a broad money aggregate as the centerpiece of their monetary policy under floating exchange rates. In the case of Japan, M2 plus Certificates of Deposit was the monetary target. In the case of the United Kingdom sterling M3 was the target. Germany targeted central bank money which is highly correlated with German broad money. Of these seven countries only Canada explicitly embraced a narrow monetary aggregate. The United States targeted broad and narrow aggregates paying more attention to the broader aggregates at a time when financial innovation was making the interpretation of the narrower

aggregates difficult.⁴

The fact that most countries did regard broad money as the relevant target suggests that it is the monetary base that should be regarded as endogenous being manipulated by the authorities in order to achieve a target (exogenous) path for the broader aggregate. If this interpretation is correct, and it seems a good description of Japan, the United Kingdom and Germany, the three countries whose output innovations fell, then the results generated here are consistent with the view that monetary policy contributes to output fluctuation--or, in the case of some countries, to their absence. The results are also consistent with the view that the business cycle is generated by a mechanism in which money does matter. The purest real business cycle theory is not consistent with this interpretation of the cross-section of data.

CONCLUSION

I have set out simple models of the world aggregate and national economies and used those models to interpret fluctuations in aggregate output, prices, and money. The conclusions reached are strong and clear.

The major source of output fluctuations in recent years has been real shocks to technology. Real shocks have not, though, been the only source of aggregate fluctuations. Money has also played an important role. Output fluctuations appear to have been independent of the forecastable component of money supply growth. Forecast errors in money supply growth have, though, generated fluctuations in output. Countries that have pursued highly stable targeting of a broad monetary aggregate have experienced lower output variability than countries that have paid little attention to the variability (and forecastability) of broad money growth.

Inflation has been generated by a mixture of monetary policy and supply shocks though mainly by monetary policy. The higher world aggregate inflation rate of the 1970s was the product of accelerating world money supply growth in the 1960s and early 1970s. Supply shocks, while raising the price level, do not produce on-going inflation through monetary accommodation. Monetary policy was significantly counterinflationary in the world aggregate data.

FOOTNOTES

¹The world is defined as the countries whose data are collected and summarized by the International Monetary Fund and published in International Financial Statistics as world aggregates.

²The dates vary slightly and for some variables begin in 1960 and end in 1984.

³The data available exclude the Soviet Union and most COMECON countries.

⁴For a useful summary of official descriptions of monetary targeting in six of the countries studied here see Paul Meek (ed.), 1983; pp. 6-31 (Germany), pp. 32-50 (U.S.A.), pp. 51-71 (U.K.), pp. 80-85 (Japan), pp. 100-105 (Canada), pp. 105-114 (France).

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Table 1

Means and Variances of World Aggregates

(a) Income, Prices, Money and Velocity

	$\Delta y + \Delta p$	=	$\Delta m_{qm} + \Delta v_{mqm}$
1960-1970	4.9 + 4.2 (0.8) (1.1)	=	9.1 \approx 9.7 - 0.4 (1.6) (2.3) (1.4)
1971-1984	3.2 + 11.5 (3.4) (7.8)	=	14.7 \approx 16.3 - 0.8 (4.0) (2.9) (3.4)

(b) Money, Reserve Money and the Money Multiplier

	$\Delta m_{qm} = \Delta m_b + \Delta m_{mn}$
1960-1970	9.7 \approx 6.8 + 2.5 (2.3) (4.1) (0.9)
1971-1984	16.3 \approx 13.7 + 1.8 (2.9) (3.8) (3.3)

Note: 1. Identities do not hold exactly in the data because second-order interaction terms are ignored and data for p and y run from 1960 while other variables run from 1958.

2. m_{qm} is money plus quasi-money and v_{mqm} is the velocity of money plus quasi-money.

Table 2a

Unrestricted Vector Autoregressions of Output, Inflation and Money
(Growth Rates)

Equation	Constant	Δy_{t-1}	Δp_{t-1}	Δm_{t-1}	Δr_t	σ_w^2	Q(11)
Δy_t	3.92 (1.97)	0.16 (0.30)	-0.41 (0.17)	0.24 (0.17)	0.07 (0.03)	1.20	13.70
Δp_t	0.25 (2.23)	-0.39 (0.34)	0.33 (0.19)	0.68 (0.19)	0.05 (0.03)	1.36	10.80
Δm_t	3.43 (2.92)	-0.42 (0.45)	-0.44 (0.25)	1.20 (0.24)	0.06 (0.04)	1.78	12.61

Table 2b

Restricted Vector Autoregressions of Output, Inflation and Money
(Growth Rates)

Equation	Constant	Δp_{t-1}	Δm_{t-1}	Δr_t	σ_w^2	Q(11)	F(n ₁ ,n ₂)
Δy_t	6.32 (0.57)	-0.30 (0.06)	-	-0.03 (0.02)	1.23	17.56	(2,18) 1.58
Δp_t	-1.86 (1.22)	0.49 (0.14)	0.61 (0.18)	0.03 (0.03)	1.36	9.71	(1,18) 1.27
Δm_t	3.12 (1.38)	-	0.75 (0.12)	-	1.88	10.48	(3,18) 1.90

Table 3a

Unrestricted Vector Autoregressions of Output, Inflation and Money
(Changes in Growth Rates)

Equation	Constant	$\Delta^2 y_{t-1}$	$\Delta^2 p_{t-1}$	$\Delta^2 m_{t-1}$	Δr_t	σ_w^2	Q(11)
$\Delta^2 y_t$	-0.34 (0.38)	-0.11 (0.24)	-0.02 (0.26)	0.07 (0.19)	-0.10 (0.03)	1.45	12.15
$\Delta^2 p_t$	0.73 (0.37)	-0.38 (0.23)	0.64 (0.25)	0.53 (0.19)	0.12 (0.03)	1.41	12.49
$\Delta^2 m_t$	0.75 (0.38)	-0.30 (0.24)	-0.96 (0.26)	0.16 (0.20)	0.02 (0.04)	1.47	15.44

Table 3b

Restricted Vector Autoregressions of Output, Inflation and Money
(Changes in Growth Rates)

Equation	Constant	$\Delta^2 p_{t-1}$	$\Delta^2 m_{t-1}$	Δr_t	σ_w^2	Q(11)	F(n ₁ , n ₂)
$\Delta^2 y_t$	0.30 (0.29)	-	-	-0.10 (0.02)	1.35	11.24	(3,17) 0.07
$\Delta^2 p_t$	0.67 (0.38)	-0.41 (0.21)	0.40 (0.18)	0.10 (0.03)	1.47	10.57	(1,17) 2.58
$\Delta^2 m_t$	0.67 (0.31)	-0.72 (0.15)	-	-	1.43	11.37	(3,17) 0.61

Table 4

Real G.D.P. Growth

	1958-1970	1971-1974	1975-1985
Canada	4.7 (3.1) 0.1 (4.4)	6.0 (2.9) 0.2 (10.9)	2.6 (7.6) 0.1 (17.4)
France	5.7 (2.0) 0.3 (4.2)	5.0 (1.5) -0.6 (1.3)	2.0 (2.5) -0.2 (4.9)
Germany	5.6 (16.0) 0.2 (31.4)	3.0 (3.9) -1.2 (6.8)	1.9 (4.3) 0.2 (7.5)
Italy ^a	6.2 (4.9) 0 (5.9)	4.0 (5.1) -0.3 (12.9)	1.8 (8.2) -0.2 (21.7)
Japan	11.2 (9.8) 0.3 (16.4)	4.8 (20.7) -2.7 (33.9)	4.3 (0.9) 0.5 (2.4)
U.K.	2.9 (2.3) 0.2 (4.8)	2.9 (13.8) -0.8 (37.1)	1.5 (4.5) 0.4 (7.4)
U.S.A.	3.6 (5.3) -0.1 (9.5)	2.8 (9.7) -0.3 (18.6)	2.8 (12.7) 0.4 (20.9)
World ^{a, b}	4.9 (0.8) -0.1 (1.5)	4.1 (3.7) -0.5 (6.4)	2.8 (3.2) 0 (5.9)

^a1975-1984

^b1960-1970

Line 1 is growth rate and line 2 is change in growth rate, mean and (variance).

Table 5

Inflation

	1958-1970	1971-1974	1975-1985
Canada	2.7 (1.9) 0.2 (0.6)	8.2 (28.9) 2.8 (9.7)	8.0 (9.7) -1.1 (5.6)
France	4.6 (7.5) -0.6 (13.1)	7.7 (5.8) 1.4 (2.0)	10.1 (5.3) -0.5 (3.8)
Germany	3.5 (2.6) 0.3 (2.9)	6.7 (1.3) -0.1 (3.0)	3.8 (1.3) -0.4 (1.0)
Italy ^a	3.9 (5.9) 0.4 (6.1)	10.9 (31.0) 2.9 (14.3)	16.7 (8.3) -0.8 (9.0)
Japan	4.1 (10.9) 0.8 (17.7)	11.2 (52.6) 3.3 (25.7)	3.7 (5.6) -1.7 (14.9)
U.K.	3.7 (2.8) 0.3 (2.6)	9.9 (11.9) 1.9 (17.8)	12.4 (47.9) -0.8 (45.8)
U.S.A.	2.7 (2.4) 0.4 (0.7)	6.7 (6.5) 1.1 (4.4)	6.6 (10.6) -0.6 (6.7)
World ^{a,b}	4.2 (1.1) 0.3 (0.6)	9.8 (20.4) 2.5 (7.5)	12.2 (2.8) 0.1 (7.4)

^a1975-1984

^b1960-1970

Line 1 is inflation rate and line 2 is change in inflation rate, mean and (variance).

Table 6

Reserve Money Growth

	1958-1970	1971-1974	1975-1985
Canada	5.7 (7.0) -0.1 (16.1)	13.8 (1.7) 1.9 (12.0)	7.9 (24.3) -0.7 (9.6)
France	7.2 (19.0) -0.5 (15.5)	15.7 (40.3) 3.3 (156.6)	6.2 (68.4) -0.4 (123.2)
Germany	8.2 (31.7) 0 (64.7)	14.8 (130.1) -3.5 (249.0)	4.6 (17.8) 0.5 (27.8)
Italy ^a	10.7 (28.3) 0.4 (54.5)	15.8 (23.9) 1.2 (54.1)	19.7 (44.8) -0.7 (37.5)
Japan	16.4 (25.3) 1.2 (33.0)	23.7 (67.7) 1.4 (120.9)	7.3 (12.6) -1.8 (37.2)
U.K.	4.5 (5.0) 0.2 (11.2)	13.0 (133.1) 2.0 (284.1)	6.7 (13.4) -0.8 (13.2)
U.S.A.	3.5 (8.6) 0.5 (3.1)	7.7 (2.3) 0.9 (7.7)	6.7 (3.1) -0.8 (4.9)
World ^{a, b}	7.3 (2.6) 0.5 (1.1)	14.1 (4.6) 1.6 (6.1)	13.2 (3.0) -0.2 (5.5)

^a1975-1984

^b1960-1970

Line 1 is growth rate and line 2 is change in growth rate, mean and (variance).

Table 7

Money Supply Growth

	1958-1970	1971-1974	1975-1985
Canada	6.3 (38.8) -1.2 (50.1)	9.8 (9.4) 2.5 (66.2)	9.2 (70.8) 2.4 (56.8)
France	9.3 (28.0) -0.6 (13.1)	12.4 (2.9) 3.5 (65.9)	10.7 (7.6) -0.5 (16.9)
Germany	8.6 (8.4) -0.5 (8.7)	9.3 (19.0) -0.2 (36.3)	7.0 (20.8) -0.2 (28.2)
Italy ^a	14.1 (12.5) 1.1 (16.2)	19.6 (8.1) -1.3 (15.7)	16.2 (30.8) -0.5 (38.5)
Japan	18.8 (63.9) 0.9 (96.1)	21.7 (36.0) -1.3 (80.5)	6.8 (17.3) -0.8 (20.6)
U.K.	3.2 (6.2) 0.6 (14.2)	10.9 (31.7) -0.9 (44.6)	13.1 (18.4) 1.2 (37.1)
U.S.A.	3.4 (3.4) 0.2 (2.3)	6.6 (1.1) 0.3 (4.5)	7.4 (3.1) 0.4 (5.3)
World ^{a,b}	7.5 (2.2) 0.4 (2.1)	12.8 (0.4) 1.4 (4.2)	13.7 (2.0) 0.1 (2.8)

^a1975-1984

^b1960-1970

Line 1 is growth rate and line 2 is change in growth rate, mean and (variance).

Table 8

Money Plus Quasi-Money Growth

	1958-1970	1971-1974	1975-1985
Canada	8.5 (17.6) -0.3 (26.3)	15.9 (36.1) 4.7 (11.3)	11.7 (36.9) -1.7 (33.8)
France	12.2 (14.9) -0.1 (10.1)	17.4 (3.8) 2.8 (47.3)	11.8 (7.6) -0.9 (4.5)
Germany	12.6 (4.9) -0.8 (3.5)	10.9 (6.7) -0.2 (11.4)	7.0 (5.5) -0.2 (4.4)
Italy ^a	13.9 (4.6) 0 (9.1)	18.5 (5.8) 2.0 (0.9)	17.2 (21.6) -0.9 (10.9)
Japan	19.1 (12.0) 0 (17.3)	20.0 (23.4) -1.2 (37.3)	9.9 (7.4) -0.5 (3.8)
U.K.	4.9 (4.6) 0.3 (6.8)	19.9 (39.1) 3.0 (61.2)	13.5 (14.5) -0.6 (20.6)
U.S.A.	6.5 (3.3) -0.3 (3.8)	10.0 (9.3) 0.5 (29.6)	9.5 (10.7) 0.3 (18.4)
World ^{a, b}	10.0 (2.0) 0.2 (2.2)	15.4 (1.0) 1.7 (8.5)	16.3 (2.3) 0.2 (2.7)

^a1975-1984

^b1960-1970

Line 1 is growth rate and line 2 is change in growth rate, mean and (variance).

Table 9

Cross Section and Regime

(a) Growth Rates

$$\text{Var}(\Delta y) = 7.55 + 0.41 \text{Var}(\Delta m)$$

(4.50) (0.14)

- 13.95 (4.88) Canada
- 7.68 (3.68) France
- 0.34 (3.69) Germany
- 4.35 (3.70) Italy
- 1.46 (3.79) Japan
- 7.16 (4.04) UK
- 1.64 (2.72) (71-74)
- 2.88 (2.56) (75-85)

$$R^2 = 0.60$$

(b) Changes in Growth Rates

$$\text{Var}(\Delta^2 y) = 9.66 + 0.41 \text{Var}(\Delta^2 m)$$

(10.47) (0.20)

- 8.11 (8.65) Canada
- 14.27 (8.58) France
- + 3.30 (8.82) Germany
- + 1.34 (8.80) Italy
- + 0.36 (8.56) Japan
- 4.93 (8.90) UK
- 0.69 (6.60) (71-74)
- 0.37 (5.62) (75-85)

$$R^2 = 0.47$$

(Standard errors in parentheses.)

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1987

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