Some Evidence on the Comparative Uncertainty Experienced under Different Monetary Regimes

Allan H. Meltzer
Carnegie Mellon University, am05@andrew.cmu.edu
Some Evidence on the Comparative Uncertainty Experienced under Different Monetary Regimes

ALLAN H. MELTZER

The twentieth century has produced diverse monetary experience. This experience can be organized in several different ways. One emphasizes the role of gold in international monetary arrangements. Early in the century, domestic monies of major trading countries were convertible into gold at a preestablished fixed price, and gold coins circulated. Currently, few governments set the price of gold, and there is no formal requirement on governments in major trading countries to exchange gold for currency or currency for gold. This is a relatively recent phenomenon, and some prefer to return to a fixed, guaranteed price of gold. A second type of organization focuses on the arrangements for exchanging a country's currency for other currencies and particularly on the choice between fixed and fluctuating exchange rates. The choice of exchange regime permits a country to seek internal or external stability in the value of its currency. Major trading countries now either permit exchange rates to be determined by market forces or adjust the rates frequently to reflect market forces. Most do not achieve either internal or external stability.

A third method of organizing experience focuses on the role of governments or central banks in the monetary system. Under either a gold standard or a regime of fixed currency exchange rates, the government sets a price and agrees to buy and sell its money at that price. The decision to control the price or exchange rate leaves the determination of the quantity of money and the internal price level to market forces. A decision to control the quantity of money perforce requires that the prices of gold and other currencies be permitted to change relative to the home currency; external stability is sacrificed, or its provision is left to others.

Experience with various monetary arrangements has served to heighten awareness of the disadvantages of each. The interwar gold standard helped to transmit the price deflation and contraction of the early 1930s and contributed to the depth and extent of the Great Depression. The postwar international system known as Bretton Woods established fixed, but adjustable, exchange rates and, after more than a decade, increased welfare by establishing convertibility for major currencies. The price of gold was fixed, but gold had a minor role, and its role diminished as the system matured. The Bretton Woods system avoided deflation but transmitted inflation. When the system ended, major trading countries moved toward a loose system of domestic monetary control with fluctuating or adjustable exchange rates and preannounced targets for growth of one or more monetary aggregates. This system is often criticized for its "excessive" volatility. McKinnon (1984) has a recent statement of the argument.

Some writers want to restrict the use of the term gold standard to refer to a relation between the number of ounces (or grams) of gold and the unit of account; for example, one guinea is one ounce of gold. Here, the guinea is a unit of account, that is, a convention for expressing values. The convention tells us nothing about money prices or about the relation of gold to money prices or the price level. For gold to affect the price level, there must be a connection between ounces of gold and money prices. This requires more than the choice of a unit of account. Fixing the price of gold, by agreeing to buy and sell ounces of gold at a fixed price, establishes a link and opens the possibility of stabilizing the price level by buying and selling gold. I see no point to "reform" the unit of account. One unit, even an abstract unit, is as useful as any other.
Allan H. Meltzer

bearing greater risk shifts resources from investment to consumption and lowers future output. The concurrent increase in the variability of interest rates and money under current arrangements suggests that the present system is inefficient; central banks may be able to reduce variability in both money growth and interest rates and in exchange rates also. Consequently, the variability of prices and output may be reduced.

Monetary management, at the discretion of central banks or governments, based on forecasts of future economic activity and inflation has not eliminated recessions as some economists expected. Experience has shown that the errors in economists’ forecasts of quarterly changes in real output often exceed the average change. Further, government fiscal actions are less stabilizing than many economists and public officials once believed.

Research based on rational expectations has shown that every policy is a choice of rule; the only purely discretionary policy is a purely random or a haphazard policy. Hence, the rational choice of policy is a choice between rules. Policy rules may differ in a variety of ways, including complexity, formal statement, prescribed flexibility, responsiveness to relative and absolute changes in supply and demand for goods and services, and the uncertainty that they engender about the future. The more frequent are changes in the policy rule, the less certain is the actual or perceived adherence to the rule. The flexibility that permits government to change policy rules has a cost: anticipations about the future conduct of policy are altered, and uncertainty about the future conduct of policy increases (Kydland and Prescott 1977; Barro and Gordon, August 1983; Cukierman and Meltzer 1986).

The main objectives of this chapter are to compare the levels of uncertainty experienced under the different monetary regimes in the United States during the twentieth century and to begin an empirical evaluation of the effects of risk or uncertainty on economic performance. An accurate assessment of different regimes requires separation of the variability induced by policy actions or social arrangements from the variability induced by nature. If nature is benign, a particular period may be relatively stable despite policy action or a policy regime that increases variability. At the other extreme, nature may introduce substantial variability in prices and output that is damped by the policy regime but is not damped enough to reduce variability relative to other periods. To compare across regimes, care must be used to separate nature and policy institutions. This chapter is, at best, a first step.

Comparisons of this kind are subject to some important caveats. Small errors in data can have a relatively large effect on computed measures of variability used in the measurement of risk and uncertainty. Data for the early years of the twentieth century, and for the latter part of the nineteenth century, have been constructed from related series long after the period ended. Gordon (1982) has a brief description of the data. Whether, or perhaps when, data collection smoothed or amplified fluctuations and variability is unclear.

There are benefits that compensate for some of the severe limitations of the data. Comparisons of the gold standard, other commodity standards, monetary rules and discretionary monetary policy, based on formal analyses, have not proved conclusive. Much of this work ignores variability, risk, and uncertainty. Conclusions of work incorporating variability often depend on the parameters and models used. Fischer’s (1977) path-breaking paper assumes that the level of output is independent of the exchange rate regime, imposes purchasing power parity, and ignores capital mobility and inflation—the principal reasons for exchange rate changes. Even with these abstractions, comparison of the effects of fixed and fluctuating exchange rate systems on the variability of prices and consumption depends on the slope of the Phillips curve, the correlation of shocks across countries, and the types of shocks that occur. Flood (1979) permits capital mobility and chooses price stability as his criterion. He shows that his conclusions about the relative merits of fixed and floating rates depend on such parameters of the model as the response of spending to interest rates and the size of real balance or wealth effects.

Removing abstractions by including the resource costs of the alternative regimes, differences in fiscal rules, the extent to which an economy is open to trade or to capital flows, and perhaps differences in relative size is unlikely to render the conclusions of formal analyses less qualified or conditional. A general conclusion about the supe-

2. McNees (1981) gives several measures of the errors of forecast by forecast horizon for sixteen separate forecasters from 1976 to 1980. The average absolute error in sixteen forecasts of the growth of real GNP made during the same quarter is 2.7 percent. (Eight forecasts made after the middle of the quarter are only slightly more accurate. Their error is 2.4 percent.) The mean error of forecasts of real growth made four quarters ahead is 1 percent for the same period. For inflation, the mean errors are about 1 percent for both the current and the four quarter ahead forecasts. Webb (1983) reports similar data on the median error of forecast computed from a large sample for the years 1971–82. For both real growth and inflation four quarters ahead, the averages of the median errors for the twelve years are the same, 1.7 percent. For the shorter period most closely corresponding to the McNees data, the average of the annual median errors is 0.8 percent for real growth and 1.3 percent for inflation.
priority of fixed or fluctuating exchange rates is not likely to be reached deductively.

In the following section, I discuss proposals for monetary reform, compare a commodity standard to a monetary rule, and suggest why empirical evidence is required to evaluate the outcomes under different monetary regimes. Next I distinguish between risk and uncertainty and discuss the procedure used here to measure risk and uncertainty. Then I compare the risk and uncertainty experienced under six monetary regimes during this century. The concluding section offers a proposal for monetary reform.

Proposals for monetary reform usually assume that the public prefers a noninflationary rate of money growth. This may be true, but it has not been demonstrated that voters in democratic countries prefer the monetary regime that best maintains price stability. Nor has it been shown that the rate of inflation that maximizes wealth, or the utility of wealth and private consumption, is identically zero. More likely, the costs and net benefit of price stability depend on the choice of institutional arrangements (or policy rules) used to achieve stability. Institutional arrangements that reduce risks and uncertainty lower the cost of achieving any chosen rate of inflation or deflation, including zero.

I avoid discussing the optimal rate of inflation and assume throughout that price stability is preferred. A monetary rule is as capable of producing one average rate of money growth as another; for a monetary rule, the issue can be resolved once the decision is made to control money and allow exchange rates to change. Proposals that permit market forces to determine the rate of money growth cannot ensure price stability. Money growth is endogenous, and its average rate of change depends on costs of production of the commodity used as money, alternative uses of the commodity, and other real factors. Those who favor a fixed exchange rate regime urge, not always explicitly, some alternative to a stable average price level or an optimal (average) rate of inflation as a means of maximizing welfare. Exchange rate stability is not an end in itself. It is a means to other ends: higher individual welfare and reduced uncertainty.

**Types of Monetary Reform**

Experience with fluctuating exchange rates has stimulated interest in monetary reform. Three types of reform, each with many variants, are advocated. The first is a return to some type of gold or commodity standard under which the central bank would be obligated to buy and sell gold, or some other commodity or basket of commodities, at a preannounced price. This reform seeks greater external monetary stability. The second, a monetary rule, emphasizes internal stability. This reform keeps the growth rate of money on a prescribed path that is either fixed or contingent on observable events. The third proposal, associated with the work of Friedrich Hayek (1978), eliminates the government and the central bank from the monetary system. Proposals for competitive, unregulated banking—often called free banking—leave control of money growth to the decisions of the public. Wealth-maximizing bankers produce the quantity and type of money that the public demands. This proposal attempts to avoid government monopoly over the quantity of money and government fixing of price or exchange rate. I have discussed this reform previously (Meltzer 1983).

This brief comparison of proposed monetary reforms suggests two reasons why analysis has not resolved the issues or prescribed a unique optimal standard. First, gold or commodity standards avoid the requirement of monopoly by increasing the resource cost of the monetary regime. Monetary rules avoid price control by establishing a government monopoly. General economic reasoning does not support price (exchange rate) control and does not support the grant of monopoly power, even limited power, except under specific circumstances (see Vaubel 1984). Second, in countries that import most of their consumables, the relevant price of consumption is the world market price. For this reason, size of country and extent of openness to trade are often suggested as main reasons for choosing between fixed and fluctuating exchange rates.

The distinguishing feature of a gold or commodity standard is that the government or central bank makes an enduring commitment to control one set of prices and to accept the monetary and economic consequences that are consistent with that set. Friedman (1951) has a thorough analysis of the benefits and costs of commodity reserve currencies under the assumption that the level of output is independent of the choice of policy. The assumption of independence is restrictive, however. The choice of a monetary system determines the types of risk and uncertainty that society bears. When there is risk aversion, risk or uncertainty is costly; further, uncertainty affects the distribution of spending between consumption and investment and thus the size of the capital stock. The assumption that output (or consumption) is independent of the choice of monetary standard

3. Examples of free banking are rare. The evidence in later sections of this chapter sheds no light on the degree to which free banking affects uncertainty.
should be relaxed. Fischer (1977) addresses part of the problem by fixing output but allowing consumption to change.

The most familiar version of a quantity rule—Milton Friedman's monetary rule—requires the central bank to keep a broad or inclusive measure of money growth at a rate equal to the long-term average rate of growth of real output. Several alternative rules do not require constant money growth; they provide for systematic changes in the growth rate of money that are contingent on prescribed events. Some of these rules require the central bank to vary money growth in the direction opposite to the short-run changes in the current or recent average rate of inflation or to the current or average rate of change in the price of a basket of commodities. These rules are a type of commodity-price stabilization scheme, but they avoid the cost of buying, selling, and storing commodities. The government sells securities to reduce money growth when the prescribed index rises and buys securities to increase money growth when the prescribed index falls.

Another type of monetary rule, proposed by Friedman (1948), requires a cyclically balanced budget, a fixed tax structure, and fixed rules for tax and transfer payments. Exchange rates fluctuate freely. The stock of money grows on average, at the rate of growth of government spending. The latter is equal to the maintained (identical) average rates of growth of taxes and output, so the average rate of money growth is equal to the average rate of growth of output.

The budget deficit or surplus fluctuates cyclically; this permits money growth to rise relative to trend during recessions and deflations and to fall relative to trend during booms or inflation. Other contingent rules make the money stock depend on the level or the rate of change of output or income. A rule that reduces fluctuations in prices and exchange rates is suggested in the conclusion of this chapter.

A credible monetary rule reduces uncertainty about money growth but does not eliminate all short- or long-term changes in prices or the rate of inflation. Changes in output, in the terms of trade, or in excise taxes often affect the price level and the measured rate of price change. These changes are permanent changes in level but transitory for rates of price change. Productivity shocks that change the growth rate of output must be followed by changes in the growth of money to avoid long-term inflation or deflation. Under a monetary rule, the risks borne by the public depend, therefore, on the type of monetary rule that is adopted, on the type of shocks that occur, on the distribution of shocks between aggregate demand and supply, on the contingencies specified by the rule, and on the errors that policymakers make when applying the rule. Generally, permanent and transitory changes in the level or growth rate of output or of demand cannot be predicted in advance or instantly identified as they occur. A contingent rule that requires the central bank to respond to events involves some unavoidable errors. In effect, the public trades the gain from a more prompt response to a permanent change, properly identified, with the loss or cost of response to a transitory change that is misperceived as permanent.

Most analyses of monetary rules fail to distinguish between permanent and transitory changes (e.g., Friedman 1948; Fischer 1977; and Flood 1979). Transitory, random shocks do not require a response. At the opposite pole, permanent changes in the growth rate of output require an adjustment of money growth if price stability, on average, is an objective. The general belief seems to be that the maintained long-term growth rate of output in the United States has varied little, so permanent changes in output growth can be neglected. Experience in Japan, postwar Europe, Brazil, parts of Asia, and elsewhere suggests, however, that relatively large changes in maintained growth rates occur. Failure to adjust money growth to observed changes in real growth means that prices are not stable on average.

If policymakers could promptly identify permanent changes in productivity growth, the size of the change in growth would be irrelevant for the policy rule. The reason is that, in this case, price level stability could be increased by changing money growth in response to changes in productivity growth or other changes in real growth. This suggests that the proper criterion for choosing to respond to these changes is not the size of the change in growth rate; it is the cost of mistaking transitory changes as permanent—the cost of excessive activism—compared to the cost of treating permanent changes as transitory—the cost of excessive passivity. These costs depend on the ability of the monetary authority to identify permanent changes in real growth. Related costs arise with respect to identifying demand and supply shocks under some monetary rules.

A rule setting the growth rate of money has two clear advantages over a rule setting the exchange rate. First, the resource costs of the monetary rule are lower, since less real output is stored as a monetary reserve (Friedman 1951). Second, the monetary rule avoids the costs of operating a gold or commodity standard unilaterally and the costs of organizing and maintaining a multilateral standard. On the other side, costs of monitoring are higher for the quantity rule. The central bank or government often has incentives to deviate from noninflationary money growth, as emphasized in Barro and Gordon (August 1983) and Cukierman and Meltzer (1986).

Friedman (1951) estimated the annual resource cost of a com-
commodity reserve currency to be as much as half of the average growth rate of annual output, using data for the late 1940s and assuming that, on average, there is no inflation. A similar computation, using the current ratio of money to income in the United States as a reference, reduces the cost to about 16 percent of the average growth rate of annual output. Unless there is a reason to anticipate a dramatic decline in average cash balances, the resource cost of a full commodity standard remains high.

The resource cost of an international standard is probably higher than the estimates for the United States. The ratio of money to income in much of the world is above the U.S. ratio, so that a larger fraction of world commodity stocks would have to be held as monetary reserves, and a larger fraction of the growth rate of output would be added to the reserves on average. If gold and other metals are exhaustible resources, their prices will rise over time relative to the prices of reproducible commodities. The rise in price encourages private holding of gold (or commodity money) instead of productive capital but also lowers the resource cost of increasing monetary gold stocks.4

It is difficult to estimate the likely rate of increase of the gold price. We cannot reliably separate, or hold constant, the policies of the principal governments that control most gold production so as to obtain an estimate of returns to scale in gold production. The crude data in the report of the Commission on the Role of Gold (Report 1982) and Fellner (1981) do not show evidence of constant returns to scale in gold production. Fellner (1981) notes that the price elasticity of the supply of gold has been low, and possibly negative, since the 1940s.

A further complication in evaluating the costs of a gold standard arises from changes in the demand for industrial and commercial uses of gold. Growth in these demands is absorbing much of the new production, but, again, it is difficult to separate the effect of expected inflation on the demand for jewelry from other determinants of the demand for gold (see Report 1982, pp. 176–78).

A gold or commodity standard is costly to operate unilaterally. Even if they use all available information, people may be slow to distinguish relative from absolute changes or permanent from transitory changes. Unless price levels adjust instantly, all the real and monetary shocks that change the world demand for gold (or whatever commodity is used as money) affect prices and output in the country that maintains the standard. For example, under a unilateral gold standard, whenever wars, revolutions, increases in inflation abroad, or other unanticipated events increase foreigners’ demand for gold, the domestic stock of money falls and the home price level falls until the rise in the relative price of gold restores equilibrium in the gold market. The agreement to supply gold at a fixed nominal price means that every unanticipated event that affects the gold market leaves its mark on real income and prices in the home country, except in the extreme case when foreign prices adjust instantly to foreign shocks and absorb the entire adjustment.

A unilateral gold standard is a service to the world. The cost of providing the service is borne by the public in the home country. Income and prices are more variable; if variability or uncertainty lowers the capital stock, future income and wealth are lower as a result.

A further advantage of a fixed growth monetary rule arises from the constancy of money growth. Suppose that money growth is set at a rate that achieves price stability on average, so that expected and actual money growth change only when there is a maintained change in the growth rate of real output or the growth rate of velocity. If the rule is specified in terms of the monetary base, constant growth of the base implies that there is no correlation between base money growth and base velocity growth, so the variance of nominal output growth equals the variance of velocity growth. The variance of velocity growth is, in this case, equal to the variance of inflation, plus the variance of the growth rate of real output, plus or minus any effect of correlation (covariance) between inflation and real growth.5 If the government or central bank stabilizes the growth rate of a more broadly defined money stock—for example, M1 defined as currency and checking deposits—there are some additional sources of variability. The quality of monetary control can reduce or increase the variability arising from these sources.

Fixed exchange rates are inconsistent with the stable growth of money; money growth is endogenous. The variance of the growth rate of nominal output in a fixed exchange rate regime is equal to the sum of the variances of money growth and velocity growth plus or minus the effect of interaction (covariance) between the growth

4. With constant returns, all of the additional gold is provided by new production and with totally inelastic supply by a rise in the price of gold relative to commodities. Between these extremes, the amount of additional resources used for gold production depends on the elasticity of supply.

5. Let \( m, v, y, \) and \( p \) be the rates of change of money, velocity, real output, and prices, and let \( V \) be a variance and \( C \) a covariance. Then

\[
V(m) + V(v) + 2C(m,v) = V(y) + V(p) + 2C(y,p).
\]

The monetary rule sets \( V(m) \) to zero, so \( C(v,m) \) is zero also. The expected rate of price change is zero, but prices change, so \( V(p) \) is not zero.
rates of money and velocity. The latter can be positive or negative, depending on the type of shocks that occur, the frequency with which supply and demand shocks occur, and the location at which they occur—at home or abroad. I see no way to decide in advance whether money growth and velocity growth are positively or negatively correlated. Indeed, the correlation may change if variances and covariances are not constant. In fact, money growth and velocity growth typically move together cyclically but not always secularly, so there is at least some evidence that the correlation depends on the length of the period used as a unit of observation.

One of two conditions is required for lower variability of nominal output or its rate of growth under fixed exchange rates. The growth rate of velocity must be less variable by an amount that compensates for the variability of money growth and any positive correlation between variability of the growth of money and velocity. Or a negative correlation between velocity growth and money growth must be large enough to compensate for the variance of money growth.

This static comparison ignores the effect of regime change on velocity and on the variability of velocity growth. One potential source of change arises from differences in the expected rate of inflation. Flexible exchange rates and monetary control are capable of keeping the average and expected rates of inflation at zero, although policymakers may not do so. There is nothing in the rules of the gold standard to keep inflation at zero, and experience under the gold standard shows decades with rising and decades with falling prices.

Another source of difference in the behavior of velocity arises from the variability of exchange rates. With fixed exchange rates, foreigners may hold larger balances in key currencies, lowering the demand for domestic money and raising the demand for the key currencies. Differences in population growth, or income growth between countries, then affect the distribution of money balances and the rate of change of velocity and its variability. Under a monetary rule, differences between expected and actual exchange rates affect interest rates, the demand for money, and velocity. This source of variability is dampened, however, by the operation of forward markets and the close relation between changes in spot and forward rates (see Mussa 1979).

A study of annual velocity growth from 1869 to 1949 using a broad

6. Using the notation in note 5, the first condition states that \( V(v) \) must be smaller under fixed exchange rates by more than \( V(m) + C(m,v) \). The second condition restricts \( C(m,v) \) to be negative and restricts \( |C(m,v)| - V(m) \) in relation to the difference in \( V(v) \) under the gold standard and the monetary rule.

belief. Following Knight (1921, pp. 224–25), we may identify the first with mathematical probability and the second with empirical probability.

Uncertainty refers to events for which the distribution of outcomes is unknown and the basis for classification is tenuous. An example, used by Keynes (1937), is the probability that capitalism would survive until 1970. Wars, atomic explosions, and various political decisions affecting tax rates or regulation are best described as uncertain as to timing and often as to occurrence. Changes in taste, technology, or political arrangements induce permanent changes in the level or growth rate of prices and output that cannot be predicted reliably. Recent events, including changes in the price of oil, in the relative size of government, or the permanence of the decline in world inflation and the stability of political regimes in the Middle East are illustrative. For events of this kind, there is no reliable way to classify times of occurrence into distributions or to compute the expected time of occurrence for a particular event.

The choice of policy regime affects the ability to classify events. A credible system of fixed exchange rates lowers risk and uncertainty about the exchange rate but increases the risk and uncertainty about money growth. A credible monetary rule lowers the risk and uncertainty about future money growth but increases the risk and uncertainty about future exchange rates and interest rates. In principle, each regime generates different expected responses of prices and output and different variability of prices and output.

Diversification, pooling, and hedging are examples of market arrangements that reduce risk and the cost of risk-bearing. The development of each of these arrangements depends on someone’s ability to classify events into probability distributions and compute expected values. Costs of risk-bearing differ with the degree of risk, as measured by the parameters describing the, often subjective, distribution of outcomes. The cost of risk bearing is likely to be smaller than the costs of uncertainty. The reason is that uncertain events cannot be readily classified, so costs cannot be reduced by market arrangements that convert risky outcomes into smaller and more certain costs.

Individuals can reduce the cost of uncertainty, under any monetary or fiscal regime, by holding relatively safe assets, including foreign assets, in place of risky assets. Private decisions of this kind do not lower the social cost of uncertainty. Countries with a history of political or economic instability generally have less capital per person, and less durable capital, than countries with stable governments. The reason is that people shift wealth to assets with values that are less dependent on policy decisions, including foreign assets and precious metals. The stock of domestic real capital remains low, and the marginal product of capital is relatively high. The high marginal product compensates owners of capital for bearing the uncertainty generated by the policy environment.

The costs of bearing avoidable uncertainty fall on present and future generations. Domestic and foreign lenders demand a premium to compensate for the additional uncertainty, so real rates of interest are higher than the rates in more certain environments. Real investment is lower; the capital stock is smaller. Future real income and consumption are reduced below the level that could be achieved in a less uncertain environment.

Monetary reform cannot compensate for all shocks arising from political instability, tax and spending policies, or other sources of uncertainty. But differences in monetary arrangements damp or augment particular shocks and change the ways in which the shocks are felt. An example is the difference in the effect of an unanticipated change in the size of a fiscal deficit. A rule requiring constant money growth prevents the deficit from being financed by money creation. A monetary rule that requires money growth to rise and fall in fixed relation to budget deficits and surpluses increases the money stock during recessions, when prices and output fall, and reduces the money stock when prices and output rise cyclically. Even if the two monetary rules are accompanied by the same restriction on the growth of government spending and the same tax arrangements, they differ in the degree to which they reduce monetary variability.

If all shocks are temporary, cyclical changes in aggregate demand, the two monetary rules generate indistinguishable steady-state outcomes but different short-term outcomes. With constant money growth, deficits are financed by selling bonds, and surpluses are financed by retiring bonds. Under a rule requiring countercyclical issues of money, an unanticipated change in money finances part of an unanticipated deficit. Money is more variable, and debt is less variable, under the countercyclical monetary rule, but there is no differential uncertainty about future budgets or money growth under the two rules. People planning consumption anticipate the same tax rates, size of government, and price level if either rule is strictly observed.

Suppose that, in addition to transitory or cyclical shocks to aggre-

8. For evidence of the effect of monetary uncertainty on interest rates, see Bomhoff (1983) and Mascaro and Meltzer (1983).
9. This is recognized in proposals for reform by, inter alia, Simons (1948), Friedman (1948), and Brennan and Buchanan (1980). Recent work by Brunner and Meltzer (1972), Christ (1979), McCallum (1984), and many others shows that some combinations of fiscal and monetary policy are unstable.
gate demand, there are permanent and transitory shocks to output. Technical innovations, fluctuations in weather, political disturbances, and variations in tariffs and cartels are examples. Before World War I, plagues or diseases that killed a significant fraction of the labor force would have had a prominent place in a list of output shocks. Agriculture was more important, so that changes in weather patterns had a larger effect on aggregate output. When there are persistent changes in the growth rate of output or the level of output, there is uncertainty about future prices and rates of price change. This uncertainty is reflected in interest rates, in exchange rates and, therefore, in portfolios and in the allocation of real resources. Since the two monetary rules require different responses of debt and money to finance any budget deficit or surplus that occurs, there are differences in uncertainty about the size and duration of the budget deficit and about the stocks of money and debt that will follow any shock. In principle, this uncertainty is reflected in future prices and interest rates also.

To measure risk and uncertainty, I compute the variance of one-period-ahead forecasts for both log levels and rates of change of the variables used in the empirical work. The forecasts are the values predicted for period \( t + 1 \) using a multistate Kalman filter and values of the individual series through period \( t \). By assumption, each error term consists of three statistically independent terms: a transitory change in the log level, a permanent change in the log level or, equivalently, a transitory change in the rate of change, and a permanent change in the rate of change. If \( x_t \) is the logarithm of the level of one of the series, following Bomhoff and Kool (1983),

\[
\begin{align*}
  x_t &= \bar{x}_t + \varepsilon_t; \\
  \bar{x}_{t+1} &= \bar{x}_{t+1} + \gamma_t; \\
  \hat{x}_t &= \hat{x}_{t+1} + \rho_t;
\end{align*}
\]

so that

\[
x_t = \hat{x}_{t-1} + \bar{x}_{t-1} + \rho_t + \gamma_t + \varepsilon_t.
\]

Here, \( \bar{x}_t \) is the expected (log) level of \( x \) at time \( t \); \( \hat{x}_t \) is the expected rate of change, and \( \varepsilon_t, \gamma_t \), and \( \rho_t \) are, respectively, serially uncorrelated, statistically independent disturbances affecting current values of \( x, \bar{x}, \) and \( \hat{x} \). By assumption, the disturbances have zero mean and nonzero variance. Transitory shocks to the (log) level are given by \( \varepsilon_t \); \( \gamma_t \) is a permanent change in the level of the series, and \( \rho_t \) is a permanent change in the growth rate.

As shown in equation (1d), people can observe \( x_t \), but they cannot observe either the (log) level of the expected (or permanent) component, \( \bar{x}_t \), or the expected (or permanent) rate of change, \( \hat{x}_t \). The multistate Kalman filter is a way of estimating the unobserved values of \( \bar{x} \) and \( \hat{x} \), using the knowledge that the permanent level, \( \bar{x} \), is a random walk with stochastic drift, as shown in (1b), and \( \hat{x} \) is a random walk (1c).

The three error terms or disturbances are divided into "normal" errors and outliers by initially setting prior probabilities on the distribution of errors so as to classify 95 percent of the errors as normal and 5 percent as outliers. The initial prior probability for each error is specified in advance. Posterior probabilities are calculated after observing the current error and are used to revise the prior probabilities. People learn about changes as they occur, but they cannot be certain whether any change is transitory or permanent. As time passes, people learn more about past shocks and use this information to revise their estimates of the variances of the permanent and transitory shocks. Persistent changes that are large or small relative to past experience induce changes in the relative weights (probabilities) assigned to the permanent and transitory components and change the parameters of the statistical model used to forecast the future.10

The data were analyzed in (log) levels and in rates of change. For the analysis of rates of change, there are no transitory changes in level. There are only transitory and permanent changes in the rate of change. Transitory changes are, in this case, observations around a given expected rate of change, and permanent changes are changes in the growth rate.

Using all the information available from the past, people can forecast the next period or as far ahead as they choose to look. If all

10. The algorithm is described more fully in Bomhoff and Kool (1983). Bomhoff (1982, p. 20) describes the procedure: The procedure "allows for feedback from the data to the forecasting algorithm. A number of separate fixed filters are applied to the data, and the forecasts are computed as a weighted average of the forecasts from the individual filters, with weights that are adjusted over time according to the success of each separate filter over the recent past. The composite forecasts therefore are both recursively determined and adapt to new information. In order to do this, we use the ARIMA (0,2,2) model,

\[
\Delta^2 x_t = (1 - Q_1 B - Q_2 B^2) a_t - N(0, \sigma^2)
\]

where \( \Delta \) is the difference operator, \( B \) is the lag operator, and \( a_t \) is the shock. The left-hand side can be written using equations (1a) to (1c) of the text, in terms of the shocks,

\[
\Delta^2 x_t = e_t - 2e_{t+1} + e_{t+2} + \gamma_t - \gamma_{t+1} + \rho_t.
\]

The values of \( Q_1 \) and \( Q_2 \), and \( a_t \) change as new information arrives. The values of \( Q_1 \) and \( Q_2 \), reflect the probabilities assigned, and reassigned, to the three types of shock, \( e, \gamma \), and \( \rho \). As the weights assigned to the various shocks change with new information, the values of \( Q \) change to reflect the new information.
errors are transitory changes in level—the errors denoted $e_t$—forecasts for the distant future are no less reliable than forecasts for the next period. The reason is that $p$, and $\gamma$, are zero in this case and $\hat{x}$ is a constant, as can be seen in equations (1a) through (1d). The permanent level, $\bar{x}$, grows at a constant rate, $\hat{x}$, and the expected value of $x$ grows at this same rate. Despite reliance on Bayesian procedures, this is a situation with risk but with no uncertainty. People either revise their estimates of the future rate of change or adjust their actions in the present as new information arrives. They act on the assumption that all changes are drawn from a distribution with a fixed mean rate of change.

At the opposite extreme, all variability is perceived as a permanent change in the rate of change, and none is perceived as a transitory change in level or growth rate: $e_t = \gamma_t = 0$. The value of $\hat{x}$ changes with new information. From equation (1), it is easy to see that the variance of the forecast error depends on the variance of $p$. If $p$ is relatively variable, levels in the distant future are highly uncertain. People adjust promptly to each change because they perceive the change as permanent, but they have little information about rates of change in the more distant future. I describe this circumstance as a situation with uncertainty but with no risk.

Computed probabilities are neither 0 nor 1. All observations are a mixture of risk and uncertainty. In the following computations, the computed probabilities of transitory and permanent changes are the weights used to distribute the computed variance of the forecast error between risk and uncertainty (see Bomhoff and Koop 1983 for the computation of the probabilities).

In a growing economy with stable prices, the levels of real income and money are expected to rise. For real (and nominal) income, and for money, it is often useful to restrict the term uncertainty to the variability of unforeseen changes in the rate of change. We can, however, discuss uncertainty about the level of income or money by combining the variance of permanent changes in level and the variance of permanent changes in the rate of change. Risk can refer to transitory changes in level, or if computations are restricted to rates of change, risk can refer to the variability of transitory changes in the rate of change of income or money. Price stability, on the other hand, refers to the level of prices, not to the rate of price change. Prices are stable and are expected to remain stable, if they vary randomly around a constant level. Unless otherwise noted, I restrict the terms risk and uncertainty to a single meaning. Uncertainty about the future price level, level of GNP, or money includes the variability of permanent changes in level and the variability of permanent changes in the rate of change. Risk refers to transitory changes in level.

**Computed Measures of Risk and Uncertainty**

Gordon (1982) compiled quarterly data on prices, output, and nominal GNP from 1890 through 1980, a total of 364 observations. Friedman and Schwartz (1963) provide quarterly data on M2 and M1 since 1907 and 1914, respectively. These series can be extended to 1980 using the *Federal Reserve Bulletin*. In all, there are 230 quarterly observations for M2 and 264 quarterly observations for M1 in the data analyzed here.

After the data were processed using the multistate Kalman filter, I divided the observations into six periods representing the six monetary regimes in the United States from 1890 to 1980. In some cases, dates for the beginning and end of a regime are based on judgment. An example is the end of the Bretton Woods regime and the shift to fluctuating exchange rates. I chose the date on which President Nixon closed the gold window, third quarter of 1971, but cases can be made for an earlier or a later date. Also, I ended the interwar gold standard with the departure of Britain (third quarter of 1931) rather than using the later date, first quarter of 1933, when the United States allowed the dollar to float. Table 4–1 describes the regimes and gives the relevant dates.

The six regimes differ considerably in the amount of variability experienced. Table 4–2 shows the variance of the levels of logarithms of the raw data by regime. There are notable differences. The variance of nominal GNP is highest under the classical gold standard and lowest in the period of pegged interest rates. The variance of real GNP has a similar pattern. The variance of the price level increased under pegged interest rates, but it is highest in the recent period of fluctuating exchange rates and relatively high inflation. The variances of the two measures of money growth do not show any consistent pattern. For M2, the variance is highest under Bretton Woods; for M1, the variance is relatively low under that regime and even lower under fluctuating exchange rates.

The variability of actual outcomes is less costly if forecasting accuracy is high. Forecasts made using the multistate Kalman filter rely on past observations, so they are "true" forecasts that, in prin-

11. M1 is currency and demand deposits. M2 is M1 plus time deposits at commercial banks other than large denomination certificates of deposit. The change in definition of M2 does not permit this series to extend beyond the fourth quarter of 1979.
Table 4-1. Six Monetary Regimes, 1890–1980

<table>
<thead>
<tr>
<th>Regime</th>
<th>Beginning</th>
<th>End</th>
<th>Description</th>
<th>Observations and comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1890-IV</td>
<td>1914-IV</td>
<td>Gold standard without a central bank</td>
<td>100^a</td>
</tr>
<tr>
<td>2</td>
<td>1915-I</td>
<td>1931-III</td>
<td>Gold exchange standard with a central bank</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>1931-IV</td>
<td>1941-IV</td>
<td>Mixed system, no clear standard</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>1942-I</td>
<td>1951-1</td>
<td>Pegged interest rates</td>
<td>37</td>
</tr>
<tr>
<td>5</td>
<td>1951-II</td>
<td>1971-III</td>
<td>Bretton Woods</td>
<td>82</td>
</tr>
<tr>
<td>6</td>
<td>1971-IV</td>
<td>1980-IV</td>
<td>Fluctuating rates</td>
<td>37^c</td>
</tr>
</tbody>
</table>

^aRoman numeral denotes quarter.
^bThirty observations for M2; none for M1; one observation lost in computation.
^cThirty-three observations for M2.

Table 4-2. Variance of Log Levels of Actual Data

<table>
<thead>
<tr>
<th>Regime</th>
<th>Nominal GNP</th>
<th>Price level</th>
<th>Real GNP</th>
<th>M2</th>
<th>M1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.150</td>
<td>0.012</td>
<td>0.084</td>
<td>0.015</td>
<td>n.a.</td>
</tr>
<tr>
<td>2</td>
<td>0.066</td>
<td>0.024</td>
<td>0.024</td>
<td>0.084</td>
<td>0.042</td>
</tr>
<tr>
<td>3</td>
<td>0.058</td>
<td>0.004</td>
<td>0.033</td>
<td>0.043</td>
<td>0.071</td>
</tr>
<tr>
<td>4</td>
<td>0.033</td>
<td>0.031</td>
<td>0.007</td>
<td>0.063</td>
<td>0.057</td>
</tr>
<tr>
<td>5</td>
<td>0.123</td>
<td>0.020</td>
<td>0.044</td>
<td>0.098</td>
<td>0.030</td>
</tr>
<tr>
<td>6</td>
<td>0.072</td>
<td>0.035</td>
<td>0.007</td>
<td>0.043</td>
<td>0.028</td>
</tr>
</tbody>
</table>

The two definitions of money, postwar variances of the log level forecasts are no more than one-third to one-fifth of the lowest prewar variance. The variance of the error for prices and real GNP declined relative to the variance for money. These findings cast doubt on the notion that the time series data can be treated as variance, as is often done in econometric studies. Different regimes appear to give rise to different variances of forecast errors.

The postwar decline in the variance of forecast errors relative to the measured variance is, at times, larger than the decline in the variance of the forecast error itself. The relative decline between regimes 1 to 3 and the postwar era is most notable for prices and nominal GNP. Money also shows a decline in relative variability in the postwar period, but the relative decline in M1 is the smallest of any variable. The principal reason appears to be that the variance of forecast errors for M1 is not very large in any of the five regimes.

There are also differences among variables within a given regime. Under the mixed standard of the 1930s (regime 3), the variance of forecast errors for real and nominal income is three times its levels...
under prior regimes, but the variance for prices is smaller. Under interest rate pegging, wartime price controls, and early postwar adjustment (regime 4), the variance of forecast errors for money and real and nominal income fell, but the variance rose for prices.

The Bretton Woods regime has the smallest variance of any regime for each of the variables, although the values are duplicated in regime 6 for nominal GNP and the price level. The shift to fluctuating exchange rates was accompanied by increased variance of forecast errors for money and real GNP, but the increase is small. By prewar standards, the period of fluctuating exchange rates has been remarkably stable, if stability is measured by short-term predictability (the variance of errors in quarterly forecasts).

An alternative measure of stability is the extent to which prices, income, and money are stationary over a longer term. Stationary prices have some attractive features, and possibly a stationary money stock is attractive also. Stationary real income implies that per capita income declines as population increases, so stationary income is not desirable.

To separate short- and long-term stability, I used the posterior probabilities computed to develop weights on the three errors, ε, γ, and p. The Kalman filter program computes these weights using past observations and an arbitrarily chosen set of initial (prior) probabilities assigned to each type of error. Each period the weights change, so the arbitrary initial values have little influence on the weights after a few periods. The change in the weights is largest when there are large forecast errors, but two consecutive errors are required to determine that an error is not transitory. A large probability of a permanent change implies that, when large errors are made, they tend to last for more than one period. Table 4–4 shows these probabilities. Normal and outlier changes are combined.

Column 1 shows the mean posterior probability of a transitory change in level. If this probability is close to 100, most forecast errors are pure random changes, or white noise. Forecast errors are randomly distributed around a stable level, so the future level of the variable is expected to be the same as the current level. When the value in column 1 is relatively small, errors in level or in growth rate persist. This is shown by relatively large probabilities in columns (2) or (3).

Under the classical gold standard (regime 1), the probability of transitory changes in level is much larger than in other regimes. The probability declines in regime 2, after the establishment of the Federal Reserve, but the lowest values are found in the postwar period. The postwar values imply that a relatively small part of the variance of forecast errors in the postwar regimes reflects risk; the postwar weight shifted toward greater relative uncertainty. For prices, the largest probability under fluctuating exchange rates is assigned to changes in level. This reflects the relatively high uncertainty about the future price level during the 1970s. The same is not true for the two measures of money stock. Principal weight is given to permanent changes in rates of change. For money, the data suggest, this is the typical allocation, common to each of the regimes.

Lower probabilities do not imply a reduction in risk or uncertainty. I measure risk and uncertainty by multiplying the probability of a particular error by the variance of the forecast error. This procedure treats the variance of the forecast error as a weighted sum with weights equal to the computed probabilities of the three types of error shown in Table 4–4. Since these probabilities sum to 1 (or 100), the sum of the measures of risk and uncertainty, in columns 1

<table>
<thead>
<tr>
<th>Regime</th>
<th>Transitory change in level (1)</th>
<th>Permanent change in level (2)</th>
<th>Permanent change in growth rate (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal GNP</td>
<td>Money (M2)</td>
<td>Money (M1)</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>1</td>
<td>19.7</td>
<td>37.4</td>
<td>42.9</td>
</tr>
<tr>
<td>2</td>
<td>2.9</td>
<td>38.5</td>
<td>58.6</td>
</tr>
<tr>
<td>3</td>
<td>3.7</td>
<td>47.5</td>
<td>48.8</td>
</tr>
<tr>
<td>4</td>
<td>3.5</td>
<td>30.7</td>
<td>65.8</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>10.0</td>
<td>89.7</td>
</tr>
<tr>
<td>6</td>
<td>1.4</td>
<td>61.4</td>
<td>37.2</td>
</tr>
</tbody>
</table>

Comparative Uncertainty under Different Monetary Regimes

Table 4–4. Posterior Probabilities* in Percentage

<table>
<thead>
<tr>
<th>Regime</th>
<th>Transitory change in level (1)</th>
<th>Permanent change in level (2)</th>
<th>Permanent change in growth rate (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal GNP</td>
<td>Money (M2)</td>
<td>Money (M1)</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>1</td>
<td>16.2</td>
<td>33.4</td>
<td>50.4</td>
</tr>
<tr>
<td>2</td>
<td>10.8</td>
<td>27.2</td>
<td>62.0</td>
</tr>
<tr>
<td>3</td>
<td>5.5</td>
<td>52.7</td>
<td>41.8</td>
</tr>
<tr>
<td>4</td>
<td>0.5</td>
<td>35.1</td>
<td>64.4</td>
</tr>
<tr>
<td>5</td>
<td>1.1</td>
<td>59.1</td>
<td>39.8</td>
</tr>
<tr>
<td>6</td>
<td>0.2</td>
<td>62.8</td>
<td>37.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regime</th>
<th>Transitory change in level (1)</th>
<th>Permanent change in level (2)</th>
<th>Permanent change in growth rate (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prices</td>
<td>Money (M1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>1</td>
<td>21.4</td>
<td>41.3</td>
<td>37.3</td>
</tr>
<tr>
<td>2</td>
<td>11.4</td>
<td>29.6</td>
<td>59.0</td>
</tr>
<tr>
<td>3</td>
<td>3.2</td>
<td>37.3</td>
<td>59.5</td>
</tr>
<tr>
<td>4</td>
<td>8.2</td>
<td>61.7</td>
<td>30.1</td>
</tr>
<tr>
<td>5</td>
<td>1.2</td>
<td>28.9</td>
<td>68.9</td>
</tr>
<tr>
<td>6</td>
<td>3.8</td>
<td>36.7</td>
<td>59.5</td>
</tr>
</tbody>
</table>

*Columns 1, 2, and 3 sum to 100.
to 3 in Table 4–5, is the variance of the forecast error shown in Table 4–3, column 1.

The measures of risk and uncertainty are shown in Table 4–5. Column 1 shows the variance of the transitory error, ε, the measure I have called risk. It is the product of the total variance of forecast error and the probability that the disturbance is transitory. Columns 2 and 3 are, respectively, the variance of changes in level and the variance of changes in the rate of change computed in an analogous way. The data in these columns are used to measure uncertainty about future values.

Risk practically vanishes in the postwar regimes for prices and money and is relatively small for real and nominal income. This implies that most postwar changes persist either in levels or in rates of change.

For prices, stability is a benefit. Under the gold standard, both

<table>
<thead>
<tr>
<th>Regime</th>
<th>Risk of level</th>
<th>Uncertainty of growth</th>
<th>Uncertainty of growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Nominal GNP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.0587</td>
<td>0.1114</td>
<td>0.1278</td>
</tr>
<tr>
<td>2</td>
<td>0.0052</td>
<td>0.0693</td>
<td>0.1055</td>
</tr>
<tr>
<td>3</td>
<td>0.0209</td>
<td>0.2679</td>
<td>0.2752</td>
</tr>
<tr>
<td>4</td>
<td>0.0023</td>
<td>0.0206</td>
<td>0.0441</td>
</tr>
<tr>
<td>5</td>
<td>0.0000</td>
<td>0.0013</td>
<td>0.0117</td>
</tr>
<tr>
<td>6</td>
<td>0.0002</td>
<td>0.0080</td>
<td>0.0048</td>
</tr>
<tr>
<td>Prices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.0040</td>
<td>0.0084</td>
<td>0.0126</td>
</tr>
<tr>
<td>2</td>
<td>0.0065</td>
<td>0.0163</td>
<td>0.0372</td>
</tr>
<tr>
<td>3</td>
<td>0.0013</td>
<td>0.0126</td>
<td>0.0100</td>
</tr>
<tr>
<td>4</td>
<td>0.0003</td>
<td>0.0211</td>
<td>0.0386</td>
</tr>
<tr>
<td>5</td>
<td>0.0000</td>
<td>0.0012</td>
<td>0.0008</td>
</tr>
<tr>
<td>6</td>
<td>0.0000</td>
<td>0.0012</td>
<td>0.0007</td>
</tr>
<tr>
<td>Real GNP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.0606</td>
<td>0.1169</td>
<td>0.1056</td>
</tr>
<tr>
<td>2</td>
<td>0.0161</td>
<td>0.0417</td>
<td>0.0832</td>
</tr>
<tr>
<td>3</td>
<td>0.0129</td>
<td>0.1499</td>
<td>0.2392</td>
</tr>
<tr>
<td>4</td>
<td>0.0064</td>
<td>0.0481</td>
<td>0.0235</td>
</tr>
<tr>
<td>5</td>
<td>0.0001</td>
<td>0.0032</td>
<td>0.0077</td>
</tr>
<tr>
<td>6</td>
<td>0.0005</td>
<td>0.0051</td>
<td>0.0083</td>
</tr>
</tbody>
</table>

*The sum is equal to the variance of forecast error shown in column 1, Table 4–3.

managed and classical, transitory errors in forecasting levels are larger than in later periods, particularly the postwar periods. The risk of short-term errors of price forecast is larger under the gold standard than under the Bretton Woods and fluctuating exchange rate regimes.

Not only was there more risk of price fluctuations under the gold standard, but there was more uncertainty also. This is seen by comparing the values in columns 2 and 3 for the prewar and postwar regimes. The sum of these columns is a measure of price level uncertainty.

The main reason that risk and uncertainty were higher under the gold standard is that errors of forecast were larger. Even after removing short-term transitory disturbances, the remaining variability—the sum of columns 2 and 3—is larger than the average error of forecast in the postwar years.

Reduced uncertainty about the future price level in the postwar years does not imply that the price level is less likely to change. The average rate of inflation was higher in the 1970s than in any of the decades covered in this study. The data do not deny that the price level is expected to rise and, with continued inflation, converge to infinity. The data suggest, instead, that forecast errors declined and the anticipated rate of change became less variable. Table 4–4 shows that since 1951 more weight has been assigned to the probability that observed errors of forecast are changes in the price level. In earlier regimes, greatest weight was assigned to permanent changes in the rate of price change. Relatively less weight was placed on changes in level, and relatively more weight on changes in rates of change.

The comparison of regimes suggests that, contrary to frequent claims, the gold standard did not provide greater long-term predictability of prices. The so-called automatic features of the gold standard limit the degree to which a single country can inflate or deflate relative to other countries. The various gold standards limited the range within which the future price changed more effectively than the current regime. These restrictions do not reduce uncertainty, however, if the range is wide and variability is relatively high. The data suggest that permanent shocks to the rate of price change were relatively large and frequent under the gold standard, so that forecasts of future price levels and rates of change were subject to large errors. The problem was most severe in the periods that include the two major wars (regimes 2 and 4), but uncertainty was relatively high also in the years of the classical gold standard.

The declines in uncertainty between regimes 1 to 3 and 5 and 6 are largest for real and nominal GNP. Under the gold standard, uncertainty about the rate of nominal GNP growth and its level were
almost equal. In the postwar years, both measures of uncertainty decline, and in regime 5, uncertainty about the rate of change dominated. Uncertainty about the level of GNP became relatively small. Permanent changes in level are transitory changes in growth rate, so the relatively low weight suggests that the public did not expect recessions, or expansions, to have a lasting effect on the maintained rate of growth of GNP. Similar, but somewhat weaker, statements about comparative weights apply to real GNP. Even in regime 3, which includes the depression of the 1930s, the public gave considerable weight to uncertainty about the level of real GNP, although the dominant uncertainty is about the rate of change.

Comparison of price and real GNP uncertainty shows the marked difference between the first four regimes and the postwar era. Within the first group, there is some evidence of a tradeoff; periods of increased uncertainty about the rate of price change have reduced levels of uncertainty about real GNP and conversely. Uncertainty about the level of real GNP declined in regime 2 and rose in regime 3, while uncertainty about the rate of price change rose in regime 2 and declined in regime 3. There is no evidence of a tradeoff in regimes 5 and 6. These regimes have lower uncertainty about both variables than the first four regimes. Further, during regime 6, price uncertainty remained almost unchanged relative to regime 5, while uncertainty about real GNP rose.

For money, risk is negligible in almost all periods; most of its variance is assigned to uncertainty. Uncertainty is lower in the postwar period but higher under fluctuating rates than under Bretton Woods. The reduction in uncertainty about money is consistent with the proposition that control of money has increased in the postwar period.

A major problem in using these data to compare monetary regimes is that lower variability of output or prices can result from greater stability in nature and trading arrangements or from greater stability in monetary and other policies or policy regimes. The policy regime can increase uncertainty, but if nature is sufficiently benign, variability and measured uncertainty may remain low. Conversely, the benefits of a stable regime will be difficult to observe, and measured uncertainty may increase, if real shocks are sufficiently destabilizing.

The data suggest that uncertainty (the sum of columns 2 and 3) about real GNP and money are related. The rank correlation for uncertainty about M1 and real GNP is 0.9 for the five regimes, 2 to 6, with complete data. The correlation is significant at the 5 percent level. For M2 and real GNP uncertainty, the rank correlation is 1.0.

Further, the data suggest that the declines in monetary and income uncertainty are of similar order of magnitude. Table 4-5 shows the ratios of the variances attributable to uncertainty about money and real income in 2 through 6, as computed from the data in Table 4-5.

Many explanations have been offered for the greater stability of income in the years after World War II. Reductions in the relative size of agriculture, greater fiscal activism, and built-in stabilizers are prominent among the explanations. Each of these may have contributed. The data in Tables 4-5 and 4-6 suggest, however, that changes in the monetary regime have had a prominent role that is often overlooked.

As a statistical matter, the differences in the probabilities between periods generally are not significant at the 5 percent level. The probability distributions overlap to a nonnegligible degree. As an economic matter, differences in the variance attributed to uncertainty are often consequential. As an example, consider the uncertainty about future real GNP. The lowest variance attributed to uncertainty is 0.1090 (0.0077 + 0.0032) in regime 5; the highest is 0.3891 (0.2392 + 0.1499) in regime 3. If we use two standard deviations to approximate the range within which the growth rate typically fluctuates from quarter to quarter, we have 0.66 for the lower value and 1.25 for the higher value. For the classical gold standard, the variance is 0.2225, so two standard deviations is 0.94; for fluctuating exchange

12. Computations were made using rates of change (first differences of logarithms) as input. In this case, uncertainty means only changes in the rate of change. We can compare this measure of uncertainty to the data reported in column 3 of Table 4-5 and computed from log levels. The principal differences are for nominal and real GNP. A principal reason is that transitory errors are larger for the GNP variables and prices, particularly in the first regime. Forecasts based on rates of change omit the transitory changes in level. These differences aside, the general appearance is similar, and the reduction in uncertainty in regimes 5 and 6 remains.

### Table 4-6. Ratios of Variances Attributed to Uncertainty

<table>
<thead>
<tr>
<th>Regime</th>
<th>M1/real income</th>
<th>M2/real income</th>
<th>M1/nominal income</th>
<th>M2/nominal income</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.23</td>
<td>0.13</td>
<td>0.18</td>
<td>0.10</td>
</tr>
<tr>
<td>3</td>
<td>0.16</td>
<td>0.46</td>
<td>0.14</td>
<td>0.39</td>
</tr>
<tr>
<td>4</td>
<td>1.00</td>
<td>0.44</td>
<td>0.52</td>
<td>0.23</td>
</tr>
<tr>
<td>5</td>
<td>0.57</td>
<td>0.29</td>
<td>0.33</td>
<td>0.17</td>
</tr>
<tr>
<td>6</td>
<td>0.44</td>
<td>0.16</td>
<td>1.60</td>
<td>0.60</td>
</tr>
</tbody>
</table>
Conclusion

The right to own gold is a valuable right. The fact that many people choose to exercise the right is informative about the uncertainty or risks that people perceive. They may fear inflation or confiscation of their assets or some type of political restriction on property. They may fear default on the note issue following a wave of bank failures. Whatever the reason, ownership of gold or precious metals reduces the uncertainty that individuals perceive and bear but also reduces the demand for productive assets and the capital stock. Society is poorer because of the uncertainty that leads individuals to hold gold instead of productive capital.

The choice of a monetary regime is a decision to reduce some private risks by incurring costs that are borne by society as a whole. These costs include the resource cost of maintaining and operating the regime and the cost of bearing the risks that the monetary standard imposes. The basis for rational, economic choice between monetary standards, or the choice between so-called free competitive banking and a central bank, is relative efficiency. The most efficient monetary arrangement minimizes the cost and maximizes the benefits to individuals subject to the standard.

The efficiency criterion is more difficult to apply to the choice of monetary regime than to many other choices. An international commodity standard, based on gold or a commodity basket, requires a cartel agreement to keep the commodity's price at a set level. An international agreement to fix exchange rates is a decision to maintain the external stability of the value of money if necessary at the expense of domestic price stability. A monetary rule that fixes the growth rate of money, or that determines money growth as part of a contingent plan, depends for its execution on a central bank with monopoly power and on a commitment to let exchange rates fluctuate. A regime of this kind requires society to choose greater stability of the internal price level at the cost of greater fluctuation in exchange rates and in the prices of imported goods and services. Economic efficiency is rarely compatible with either price-fixing or monopoly arrangements. Yet, in the case of money, a central bank with monopoly power can be the most efficient method of producing money.

Among the principal ways that a central bank monopoly can increase efficiency are substituting inconvertible paper money for commodity money to reduce the resource cost, reducing some monitoring or enforcements costs that arise under a fixed exchange rate system, maintaining domestic price stability, and reducing uncertainty about expected future values. On the other hand, any rule limiting the issue of inconvertible paper money requires monitoring to prevent inflation or deflation. And a fluctuating exchange rate introduces risks of exchange rate changes in place of the risk of domestic price fluctuations inherent in a system of fixed exchange rates. Hence, no unique optimum is likely to be found analytically. The optimum, if one exists, depends on the relative costs and benefits of each regime.

For small countries that trade with the rest of the world, the cost of exchange rate fluctuations often exceeds any gain from controlling the price level of domestic commodities. Such countries can fix their exchange rates by pegging to the currency of a larger country that chooses a monetary rule. They benefit from price stability elsewhere by paying the cost of maintaining a fixed exchange rate and by incurring the risk of policy changes in the large country. A large country, with relatively little foreign trade, can increase the stability of its income, consumption, and prices, at least in principle, by choosing a quantity rule. Large and small countries may therefore have a symbiotic relation. All can gain if the large country chooses a regime that increases stability.

Pure monetary regimes have not occurred in practice, and few comparisons of actual monetary regimes have been made. This chapter compares measures of risk and uncertainty about levels and rates of change of money, prices, and GNP under six monetary regimes that governed the U.S. money stock in the twentieth century. A multistate Kalman filter provides an estimate of the variance of the one-quarter-ahead forecast, using information available at the time the forecast could have been made. Changes in each data series are divided into transitory and permanent changes in level and permanent changes in rates of change, based on prior probabilities of each type of change. The prior probabilities are revised as new information arrives. I used the computed posterior probabilities and the variances of forecast errors to compute measures of risk and uncertainty for each of the six monetary regimes.

The data suggest that, for prices and GNP, risk and uncertainty were greater under the gold standard, with or without a central bank, than under either the Bretton Woods regime or the current regime of fluctuating exchange rates. Risk and uncertainty about real GNP declined initially after the Federal Reserve was established, but the decline was relatively small and did not persist. The decline was accompanied by a rise in uncertainty about rates of price change.
A much larger decline in both risk and uncertainty about real GNP followed World War II, when the gold standard was replaced by the Bretton Woods regime and later by fluctuating exchange rates. For prices, differences in risk and uncertainty between the pre-Federal Reserve gold standard and the post-World War II period are somewhat smaller. The data place a higher probability that the long-term price level would remain constant under the gold standard than under either postwar monetary regime. Forecast errors were larger under the gold standard, however, so uncertainty about the future price level is higher under the gold standard than under the postwar regimes. Price level risk is higher under the gold standard also.

The rate of inflation has been higher in many of the postwar years than it was under the gold standard. People do not expect prices to be stable; they expect prices to rise without limit. The lower variance of forecast errors in the postwar years implies that the change in prices is more predictable now than under earlier regimes, even though the expected change is larger. This is the sense in which uncertainty about future prices has been reduced.

Many of my findings rely on computations of variances from quarterly forecasts. These findings can be heavily influenced by a few large outliers. The procedure used permits recomputation to omit the influence of outliers. None of the main qualitative conclusions change, but, obviously, there are changes in the quantitative conclusions. A further problem is reliance in the early years on quarterly data constructed by interpolation, using "related" series, long after the event. These qualifications should be kept in mind when judging the results.

The variability of many economic time series is lower after World War II. Comparison of the two postwar regimes shows similar levels of risk and uncertainty in each regime. Risk and uncertainty are higher for real GNP under fluctuating exchange rates. The increase in uncertainty about real GNP, though large relative to the increase in monetary uncertainty, is relatively small in absolute value. It seems likely that the increase is as much a consequence of the oil shocks of the 1970s as of the change in monetary regime. Uncertainty about the future price level declined marginally under fluctuating exchange rates.

The data suggest that the observed fluctuations in exchange rates from 1971 to 1980 have not had a large effect on the variance of forecast errors for GNP, prices, and money. Contrary to McKinnon (1984), fluctuating rates have not imposed a large excess burden, at least not for the United States. The rate of inflation is higher, but uncertainty about the future price level is lower than in the prewar regimes and not much changed from the Bretton Woods years.

The data suggest, more strongly, that the shift to fluctuating exchange rates did not trade greater internal for lesser external price stability. Further, a potential gain from fluctuating rates—improved monetary control—has not been achieved. The Federal Reserve has not increased monetary controls; uncertainty about money growth and future levels of the money stock is higher under fluctuating rates than under the Bretton Woods regime.

These findings suggest that improvements in monetary arrangements can increase welfare by reducing uncertainty below current levels. A firm commitment to price stability, expressed in a monetary rule, would reduce inflation and uncertainty about future rates of price change. Further, a rule adopted by leading countries—the United States, Japan, Germany, and the United Kingdom—under which each nation agrees to maintain that rate of growth of its monetary base consistent with its own internal price stability would increase exchange rate stability for major currencies.

A rule of this kind has an additional benefit. Other countries can increase price stability by pegging to one of the major currencies or by pegging to a basket of the major currencies. Under the proposed regime, the stability of internal and external prices increases together for small countries.

A by-product of the empirical work presented in this chapter is the finding that the variance of forecast errors differs across regimes. At times, particularly in the 1930s, the variances are large relative to earlier or later periods. This suggests that a standard assumption in econometric work—that the variance of the error term is constant over time—may not hold across regimes. This finding is, of course, consistent with the presence of the so-called Lucas effect, under which parameters estimated from time series data depend on the policy regime during the period of observation.

REFERENCES


13. Data end in 1980, so most of the period after 1979, in which the Federal Reserve attempted to control nonborrowed reserves, is omitted. Mascaro and Meltzer (1983) and Brunner (1983) suggest that uncertainty increased in this period.
Comparative Uncertainty under Different Monetary Regimes


——. "Monetary Reform in an Uncertain Environment." Cato Journal 3 (Spring 1983), 93–112.


