A Conference on Price Stability

by Charles T. Carlstrom and William T. Gavin

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Introduction

The Federal Reserve Bank of Cleveland has publicly endorsed a legislative resolution that would make zero inflation, or price-level stability, the overriding long-run objective of the Federal Reserve System. Price-level stability means a policy intended to keep the price level reasonably constant over long horizons. That is, although the price level may fluctuate temporarily in response to transitory real output and money demand shocks, permanent shifts in money demand and in real output would be offset in order to ensure that the long-run price level is stationary.

The term zero inflation is commonly used as a synonym for price-level stability. Care must be taken to distinguish this usage from a monetary growth rule that would result in zero expected inflation in the long run, but that could cause wide deviations of the price level from a constant trend as the income velocity of money shifts. Price-level stability should also be distinguished from a zero-inflation target in which the central bank tries to achieve zero inflation in every month or quarter. Such a strategy allows target misses to accumulate, which in turn allows the price level to follow a random walk.

In principle, a price-level rule would not preclude temporary policies to stabilize the business cycle. In practice, such a rule would remove uncertainty about the long-run price level and would be, in our judgment, the best policy to ensure sustained economic growth. Admittedly, economists have not offered much formal analysis in support of this issue.

Policymakers, however, are often required to make choices regardless of whether academic debates have been fully resolved. In order to advance the research about the role of inflation in the design of monetary policy, the Federal Reserve Bank of Cleveland sponsored a Conference on Price Stability in November 1990. The full proceedings of the conference appear in the August 1991 issue of the *Journal of Money, Credit, and Banking.*[1] In particular, we asked the participating economists to explain what recent developments in macroeconomic research have taught us about the optimal inflation policy.

The most widely cited origin of the optimal inflation literature is a 1969 article by Milton

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■ **1** Authors cited in this paper without a referenced year were conference participants, and complete citations of their papers can be found in the reference list.

Friedman, which explains why optimal inflation is achieved by allowing the money supply to grow (shrink) at a rate that results in a zero nominal interest rate. Here, Friedman estimates that this result would be achieved if the money supply were forced to grow at a relatively constant 2 percent rate. Assuming that the marginal cost of fiat money is zero, a zero nominal interest rate leads people to hold the optimal quantity of cash balances. This policy has become known as the "Chicago rule."

The Chicago rule is based on the assumption that government can raise revenue with a nondistorting tax. In response, Phelps (1973) presents a model in which only distorting taxes are available to replace the seigniorage lost when eliminating a moderate inflation. He shows that the trend inflation rate should be chosen so that the marginal welfare cost of the last dollar raised through inflation is equal to the marginal welfare cost of the last dollar raised through other taxes. A large body of literature debates the relevance of Phelps' criticism of Friedman's rule.[2] Whether Friedman's rule is optimal or whether some positive inflation rate would be preferred depends importantly on the role of money in the economy (medium of exchange, store of value, or unit of account) and on the alternative revenue sources available to the government. Resolving the issue requires considerably more detail about the economy than Friedman and Phelps presented in their respective partial-equilibrium models.

Our discussion of the six papers presented at the Conference on Price Stability is organized around two policy issues. The first is the implication of the papers for the optimal inflation trend — the Friedman–Phelps debate; the second is the implication for the degree of variability of inflation around the trend. We begin section I with a description of the Chari, Christiano, and Kehoe paper, which derives the optimal mix of monetary and fiscal policy rules. Henning Bohn's evaluation of the sustainability of fiscal policies in a stochastic environment follows naturally from this discussion. Section II includes an extended explanation of the Cooley and Hansen paper, which attempts to measure the net welfare cost of policies that would reduce inflation to zero and replace the lost seigniorage with higher taxes on capital or labor. Altig and Carlstrom then focus on the interaction of inflation with the nominal tax system. Section III describes the Imrohoroglu and Prescott paper, which calculates the efficiency of the seigniorage tax under alternative institutional

arrangements. Section IV discusses Laurence Ball's explanation of why attempts to eliminate inflation almost always lead to recession. In section V, we conclude with a summary of the policy implications that might be drawn from these studies.

I. Optimal Inflation and Nonindexed Government Debt

In "Optimal Fiscal and Monetary Policy: Some Recent Results," V.V. Chari, Lawrence Christiano, and Patrick Kehoe derive the optimal inflation policy jointly with the optimal tax policy. Using a stochastic, equilibrium business cycle framework, they work out the optimal labor and capital tax policies in a two-factor production economy, and the optimal inflation tax in a one-factor production economy without capital. They follow Lucas and Stokey (1983) in assuming a cash-in-advance role for money; some goods are purchased with cash and others with credit.

Chari et al. present four interesting results from the analysis of these models. First, they show that the optimal policy implies that either government debt or capital taxes should be indexed to government consumption and productivity shocks. For example, during a war or some positive shock to government consumption, the value of government debt should decline. This enables the government to avoid raising taxes during a war. They argue that because debt is difficult, if not impossible, to index, monetary policy should be used to provide the appropriate ex post real payments. Over the business cycle, policy should be set so that money varies positively with government consumption and negatively with productivity shocks.

Contrary to Barro (1979), they find that optimal tax rates on labor do not follow a random walk, but inherit the persistence properties of the underlying shocks and, for practical purposes, are roughly constant over the business cycle. The difference seems to arise because Barro does not allow government the right to issue state-contingent debt. Henning Bohn, in the paper discussed later in this section, shows that tax smoothing is, in general, not sustainable in the absence of state-contingent government debt.

Third, Chari et al. show that capital taxes should be zero on average in a stochastic steady state. This extends the results of Chamley (1986), who shows that the optimal tax on capital income is zero in a deterministic steady state. Although Chari et al. indicate that steady-state capital taxes are zero, state-by-state capital taxes

■ **2** Woodford (1990) summarizes much of this literature and gives a detailed analysis of the assumptions underlying Friedman's rule.

are not uniquely determined in a model with state-contingent government debt. Equivalently, the optimal level of indexing for government debt is not uniquely determined given state-contingent capital taxation.

Finally, they analyze optimal monetary policy in an economy without capital. In this model, Friedman's rule holds even in the presence of distorting taxes: A zero nominal interest rate prevails in every period. The intuition is simply that the optimal policy taxes both credit and cash goods at the same rate. This occurs when all revenue is raised through a tax on labor income. Without capital, a wage tax is equivalent to a consumption tax, where both cash and credit goods are taxed at the same rate.

In his comments on Chari et al.'s paper, R. Anton Braun shows that the optimality of Friedman's rule also depends on the particular form of preferences chosen; that is, utility is homogeneous in degree k with respect to both types of goods. Also, leisure is weakly separable from both cash and credit goods. Braun argues that empirical evidence from money-demand studies does not support this preference structure. Instead, he contends that the cash good is weakly separable from both the credit good and leisure, and that utility is homogeneous in degree k in leisure and in the credit good. This form of utility implies that wage taxes should equal zero and that efficient tax structure includes positive inflation.

If government debt cannot be indexed to either government consumption or productivity shocks, and if capital taxes cannot be made contingent on these shocks, then monetary policy can be used to effectively index the real return on fixed nominal government debt. Although the optimal policy results in a zero nominal interest rate, Friedman's result that money should be deflated each period at the rate of time preference is far from optimal.

Ex ante, the expected level of deflation in each period will equal the real interest rate. Thus, with the nominal interest rate on government debt being equal to zero in every period, the expected amount of deflation will be set such that, ex ante, the rate of return on all assets will be equal (although the Chari et al. monetary model does not actually include private capital). However, because monetary policy is being used to effectively index government debt, ex post optimal monetary policy results in an inflation rate that has a very large variance around a near-zero trend. Thus, while seigniorage should not be part of an optimal tax policy, substantial amounts of inflation and deflation should exist in order to decrease the real value of government debt during wars or negative

technology shocks and to increase the real value of government debt during booms.

Henning Bohn also discusses the issue of indexed government debt in "The Sustainability of Budget Deficits with Lump-Sum and with Income-Based Taxation." Bohn uses a stochastic environment to analyze the feasibility of some commonly recommended fiscal policies. Although his paper is not directly aimed at the issue of price stability, it has important implications for analyzing alternative inflation policies. His method could be extended to examine the sustainability of specific monetary policies in a stochastic environment.

Bohn considers the sustainability of two fiscal policies, a tax-smoothing policy and a balanced budget, under two different assumptions about the tax collection mechanism, a lump-sum and an income-based tax. He defines these terms carefully and shows that although many economists have espoused such policies and shown them to be sustainable in a deterministic world, they are not necessarily sustainable in a stochastic environment. He argues that it is imperative to specify the complete general-equilibrium environment, including the incentives of taxpayers and the constraints on tax collectors, when examining these issues.

Bohn shows that both tax-smoothing and a balanced budget are typically sustainable if the government is able to levy lump-sum taxes, but not if taxation is limited by the amount of income. He also demonstrates that in an uncertain environment, state-contingent government debt can be used to design sustainable versions of tax-smoothing and balanced budget policies. Like Chari et al., Bohn argues that inflation policy might be used to index government debt. He shows that a tax-smoothing policy can be maintained in a stochastic environment if inflation is perfectly negatively correlated with real output. The optimal inflation rate in Chari et al. actually has very little correlation with changes in output due to government consumption shocks.

Together, these papers indicate that government debt should be indexed. In theory, monetary policy could be used to accomplish this. Lucas and Stokey (1983) argue that, at least in the years following wars, monetary policy has been used to retire a substantial amount of the real value of outstanding government debt. However, this ex post indexing has not occurred on the scale proposed by Chari et al. Inflation has rarely exceeded 10 percent in the United States, while their model proposes that a third of the time inflation should either be greater than 20 percent or lower than -20 percent.

II. The Efficiency of Seigniorage

Thomas Cooley and Gary Hansen measure the net welfare effects of a policy to eliminate inflation, starting from the current pattern of effective tax rates on labor and capital. They begin with a real business cycle model that includes an indivisible labor supply specification and a cash-in-advance role for money. Like Chari et al., they use the Lucas–Stokey setup with cash and credit goods. Their baseline model is calibrated to fit the post-war U.S. economy, and baseline tax rates are set at historical averages: a 23-percent effective tax on labor and a 50-percent effective tax on capital.

The first experiment is to reduce inflation from 5, 10, or 20 percent to zero. In their simulations, Cooley and Hansen show that the welfare costs of inflation are substantially larger than those estimated by Fischer (1981). In his comment on this paper, Roland Benabou uses the Cooley–Hansen general equilibrium model to show analytically that inflation is much more costly than is implied by the usual partial-equilibrium estimates (the area represented by the Harberger triangle under the demand curve for money).

Although Cooley and Hansen argue that the benefits of ending inflation are greater than previously thought, eliminating inflation actually makes people worse off, because, on the margin, keeping the inflation tax is more efficient than increasing the tax on either capital or labor income. In their model, Phelps' argument is correct. They show that eliminating inflation makes people slightly worse off when the lost revenue is replaced with higher taxes on labor income, and makes them much worse off when the lost revenue is replaced with higher taxes on capital. The marginal welfare cost of revenue raised from the capital tax is already so high that attempting to extract extra revenue from this source is very costly.

The policy conclusions drawn by Cooley and Hansen for their model economy are straightforward. At the margin, the inflation tax is clearly less burdensome than either labor or capital taxes. The government can make people better off by raising inflation and lowering other taxes, particularly the capital tax. This conclusion is in contrast to that reached by Chari et al., who find that Friedman's rule holds.

Both papers use a cash-in-advance specification for the role of money. The important difference is that Chari et al. exclude capital when analyzing optimal monetary policy, which makes their labor tax equivalent to a consumption tax. In both papers, inflation is a tax on cash goods, driving a wedge between cash and credit goods.

With capital, an inflation tax shares the properties of a consumption tax in that it is a lump-sum tax on the existing capital stock. If Chari et al. extended their monetary model to include capital, Friedman's rule would no longer be optimal. Similarly, however, if either Cooley and Hansen or Chari et al. extended their papers to allow for a consumption tax that equally taxes both cash and credit goods, Friedman's rule of a zero nominal interest rate would again be optimal.

In Cooley and Hansen's model, the tax code is perfectly indexed for inflation. They assume that the effective tax rate on capital income is 50 percent, based on real-world studies in which the capital tax was not indexed for inflation. In reality, the effective capital tax rate was as high as 50 percent only because inflation averaged about 5 percent and because nominal rather than real returns were taxed. If the real rate of return to capital were 5 percent and the inflation rate were 5 percent, then a 25 percent tax on nominal capital income would be a 50 percent tax on real capital income. If the Fed actually went to zero inflation, the effective capital tax would decline unless Congress increased the tax rate. One can argue that Congress made such an adjustment in the early 1980s when inflation was reduced from 10 percent to 4 percent. The effective capital tax had been reduced in 1981, but was raised again by the Economic Reform Tax Act of 1983 and by the Tax Reform Act of 1986.

With nominal taxation of capital income, the Federal Reserve can lower the effective capital tax rate by lowering the inflation rate. Indeed, that is one of the arguments in favor of zero inflation. Cooley and Hansen generously agreed to run one further experiment in which the inflation rate was lowered to zero and the capital tax rate was cut to 25 percent to simulate the reduced capital tax that would occur with reduced inflation.[3] This experiment approximately represents the sort of policy change that would result if the Fed lowered the current inflation trend to zero and if Congress made up the lost revenue by raising the rates in the personal income tax code. The simulation shows that when the lost revenue from both seigniorage and the capital tax is made up with a higher wage tax, welfare increases by approximately 0.56 percent of GNP.[4]

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3 The assumed real rate is 4 percent in the Cooley and Hansen paper, instead of the 5 percent rate that was assumed in our calculations.

4 Cooley and Hansen report that the steady-state welfare gain is approximately 2.6 percent of GNP.

In "Inflation, Personal Taxes, and Real Output: A Dynamic Analysis," David Altig and Charles Carlstrom analyze the interaction between inflation and the taxation of nominal capital income. They use a stochastic version of the overlapping-generations model developed by Auerbach and Kotlikoff (1987) to examine both steady-state and business cycle consequences of changes in capital tax rates induced by changes in the inflation rate. There is no explicit model of money; rather, inflation is introduced as exogenous changes in an arbitrary unit of account. This simple framework allows marginal tax rates to be endogenous in a world with a graduated income tax. The authors concentrate on the interaction between the personal tax code and the inflation rate and ignore distortions associated with corporate taxation of capital.

Altig and Carlstrom find that changes in the inflation trend have large effects on the steady-state capital stock and hence on output. They estimate that steady-state output is approximately 5 percent lower than it would be if inflation were eliminated or equivalently if capital income were indexed. Although the authors do not investigate the welfare consequences of reducing inflation, their subsequent simulations show that, in the steady state, a worker just entering the labor force would need a one-time compensation equal to 0.75 percent of his or her "full lifetime wealth" in order to compensate for having a 4 percent inflation rather than zero (or perfect indexation of capital income).[5]

The decrease in steady-state output in their model is almost entirely due to the negative effect that the nominal taxation of nominal capital income has on the capital stock. The rate of inflation has almost no influence on steady-state hours worked, because the substitution and income effects cancel. In contrast to their steady-state results, Altig and Carlstrom find that the variability of inflation has little effect on the cyclical variability of capital, but has a substantial impact on the cyclical behavior of labor.

Inflation affects the cyclical properties of hours worked for two reasons. First, it raises the effective tax rate on capital income and lowers the return on savings. This causes people to substitute intertemporally toward both consumption and leisure. Second, although wages are assumed to be indexed for inflation, capital income is not. Thus, rising inflation causes capital income to

be overstated and, with a graduated income tax, throws savers into higher tax brackets. In this model, variable inflation has little effect on short-run fluctuations in real economic activity. Nevertheless, variable inflation increases the variability of hours worked and decreases the covariance between hours worked and output.

Altig and Carlstrom report that the short-run price instability typical of postwar U.S. history has had little impact on the real economy. Their analysis supports the notion that we should have a "zero expected inflation" target in order to effectively cut the tax rate on capital; however, in their model, there are no further gains from adopting an explicit path for the price level as a long-run objective. These observations are based on the reported real effects from variable inflation; deadweight loss calculations are not presented.

III. The Inefficiency of Seigniorage

In "Seigniorage as a Tax: A Quantitative Evaluation," Ayse Imrohoroglu and Edward Prescott examine the efficiency of the inflation tax under different assumptions about monetary institutions. The authors use a model with a simple one-factor production function and calibrate it using actual U.S. data. Instead of assuming that money is held for transaction purposes (as do Chari et al. and Cooley and Hansen), they specify a model in which money serves as a store of value to smooth consumption over time. There are two assets in the model, large-denomination government bonds and money. Banks take deposits from households and buy government bonds. The alternative to seigniorage is a tax on labor income. In each case, the revenue lost from reducing inflation is recovered with enough extra revenue from the labor tax to keep the government's budget balanced.

Imrohoroglu and Prescott consider three scenarios: (1) a case with 100 percent reserve requirements, in which currency is the only store of value, (2) a case in which monetary policy is uncertain from period to period, but everyone knows the trend inflation rate, and (3) a case with fractional reserves.

With 100 percent reserve requirements, only money is available to smooth consumption. Consequently, the welfare costs of inflation can be two to three times higher than the costs typically measured by the Harberger triangle under the money demand curve. Again, this is also the result that Benabou found in his analysis of Cooley and Hansen's paper.

■ 5 Their simulations assume that the lost revenue from reducing inflation is replaced through a proportional increase in the income tax. Full wealth is defined to be the present discounted value of a person's wage income assuming that all nonsleeping hours are spent working.

Thus, in two separate models with two very different assumptions about the purpose of holding money, general equilibrium measures of the cost of inflation (non-revenue-compensated) are significantly greater than the partial-equilibrium measures. Contrary to Cooley and Hansen, however, Imrohoroglu and Prescott find that when income taxes are increased to compensate for lost seigniorage, Friedman's rule is again optimal. This result continues to hold when the model is modified to include fractional reserves. As expected, allowing interest-bearing assets to smooth consumption reduces the cost of inflation. Adding short-run uncertainty about monetary policy imposes no additional welfare costs in this model. The welfare costs of a variable inflation policy that results in an average 4 percent inflation are approximately identical to those where the price level grows at a constant rate of 4 percent every year.

IV. Inflation Policy and Recessions

None of the five papers discussed above addresses an important concern of traditional macroeconomics — whether attempts to end inflation have been a major cause of recessions. This issue is advanced by Laurence Ball, who asks why efforts to end inflation almost always seem to be associated with recessions. Ball accepts as a stylized fact not only that all disinflations have been associated with recessions, but also that, on average, *announcements* of disinflation have led to recessions. He argues that neither of two simple explanations alone — price stickiness as suggested by New Keynesian economists, nor the lack of credibility as suggested by New Classical economists — can explain these phenomena if expectations are rational.

Ball shows that nominal price rigidity, as represented in models with staggered price-setting arrangements, cannot explain why ending inflation causes recessions. By carefully distinguishing between changes in the growth rate of money and changes in the level of money, he explains how a credible disinflationary policy will lead to a boom in a model with staggered price setting. The intuition behind this argument is simple: If price setters expect inflation to decline, they will lower prices immediately because they can readjust prices only periodically. This immediate decline in the price level will lead to an increase in real balances and consequently in output. Thus, fixed-price models alone cannot explain why disinflation leads to recessions.

He then argues that the New Classical explanation — that disinflations cause recessions because policy announcements are not credible — also is incomplete. If policy is partly credible (that is, if the Fed announces disinflation and sometimes follows through), market-clearing models predict that announcements of disinflation will sometimes lead to recession. The average expectation will be that the money growth rate will decline, but not by as much as the central bank announces. Sometimes actual money growth will fall faster than the expectation (the economy will recede); other times it will not (the economy will expand). On average, in a New Classical model with partial credibility, there should be no correlation between announcements of disinflation and deviations of output from trend.

This stylized fact that, on average, announcements of disinflation lead to recession is based on the controversial definition of announcements contained in Romer and Romer (1989). They identify six such announcements of disinflation in the postwar period, drawing sharp distinctions about what constitutes an announcement where we would not. If one believes that there were many announcements of disinflation but only a few actions, then the probability of follow-through is small. In the New Classical model in which policy has almost no credibility for disinflation policies, there is no reason to expect that false announcements of disinflation would lead to recognizable booms. However, true announcements of disinflation would lead to recessions.

After making the point that neither New Keynesian nor New Classical ideas *alone* can explain why announcements of disinflation lead to recessions, Ball notes that the two assumptions together can explain why announced disinflations on average lead to recessions and why actual disinflationary episodes are followed by recessions. Although these results occur even in the presence of rational expectations, Ball suggests that perhaps we should "... overcome our qualms about adaptive expectations." He recommends the adaptive expectations assumption because it can explain both why ending inflation causes recessions and why one-time macroeconomic shocks can lead to persistent inflation.

V. Conclusions and Directions for Future Research

Although the practical policy implications of these papers are limited, the discussions help us to understand more fully some of the issues

involved in the Friedman–Phelps debate. The resolution of this debate depends on the type of taxation used to replace lost seigniorage. If a consumption tax is feasible, Friedman's rule is optimal. However, if lost revenue can be replaced only with a wage, capital, or income tax, then the resolution also depends partly on the role of money in the economy.

When money is introduced into the model with a cash-in-advance constraint, inflation is a tax on consumption. Because a consumption tax acts like a lump-sum tax on the capital stock, some inflation will be part of an optimal tax package in a cash-in-advance model. When money is introduced into the model as a store of value, Friedman's rule is optimal. However, such models do not include private capital, and the generality of the result is still open to question.

None of the papers in this conference provides a comprehensive answer to the policymaker's question about the optimal inflation rate. No author has built a model to evaluate the effect of inflation on the efficiency of the monetary standard. Modeling money as a standard of value is problematic because the tools of microeconomic analysis assume away the frictions that make a standard useful. Money exists to facilitate trade and transactions — to make markets work more efficiently. Because we generally begin with models in which indexing is costless, or in which the efficiency of the payments and accounting systems is independent of the inflation policy, we should not be surprised that inflation appears to be rather harmless.

Support for zero inflation can also be found in the arguments contained in Altig and Carlstrom (1991a, 1991b). The interaction between inflation and the nominal tax system can result in significant distortions. It is not clear why Congress designed a tax system in which the effective capital tax rises with inflation. Perhaps legislators had some sort of state-contingent tax plan in mind, or perhaps they chose not to index the capital tax because of equity considerations. Another explanation is simply that indexing is difficult to achieve. Altig and Carlstrom (1991a) show that the indexing provisions for bracket creep contained in the Economic Recovery Tax Act of 1983 and the Tax Reform Act of 1986 are imperfect and still result in significant welfare losses.

The Friedman–Phelps debate centers on the optimal trend in the inflation rate. Chari et al. argue that constant inflation might not be optimal because of the presence of nonindexed debt. In their model, the government can use inflation changes with nonindexed debt in order to simulate indexed debt. Although their argument has merit, it leaves many questions unanswered. Can the government control the inflation rate precisely as needed to get the required pattern of real returns on government debt? Does it have an incentive to do so? What real-world uncertainties would accompany such a radical change in policy?

Perhaps the strongest argument against price stability per se (versus state-contingent inflationary policy around a zero-inflation trend) is presented by Henning Bohn, who shows that a policy of constant tax rates and a constant price level is not sustainable in a stochastic environment. Further research is needed to determine whether different operating strategies, for example, constant money growth targets, constant inflation targets, or a band around a path for the price level, would satisfy the conditions for sustainability.

An obvious gap exists between academic analysis and the actual practice of monetary policy. In theoretical modeling, the money supply rule completes the model and enables the researcher to determine the price level. In practice, the money supply rule is not sufficiently well defined to enable people to forecast inflation accurately. Adopting any reasonable and explicit rule may enhance economic performance by reducing uncertainty about future inflation.

None of the papers in this conference addresses the welfare or output effects of uncertainty about policy and the future price level. The rationale for an explicit multiyear path for a price index is based on the intuition that this uncertainty matters. If it does, a credible multiyear target for a price index would greatly reduce uncertainty about the future price level, eliminate the unexpected changes in the inflation trend that have been associated with recessions, and enhance the efficient operation of our accounting, contracting, and payments systems.

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