Monetary Policy and the Quality of Information

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I. Introduction

The personal computer and the development of websites permit everyone to have rapid access to enormous quantities of data. If it were ever true that policy analysis in developed countries was hindered by the availability of timely information, that restriction has now all but disappeared. Data in developed countries become available to all interested parties everywhere almost as soon as they are put out.

The organizers of the Bank of Japan's eighth international conference ask us to consider an important question: Has the quality of information increased commensurately? Do we now know substantially more about what is happening in the world or in our own countries? Or has the increase in information lagged far behind the increase in data that central bankers and financial markets receive?

One important issue of this kind is the measurement of productivity and economic growth. In developed countries especially, and in many developing countries to a lesser degree, service-sector output has grown relative to agricultural output. In developing countries, the share of agricultural and manufacturing output in total output and employment peaked some time ago. A significant share of employment is now in government, financial services, health care, education, and other services where output is difficult to measure with precision and, often, to measure at all.

If one cannot measure output reliably, one cannot know what is happening to the price level. Recent, extensive discussion of the several biases affecting the U.S. consumer price index suggests that the bias in the index may be as much as 1.5 percent. A central bank seeking to maintain price stability has difficulties enough without adding uncertainty about the level that it seeks to maintain.

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The problem is not limited to the price level and output. In the United States, and no doubt elsewhere, there is considerable uncertainty about the unemployment rate at which the price level begins to accelerate, or NAIRU, and a sizeable shift in mainstream beliefs. A standard range for NAIRU of 6 to 6.5 percent a few years ago has been adjusted down to 5 percent or below.[1]

These examples are not meant to be exhaustive. Others could be added without changing the point. The main issues for monetary policy makers and economists lie not in the number of examples but in their consequences for effective policy. Two issues are critical: whether the quality of information has worsened and, if so, whether the reduced quality significantly changes the opportunities for monetary policy or requires a shift in the way monetary policy is conducted.

I reach a mixed conclusion. The following section looks at changes in data for U.S. GDP over time. I find that short-term movements are now much less variable, and there is evidence of a change in the trend rate of growth. Next I consider whether there is sufficient stability over time in nominal magnitudes and their relation to money growth to be useful for policy in Germany, Japan, and the United States. I conclude that there is sufficient stability in monetary relations to support a policy of monetary control if policy makers take a long-term view.

II. The Changing Quality of Data

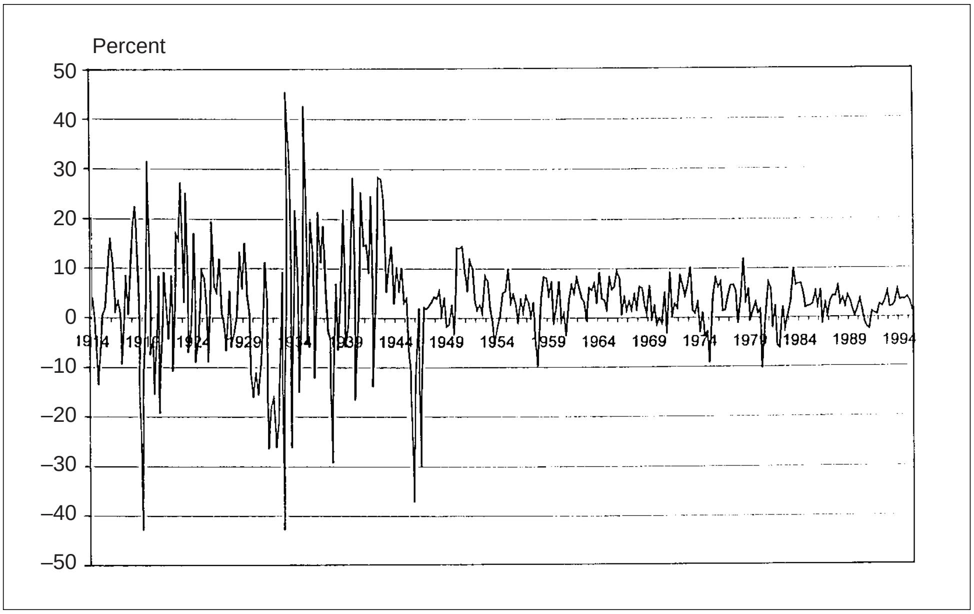
Most measures of output, employment, or productivity on which we rely are of recent origin. Pioneering work in measurement of GNP was done in the 1930s by Kuznets and others. Much of what is reported for the years before World War II was constructed long after the event. Often data for GNP are based on relatively few underlying series.

Data for real GNP growth show a major change in the postwar years. Measured variability declines sharply. There is nothing comparable to the depressions of 1920–22 or 1929–33. And reported quarterly values are also much less variable. Figure 1 shows the Balke and Gordon (1986) data for the United States. Data for prices and rates of price change would show a persistent trend rate of inflation but substantially lower variability around the trend after World War II. Recent research suggests that part of the increased variability in earlier years is spurious, a result of building GNP from the few series that are available (Watson [1994]). Nevertheless, some of the underlying series were the data available to policy makers when they made their decisions.

Answering the questions that central bankers now ask was harder, not easier, in the 1920s and 1930s. The much greater variance would have made it relatively more difficult to separate temporary from permanent changes in GNP, if these data had been available. The risk of over- or under-response to short-term changes would have been greater and, with it, the prospect of increasing variability.

1. Econometric work by King and Watson (1994) suggests considerable variability in NAIRU and a relatively unstable trade-off between inflation and unemployment. There is no reason why NAIRU should be constant or invariant to changes in tax rates, regulation, and demographic changes.

Figure 1 United States, Annualized Quarterly Real GNP Growth, 1914–94



Since GNP or GDP was not available, central bankers used substitutes—generally less comprehensive measures of economic activity and prices than are available now. Central banks often took the lead in developing or improving measures of industrial production, prices, department store sales, and other measures of activity. However, in the 1920s and after, central bankers relied heavily on proxy measures of activity such as the growth of credit or changes in member bank borrowing from the central bank. Excess reserves of member banks had a similar role in the mid-1930s (Friedman and Schwartz [1963)].[2]

Imprecise data did not prevent the Federal Reserve from maintaining low inflation and steady growth interrupted only by brief recessions in 1923–24 and 1926–27. Nor did it prevent Federal Reserve officials from recognizing recessions when they occurred. This period is generally judged to have been one of the most successful in Federal Reserve history. Friedman and Schwartz (1963) call it the Federal Reserve's "high tide."

As is well known, the period of relative stability ended in the Great Depression. The main causes of the depression were policy mistakes, not imprecise data. The Federal Reserve, and much of the world, believed in the real bills doctrine, so they regarded the use of credit in the stock market as evidence of inflation. And although there was widespread agreement about the stabilizing properties of the gold standard, neither France nor the United States was willing to follow gold standard rules when they called for domestic inflation (Meltzer [1997]).

2. Prewar errors in monetary policy were not due principally to faulty data. To cite just two examples, central bankers could not, and did not, fail to notice the rise in unemployment after 1929, nor did the Reichsbank fail to notice that inflation was rising rapidly prior to 1924.

Again, the quality of data had no role in the Great Inflation from 1965 to 1980. After 1971, inflation in developed countries differed markedly in ways that depend very much on the theories or beliefs guiding central banks, or the goals they pursued, and very little on differences in the quantity or quality of information. Freed of the restraints imposed by the Bretton Woods system, Japan, Germany, and Switzerland adopted policies leading to low inflation. The United States, Britain, and France chose very different policies and produced very different results.

The major welfare losses resulting from the Great Depression or the Great Inflation owed little to lack of information. Can a better case be made for more normal periods?

U.S. real GDP is often approximated by a random walk along a growth trend. The assumption of a constant trend within each of the two periods, 1951–1973 and 1973–1997, is well supported by the data. Differences between the two periods are relatively small; the main difference is the estimated trend. As is well known, trend growth of GDP was lower in the second period. The first two rows of Table 1 show estimates for

$$y_t = a + by_{t-1} + u_t \qquad (1)$$

where y_t is quarterly U.S. GDP growth at annual rates.

Table 1 GDP Growth as a Random Walk

Period	*a*	*b*	s.e.	DW
1951/I–1973/I	0.025 0.006	0.34 0.10	0.041	1.96
1973/II–1997/IV	0.018 0.004	0.29 0.09	0.034	2.01
1951/I–1973/I	0.008 0.003	0.78 0.06	0.016	1.03
1973/II–1997/IV	0.004 0.002	0.83 0.05	0.012	1.29

Note: Standard errors are below the coefficients.

To reduce some of the noise, the last two rows of Table 1 repeat the comparison for the two periods with y_t measured as a four-quarter moving average. The smoothed data show a much larger response to their lagged value and, as expected, serial correlation increases markedly.[3]

The data in Table 1 show no evidence of substantial change in the process underlying U.S. GDP growth. Of course, a relatively small, recent change in trend may be hidden within the range covered by the standard error. To check on this possibility, I used a unit dummy variable for the expansion beginning in 1991/II. The results show no evidence of a shift in trend growth. The coefficient of the

3. Efforts to estimate equation (1) for Germany and Japan did not produce useful results, perhaps because fewer data points were available in the two sub-samples.

dummy variable using quarterly data from 1973 to 1997 is 0.002 ± 0.008. Similar results are found using a four-quarter moving average. These findings provide no evidence of an important shift in trend. The point estimate, though not significant, suggests that the trend could be 0.2 percent higher in the 1990s.[4] A change of this magnitude is well within the control error for monetary policy and has no significance for policy.

One solution for central banks and governments is to invest heavily in measurement and data gathering. Another is to develop procedures that are less subject to measurement errors. Although some improvements in data quality would be cost-effective, conceptual problems limit possibilities for improving measures of service-sector output.

Unless the size of measurement errors changes frequently, difficulties in measuring prices and output do not carry over fully to output growth and inflation. By basing decisions on rates of change, central banks can avoid some measurement problems. They would not know the "true" growth rate or rate of inflation, but they would have useful information about acceleration and deceleration of prices and output. This information could be used with a policy of controlling nominal GDP.

III. Velocity and Interest Rates

Monetary measures and nominal interest rates are much less influenced by problems arising in the measurement of prices or the productivity of capital and labor. The long-term interest rate reflects the expected productivity of capital, expected inflation, and any risk premium that the market demands for holding non-money assets. The long-term interest rate would change with a change in perceived productivity or its rate of change. Monetary velocity is the ratio of nominal GDP (GNP) to nominal money, so the division between productivity and price changes has no effect on velocity.

Innovation and productivity growth affect financial instruments also. The preferred definition of money is the one least subject to major change. The monetary base, consisting mainly of currency on the uses side, is less subject to change due to innovation than other monetary aggregates. It is not free of all influences of this kind. Credit cards are substitutes for currency. Electronic payments may become important in the future.

This section looks at the relation of base velocity to interest rates in Germany, Japan, and the United States. Base velocity is the ratio of nominal GNP or GDP to the monetary base. Nominal GDP is unaffected by biases in the measurement of prices and output, although it may be subject to change arising from increases in market activity relative to non-market activity, leisure, or unreported transactions.

If base velocity has a relatively stable relation to an interest rate, a central bank can influence nominal GNP by changing the monetary base. Moreover, stability

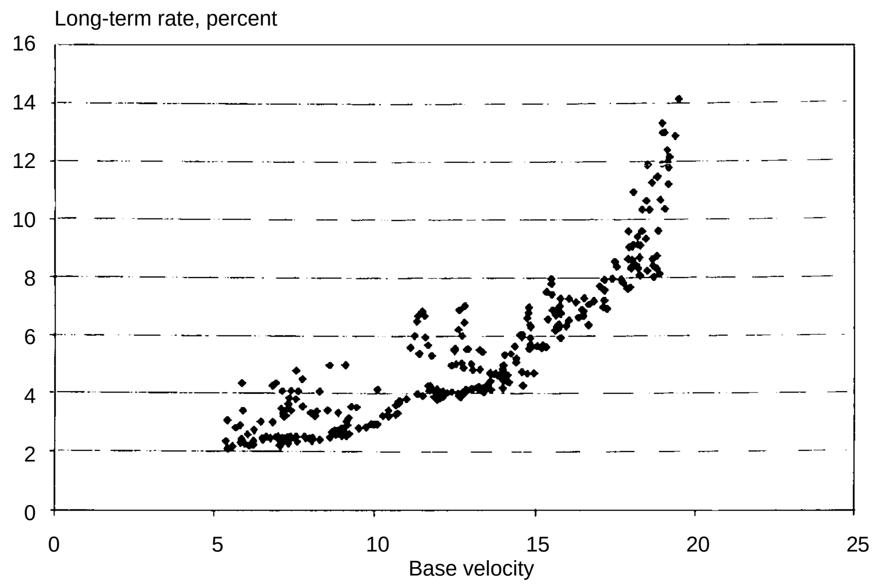
4. Reporting error may make such estimates unreliable. Griliches (1994) concluded, after decades of work, that we cannot expect to measure productivity growth accurately or satisfactorily explain why it changed around 1970.

of the relation over time would suggest that the velocity relation is independent of productivity growth. Evidence of this kind would suggest that the relation is robust and useful for policy operations.

A. United States

Figure 2 shows the relation of monetary base velocity to a long-term interest rate in the United States, on a quarterly basis, for 306 quarters from the beginning of 1919 to the middle of 1995. All observations are included: depressions and recessions, wars, inflations and deflations, periods of price control, and periods with very different rates of productivity growth.

Figure 2 United States, Base Velocity versus Long-Term Treasury Bond Rate, 1919/I–1995/II



The points in the figure cover a wide range: interest rates from 2 to 14 percent, velocity from about 5 to 20. Two periods show persistent deviations from what appears to be almost a textbook drawing of the relation between velocity and an interest rate. From 1919 to 1923 and from 1931 to 1934, the data lie above the curve. Relative to the long-term relation, velocity is lower than expected for the prevailing interest rates. Both periods include sizeable deflations, periods when the return to holding money was positive. Both are also periods of heightened uncertainty. Allowing for these influences removes at least part of the discrepancy.

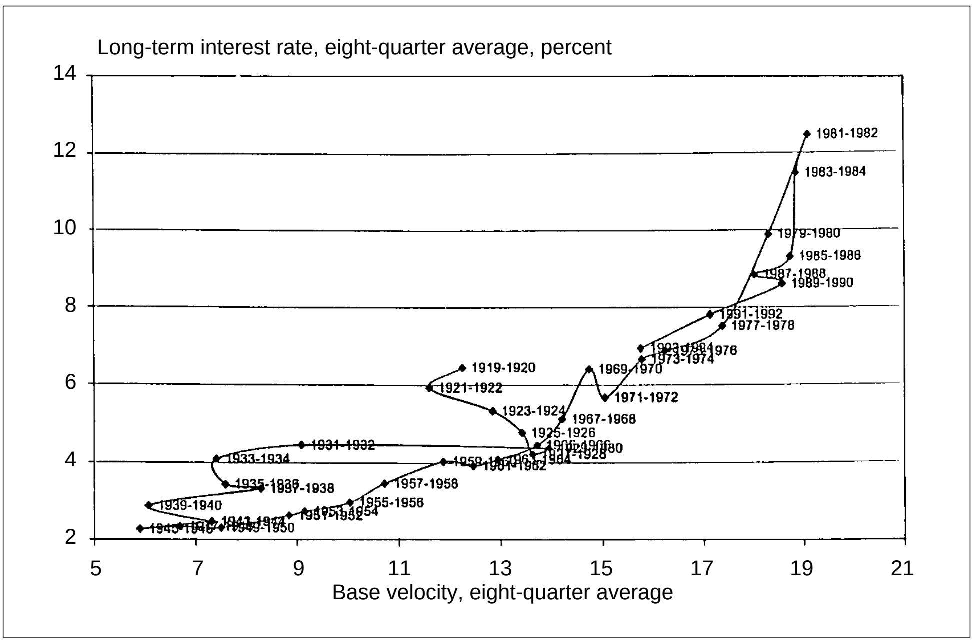
The deflation following World War I caused many bankruptcies. The gold standard had not been restored. This was a fact of great importance to many businesses and bankers at the time and one that altered their anticipations. A new institution, the Federal Reserve, faced its first major recession.

The period 1931–33 raised doubts about the survival of the financial system and capitalism. Uncertainty, deflation, or both together encouraged increased money holdings relative to output, so velocity was smaller than expected from the relation. In both periods, therefore, money holding should be high relative to GNP, reducing velocity. And the shift in demand for money, resulting from the higher pecuniary and non-pecuniary return to money holding, raised the interest rate.

The data in the figure help to answer the question about the importance of measurement bias for monetary policy. Data points for the 1950s and 1960s lie on top of points for the 1920s. When the long-term rate returned to the level reached in the late 1920s, velocity returned to that level also. Further, when the long-term rate and velocity declined with falling inflation in the 1980s and 1990s, the points descend along the path followed during the period of rising inflation in the 1970s.

There is no evidence of a significant shift in the velocity relation, or instability, during the nearly 80 years covered by these data. Because the points in Figure 2 overlap in several periods, Figure 3 shows the same data smoothed using an eight-quarter moving average. I chose eight quarters to represent the medium term over which many central bankers claim to operate.

Figure 3 United States, Base Velocity versus Long-Term Interest Rate, Eight-Quarter Averages, 1919–94

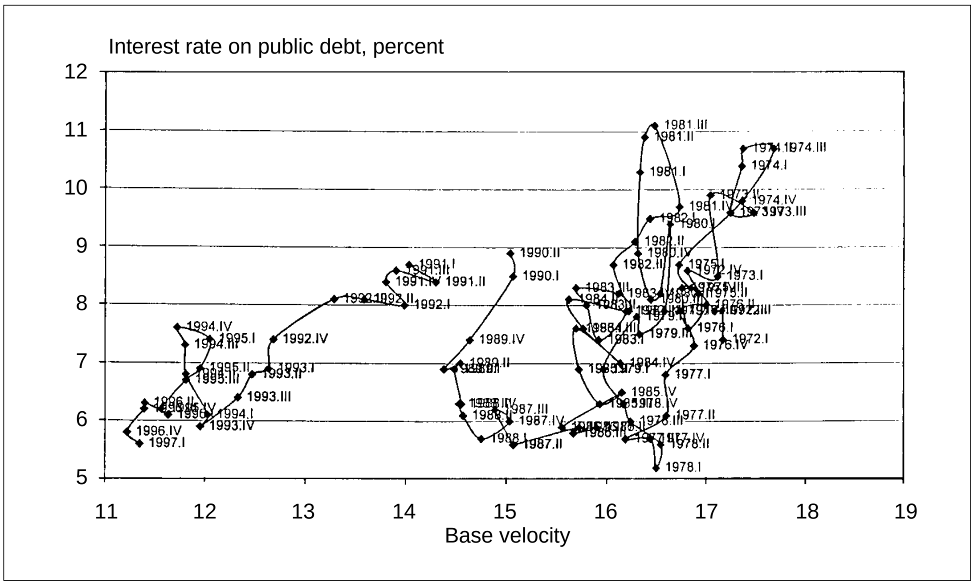


Some comment on the use of a long-term interest rate is in order. This is the rate I have used in previous work on the demand for money. Aside from consistency, the use of the long-term rate reflects the Brunner and Meltzer (1976) general equilibrium model of assets, output, and price level. In that model, short-term rates depend principally on activity in banking or credit markets, while the long-term rate more fully reflects the expected return to real capital, expected inflation, and the effects of productivity growth. If these disrupt or alter the relation with velocity, because of changes in the quality of monetary or output data, the data will show the problem. Use of a long-term rate reflects also the hypothesis that, even in periods of high inflation, a central bank can reduce a short-term rate temporarily both absolutely and relative to the long rate. Unless expectations of persistent inflation change, the long-term rate will change much less than the short rate, and the demand for money (and velocity) will continue to be dominated by the anticipation of long-term inflation or deflation. For these reasons, I continue to treat the long-term rate as relevant for velocity, but I do not exclude additional or supplemental effects from a short-term rate.

B. Germany

Hyperinflation and political division limit the availability of data for Germany. For part of the period after World War II, there is no long-term debt. In Figure 4, I have used quarterly data for 25 years, 1972 to 1997, 101 observations in all. Data for the (long-term) interest rate on the public debt range from 5 to 11 percent, data for velocity from about 11 to 18.

Figure 4 Germany, Base Velocity versus Interest Rate on Public Debt, 1972/I–1997/I



The slope and position of the relation appears to change at the time of reunification. Nevertheless, in both periods, points with different dates lie atop one another. These data again suggest that, for the period examined, there is little evidence of measurement errors, changes in intermediation, or other changes in financial structure that would mislead a central bank attempting to follow a medium-term strategy of controlling inflation using the monetary base (or central bank money) as its instrument. This conclusion is partly supported by the experience of the Federal

Republic, in which control of money, using a broader monetary aggregate, is the means of implementing the central bank's medium-term strategy (Issing [1997]).

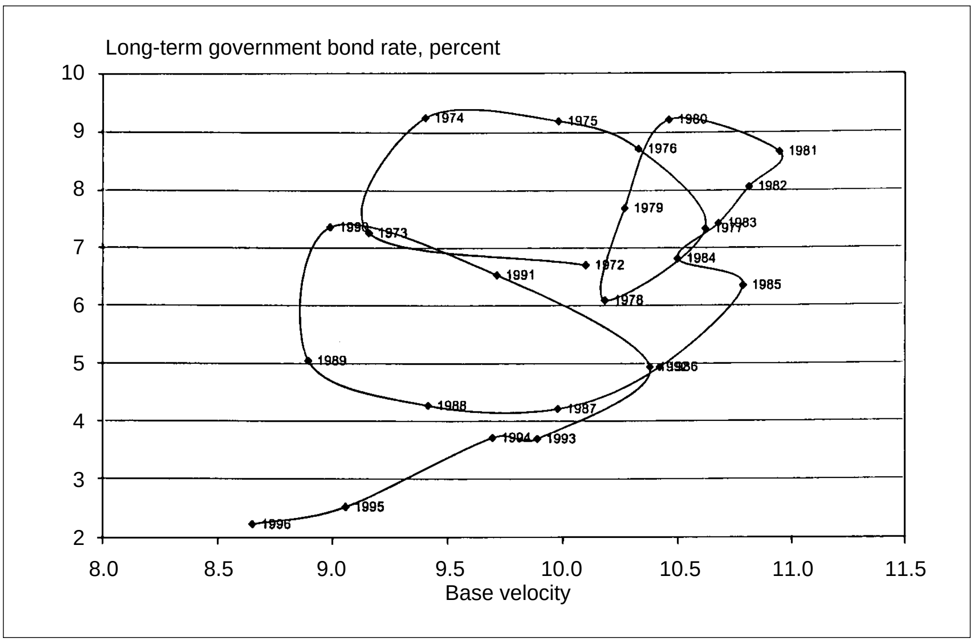
C. Japan

Japanese data offer some challenge, but they do not contradict the conclusion about problems associated with productivity measurement error. After the early 1970s, Japan's average real growth rate fell from about 7 to 10 percent to 4 to 5 percent. In the 1990s, the average growth rate declined again. The first decline, coming at the time of the oil shock and the first postwar revaluation of the yen following the "Nixon shock," heightened uncertainty about future growth. The steep increase in oil prices was mitigated by a 15 to 20 percent appreciation of the yen against the U.S. dollar, but the combined effect was a steep increase in the imported price of oil and the U.S. dollar price of Japanese exports.

The second large shock came at the end of the boom in the 1980s. Again, there was a large appreciation of the yen after the internationally coordinated attempt to manage exchange rates failed. And again there was substantial uncertainty about future growth, as suggested by the decline in the index of common stock prices from almost 40,000 to about 15,000.

A striking feature of Figure 5 is the similarity of the movement in velocity relative to the interest rate in the years 1972 to 1976 and 1987 to 1992. The two periods—one following the oil shock, the other following the "bubble" economy—are clearly visible in the figure. In both cases, base velocity declines at first; money holders increase cash balances relative to GDP. This behavior in the face of rapid change and heightened uncertainty has an effect on velocity similar in direction to but larger in

Figure 5 Japan, Base Velocity versus Long-Term Government Bond Rate, 1972–96



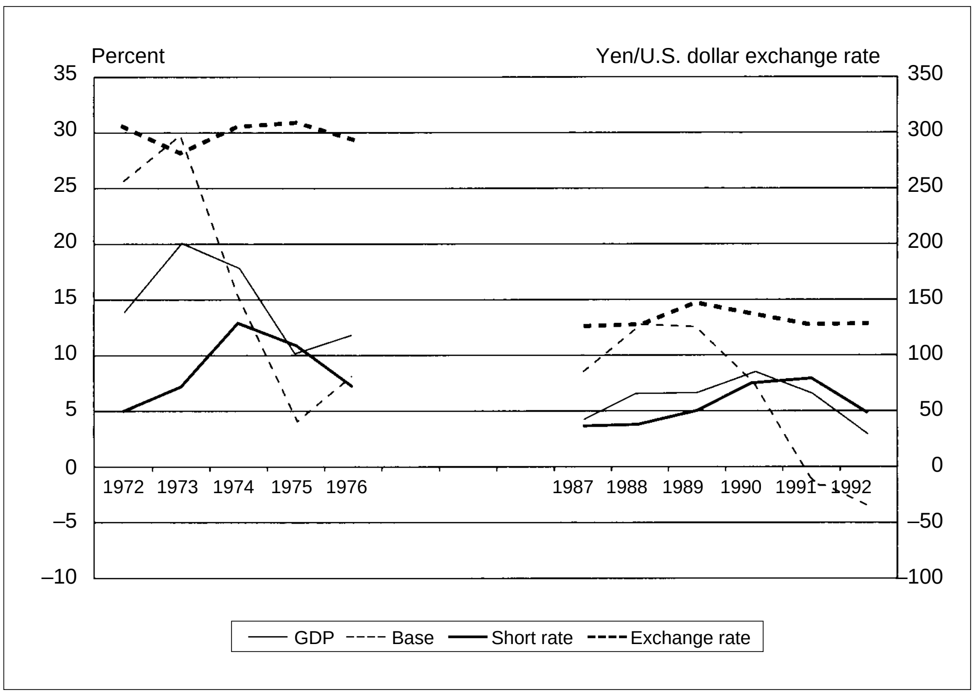
magnitude than the effect of the 1920s and 1930s deflations in the United States and reunification in Germany. In each of these cases, velocity is lower for a given interest rate during the period of heightened uncertainty. Again, the data suggest that in these periods of uncertainty and/or deflation, the return to holding money rose, and the demand for base money increased.

In Japan, as in the United States, velocity returned to a stable path relating base velocity to a long-term interest rate. For Japan, the path is much clearer using annual rather than quarterly data, but the number of Japanese data points is therefore limited. Opportunity to extend the annual data is restricted by the absence of long-term government debt in the early postwar decades.

The two periods pose a challenge to economic analysis. The data suggest that similar processes were at work—that whatever happened to the relation of money to output during the "bubble" years had happened before. The challenge is to go behind the "bubble" to see if systematic forces were at work.

Figure 6 suggests some similarity in the way in which the rise in velocity occurred in the two periods. At the start of both periods, the monetary base rose absolutely and relative to nominal GDP. Then the base decelerated sharply, preceded by deceleration of output in one case and followed by deceleration of output in the other. In both periods, short-term interest rates rose at first, then declined. The decline in interest rates followed deceleration of the monetary base. Judged by the deceleration of the monetary base, monetary policy was contractive both in 1974–75 and

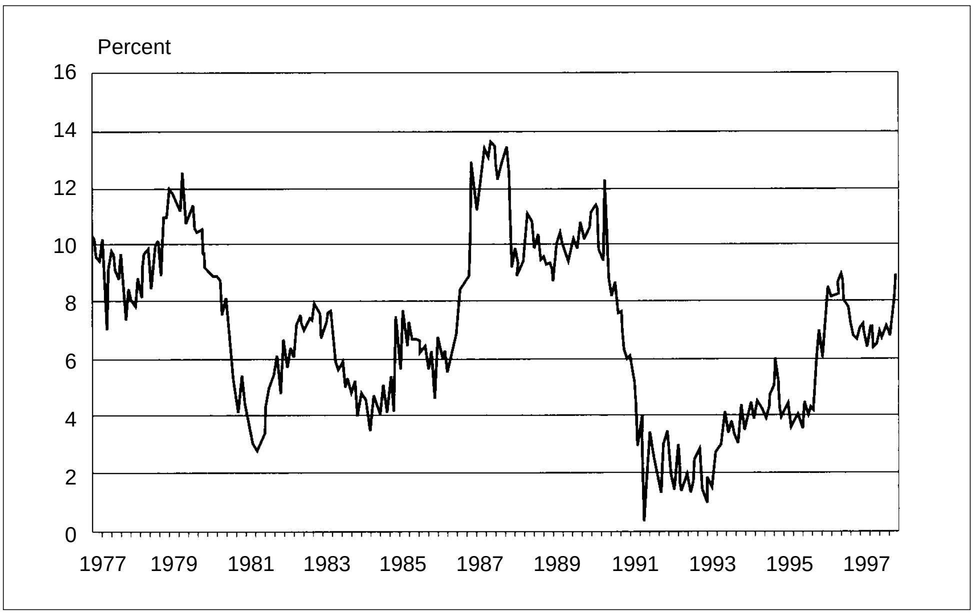
Figure 6 Japan, Nominal GDP Growth, Money Market Rate, Exchange Rate, and Monetary Base Growth, 1972–76 and 1987–1992



1990–92. Judged by the decline in short-term interest rates, monetary policy was expansive after 1973 and 1989. In both periods, growth of nominal GDP either declined or remained low, as suggested by monetary base growth.

A second similarity is that both periods are preceded by large changes in the nominal exchange rate. From 1971 to 1986, the yen/U.S. dollar exchange rate appreciated more than 50 percent, from ¥360/US$1 to ¥168/US$1.[5] Much of this movement occurred in two years; in 1971–72 and 1985–86, the years before the two puzzling sequences. The Louvre agreement to fix exchange rates within a band slowed the appreciation after 1986 but required the Bank of Japan to accelerate the monetary base. Growth of the base rose from 6 percent per year to 14 percent. Base growth remained above a 10 percent annual rate until the spring of 1990. In the 12 to 18 months following April 1990, base growth declined from 10 percent or more to 2 percent or less. The deflationary impulse continued with modest change until 1996. Figure 7 shows the magnitude and sharpness of these changes in the 12-month moving average.

Figure 7 Japan, Monetary Base Growth, 12-Month Moving Average, 1977–97



D. Preliminary Conclusion

Three preliminary conclusions about central bank control of a nominal aggregate can be drawn from these figures. First, a central bank that relies on the stability of the velocity relation would have problems following a medium-term strategy only when there are very large changes in the economy. For Japan, periods of heightened uncertainty accompanied by large currency revaluations have disrupted the velocity

5. There is a period of relative stability, even slight reversal, from 1980 to 1985, the years of the strong U.S. dollar. The yen/U.S. dollar rate rose from ¥226/US$1 to ¥238/US$1. There was a local peak at ¥249/US$1 in 1982.

relation for a time. In the following section I show that, with a modest addition, the bivariate relation remains useful even in these years. For the United States, severe deflation temporarily interfered with the bivariate relation in the past, but the relation was restored and remains useful. For Germany, uncertainties associated with reunification, and reunification itself, produced one-time changes in the relation that appear to have persisted. Second, many of these changes had their origin in public policy—deflation in the United States, monetary aspects of German reunification, substantial acceleration or deceleration of the monetary base in Japan.[6] Third, there is no evidence of drift or disturbance resulting from changes in productivity and financial innovation or from changes in the quality of information.

IV. Some Econometric Evidence

An important research finding of the past 20 years is that many economic time-series are reasonably well described as random walks at quarterly, or shorter, frequencies. This section investigates whether monetary policy, acting through its effects on anticipated inflation and the expected return to capital, has a statistically significant effect on monetary velocity after allowing for a random walk.

A. United States

Table 2 shows two different sets of regressions using logarithms of annual data for the United States in two periods, 1920–1994 and 1960–1996. The first data set uses high-powered money (the monetary base) from Friedman and Schwartz (1963). These data do not adjust for changes in reserve requirement ratios. The interest rate is a long-term bond rate; its maturity changes with debt management practice. The second data set removes these problems by using the St. Louis monetary base and a 10-year bond rate. This measure of the base adjusts for changes in reserve requirement ratios by removing or adding the reserve equivalent of changes in reserve requirement ratios.[7]

Table 2 Annual Regressions for Velocity

Period	i_t	V_{t-1}	c	AR1	R^2	DW
1920–94	0.03 (0.67)	0.94 (14.24)	0.11 (1.11)		0.94	1.33
1921–94	0.27 (3.33)	0.56 (3.80)	0.67 (2.40)	0.65 (4.37)	0.96	1.75
1960–96	0.11 (4.09)	0.68 (10.42)	0.69 (4.93)		0.96	1.29
1961–96	0.11 (4.00)	0.66 (8.44)	0.77 (4.22)	0.37 (2.06)	0.97	1.96

Note: All data are logarithms; t-statistics are in parentheses; the interest rate is the long-term rate. The table is reproduced from Meltzer (1998).

6. All data for the base are taken from the Bank of Japan's Internet website.
7. The Federal Reserve used an interest target during most of the period. If the interest target remained unchanged, the effect of reserve requirement changes was offset on the monetary base.

The equations that use an AR1 correction to adjust for serial correlation show a significant effect of interest rates on velocity in both periods. The different point estimates for the two periods are economically, but not statistically, significant.

Table 3 repeats these estimates using first differences of the logarithms. The estimated interest elasticities are about the same for levels and first differences. The significant effect of lagged changes in velocity in the 1964–96 period suggests that, at annual frequency, velocity does not follow a sample random walk. This evidence suggests persistent effects of changes in payment arrangements and other technological changes affecting the payment system. Innovations such as credit cards, automated teller machines, and other changes in financial arrangements permanently increase the velocity level. They do not appear to make the velocity relation unstable.[8] There is no evidence of instability that would stop the Federal Reserve from achieving its medium-term goal for nominal GDP or its growth rate.

Table 3 Annual Regressions for Velocity Growth

Period	Δi_t	ΔV_{t-1}	c	AR1	R^2	DW
1921–94	0.19 (2.25)	0.26 (2.42)	0.003 (0.32)		0.14	1.71
1922–94	0.24 (2.84)	0.05 (0.16)	0.002 (0.13)	0.32 (1.04)	0.16	1.85
1963–96	0.09 (3.20)	0.36 (2.54)	0.002 (0.42)		0.32	2.24
1964–96	0.09 (3.18)	0.48 (2.83)	0.001 (0.34)	–0.23 (1.02)	0.32	2.05

Note: See notes to Table 2.

B. Japan

Row 1 of Table 4 shows annual estimates for Japan using the same specification as for the United States.

Table 4 Regressions for Japan

Period	i_t	V_{t-1}	V_{t-2}	p_t	var_t (×10,000)	AR1	R^2/DW
1973–96	0.09 (1.78)	0.69 (2.24)				0.50 (1.06)	0.80 1.90
1972–96	0.06 (4.37)	1.11 (8.56)	–0.59 (4.87)				0.84 2.09
1972–96	0.14 (4.01)			–0.79 (2.80)	1.17 (1.34)		0.46 (1.00)
1972–96	0.13 (3.07)			–0.67 (2.08)	0.66 (0.83)	0.47 (2.51)	0.57 (1.16)
1972–96	0.11 (3.62)	0.55 (4.01)		–0.41 (1.69)			0.71 1.05

Note: V_t and i_t are logarithms of fourth-quarter values; p_t is the current inflation rate, and var_t is the variance of monthly exchange rates. p_t and var_t are decimals.

8. This conclusion is the opposite of the conclusion reached by Friedman (1997 and elsewhere). One reason is that Friedman considers only quarterly data where the random-walk properties are strong.

The coefficients for Japan are similar to postwar estimates for the United States using the comparable specification. Both estimates for Japan show significant effects of anticipated inflation and productivity growth operating on velocity via the long-term interest rate.

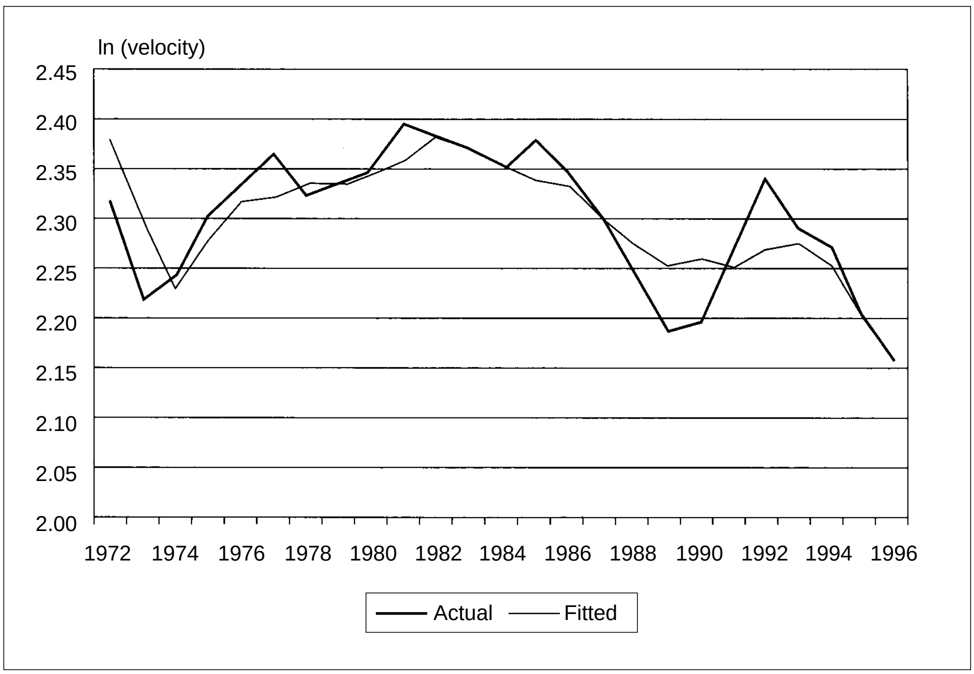
As expected from Figure 5, the equation for Japan fits less well than comparable equations for the United States or Germany. In discussing Figure 5, I suggested that deflation provides a positive return to holding money. The demand for money or velocity should reflect this return in addition to the opportunity cost of holding money. Similarly, inflation may impose a cost of holding money that is not fully reflected in a single market interest rate. To test this suggestion and the effect of uncertainty, rows 3 and 4 of Table 4 introduce the measured rate of inflation (p_t) and the average monthly variance of the nominal exchange rate (var_t).

The data give better support to the additional effect of inflation, given the interest rate, than to the measure of uncertainty used in this test. The results are suggestive only. I have used actual inflation instead of expected inflation and have not tried other measures of uncertainty. A measure such as the spread between yields on risky bonds and government bonds may do better.

Row 5 shows that the effect of inflation remains after reintroducing $\ln V_{t-1}$ in the regression. An AR1 correction did not converge after 20 iterations and was not significant when convergence was achieved after more than 40 iterations.

Figure 8 shows that including the effects of inflation and uncertainty (as in row 4) improves the fit. The large deviations from 1973 to 1975 are substantially reduced.

Figure 8 Japan, Regression of ln (Base Velocity) on ln (Long-Term Interest Rate), Inflation, and ln (Base Velocity –1), 1972–96



The same is true of 1988 and 1991, two years with large deviations in Figure 5. Errors in 1989 and 1990 are reduced but remain relatively large.[9]

Previous estimates of the demand for base money in Japan have an estimated income elasticity slightly above unity, based on quarterly data (Bank of Japan [1997]). They suggest that making base velocity independent of real income does not introduce a major error for the sample period. The Bank's study also shows that the fit of the base velocity equation could be improved.[10] As suggested, better measures of uncertainty and expected inflation are candidates.

C. Germany

Data for Germany (Figure 4) suggest that the slope and level of the velocity relation changed about 1991. I have used dummy variables in the regressions shown in Table 5. Both dummy variables have a value of zero until 1991 and a value of one for 1991 to 1996. The coefficient for the change in the slope (DS) suggests that the slope declined modestly from 0.14 to 0.12; the intercept declined also for reasons discussed earlier.

The annual regressions suggest that the interest elasticity of the velocity relation is approximately the same in the three countries, 0.09 to 0.12, using the estimate for Germany after reunification. The elasticity with respect to lagged velocity also lies in a narrow range, 0.66 to 0.77. The principal difference between the countries is in goodness of fit. The German data fit less well than the others. The last row of Table 5 shows that the fit for Germany improves using quarterly data.

Table 5 Regressions for Germany

Period	i_t	V_{t-1}	D	DS	AR1	R^2/DW
1973–96	0.14 (2.68)	0.77 (6.35)	–0.05 (1.81)	–0.02 (1.90)		0.75 2.38
1973–96	0.14 (2.67)	0.79 (4.70)	–0.47 (1.70)	–0.19 (1.78)	–0.04 (0.14)	0.75 2.35
1972/III–1997/I	0.02 (3.03)	0.92 (36.16)	–0.03 (4.05)		–0.27 (2.67)	0.99 2.03

Note: Logarithms of annual data are for the fourth quarter.

V. Conclusion

A stable velocity function is a necessary condition for a predictable effect of money on nominal GDP. The evidence for the three countries suggests that if the central bank chooses to control or respond to growth of the monetary base, it could keep growth of nominal GDP at a rate consistent with low inflation. This does not require the central bank to use the base as its instrument. It could continue to carry out policy actions by changing a short-term interest rate.

9. Using the regression in row 5 with ln V_{t-1} produces nearly identical errors.
10. The Bank's study finds that base money and GDP are cointegrated. There is also evidence of variable lags, not surprising in the light of Figure 5.

Of all monetary aggregates, the monetary base is perhaps least influenced by changes in the quality of information resulting from financial innovation, changes in intermediation, or financial regulation. It is often said that the base consists mainly of currency. It is no less true that the base consists of the principal assets that the central bank acquires through its operations in domestic credit markets and the foreign exchange market.

It may be said that evidence of the ability to affect nominal GDP bypasses the issue of measuring and separating nominal and real magnitudes. If so, the evidence here does not address the measurement problem for an economy where productivity growth cannot be measured reliably because of a large service sector or increasing reliance on information technology. There is some truth to that criticism but, for monetary policy, the criticism is overstated.

There are two reasons. First, precise measurement, though desirable, is not necessary for effective policy. Measurement of productivity or its growth rate may have become more difficult in principle, but measurement of real GDP or output has improved considerably in practice. This is shown by comparison of recent data with the highly variable data reported for the 1920s and 1930s. Arguably, the years 1922 to 1928 were one of the best periods for monetary policy in the United States. Available data were rudimentary when compared to current data. Yet the Federal Reserve was more successful in keeping inflation close to zero than in any period of comparable length.[11]

Second, many central banks now claim that their principal goal is medium-term stability. A few have adopted medium-term strategies, for example, rules or quasi-rules to achieve price stability or zero inflation. Some have successfully implemented such rules for the last five to ten years. By using adaptive rules, these central banks have been able to conduct policy effectively, despite problems arising from mismeasurement of productivity growth and other causes. McCallum (1993) shows that an adaptive rule using the monetary base worked reliably in Japan and elsewhere.

Concern for the measurement problem is perhaps most acute in countries such as the United States where market practitioners and policy makers seem most concerned about the ebb and flow of monthly and quarterly data. Here too, errors in measuring prices and productivity growth seem small compared to the difficulties of estimating seasonal factors, sorting the systematic from the large random component in these data, or separating persistent and transitory changes. Recent work by Shiratsuka (1997) and Cecchetti (1996), using trimmed means, suggests that large, transitory changes in a small number of commodity prices often have effects on reported rates of inflation that are likely to overwhelm the effects of mismeasurement of productivity growth. These effects typically do not persist. A central bank that follows a medium-term strategy does not respond to such short-term changes.

I draw the following lessons: First, a central bank that tries to make frequent, small adjustments faces many problems. Errors of measurement in separating real and nominal values are one of those problems, though probably not the most serious

11. The Federal Reserve took the lead in developing many statistical series, so U.S. data at the time were better than data for many other countries.

problem. Second, there are many reasons for a central bank to follow a medium-term strategy to control inflation or nominal GDP. Measurement error, or quality of information, is one of the reasons, but probably not the most important one. Third, the effects of major policy changes aside, the evidence suggests that the relation between monetary base and nominal GDP has remained stable through many years of financial innovation and economic change.

Economics has never been the science that delivers highly accurate quarterly or annual forecasts or precise measures of most variables. There is no such science. Policy makers have learned to use procedures that do not depend on precisely measured data and very accurate forecasts. Robust relations will generally be more useful for planning and implementing medium-term strategies. The data suggest that, with some qualifications, some robust relations relating money to nominal GDP are available and useful for policy decisions.

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