FEDERAL RESERVE BANK OF ST. LOUIS

REVIEW

SEPTEMBER/OCTOBER 2001 | VOLUME 83, NUMBER 5

THE FEDERAL RESERVE BANK of ST. LOUIS

REVIEW

Director of Research
Robert H. Rasche

Associate Director of Research
Cletus C. Coughlin

Review Editor
William T. Gavin

Banking
R. Alton Gilbert
Frank A. Schmid
David C. Wheelock

International
Christopher J. Neely
Michael R. Pakko
Patricia S. Pollard

Macroeconomics
Richard G. Anderson
James B. Bullard
Michael J. Dueker
Hui Guo
Kevin L. Kliesen
Michael T. Owyang
Daniel L. Thornton

Regional
Ruben Hernandez-Murillo
Howard J. Wall
Adam M. Zaretsky

Managing Editor
George E. Fortier

Assistant Editor
Lydia H. Johnson

Graphic Designer
Donna M. Stiller

Review is published six times per year by the Research Division of the Federal Reserve Bank of St. Louis. Single-copy subscriptions are available free of charge. Send requests to: Federal Reserve Bank of St. Louis, Public Affairs Department, P.O. Box 442, St. Louis, Missouri 63166-0442, or call (314) 444-8808 or 8809.

The views expressed are those of the individual authors and do not necessarily reflect official positions of the Federal Reserve Bank of St. Louis, the Federal Reserve System, or the Board of Governors.

© 2001, The Federal Reserve Bank of St. Louis. Articles may be reprinted, reproduced, published, distributed, displayed, and transmitted in their entirety if this copyright notice is included. Please provide the Research Division, Federal Reserve Bank of St. Louis, P.O. Box 442, St. Louis, Missouri 63166-0442, with a copy of any reprinted, published, or displayed materials. Please note: Abstracts, synopses, and other derivative works may be made only with prior written permission of the Federal Reserve Bank of St. Louis. Please contact the Research Division at the above address to request permission.

Contents

Volume 83, Number 5

begin with a standard economy in which a version of the Taylor rule constitutes the optimal monetary policy for a given inflation target and a given level of productivity. We augment this model with regime switching in productivity and calculate the optimal monetary policy rule in the altered environment. We find that, in the altered environment, a rule that incorporates leading indicators about regimes significantly outperforms the Taylor rule. We use this result to comment on the "new economy" events of the 1990s and the "stagflation" events of the 1970s from the perspective of our model.

Does Money Matter?

Laurence H. Meyer

It is always a pleasure to return to St. Louis and to Washington University and to see so many friends and former colleagues. But it is a special pleasure to be here for this occasion, the Homer Jones Lecture. Homer Jones was still active at the Federal Reserve Bank of St. Louis when I arrived at Washington University in 1969, and his wife, Alice, was a faculty member in the economics department. I had the pleasure of getting to know both. Homer was special in many ways. He was, of course, a leader in building the research department of the Federal Reserve Bank of St. Louis and in orienting it toward a monetarist perspective. But there was also the remarkable contrast of his strong convictions and his gentle manner. It was a combination to both admire and emulate. I admit I may have been more successful in emulating the strong convictions than the gentle manner. But that only makes me admire Homer even more.

I can remember vividly my first visit to St. Louis and Washington University in early 1969. I was a graduate student at MIT visiting the university in search of an appointment as an assistant professor of economics. I was picked up at the airport and delivered to my hotel, in advance of my seminar at the university the following day. When I walked into my hotel room, a small sign on a desk immediately caught my attention. It read: "Money matters." My first reaction was awe at the reach of the St. Louis Fed. They take this monetarism bit pretty seriously, I thought. It turned out in fact to be an ad for a local commercial bank, not for the St. Louis Fed. But the story about this incident provided a humorous opening to my seminar the next day. I was nervous, so getting the seminar off to a good start with an amusing story helped. It gave me momentum. And look where I ended up.

So when I considered topics for the Homer Jones Lecture, I thought of monetarism and the role of money. My mind quickly took me back to that incident, and I took as my title, "Does Money Matter?" What I had in mind was an assessment of monetarism's role in shaping current thinking about macroeconomic modeling and the conduct of monetary policy.

I often start my papers working back from my conclusion. Monetarism is about money, but money plays no explicit role in today's consensus macro model. It plays virtually no role in the conduct of monetary policy, at least in the United States. The conclusion appeared to be, therefore, that monetarism has had no influence on either macroeconomics or monetary policy. That conclusion was a problem: I did not want to write that paper for the Homer Jones Lecture.

I decided, therefore, to take a completely novel approach to this paper. I would postpone writing the conclusion until I had written the paper. So I invite you to share my journey in search of a conclusion. I will start by outlining the essential features of monetarism, set out my interpretation of today's consensus macro model, and interpret the role of monetarism in shaping this consensus. Whatever the lasting influence of monetarism, this journey will still find no explicit role for money in the consensus model and little or no explicit role in the current practice of monetary policy, at least in the United States. This leads me to explore whether current models and current practice undervalue the role of money.

MONEY AND MONETARISM

In my view, monetarism has several essential features. First and foremost, monetarism is the reincarnation of classical macroeconomics, with its focus on the long-run properties of the economy as opposed to short-run dynamics.

Classical macroeconomics emphasized several key long-run properties of the economy, including the neutrality of money and the quantity theory of money. Neutrality holds if the equilibrium values of real variables—including the level of output—are independent of the level of the money supply in the long run. Superneutrality holds when real variables—including the rate of growth of output—are independent of the rate of growth in the money supply in the long run. The quantity theory of money holds that prices move proportionately to changes in the money supply so that inflation is linked to money growth. Together, these propositions identify both what monetary policy can achieve and what it cannot achieve and therefore delineate the responsibilities of central banks. They mean that central banks have no effect on the level

This paper was prepared for the Homer Jones Lecture, Federal Reserve Bank of St. Louis, March 28, 2001. Laurence H. Meyer is a member of the Board of Governors of the Federal Reserve System.

or growth rate of output in the long run but do determine the rate of inflation in the long run.[1]

Second, monetarism focuses less on the structure of the economy and short-run dynamics and more on longer-run conclusions, such as the long-run relationship between money and output and money and inflation. This focus reflects, in part, a skepticism about our ability to understand or to adequately quantify the structural linkages and dynamics. For this reason, monetarists tend to prefer reduced-form equations or VARs to structural equations or structural econometric models and focus more on long-run results rather than short-run dynamics.

Third, monetarists are skeptical of the ability to use monetary policy for short-run stabilization, despite the fact that they believe short-run variations in money growth do affect aggregate demand and hence output. As a result, they favor rules, often passive rules, that focus on achieving a rate of money growth consistent with price stability in the long run, with no adjustment to cushion short-run fluctuations in aggregate demand.[2] This preference reflects again the uncertainty about the structure of the economy and about short-run dynamics and the long and variable lags in the response of aggregate demand to changes in the money supply.

There is an overriding theme across these features of monetarism: They focus on the role of money and the conclusion that "money matters." Money matters—indeed it is just about all that matters—for inflation in the long run. Given the widespread commitment to price stability, monetarists believe that central banks should therefore give appropriate attention to money growth in the conduct of monetary policy.

THE CONSENSUS MACRO MODEL: MONETARISM WITHOUT MONEY?

One way to judge the influence of monetarism is by the conformity of today's consensus macro model with monetarism's central features, as set out above.

One of my favorite sayings about economists is, "Two economists, three opinions." That saying is more true of macroeconomists than of microeconomists. For that reason, defining a consensus macro model has always been a challenge. But I believe there has been some convergence toward a consensus in recent years. This consensus is typically expressed in terms of a simple three-equation dynamic model[3]:

$$(1)\quad Y^g_t = aY^g_{t-1} + bE_t(Y^g_{t+1}) - c[R_t - E_t(p_{t+1})] + x_t$$

$$(2)\quad p_t = d(Y^g_t) + w_1\, p_{t-1} + w_2\, E_t(p_{t+1}) + z_t,\ w_1 + w_2 = 1$$

$$(3)\quad R_t = r^* + E_t(p_{t+1}) + f\,Y^g_{t-1} + g(p_{t-1} - p^T),$$

where Y^g equals the output gap (the percentage point difference between actual and potential output), R equals nominal interest rate, r^* equals equilibrium real interest rate, p equals inflation, p^T equals inflation target, x and z are stochastic shocks, and all the coefficients are positive.

The model includes an aggregate demand equation, a Phillips curve, and a monetary policy rule. The aggregate demand equation, given by equation (1), is essentially a dynamic version of the old IS curve, in which the level of output (in this case the output gap) depends on the real interest rate. This specification allows for effects of both lagged output and expectations about future output. The Phillips curve, given by equation (2), relates the inflation rate to the output gap (measuring the balance between supply and demand in the output market) and to both past inflation and inflation expectations. The effect of past inflation captures the role of sticky prices, while inflation expectations are assumed to be set, as in equation (1), according to rational expectations. The policy rule, equation (3), relates the interest rate, viewed as the instrument of monetary policy, to the output gap and the difference between inflation and the central bank's inflation target. That is, policy is adjusted in response to the deviations of output and inflation from their

1 Superneutrality is more controversial than neutrality. Indeed, the fundamental justification for a price stability objective is that inflation undermines the efficiency of the economy and perhaps distorts saving and investment choices. What is essential is that monetary policy cannot raise the level or growth rate of output by increasing the rate of money growth.

2 Many monetarists came to believe that short-run variations in money growth had significant effects on real variables in the short run. The important effects of variations in money growth for short-run economic activity were demonstrated in empirical research conducted at the Federal Reserve Bank of St. Louis, notably by Andersen and Jordan (1968) and by Andersen and Carlson (1970). But skepticism about the ability to harness this effect for use in stabilization policy remained. Still, as Hafer and Wheelock (2001) have noted, there was a temptation, not always resisted, to use the short-run relationship to prescribe a monetarist strategy for stabilization policy.

3 See, for example, Fuhrer and Moore (1995), Clarida, Gali, and Gertler (1999), and McCallum (2000).

respective objectives—full employment and price stability.[4]

There are at least three innovations in the consensus model compared with the IS-LM framework, perhaps yesterday's consensus model. First, the IS-LM model had two equations and three unknowns and therefore could be solved only by assuming that either the price level or the output level was fixed. Today's consensus model allows for both sticky prices in the short run and full price flexibility in the long run by introducing the Phillips curve. In effect, the Phillips curve pins down the degree to which prices are sticky in the short run, allowing scope for both short-run movements in actual output relative to potential and for stabilization policy, while providing a mechanism that ensures a transition to the long-run classic equilibrium.

Second, today's consensus model replaces the LM equation with a policy rule. The LM curve expresses the equilibrium condition in the money market, the balance between the supply of and the demand for money. Implicitly, the money supply is treated as the instrument of monetary policy. The policy rule in today's consensus model specifies the way policymakers adjust the interest rate to economic developments. This specification has the advantage of more accurately capturing the prevailing operating procedure at central banks around the world, given that they, almost without exception, implement monetary policy by setting a target for some key interest rate. It also reflects a more modern view of "policy" as a systematic adjustment of the policy instrument or instruments to ongoing economic developments rather than simply as an exogenous process, outside the model.

Third, the model explicitly incorporates forward-looking elements in economic behavior and accounts for the importance of expectations. In the eclectic form presented here, the model allows for both forward-looking elements and lagged adjustment due, for example, to adjustment costs.

The consensus model is widely used in teaching macroeconomics and in policy analysis, specifically in evaluating the properties of alternative policy rules. Larger-scale macro models used for policy analysis and forecasting typically have richer structures, including a more richly defined set of monetary policy channels. This set generally includes a range of interest rates and asset prices and the exchange rate, but almost never a direct or independent role for money. This is true of the FRB-US model used by the staff at the Board of Governors for policy analysis and forecasting. That model has a structure very much consistent with this simple consensus model in that its aggregate demand and inflation equations, for example, have the same mix of lagged adjustment and forward-looking expectations and its interest rate determination is anchored by a policy rule.

So what is the influence of monetarism on today's consensus model? On the one hand, the model has no apparent role for money. On the surface, therefore, today's consensus model appears to be a clear and definitive rejection of the "money matters" focus of monetarism. On the other hand, the classic properties I outlined hold in this model (at least if we redefine them in terms of "monetary policy" rather than the "money supply"). Monetary policy does not affect the level or growth rate of potential output, and inflation is determined by monetary policy in that it converges to a target set by the central bank in the policy rule.

My conclusion, therefore, is that we can still clearly see the influence of monetarism in the consensus model. Monetarism focused attention on the role of the central bank in determining inflation by emphasizing the relation between money and inflation. The consensus model may bypass money, but it has retained the key conclusion that central banks ultimately determine the inflation rate.

The relation among money, output, and inflation is obviously beneath the surface of this model. We could bring it to the surface by simply appending yesterday's LM curve to today's consensus model. This provides a fourth equation and a fourth variable, the money supply. The LM curve, however, is not part of the simultaneous structure of the expanded model. The first three equations determine output, interest rate, and inflation without calling upon the LM curve. All the LM curve does is determine the level of the nominal money supply consistent with solutions for output, prices, and the interest rate. In effect, the LM curve identifies the amount of money that the central bank will

---

[4] The effect of supply and demand shocks on the evolution of real economic activity is not clear in this specification. In the simple specification I have used, the effect of supply shocks is hidden in the measure of potential output, part of the output gap variable, and in the shock term in the Phillips curve. The last several years have heightened appreciation that shocks to the level of potential output (arising, for example, from changes in the non-accelerating inflation rate of unemployment) or to the growth rate of potential output (arising from shocks to structural productivity growth) play an important role in shaping short-run as well as long-run movements in real economic activity.

find that it has to supply when it follows the policy rule, given the shocks to the economy. So the money supply has become a less interesting, minor endogenous variable in the story.

This approach, however, is not inconsistent with a stable empirical relationship between money growth and other economic variables, specifically between money growth and inflation. In fact, if the money demand equation (underlying the LM curve) is stable, there will be a stable relationship between money and inflation in the long run.

The expanded model also makes clear that there is nothing inconsistent with a stable long-run relationship between money and inflation, as emphasized by monetarists, and the expectations-augmented Phillips curve, a mainstay in Keynesian-type structural models as well as a part of today's consensus macro model. The monetarist proposition is about an outcome, a result. This conclusion about the long-run relationship between money and prices is implicit in the consensus model, provided the money demand equation is stable. The consensus structural model is also about structure or process. It explains how monetary stimulus raises inflation.

The consensus model remains consistent with a relationship between money growth and inflation, but it appears to downgrade the role of money. But does it shortchange the role of money? In a search for answers, I will focus on monetary policy in Japan and on the differing role of money in the conduct of monetary policy by the European Central Bank and the Federal Reserve.

THE MONETIZATION DEBATE: DOES THE CONSENSUS MODEL SHORTCHANGE THE ROLE OF MONEY?

In Japan, the policy interest rate was taken to zero and remains close to zero. Zero is the logical lower bound for the nominal rate because, if the interest rate were negative, everyone would prefer to hold cash and there would be no demand for bonds. But even with a short-term policy rate nearly at zero, the Japanese economy remains weak, and a case can be made for additional monetary stimulus. However, according to the consensus model, once the policy rate is taken to zero, the central bank has exhausted its ability to stimulate the economy.

Monetarists, among others, reject this conclusion. They argue that Japan should embark on a strategy of monetization, or quantitative easing, and judge the stimulus of its policies in terms of the rate of growth in the money supply, not by the level of its policy rate. The Bank of Japan has recently taken a step in the direction of such a monetization strategy.

There are two paths to the conclusion that such a strategy will allow monetary policy to provide additional stimulus, even once the policy rate is driven to zero. First, some monetarists argue that money directly affects aggregate demand. That is, the IS curve in the consensus model is misspecified because it allows only for an interest-rate channel of influence and not for a direct effect of money on spending. Plug in the money supply as an additional determinant of aggregate demand and, presto, monetization works! Second, even if money does not directly affect aggregate demand, the transmission mechanism is certainly more complicated than the simple IS curve specification suggests. Money could play a role in structural equations for aggregate demand, or in VARs, as a proxy for channels that may be difficult to quantify or were simply left out.

Personally, I do not believe that there is a direct effect of money on aggregate demand. But I may be biased. My view is based in part on my own research. I tested and rejected the hypothesis of such a direct effect in my dissertation. In my dissertation I also tested the proxy role hypothesis and rejected it, too. But, the proxy role for money deserves further attention.[5]

When leading monetarists, such as Milton Friedman, have discussed the transmission mechanism, they have described monetary policy as operating through a broad range of interest rates and asset prices.[6] As I noted earlier, large-scale structural models also incorporate a much more detailed treatment of the channels of monetary policy—including not only a range of after-tax real interest rates but also equity prices and the real exchange rate—compared with the single policy rate in the consensus model. The consensus model adequately

[5] Large-scale models allow for the well-known real balance effect. Increases in real money balances that raise the real value of net worth operate through the wealth effect in such models. However, open market operations involve an exchange of money for bonds and therefore do not directly alter household wealth. McCallum (2000) and Svensson (2001) discuss conditions under which money could directly affect aggregate demand. Svensson summarizes the conditions as follows: "[A] direct money effect would arise if real balances entered the representative agent's utility function and this utility function was not additively separable in consumption and real balances but had a positive cross derivative." Svensson and McCallum agree that, for reasonable parameter values, this effect is likely to be so small that it can be disregarded.

[6] Friedman and Meiselman (1963).

summarizes this transmission mechanism with a single policy rate under two assumptions: First, monetary policy operates by changing some short-term interest rate; second, all other interest rates and asset prices are linked, directly or indirectly, to the policy rate through stable and predictable arbitrage relationships.

Monetary policy might still have life left in it, even after the policy rate has been driven to zero, if monetary policy operations could somehow affect the spreads between the policy rate and other interest rates—longer-term rates and private rates—and its relationship to other asset prices, such as equity prices or exchange rates.

In simple theoretical models, such an effect is possible as long as short-term government bonds are not perfect substitutes for longer-term bonds, private bonds, equities, and foreign financial assets. In this case, open market operations in long-term government bonds could in principle lower the long-term government bond rate relative to the policy rate, with spillover effects on longer-term private rates. Monetary policy in short-term private assets, such as commercial paper, could not only lower private rates relative to government rates but also allow the central bank to work around an ailing banking system. Finally, open market operations involving foreign financial assets—effectively unsterilized intervention in the foreign exchange markets—could, in principle, affect exchange rates. However, there is really no substantive difference between sterilized and unsterilized operations when the short-term interest rate is already zero.

One way in which open market operations in other assets might affect other rates or other asset prices would be if there were relative asset-supply effects determining longer-term private rates and exchange rates. For example, if the relative supplies of short- and longer-term government bonds affected their relative yields, open market purchases of long-term bonds could lower long-term rates relative to the already near-zero short-term rate. Whether or not the relative supply effects are significant is then an empirical question. The traditional answer has been that such effects, though possible, are negligible and, effectively, not a useful part of monetary policy. And even if monetization could push long-term rates to zero, there is no guarantee that will provide enough stimulus, given the prevailing deflation. The real bond rate could still be too high.

This proxy role for money could, in principle, cover other channels besides long-term government and private interest rates and asset prices—such as liquidity and credit effects—that might be activated by increases in the money supply. In this case, even additional conventional operations—open market operations in Treasury bills—might stimulate aggregate demand, even if they could not further lower the short-term nominal interest rate. However, that affect does not seem very plausible. For example, would the increased liquidity of holding money versus short-term bills stimulate aggregate demand? If economic agents wanted the additional liquidity, they could have acquired it with no holding cost by selling zero-interest-rate bills and acquiring cash. Why, when the central bank initiates this change, would it affect spending if no interest rates or asset prices were affected?

Bernanke and Gertler have emphasized a credit channel as part of the transmission mechanism.[7] But this channel—though amplifying the effect of monetary policy—seems itself to require a change in interest rates. For example, a decline in interest rates would, according to Bernanke and Gertler, reduce existing committed cash flows of borrowers and therefore make the borrower more creditworthy. This, in turn, could result in lenders offering additional credit. However, if interest rates do not decline, this channel is not activated.[8]

Finally, the proxy role for money could include the effect of monetization on expectations. This channel depends on the ability of policymakers to alter expectations about the course and effects of future policy. That is, the policy effect does not derive from a higher money supply today but from a perceived commitment to a higher money stock in the future.

Expectation effects could alter current long-term real interest rates in two ways. First, convincing the public that monetary policy will remain stimulative longer will lower expected future nominal short-term interest rates and therefore longer-term nominal interest rates.[9] Second, convincing the public that monetary policy will achieve a higher inflation rate in the future, at least on average, could lower expected current longer-term *real* interest rates, reinforcing the effect on expected long-term interest

---

[7] Bernanke and Gertler (1995).

[8] Clouse et al. (2000).

[9] I am assuming a standard expectations theory of the term structure of interest rates and constant risk premiums. Long-term interest rates are, in this case, an average of current and expected future short-term interest rates.

rates of a perceived commitment to a given path for the nominal policy rate.

These effects can be illustrated in terms of a simple model with two-period (non-overlapping) price contracts. The current and expected future one-period nominal interest rates determine the current nominal interest rate on the two-period bond. Assume that the current one-period interest rate (the policy rate) has been driven to zero, but that the public expects a positive rate on the one-period bond next period. If policymakers can convince the public that policymakers will drive the one-period rate to zero in period two, the interest rate on the two-period bond will fall in the first period, stimulating aggregate demand.

The first channel thus operates by lowering the expected future nominal policy rate, thereby lowering current longer-term nominal interest rates. Essentially, it tries to lower nominal rates further along the term structure, once the short-term policy rate has been driven to zero. It depends on the credibility of the policy authorities to pre-commit to a more stimulative policy in the future—for example, to maintain the zero rate policy for a longer period than is now anticipated.

The second way in which expectations can affect current real long-term interest rates involves the effect of policy on inflation expectations. In order for this effect to work, policymakers must first convince the public that policymakers will maintain a given path for the short-term nominal policy rate; thus the second effect builds upon and reinforces the first effect. The second effect, by convincing the public that inflation will be higher in the future, converts the perceived commitment to a given path for the short-term nominal policy rate to a decline in future expected short-term real interest rates and hence in current expected longer-term real interest rates.

Note that it is sufficient for policymakers to convince the public that inflation will be higher than otherwise only for a while, not indefinitely. This is important, given that a promise to maintain higher inflation indefinitely might be neither necessary nor credible. One way to activate the inflation-expectations effect to stimulate aggregate demand in the short run, without compromising the longer-run inflation objective, would be to implement a target price *level*. The central bank would promise, for example, to target prices at a predetermined constant level and would indicate in advance the period over which it would attempt to return to the price-level target. If deflation follows, a price-level target implies that the central bank will target rising prices—or inflation—for a while in order to return the price level to its target level. The longer deflation lasts, the higher or longer lasting the expected future inflation. Once higher inflation restored the initial price level, the objective would again be price stability and, hence, zero inflation. A similar motivation underlies calls for the Bank of Japan to adopt an inflation-targeting strategy.[10] That is, by announcing an explicit inflation target, the Bank of Japan might raise expectations of future inflation and therefore lower real long-term interest rates today.

On the one hand, simply undertaking monetization operations without effectively communicating the intention with respect to future policy might not be effective. On the other hand, simply announcing an inflation target without carrying out operations today that might support the objective also might not be effective. However, doing both—carrying out monetization operations in support of an inflation target—could possibly activate the expectations effect.

The relative supply effect is likely to be so small that it is not relevant to the conduct of monetary policy in normal periods. This channel, therefore, is perhaps only of interest when the nominal interest rate has been driven to zero, when further policy stimulus is desired, and when the size of policy operations could be much larger than in normal times. However, the expectations channel—the effect of expectations about future monetary policy on long-term real interest rates and hence on aggregate demand today—is, I believe, an important part of the transmission mechanism both in normal periods and in the more extreme circumstances.

Despite uncertainties about the effectiveness of monetization operations, we may have to think more seriously about them when the policy rate has been taken to zero and there is still a case for further monetary stimulus. The problem is that, if there is a possibility of providing stimulus through monetization, we are not likely to find it by experimenting with such operations at the margin, especially if the stimulus arises through relative supply effects. To have any promise of significant results, such unconventional policy operations more likely would need to be implemented on a bold scale. Moving in this direction is understandably difficult

[10] See, for example, Krugman (1998).

when there is uncertainty about the effectiveness of the approach.

A fuller consideration of this topic would require us to assess the costs of such operations and the ways these costs balance against the cost of not pursuing this direction in a period of persistent deflation.[11] If the costs are low, there is little damage if the operations are ineffective. But I will not try here to reach a conclusion on the overall merits of monetization. My objective was to use the current debate about monetary policy in Japan to highlight channels of monetary policy and a possible role for monetary policy at the zero bound, which are left out of the consensus model.

Let me now sum up conclusions about the absence of any role for money in the consensus model. First, the consensus model incorporates a caricature of the consensus view of the determination of output and inflation, including the transmission mechanism. In effect, it treats "the" interest rate as an index of overall financial conditions, assuming that long-term interest rates, equity prices, and the exchange rate all move in a stable and predictable way with changes in the policy rate. To be sure, this is a considerable simplification, and some of the shortcomings become apparent when the policy rate is driven to the zero nominal bound.

Second, though the consensus model has its shortcomings, the absence of money is not one of them—except perhaps for the zero nominal bound case. As just noted, the consensus model significantly oversimplifies the transmission mechanism. It also oversimplifies the supply side of the economy—failing, in particular, to model the complex dynamics of the economy's response to an unexpected acceleration in structural productivity growth.

Third, in situations where the policy rate has been driven to the zero nominal bound—as is the case in Japan today—what the consensus model is missing (i.e., the proxy role for money) becomes the only remaining leverage for monetary policy. Interestingly, larger macro models do not do much better either, as they typically do not allow for relative asset-supply effects and often do not provide opportunity for the inflation-expectations effects that might be so important. In this case, money growth could be a valuable indicator of the degree of current and intended future stimulus to be provided by monetary policy.

Fourth, understanding the ways in which monetary policy might still provide additional stimulus—once the nominal policy rate had been driven to zero—may also provide us with a richer understanding of how monetary policy works in normal times. In particular, the monetization debate highlights the role that expectations play—in both normal and more extreme circumstances—in the effect of monetary policy on aggregate demand. Indeed, it has become increasingly clear that monetary policy works not only through decisions about the policy rate taken at each meeting but also by the expectations that policymakers encourage—intentionally or otherwise—about expected future policy. The language in the statement issued at the end of FOMC meetings and the statement about the balance of risks, as well as comments from FOMC members between meetings, can affect those expectations. Those expectations, in turn, have immediate effects on longer-term interest rates, on asset prices, and on real exchange rates—channels of monetary policy that are not directly incorporated in the consensus model.

MONEY AND MONETARY POLICY AT THE EUROPEAN CENTRAL BANK AND THE FEDERAL RESERVE

The consensus model implies that monetary policy is conducted by setting a target for a policy interest rate, without any consideration given to the prevailing rate of money growth. Does such an operating strategy undervalue the usefulness of money in the conduct of monetary policy?

This question takes on added interest because of two recent and seemingly contradictory developments. The European Central Bank (ECB), a new central bank, has a two-pillar strategy, one pillar being a reference value for money growth. The Federal Reserve, in sharp contrast, asked to be and was relieved of the requirement to report semiannually on its target ranges for the growth of monetary and credit aggregates. In this section, I discuss the evolution of money growth targets at the Federal Reserve and the role of the reference value for money growth at the ECB. In the following section, I discuss how a reference value for money growth might be set for the United States and whether or not such an approach might be constructive.

Money Growth and the Federal Reserve

Until the late 1960s, money did not play a meaningful role in the formulation of monetary

[11] See Fujiki et al. (2001) for an assessment of the potential benefits and risks associated with a monetization strategy in Japan.

policy in the United States.[12] By the end of that decade, however, intellectual inroads by proponents of monetarism—including important work at the Federal Reserve Bank of St. Louis—and dissatisfaction with the inflationary outcomes of the policy procedures in place, led to consideration of greater emphasis on money in the conduct of monetary policy.

The first conference of the well-known series by the Federal Reserve Bank of Boston, held in June 1969 and titled "Controlling Monetary Aggregates," was indicative of this trend. At the time, an FOMC subcommittee was already investigating how the Committee could improve its control of the money stock. The FOMC took a small step in January 1970, when the policy directive for the first time noted "the Committee's desire to see a modest growth in money and bank credit" as one of the factors to be taken into account in implementing monetary policy.

The Fed was operating then, as now, essentially by setting a target for the federal funds rate. But during this period it began to set short-run targets for money growth: two-month targets set for each intermeeting period calibrated to be consistent with its policy objectives. The federal funds rate was then set at a level that was estimated to be consistent with achieving the money-growth target. I was on leave from Washington University at the Federal Reserve Bank of New York in 1975-76 and wrote from time to time the periodic staff memo that set out the funds rate target estimated to be consistent with the money-growth range. However, when money growth deviated from this short-run target, it was more likely that the money-growth target was reset than it was that the interest rate was adjusted. In addition, the target was rebased for each meeting, so that past errors were typically ignored.

In 1975, reflecting in part the monetarist critique of monetary policymaking and in part disappointment with recent macroeconomic performance, the Congress passed a concurrent resolution encouraging the Federal Reserve to set targets for the money supply. Following the passage of this resolution, the FOMC adopted for the first time annual target ranges for money growth and announced them publicly. The Full Employment and Balanced Growth Act of 1978 required the Fed to set, semiannually, monetary targets for calendar years and to explain any deviations from the targets.

From 1979 to 1982, money-growth targets took on an even more central role in the conduct of policy. Policy was implemented during this period by estimating the total reserve growth necessary to meet the money-growth target and by holding to the associated path for nonborrowed reserves. In the process, the federal funds rate was free to move to whatever level would be consistent with the money-growth objective over time. Monetary policy was focused on steadily reducing inflation, and policymakers were less certain about what increase in nominal and real interest rates would be required to achieve the objective of reducing inflation than they were about the money-inflation relationship. Moreover, it served the interests of policymakers to emphasize that the markets, not policymakers, were controlling interest rates along the way.

At the outset, the money-growth ranges were interpreted as intermediate objectives, with the ultimate objective being to reduce inflation. The 1979 monetary policy report described the policy as "the gradual reduction of rates of increase of the monetary aggregates in order to curb inflation." The initial ranges for money growth were high to reflect the prevailing inflation rate but were to be gradually lowered over time.

Initially, growth targets were set for M1, M2, and bank credit, although the emphasis was on the M1 measure. But, after the downward shift in velocity for M1, associated with the introduction of nationwide NOW accounts and other innovations, the FOMC downplayed its M1 target in late 1982 and shifted emphasis to M2 and M3.

With deregulation and innovation making velocity less predictable, in late 1982 the FOMC also began a gradual return toward an interest-rate operating strategy. The monetary aggregate targets were described as being "set with the aim of slowing the expansion of money over time to rates consistent with the economy's productive potential at reasonably stable prices." Money-growth targets were evolving toward a point when they would be consistent with the FOMC's price-stability objective.

In 1995, the language describing the money-growth ranges changed in an important way. Up to that point, the money-growth target ranges appeared to apply to the period immediately ahead and were being gradually adjusted to be consistent with a transition toward lower inflation. The money-growth ranges were reinterpreted at this time to apply not to the period immediately ahead but rather to some intermediate and hypothetical period when price

[12] For a good discussion of the evolution of the role of money in monetary policy, see Ann-Marie Meulendyke (1998).

stability would be achieved and the pattern of velocity would be "normal." The purpose of the M2 growth rate range was "to serve as a benchmark for a rate of growth of M2 that would be expected under conditions of reasonable price stability and historical velocity behavior." The same language was used thereafter, until the Congress last year removed the requirement that money-growth ranges be reported to the Congress.

There are two explanations for this change in 1995 in the interpretation of the money-growth ranges. First, the new approach reflected a reduced willingness of policymakers to adjust monetary policy in response to deviations of money growth relative to the target range. This reluctance reflected the diminished confidence of policymakers in the signal from such deviations as a result of the unexpected jump in and continued volatility of velocity. Second, the new approach was better tuned to the lower and more stable inflation rate by the mid-1990s. Previously, money-growth ranges had been gradually lowered to signal the intent to lower inflation and to be consistent with gradual decline in inflation. The fixed range set in the mid-1990s was consistent with price stability, an objective now in reach.

Money and the ECB Two-Pillar Strategy

The Maastrich treaty identifies price stability as the overriding objective for the ECB. Like the Fed and other central banks, the ECB chooses to implement its policy by setting a target for a short-term interest rate. But the ECB also gives a more prominent role to the money supply than the Fed does today.[13]

The ECB has set out a two-pillar strategy for guiding its adjustment of interest rates in pursuit of price stability.[14] The first pillar is a reference value for money growth. The ECB sets a reference value for a single monetary aggregate, the M3 definition that is essentially the same as the M2 definition for the United States. The ECB reference value is the rate of M3 growth consistent with achieving its inflation target over an intermediate term, based on estimates of trend growth in potential output and velocity. The second pillar considers the appropriate setting for the policy rate in terms of the wide range of information available and the prospect for inflation over the medium term.

The ECB rationale for the reference value for M3 is the long-run stable relationship between its rate of growth and inflation. The reference value provides a second check for policymakers to ensure that monetary policy, set in terms of the ECB's policy rate and in consideration of pillar 2, is consistent with price stability. The ECB is very explicit about the fact that, in light of the short-term volatility of velocity, short-run deviations of money growth from the reference value might provide little useful information that would help policymakers adjust the stance of monetary policy. But in light of the more stable longer-term relationship, continued deviations would raise significant questions and should, at the least, require a careful reassessment of whether the prevailing monetary policy is consistent with the inflation objective.

The ECB uses the term "reference value" rather than a target to make clear that deviations from the reference value will not necessarily result in policy adjustments to encourage a return of money growth to the reference value. Each year the ECB updates its estimate for potential output growth and, if necessary, updates the reference value to ensure that it is lined up on the inflation target.

A REFERENCE VALUE FOR M2 FOR THE UNITED STATES?

The ECB approach to the reference value for M3 is very close to the way in which the Fed was setting its benchmark range for M2 until the recent revision to the Federal Reserve Act. The major differences are that the Fed was perhaps somewhat less transparent about how it derived the range for M2 and did not update it regularly to maintain an estimated consistency with an unchanged trend inflation rate objective. At any rate, the recent change in the Federal Reserve Act removed the requirement that the Federal Reserve report to the Congress on growth ranges for M2 and other money and credit aggregates. My final topic is whether setting a reference value for money growth would be constructive for the FOMC and, if so, how such an approach would be implemented.

To move in this direction would have the advantage of allowing money growth once again to play a role as a failsafe, or second check, on the consistency of monetary policy with the FOMC's medium-

[13] The Bank of Canada also assigns the monetary aggregates a more prominent role in the conduct of monetary policy. Freedman (2000) provides a summary of the role of the monetary aggregates at the Bank of Canada.

[14] See Angeloni et al. (2000) for a thorough discussion of the role of the money-growth reference value in the overall policy strategy of the ECB.

term inflation objective. On the other hand, moving in this direction would require other significant changes in the conduct of policy. The FOMC—presumably in consultation with the Congress—would have to establish an explicit inflation target and would have to reveal its estimate of the rate of growth in potential output. This direction would itself be even a more significant step than setting a reference value for money growth. An intermediate approach might be to set a reference value based on implicit assumptions about both the target inflation rate and the rate of growth of potential output—without explicitly identifying either. This would be similar to how the benchmark range was set for M2 in the last few years before the benchmark ranges for the monetary aggregates were abandoned.

A Money Growth Reference Value and the Consensus Model

But why would monitoring money growth be useful, as long as policymakers followed a disciplined policy of adjusting their policy rate to ongoing economic developments, as reflected in the policy rule in the consensus model? It is well known that holding nominal interest rates fixed in the face of aggregate demand shocks can lead to monetary policy, in effect, reinforcing rather than damping such shocks. The FOMC instructs the manager of the System Open Market Account to hit a given interest rate target. If upward pressure on rates arises, for example, from higher nominal income growth or higher inflation expectations, the manager will automatically add reserves with open market operations to prevent a rise in the funds rate above its target. Hence, absent a change in the stance of policy, a positive demand shock automatically leads to higher reserve growth and hence higher money growth, in effect reinforcing the demand shock. The faster money supply growth relative to some reference value, in this case, would alert policymakers to the possibility that the policy stance was no longer consistent with its objectives. Policymakers would still have to evaluate whether the more-rapid money growth reflected a shift in money demand or a shock to aggregate demand.

However, the policy rule in the consensus model is designed to prevent precisely this type of persistent error in the response to shocks. If there is an aggregate demand shock, its effect on utilization rates and inflation will result in an adjustment of the policy rate over time that is consistent with policymakers' objectives for output and inflation. In effect, the policy rule substitutes for the discipline of a money growth target in the face of aggregate demand shocks.

So what value would a reference value for money growth have if policy were in fact conducted in a manner consistent with the policy rule? First, the policy rule is an attempt to summarize the systematic responses of policymakers. Policymakers do not, of course, commit to follow such a rule. So, having an additional check on the consistency of policy with medium-term objectives could be useful when policymakers choose not to adjust policy in line with the policy rule. Second, even if the rule were adhered to, another check might be useful. In particular, the difficulty in implementing the policy rule in practice makes a reference value for money growth valuable.

If the policy rule were lined up precisely on the equilibrium real interest rate and if the output gap were calibrated correctly relative to potential output, the benefits from monitoring money growth might be limited to its early signal of changes in output and inflation. But recent experience, along with the earlier experience of the 1970s, suggests that uncertainty about the real equilibrium interest rate and about the level of potential output makes implementing the policy rule challenging. Just as model-based forecasters often look at forecasts from VARs, so policymakers under a policy rule might benefit from a second check provided by a money-growth reference value. This justification for a money-growth reference value seems consistent with monetarists' skepticism about structural models.

An Operational Reference Value for M2 Growth

Let me set out a possible approach to implementing a reference value for money growth at the Federal Reserve. A simple point of departure is the famous quantity theory equation, $MV = PY$, where M is the money supply, V is velocity, P is the price level, and Y is the level of output. This can be rewritten, in terms of growth rates, as $m + v = p + y$, where lowercase letters are the growth rates of M, V, P, and Y, respectively. Rewriting the growth relationship as an equation for money growth,

(4) $$m = p + y - v.$$

To solve for the reference value for money growth, we need a definition of the money supply, a target for inflation, and estimates of the trend rate of growth in potential output and the trend in the growth of velocity.

I have implemented such a framework as part of a memo prepared by the staff for me in advance of FOMC meetings. After discussion with the staff, it was agreed that M2 was a sensible choice, though a case could have been made for other aggregates. M2 has the virtue of being broad enough to internalize many technological changes that would affect its composition, such as sweeps from demand deposit accounts to interest-bearing saving accounts, but also narrow enough to represent assets principally used for transactions. In the past, there has been a preference for setting ranges for multiple aggregates, increasing the potential for both information and noise, but I have been focusing on M2.

If this were being developed for the FOMC, the calibration of the reference value for M2 growth would need to incorporate either the staff estimate of trend growth or, still more likely, an estimate derived from a survey of FOMC members. For my calculation, I use my own estimate of the trend rate of growth in potential output, with input from the staff. It is important that this estimate be updated at least annually to incorporate the best judgment about the underlying trend. I am currently using $3^1/_2$ percent to 4 percent.

The next step is to specify the inflation target. This is a potential problem because the FOMC has not set an explicit numerical inflation target. It might be more appropriate for the Congress, presumably with input from the Fed, to set such a target given that the Congress is responsible for setting the broad objectives for monetary policy. At any rate, the upside or downside of publicly reporting a reference value is that the FOMC would have to be more explicit about its objectives.

To calibrate my reference value, I provide the staff with my personal inflation target. For the chain gross domestic product (GDP) price measure, the appropriate choice in the equation of exchange, my inflation target is $1^1/_2$ percent. I allow $^1/_2$ percent for measurement error and add an additional 1 percentage point as a "cushion," in light of the potential deterioration of cyclical performance in economies operating at very low inflation rates. This would be consistent with a $1^1/_2$ percent target for the personal consumption expenditure measure of consumer prices and about a 2 percent target for the consumer price index, based on recent experience with the differentials among these alternative measures of inflation.

Finally, we consider whether adjusting the M2 reference value for a systematic trend in M2 velocity (V2) is appropriate. Before the velocity shifts of the early 1990s, there seemed to be a long-standing and small, but positive, trend in V2. The pattern is no longer clear. Of course, the velocity shift in the early 1990s was, at least at the beginning, unexpected and unexplainable. For the reference value to be informative, adjustments for shifts of velocity would be necessary, and the ability to detect such shifts in "real time" is a potential problem. At this point, we assume that trend growth in V2 is zero.

Bringing all the steps together, my resulting reference value for M2 growth is 5 percent to $5^1/_2$ percent, the sum of my inflation target and my estimate for trend growth. Given the uncertainty about some of the inputs to the calculation, we might end up with a narrow range, as opposed to a point.

The next issue is how to effectively make use of the reference value. The purpose of the reference value, in my view, is not to read short-run deviations from it as signals of the need for adjustments in policy. The short-term variability in velocity makes the extraction of such a signal too difficult. Instead, the purpose of the reference value is to provide a check that might help avoid significant and persistent errors that undermine the Fed's medium-term inflation objective.

The traditional way the Federal Reserve presented its benchmarks for money growth in the past was the "cone" chart. Figure 1 shows the very last such chart for M2 published by the Federal Reserve in February 2000.[15] The base of the cone is the fourth quarter of the previous year—in this case, the fourth quarter of 1998. The cone shows the range of M2 paths that would be consistent with the chosen range over the coming year. The flatter solid line on the bottom shows the path for M2 that would be consistent with growth at the lower end of the benchmark range; the steeper solid line shows the path of M2 that would be consistent with growth at the upper end of the range. The actual path of M2 is shown by the shaded line. This approach, in my view, focuses too much attention on short-run deviations in money from its target path and fails to take into account the pattern of money growth before the previous fourth quarter.

Perhaps a better way of using the reference

[15] This chart was published in the *Monetary Policy Report* in February 2000.

Figure 1

Weekly M2

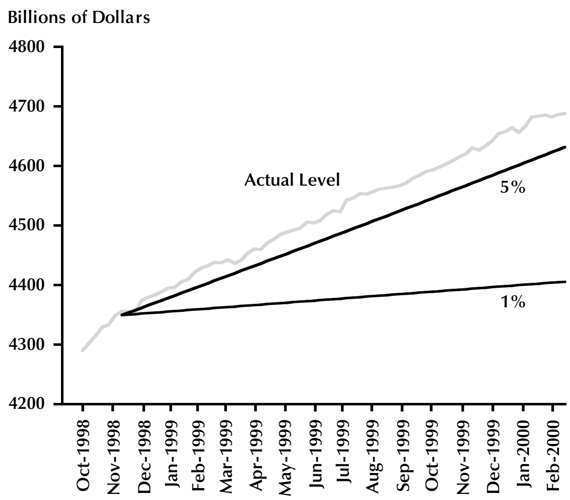
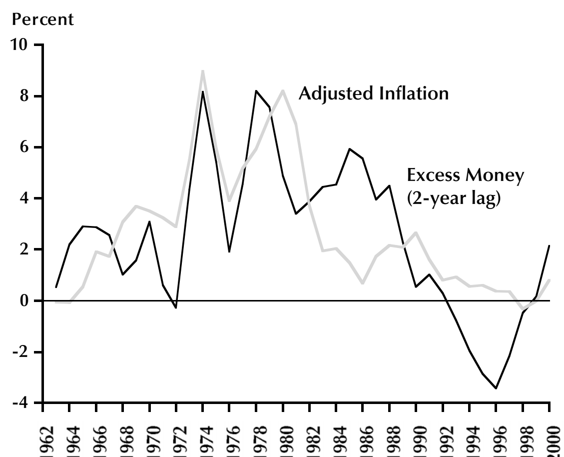


Figure 2

Excess Money with Inflation

(Yearly)

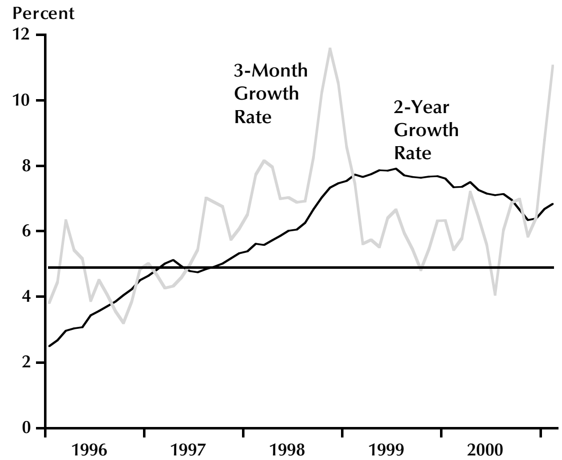


NOTE: Inflation is Q4/Q4 growth rates of the GDP deflator. Excess money is a 2-year moving average of Q4/Q4 growth rates of actual M2 less reference value. The reference value is the sum of potential GDP growth, inflation of 1.5 percent, and trend velocity of 0 percent. Potential GDP is based on CBO estimates for each year, published in *The Budget and Economic Outlook: Fiscal Years 2002-11*. The inflation rate of 1.5 percent in the GDP deflator is assumed to be consistent with reasonable price stability.

Figure 3

Growth Rates of M2 with Reference Line

(Monthly)



NOTE: The reference value is the sum of potential GDP growth, inflation of 1.5 percent, and trend velocity of 0 percent. Potential GDP is based on CBO estimates for each year, published in *The Budget and Economic Outlook: Fiscal Years 2002-11*. The inflation rate of 1.5 percent in the GDP deflator is assumed to be consistent with reasonable price stability.

value—focusing on its implications for medium-term inflation—would be to compare it with a longer-run average growth rate for M2. Figure 2, for example, compares excess money growth relative to the reference value—using the estimates of the Congressional Budget Office (CBO) for potential GDP growth—with the deviation of inflation from its target. To focus on more persistent deviations in money growth and in consideration of the lags in the effect of money growth on inflation, the Figure uses a two-year growth rate for M2, lagged two years, to compute the excess of money growth relative to its reference value. This is plotted against the excess of the rate of inflation over the previous four quarters relative to the inflation target.

Figure 3 plots the two-year and the three-month money growth rates. This combination offers the opportunity to review shorter-term movements in money supply in the context of early warnings of more persistent deviations.

A Cost-Benefit Analysis of an M2 Reference Value for the United States

Should the FOMC reinstate benchmark growth ranges for one or more monetary aggregates? First, this would be most useful if the committee were prepared to align such a reference value with an intermediate-term inflation target and a consensus on the growth of potential output and if it were prepared to update the reference value or range as its estimate of potential growth changed to maintain consistency with the inflation target. This takes us potentially to the broader question of whether the Fed should have an explicit inflation target. That will have to be the subject of another paper.

The second precondition for reinstating a money-growth reference value or range would be an evaluation of whether such a reference value would have improved or undermined the conduct of monetary policy over history. Are there, for example, historical episodes where it appears that responding to deviations of money growth from its reference value would have improved the conduct of monetary policy? Are there also episodes where such a response encouraged or would have encouraged inappropriate adjustments in policy?

Figure 2 points to some episodes that might be useful in assessing the costs and benefits of implementing a reference value for M2 growth in the United States. It suggests that M2 growth relative to its reference value seems to have been a good leading indicator of inflation in the 1960s and 1970s. Perhaps the best example of an episode in which money growth provided information that might have helped to avoid a policy mistake was the late 1960s through the early 1970s. During the late 1960s, utilization rates were increasing to historically high levels, and inflation was trending upward. There was political resistance to using fiscal restraint to slow the economy. Monetary policy ended up accommodating, and indeed reinforcing, the high level of aggregate demand, setting the stage for a significant rise in inflation in advance of the sharp rise in oil prices in late 1973 and 1974. And Figure 2 shows that money growth, though quite volatile, generally remained above its reference value during this period, signaling the inflation risks in the prevailing stance of monetary policy.[16]

But Figure 3 also flashes some caution about the usefulness of a reference value, at least after the early 1980s and especially after the early 1990s. The Figure allows us to identify several episodes in which money growth gave potentially misleading signals about inflation risks. The question in these cases is whether policymakers had enough specialized knowledge about financial innovations or disturbances to make a timely judgment that the information about money growth should be discounted.[17]

The surge in M2 growth in 1983, for example, was associated largely with regulatory changes allowing for the introduction of money market deposit accounts. At the time, policymakers were well aware of the potential for such effects of deregulation and hence were not "misled" by the money growth developments.

Another example is the fall in excess M2 growth in the early 1990s, which did not portend as steep a fall in inflation. Instead, it was the result of the well-known rise in V2 at the time. Reviewing the discussions in the Bluebook—now part of the public record—policymakers apparently caught on to this shift within a year or two.

More recently, the uptick in M2 growth in 1998 seems to have been associated, in part, with the run-up in equity prices, which raised household wealth relative to income and, as a consequence, induced households to rebalance their portfolios. Here, again, policymakers seem to have caught on quickly.

Money growth accelerated to a rate above 10 percent in the first quarter of 2001. The recent jump in money growth is evident in Figure 3 where I have plotted the three-month and two-year growth rates for M2 along with the reference value. There is, in general, too much noise, in my view, in the three-month rate to make it useful for monitoring the monetary aggregates. But this episode does provide an opportunity to take note of a variety of financial developments and special factors that affect money growth in the short run.

Six factors appear to have contributed to the upsurge in M2 growth in the first quarter. First, the policy easings narrowed the opportunity cost of holding M2 and thereby raised the demand for M2. Second, the yield curve, while no longer inverted, is still relatively flat, giving investors little incentive

[16] Interestingly, if we had constructed Figure 2 based on M1 rather than M2, it would have been less clear that that money growth was inconsistent with maintaining low inflation. In the early 1970s, however, the Federal Reserve had a single money supply measure, corresponding most closely to M1 today. The Federal Reserve discussions of the monetary aggregates at that time sometimes referred to "adjusted" measures of the money supply that included, for example, time deposits and therefore corresponded to what we now call M2. Milton Friedman at this time was focusing on this broader M2-type measure. At any rate, the different signals from narrower and broader measures in the early 1970s highlight the value of monitoring growth rates for a number of different definitions of the money supply, as the FOMC routinely did during the period it was setting benchmarks for the growth of the monetary aggregates.

[17] Orphanides and Porter (2001) address precisely this issue.

to hold longer maturity assets. Third, stock market volatility is elevated, making the liquidity and safety of money more attractive. Fourth, individuals apparently built up M2 balances to a greater extent than in earlier years to make January tax payments. Fifth, though these balances typically run off in February, higher refunds than allowed for by seasonal factors apparently offset the drag from tax payments. Sixth, mortgage refinancings have boosted M2 growth, as funds accumulate in transactions balances before being remitted to investors. Some or all of these effects can be quantified, though with considerable margin of error. At any rate, this is the type of analysis that needs to be undertaken to interpret very short-run deviations of money growth from the reference value.

This discussion perhaps only scratches the surface of the more thorough analysis that would be required to reach a definitive conclusion about the costs and benefits of a reference value. Still, it leaves me with both a recognition of the potential value of such a reference value and an appreciation of the challenge associated with wisely using the information about deviations of money growth from the reference value.

Let me now sum up my conclusions about the usefulness of a reference value for money growth for the United States. First, I would not elevate the reference value to a second pillar, on a par with the eclectic approach of adjusting interest rates to changing economic conditions, as captured in either pillar two for the ECB or the policy rule in the consensus model. This would overemphasize the importance of the reference value in the conduct of monetary policy and thereby ultimately confuse the markets as they assess the role of money growth in the conduct of monetary policy.

Second, the purpose of a reference value for money growth is not to identify money growth as the policy instrument. It is not. Nor is it to identify money growth as an intermediate target for monetary policy. It is not. The purpose of the reference value is to allow money growth to serve as a potentially useful information variable—a potential signal of inconsistency between prevailing policy and the medium-term inflation objective. That is, persistent deviations of money growth from the reference value might influence monetary policy by raising questions about the consistency of policy with its objectives and thereby encouraging a reassessment of that policy.

Third, money growth is an imperfect information variable, and, as a result, deviations of money growth from its reference value have to be carefully evaluated before a judgment is made that policy is inconsistent with the medium-term inflation objective.

Finally, given the ability of central banks to identify and understand financial market innovations and disturbances, they are in a good position to extract the benefits of the reference value without being misled by the short-run variability and occasional structural breaks in velocity.

CONCLUSION

Monetarism has had a profound influence on prevailing views about what monetary policy is capable of achieving and what monetary policy cannot do. It has helped to forge a consensus that central banks are responsible for preventing sustained inflation, and central banks have generally accepted that responsibility. Monetarism has not, however, had as great an influence in terms of elevating or even maintaining the role accorded to money in either macroeconomic modeling or monetary policy. Nevertheless, sometimes the pendulum swings too far in one direction or another, only to be corrected later. It may be that we have discounted the role of money in macro modeling and monetary policy more than is justified.

I reach three other conclusions from my journey. First, I believe we have more to learn about the role that monetary policy can play once the policy rate is driven to zero. This issue is important today in Japan. But given the relatively low inflation rates around the world, especially among industrial economies and therefore, on average, relatively low nominal interest rates, it is a subject of interest to a wider audience. Second, some of what we can learn from the debate about monetization in Japan may also enrich our understanding of how monetary policy works in normal times. Third, I believe monitoring money growth has value, even for central banks that follow a disciplined strategy of adjusting their policy rate to ongoing economic developments. The value may be particularly important at the extremes: during periods of very high inflation, as in the late 1970s and early 1980s in the United States, and when the policy rate is driven to zero in deflationary episodes, as is the case in Japan today.

REFERENCES

Andersen, Leonall C. and Jordan, Jerry L. “Monetary and Fiscal Actions: A Test of Their Relative Importance in

Economic Stabilization." Federal Reserve Bank of St. Louis *Review*, November 1968, *50*(11), pp. 11-24.

Angeloni, Ignazio; Gaspar, Victor; Issing, Otmar and Tristani, Oreste. "Monetary Policy in the Euro Area: Strategy and Decision-Making at the European Central Bank." European Central Bank, July 2000.

Bernanke, Ben S. and Gertler, Mark. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *Journal of Economic Perspectives*, Fall 1995, *9*(4), pp. 27-48.

Clarida, Richard; Gali, Jordi and Gertler, Mark. "The Science of Monetary Policy: A New Keynesian Perspective." *Journal of Economic Literature*, December 1999, *37*(4), pp. 1661-707.

Clouse, James; Henderson, Dale; Orphanides, Athanasios; Small, David and Tinsley, Peter. "Monetary Policy When the Nominal Short-Term Interest Rate Is Zero." Board of Governors of the Federal Reserve System *Finance and Economics Discussion Series*, 2000-51.

Controlling Monetary Aggregates. Federal Reserve Bank of Boston *Conference Series No. 1*, June 1969.

Freedman, Charles. "The Framework for the Conduct of Monetary Policy in Canada: Some Recent Developments." Presented to the Ottawa Economics Association, 25 January 2000.

Friedman, Milton. *A Program for Monetary Stability*. New York: Fordham University Press, 1960.

___________ and Meiselman, David. "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958," in *Stabilization Policies*. Englewood Cliffs, N.J.: Prentice Hall, 1963, pp. 165–268.

Fuhrer, Jeffrey C. and Moore, George R. "Inflation Persistence." *Quarterly Journal of Economics*, February 1995, *110*(1), pp. 127-59.

Fujiki, Hiroshi; Okina, Kunio and Shiratsuka, Shigenori. "Monetary Policy Under Zero Interest Rate: Viewpoints of Central Bank Economists." Bank of Japan *Monetary and Economic Studies*, February 2001, *19*(1).

Hafer, R.W. and Wheelock, David C. "The Rise and Fall of a Policy Rule: Monetarism at the St. Louis Fed, 1968-86." Federal Reserve Bank of St. Louis *Review*, January/February 2001, *83*(1), pp. 1-24.

Krugman, Paul. "Japan's Trap." <http://web.mit.edu.krugman/www/japtrap.html>, MIT, May 1998.

McCallum, Bennett T. "Monetary Policy Analysis in Models Without Money." Federal Reserve Bank of St. Louis *Review*, July/August 2001, *83*(4), pp. 145-60.

Meltzer, Allan. "The Transmission Process," prepared for The Monetary Transmission Process: Recent Developments and Lessons for Europe, Bundesbank, Frankfurt, Germany, 26-27 March 1999.

Meulendyke, Ann-Marie. *U.S. Monetary Policy and Financial Markets*. New York: Federal Reserve Bank of New York, 1998.

Orphanides, Athanasios and Porter, Richard D. "Money and Inflation: The Role of Information Regarding the Determinants of M2 Behavior." Unpublished manuscript, Board of Governors of the Federal Reserve System [prepared for the European Central Bank Seminar on Monetary Analysis: Tools and Applications, November 2000].

Svensson, Lars E.O. "The Zero Bound in an Open Economy: A Foolproof Way of Escaping from a Liquidity Trap." Bank of Japan *Monetary and Economic Studies* (Special Edition), February 2001, 19(S-1), pp. 277-312.

The Creation of the Euro and the Role of the Dollar in International Markets

Patricia S. Pollard

During the nineteenth and the first half of the twentieth centuries, the British pound was the preeminent international currency. It was used in both international trade and financial transactions and circulated throughout the British empire. With the decline of British economic power in the 20th century, the U.S. dollar replaced the pound as the leading international currency. For over 50 years the U.S. dollar has been the leading currency used in international trade and debt contracts. Primary commodities are generally priced in dollars on world exchanges. Central banks and governments hold the bulk of their foreign exchange reserves in dollars. In addition, in some countries dollars are accepted for making transactions as readily as (if not more so than) the domestic currency.

On January 1, 1999, a new currency—the euro—was created, culminating the progress toward economic and monetary union in Europe. The euro replaced the currencies of 11 European countries: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.[1] Two years later Greece became the 12th member of the euro area.

Although the Japanese yen and particularly the German mark have been used internationally in the past several decades, neither currency approached the international use of the dollar. With the creation of the euro, for the first time the dollar has a potential rival for the status as the primary international currency. What changes in the international use of the dollar have occurred in the first two years of the euro's existence? What changes are likely over the next decade? Moreover, what are the implications for the United States and the euro area as a result of these changes? To answer these questions, this article begins with an overview of the functions of an international currency and the major factors that determine whether a currency will be used outside its borders. It then examines the use of currencies in international markets prior to the establishment of the euro and the changes brought about by the creation of the euro.[2]

Patricia S. Pollard is a research officer and economist at the Federal Reserve Bank of St. Louis. Heidi L. Beyer provided research assistance.

FUNCTIONS OF AN INTERNATIONAL CURRENCY

Economists define money as anything that serves the following three functions: a unit of account, a store of value, and a medium of exchange. To operate as a unit of account, prices must be set in terms of the money. To function as a store of value, the purchasing power of money must be maintained over time.[3] To function as a medium of exchange, the money must be used for purchasing goods and services. For an international currency, one used as money outside its country of issue, these functions are generally divided by sector of use—private and official, as listed in Table 1.[4]

A currency serves as a unit of account for private international transactions if it is used as an invoice currency in international trade contracts. It serves as a store of value if international financial assets are denominated in this currency. It serves as a medium of exchange internationally if it is used as a vehicle currency through which two other currencies are traded, and as a substitute for a domestic currency.

A currency serves as a unit of account for official international purposes if it is used as an exchange rate peg. It serves (i) as a store of value if governments and/or central banks hold foreign exchange

[1] Although the national currencies will continue to exist until 2002, they are merely subunits of the euro.

[2] Between the time that the Treaty on European Union established the process for the completion of economic and monetary union and the creation of the euro, many economists studied the likely international role of the euro. Among these are Bekx (1998), Bénassy-Quéré, Mojon, and Schor (1998), Bergsten (1997), Hartmann (1996), Johnson (1994), Kenen (1993), Pollard (1998), and Portes and Ray (1998). Most of these studies concluded that the euro would be a major international currency but that the process would be gradual. Bergsten and Portes and Ray, however, expected a quick ascent for the euro.

[3] This is the most difficult role for currency to achieve. Inflation reduces the purchasing power of money. As long as inflation is moderate, the ability of money to operate as a unit of account and medium of exchange ensure its continued use. Hyperinflation causes money to lose its store of value function and is associated with an increase in the use of barter and substitute currencies.

[4] This sectoral division of the three functions of international money was first adopted by Cohen (1971).

© 2001, THE FEDERAL RESERVE BANK OF ST. LOUIS

Table 1

Functions of an International Currency

	Sector	
Function	Private	Official
Unit of account	Invoice	Exchange rate peg
Store of value	Financial assets	Reserves
Medium of exchange	Vehicle/substitution	Intervention

reserves in this currency and (ii) as a medium of exchange if it is used for intervening in currency markets.

The three functions of an international currency reinforce each other. For example, the use of a currency for invoicing trade and holding financial assets increases the likelihood that the currency will be used as a vehicle currency. In the official sector, if a country pegs its exchange rate to another currency, it is likely to hold reserves in that currency and conduct its interventions in exchange markets in that currency. In addition, the use of an international currency by one sector reinforces its use by the other sector. For example, using a currency as an exchange rate peg facilitates the use of that currency in debt contracts and foreign trade.

DETERMINANTS OF AN INTERNATIONAL CURRENCY

What determines the likelihood that a currency will be used in the international exchange of goods, services, and assets? Five key factors are as follows:

- Size of the economy
- Importance in international trade
- Size, depth, liquidity, and openness of domestic financial markets
- Convertibility of the currency
- Macroeconomic policies

The size of a country's economy is important because it determines the potential use of the currency in international markets. Economic size is linked with the importance of a country in international trade and the size of its financial markets. For example, exports account for a much greater share of the output of the Korean economy than for the U.S. economy. Nevertheless, because the U.S. economy is nearly 14 times larger than the Korean economy, U.S. exports comprise a much larger share of world exports.

Clearly the dominance of the U.S. economy and the decline of the U.K. economy in the twentieth century were related to the rise of the dollar and the decline of the pound as international currencies. Likewise, the growth of the German and Japanese economies in the last several decades of the twentieth century prompted the use of their currencies in international markets. As a result, the overwhelming dominance the dollar held in international markets in the 1950s and 1960s diminished.

Table 2 compares the relative size of the U.S., euro-area, and Japanese economies. The U.S. economy is the largest in the world, accounting for about 22 percent of world output. The establishment of economic and monetary union in Europe, linked through the euro, has created the world's second largest economy. The Japanese economy is less than half the size of the euro area.[5]

The share of a country in international trade as well as the size and openness of its financial markets are determinants of the demand for that country's currency in world markets. The United States accounts for a lower share of world exports than does the current euro area, as shown in Table 2. The size of U.S. financial markets as measured by the sum of bank assets, outstanding domestic debt securities, and stock market capitalization, however, is much larger than in the euro area. Japan is a distant third in terms of its share of world exports, but its financial markets are close in size to those in the euro area.

The convertibility of a country's currency is another important determinant of its use in international markets. Restrictions on the ability to

[5] In 1994 the Chinese economy surpassed the size of the Japanese economy. Based on purchasing power parity valuations of GDP, China accounted for 11.2 percent of the world's output in 1999. Nevertheless, Japan remains the world's third major economic power.

Table 2

Comparison of United States, Euro-Area, and Japanese Economies in 1999

	United States	Euro area	Japan
Share of world GDP (%)	21.9	15.8	7.6
Share of world exports (%)	15.3	19.4	9.3
Financial markets ($ billions)	40,543.8	24,133.4	20,888.5
Bank assets ($ billions)	7,555.3	12,731.3	6,662.5
Domestic debt securities outstanding ($ billions)	15,426.3	5,521.9	6,444.9
Stock market capitalization ($ billions)	17,562.2	5,880.2	7,781.4

NOTE: GDP is based on purchasing power parity equivalents. World exports excludes intra-euro-area trade.

SOURCE: GDP: IMF, *World Economic Outlook*, October 2000. Exports: IMF, *Direction of Trade Statistics Quarterly*, September 2000. Bank assets: European Central Bank, *Monthly Bulletin*; Board of Governors of the Federal Reserve System, *Flow of Funds Accounts*; IMF, *International Financial Statistics*. Debt securities: Bank for International Settlements, *Quarterly Review of International Banking and Financial Market Developments*. Stock market: Eurostat.

exchange a currency for other currencies limits its global use. At the end of World War II almost every country, with the exception of the United States, restricted the convertibility of its currency. This inconvertibility persisted for the first decade after the war. The convertibility of the U.S. dollar prompted its use as the currency in which international trade was conducted.

Macroeconomic policies also play an important role in determining whether a country's currency will be used internationally. These policies affect a country's economic growth and its openness to the world economy. Policies fostering a low inflation environment are especially important. Countries experiencing hyperinflation and/or political crises often see the use of their currencies collapse not only internationally but also within the domestic economy, as residents turn to a substitute currency.

Clearly the size and openness of the U.S. economy have been major factors in encouraging the international use of the dollar in the post-World War II period. Its use as an international currency in the private sector and the effect of the emergence of the euro in this sector is examined in the next section.

THE PRIVATE USES OF AN INTERNATIONAL CURRENCY

As stated above, a currency operates as an international currency in the private sector (i) if international trade and debt contracts are priced in this currency; (ii) if this currency is used to facilitate the exchange of other currencies; and (iii) if this currency is used as a substitute currency.

Invoice Currency

The dollar is the main currency that functions as a unit of account for private international transactions. Although data on the currency of invoice in international trade are limited, the available data confirm the dominance of the dollar. In 1995 the U.S. dollar was used as the invoice currency for more than half of world exports, down only slightly from 1980, as shown in Table 3. The Deutsche mark was the next most popular invoice currency, used for approximately 13 percent of world exports, followed by the French franc and the British pound. While the yen's use in world trade lagged behind these European currencies, its share had more than doubled since 1980. The combined share of the four major euro currencies was less than half that of the U.S. dollar.

More importantly, there is a clear distinction between the use of the dollar and other invoice currencies. The U.S. dollar is the only currency whose use in world trade far surpasses its country share in world trade, as shown by its internationalization ratio in Table 3. An internationalization ratio less than 1.0, as with the yen, lira, and guilder, indicates that not all of that country's exports are denominated in the local currency. An internationalization ratio greater than 1.0, as with the dollar, the mark, and the pound, indicates that other coun-

Table 3

Trade Invoiced in Major Currencies

Currency	Percent of world exports 1980	Percent of world exports 1995	Internationalization ratio 1980	Internationalization ratio 1995
U.S. dollar	56.4	52.0	4.5	3.9
Japanese yen	2.1	4.7	0.3	0.6
Deutsche mark	13.6	13.2	1.4	1.4
French franc	6.2	5.5	0.9	1.0
British pound	6.5	5.4	1.1	1.1
Italian lira	2.2	3.3	0.5	0.8
Netherlands guilder	2.6	2.8	0.7	0.9
Euro-4	24.6	24.8	NA	NA

NOTE: Euro-4 is the share of the four euro-area currencies listed in the table. No data were available for the other euro-area currencies. World exports includes intra-euro-area trade. The internationalization ratio is the ratio of the share of world exports denominated in a currency to the share of the issuing country in world exports.

SOURCE: Bekx (1998, Table 3, p. 8).

tries use that currency to invoice some (or all) of their exports.[6]

What determines the currency of invoice in world trade? A number of studies including those by Grassman (1973), Page (1981), and Black (1990) revealed the following patterns. Trade in manufactured goods among the industrial economies is most often priced in the currency of the exporter. If the exporter's currency is not used, then the importer's currency is the most frequent choice. Only rarely is a third country's currency used. Trade between industrial and developing countries is generally priced in the currency of the industrial country or that of a third country. Trade between developing countries is often priced in the currency of a third country. When a third country's currency is used for invoicing trade, the U.S. dollar is the most likely choice. Trade in primary commodities is almost always invoiced in U.S. dollars because these products are predominantly priced in dollars on international exchanges.

According to Hartmann (1996), two factors that explain these patterns are transaction costs and acceptability. The lower the cost of buying and selling a currency in the foreign exchange market, the more likely is its use for invoicing trade. In addition, the more accepted a currency is for other transactions, the more likely it is to be used as an invoice currency. Clearly these two factors are mutually supportive. The more accepted a currency is, the lower its transaction costs; the lower its transaction costs, the more likely it is to be accepted.

Related factors that explain these patterns are convertibility and the expected stability of the currency. As noted above, the use of the dollar as an invoice currency was prompted by the lack of convertibility of most other currencies in the 1950s. The limited use of developing countries' currencies in world trade arose in part because many of these countries restricted (and some continue to restrict) the convertibility of their currencies. Black (1990) showed that the share of a country's exports denominated in its domestic currency declines the greater is the expected depreciation of its currency. Thus, the currencies of countries with high inflation are seldom used in international trade.

The mere creation of the euro as a currency should provide ample incentive for its use as an invoice currency. Replacing the currencies of 12 countries with a single currency reduces the transaction costs involved in currency exchanges. Although only a small number of firms within the euro area have already switched to invoicing in euros, the advent of euro notes and coins, along

[6] An internationalization ratio greater than or equal to 1.0 does not imply that all of the home country's exports are priced in its currency. According to data provided in Bekx (1998) in 1995, 92 percent of U.S. exports, 75 percent of German exports, 62 percent of British exports, and 52 percent of French exports were invoiced in their domestic currencies.

Table 4

Volatility of Real Oil Prices in the United States and Germany* (Percent)

Year	Volatility of real U.S. $ price	Volatility of real DM price	F-test probability†
1985	4.5	5.7	48.8
1986	17.8	17.3	93.6
1987	5.7	5.8	96.6
1988	8.2	8.1	96.3
1989	6.3	6.9	79.0
1990	18.9	17.8	84.0
1991	8.6	9.5	74.8
1992	4.4	4.5	95.9
1993	4.6	4.9	85.6
1994	5.4	5.2	91.3
1995	5.3	6.2	61.4
1996	6.1	6.6	80.5
1997	6.8	6.3	79.4
1998	8.2	6.7	50.4
1999	9.4	10.0	84.3
2000	11.6	13.4	64.2

NOTE: Shaded rows indicate no statistical difference in the volatility of real dollar vs. real mark crude oil prices.

*Volatility is measured by the standard deviation of monthly changes in the real price of oil.

†The last column shows the probability that the standard deviations of the two series are statistically equal.

SOURCE: IMF, *International Financial Statistics*, and *Wall Street Journal*.

with the withdrawal from circulation of the notes and coins of the legacy currencies in 2002, will prompt several changes. According to Page (1981), the use of the dollar is negligible in intra-European Union trade, so the creation of the euro should not have had a noticeable effect on invoicing in the region. Where its effect is likely to be largest is in extra-euro-area trade, where most exports are likely to be invoiced in euros. It is unlikely, however, that trade currently invoiced in dollars and involving neither the euro area nor the United States will shift in the near term to euros. This argument is supported by the European Central Bank (ECB), which estimates that the percent of world exports denominated in euros "is likely not to differ significantly from that of euro area exports" (ECB, 1999, p. 36). Thus, the internationalization ratio for the euro area will be close to 1.

What effects will the use of the euro as an invoice currency have on the euro area and the United States? For firms in the euro area, gains will arise from a reduction in transactions costs and exchange rate risk. In intra-euro-area trade, exchange rate risk has already been eliminated and the transactions costs will be eliminated by 2002. Turning to the external trade of the euro area, the smaller euro-area countries will gain the most from the reduction in transactions costs because, prior to the establishment of the euro, the limited demand for their currencies resulted in higher costs for exchanging their currencies for other currencies. A rise in the share of euro-area external trade invoiced in euros may also reduce the exposure of its businesses to short-term exchange rate variability. To the extent that there is an increase in the use of the euro in trade between the euro area and the United States, the exposure of U.S. businesses to exchange rate risk will rise. The importance of such a change is unclear. There exists a wide range of options to hedge exchange rate risk, but these options are not costless. Magee and Rao (1980), however, argue that the currency of denomination in trade contracts is irrelevant if both the exporter and importer have the same risk preferences; this

Table 5

Funds Raised in International Bond Markets by Currency of Issue (Percent)

Currency	1950-59	1960-69	1970-79	1980-89
U.S. dollar	78.2	69.9	49.2	50.7
Japanese yen	0.0	0.0	5.2	8.9
Swiss franc	7.1	5.4	17.5	11.4
Euro area*	3.2	20.3	24.1	15.8
Deutsche mark	2.0	16.3	17.9	8.0
Other E.U.†	8.7	3.1	0.7	6.8
Pound sterling	8.3	2.9	0.6	6.4

*Euro area includes the currencies of all current members of the euro area and currency composites, such as the ecu.

†Other E.U. includes the currencies of Denmark, Greece, Sweden, and the United Kingdom.

SOURCE: OECD, *International Capital Market Statistics*, 1996, and *Financial Statistics Monthly*, June 1997.

is so because the contract price should incorporate an exchange rate risk premium.

The dollar is also the main currency used for pricing internationally traded commodities, with the British pound being the only other currency used. As Tavlas (1997) notes, the commodity exchanges on which these products are traded are located in countries "that have a comparative advantage as financial centers," thus explaining the dominance of the United States and the United Kingdom and hence the currency choice.

The creation of the euro is unlikely to lead to any change in the pricing of these commodities. The location of major commodity exchanges in the United States, while not a necessary requirement for dollar pricing, does increase the likelihood that these commodities will continue to be priced in dollars. Although it is possible that an integrated Europe will develop commodity exchanges to rival those of the United States, such a shift is likely to be gradual. Any shift in pricing of these commodities is unlikely to occur until the stability of Europe's new monetary system is well established.[7]

Suppose, however, that there is eventually a shift in the pricing of commodities from dollars to euros. Would such a change increase the volatility of these prices for U.S. consumers while lowering the volatility for euro-area consumers? For this to occur, exchange rate fluctuations must not only introduce another source of volatility into the price of these commodities but must be positively correlated with the price volatility. There is no reason to expect this to hold. An examination of data on the real price of crude oil in U.S. dollars and in Deutsche marks illustrates this point. The real price of oil in the U.S. depends on the dollar price of oil in international markets and the U.S. inflation rate, whereas the real price of oil in Germany depends on the dollar price of oil in international markets, the mark/dollar (now euro/dollar) exchange rate, and the German inflation rate. Table 4 indicates the yearly volatility of each of these measures from 1985 to 2000. In 3 of the 16 years there was no statistical difference in the volatility of the real dollar price and the real mark price of crude oil.[8] In 8 of the 16 years the volatility of the real mark price was greater than the volatility of the real dollar price. In the remaining 5 years the volatility of the real dollar price was greater than the volatility of the real mark price. These data do not provide clear support for the idea that having commodities priced in a country's domestic currency on world exchanges results in lower variability in the real domestic-currency price of the commodity.

Financial Assets

In international bond markets the U.S. dollar was the currency of choice for nearly all issues in

[7] In October 2000, Iraq began requiring payment for its oil exports in euros. There is no indication that this move will be followed by other major oil producers. A general shift to requiring payment in euros would probably hasten a switch to pricing oil in euros, but such a dual system is not without precedent. Bénassy and Deusy-Fournier (1994) state that until 1974 oil was priced in dollars, but payment was made in pounds sterling.

[8] Measured by a 95 percent or higher probability.

Table 6

International Debt Securities by Currency of Issue (Percent)

Currency	Amounts outstanding 1993	Amounts outstanding 1998	Amounts outstanding 2000	Share of new issues 1998	Share of new issues 1999	Share of new issues 2000
Total securities						
U.S. dollar	41.1	45.9	48.7	54.1	45.2	44.0
Japanese yen	13.2	11.3	8.2	5.6	5.3	8.3
Swiss franc	7.3	3.8	2.2	3.3	2.0	1.7
Euro area*	24.8	27.2	30.1	24.6	36.8	33.9
Other E.U.†	7.9	8.5	8.2	8.9	8.0	9.2
Pound sterling	7.6	7.9	7.8	8.3	7.7	9.1
Bonds and notes						
U.S. dollar	38.9	45.3	48.7	51.1	43.8	42.3
Japanese yen	14.0	11.7	8.6	6.3	6.7	11.4
Swiss franc	7.7	3.8	2.2	2.7	1.6	1.4
Euro area*	25.7	27.6	30.0	28.0	38.3	34.2
Other E.U.†	8.1	8.5	8.1	9.0	7.3	8.4
Pound sterling	7.8	7.9	7.7	8.2	7.0	8.2
Money Market						
U.S. dollar	79.4	59.9	49.1	61.0	48.8	47.5
Japanese yen	0.2	2.5	2.3	4.0	1.4	1.9
Swiss franc	1.8	4.5	2.3	4.7	2.9	2.3
Euro area*	8.5	19.2	32.4	17.2	32.9	33.2
Other E.U.†	4.1	8.4	9.5	8.8	9.8	11.0
Pound sterling	4.0	8.3	9.3	8.7	9.7	11.0

*Euro area includes the currencies of the 11 original members of the euro area and currency composites, such as the ecu.

†Other E.U. includes the currencies of Denmark, Sweden, and the United Kingdom.

SOURCE: Bank for International Settlements, *Quarterly Review of International Banking and Financial Market Developments*, March 2001.

the 1950s. By the 1970s, however, the currency denomination of bond issues had become more diversified, as shown in Table 5. Nevertheless, the U.S. dollar has remained the most popular currency choice for issuing bonds in international markets, as shown in Table 6.[9] By the 1960s the euro legacy currencies, taken together as a group, had become the second most widely used currency in international bond markets, a status that continues today. The Japanese yen was not used at all until the 1970s, and its share of new issues lags far below that of the dollar or euro. The use of the Swiss franc in international bond markets, which rivaled the Deutsche mark in the 1970s, declined precipitously in the 1990s.[10]

In international money markets as well, the dollar is the currency of choice, but again its dominance has declined, as noted in Table 6. The increased use of the euro legacy currencies in these markets during the 1990s is particularly noteworthy. In 1993 these currencies accounted for 8.5 percent of the outstanding debt in international money markets. By 1998 this share had increased to 19.2 percent.

9 The data in Tables 5 and 6 rely on different sources and hence may not be directly comparable.

10 Some policymakers in Switzerland were concerned that the creation of the euro might result in a sharp rise in demand for assets denominated in Swiss francs. See Laxton and Prasad (1997) for an analysis of this argument.

Table 7

Banks' Cross-Border Positions: Amounts Outstanding* (Percent)

Currency	1983-89	1990-99	1998	1999	2000:Q3
Assets					
U.S. dollar	59.7	47.0	45.2	45.4	47.0
Japanese yen	10.0	12.0	11.6	10.3	9.9
Euro area†	18.6	27.4	28.1	31.8	30.7
Pound sterling	3.4	4.3	4.9	4.9	5.1
Liabilities					
U.S. dollar	62.4	49.3	47.6	49.9	51.9
Japanese yen	7.9	8.0	8.4	7.8	7.4
Euro area†	17.2	26.8	26.3	26.9	25.4
Pound sterling	4.3	5.6	6.5	6.7	6.9

*Includes both domestic and foreign currency assets and liabilities.

†Euro area includes the banks of the 11 original members of the euro area.

SOURCE: Bank for International Settlements, *Quarterly Review of International Banking and Financial Market Developments*, March 2001.

The creation of the euro led to a sharp rise in its use in international debt markets relative to its legacy currencies. The share of new issues of international securities denominated in the euro legacy currencies was 24.6 percent in 1998. In the following year, the share denominated in euros was 36.8 percent. Although the use of the euro relative to its legacy currencies rose strongly in both the bond and money market, the increase was highest in the money market. In international debt markets, there is now a clear alternative to the use of the dollar.[11]

In international banking there is also evidence of currency diversification over the last two decades. Table 7 shows the assets and liabilities of banks accounted for by transactions with foreign residents (either in the domestic or foreign currencies). During the 1980s, 60 percent of the cross-border assets of banks were in dollars and 19 percent in the euro legacy currencies. In the 1990s, the dollar's share fell to 47 percent and the euro legacy currencies' share rose to 27 percent. A similar pattern is noted for cross-border liabilities. The advent of the euro, however, has had little initial effect on international banking. The dollar's share of cross-border assets remained nearly constant while its share of cross-border liabilities increased slightly. The opposite pattern held for euros. There was a slight increase in the share of cross-border assets denominated in euros, relative to the euro legacy currencies, and virtually no change in liabilities.[12]

The use of a country's currency in international capital markets is determined by the size, openness, and liquidity of that country's financial markets and the stability of its currency. The decline in the dollar's dominance in world capital markets, prior to the creation of the euro, is a result of the emergence of other strong economies that, in conjunction with the liberalization and deregulation of financial systems worldwide, increased the attractiveness of assets denominated in other currencies. This is particularly evident in the bond markets where there has been a rapid increase in the number of currencies used.

The creation of the euro has spurred changes within euro-area financial markets. Integration has been most evident in the money market. Overnight interbank interest rates have become nearly harmonized throughout the euro area, aided in part by the creation of the TARGET payments system and also by the common monetary policy.[13] Although the unsecured deposit market has become highly integrated, other aspects of the money market (for

[11] Kool (2000) addresses the use of the euro in international bond markets.

[12] The data in Table 7 do not exclude bank transactions between members of the euro area.

[13] TARGET is an acronym for Trans-European Automated Real-time Gross settlement Express Transfer system.

example the repo market and short-term securities market) remain more segregated.[14]

There also has been some progress in the bond market as both the size and integration of the market have increased accompanied by an increase in liquidity in the secondary market.[15] Although there has been an increase in euro bonds issued by residents outside the euro area, most of the international issues were placed by euro-area residents.[16] One reason for the sharp increase in the latter issues is that the establishment of the euro reduced barriers to cross-border investment within the euro area. For example, insurance companies and some pension funds within the euro area are restricted in their ability to issue international debt. Liabilities in a foreign currency must be 80 percent matched by assets in that same currency. With the creation of the euro this matching rule becomes less restrictive.

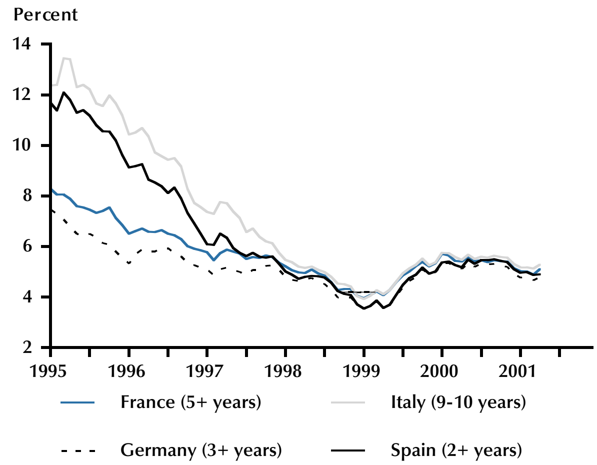
Despite this progress, Santillán et al. (2000) note that the euro-area corporate bond market lags that of the United States with regard to liquidity, size, and market completeness. Indeed the ability of European capital markets to rival those of the United States, at least in the short-term, is not certain. Cecchetti (1999) cautions that differences in legal structures across Europe will limit the degree of integration of financial structures. Kregel (2000) argues that the European monetary union is based on "an internal contradiction which attempts to combine the preservation of the institutional characteristics of national markets with convergence of macroeconomic performance." Thus he states it is not clear that the introduction of the euro will eliminate national segmentation.

This segmentation also exists in the euro-area government bond market. Although differences in yields on government bonds issued by the member states of the euro area have declined in the last several years, complete convergence has not occurred. According to a report by the Bank for International Settlements (BIS) (2000b), these differences are caused not so much by differences in risk but by "technical and liquidity considerations." The report further notes that this lack of integration implies that no euro-area government bond market can serve as a benchmark for the whole euro area and as such there is no "well defined reference government yield curve" that would aid the pricing of euro-area corporate bond issues, among other things.

Figure 1 illustrates these points using long-term government bond yields for four euro-area countries. There was a noticeable convergence in yields as

Figure 1

Government Bond Yields
Monthly data, various euro-area countries



SOURCE: IMF, *International Financial Statistics*.

monetary union approached. Although differences remain, these are likely related to the lack of a common benchmark. As Figure 1 shows, there is no standard maturity structure for bonds in the euro area.

The euro-area government bond market thus does not present itself as a challenger to the U.S. market, which benefits from having a single issuer—the U.S. Treasury. In addition, in the United States, the Federal Reserve plays a role in the liquidity of the government bond market.[17] Prati and Schinasi (1997) argue that the use of open market operations as the primary tool of monetary policy by the Federal Reserve "has fostered the development of efficient money and securities markets in the United States." Daily Federal Reserve activity in the securities market, they state, occurs not simply from a monetary policy objective but the desire to promote "the smooth functioning and stability of financial mar-

[14] For a discussion of developments in these markets, see European Central Bank (2000) and International Monetary Fund (1999).

[15] See Santillán et al. (2000) for an analysis of the effects of the euro on the money and bond markets in Europe.

[16] Unlike the trade data, international bond market data currently do not exclude cross-border transactions within the euro area.

[17] The recent reduction in the federal debt has raised concerns about the future liquidity of the U.S. Treasury market. See Fleming (2000) and Bennet et al. (2000) for a discussion of the effects of the decline in public debt and ways to maintain liquidity in the Treasury market.

Table 8

Foreign Exchange Market Transactions Involving Select Currencies (Percent of Total) April 1998

Category	U.S. dollar	Japanese yen	Deutsche mark	French franc	Euro area*	Pound sterling
Spot	78.8	24.7	42.7	3.3	56.8	11.6
Forwards	81.4	26.7	28.0	5.1	50.7	12.3
Swaps	95.2	16.7	20.0	6.5	48.8	10.2
Total	87.4	20.8	29.8	5.1	52.2	11.0

*Euro area includes the currencies of the current member countries plus the Danish krone and the ecu.

SOURCE: Bank for International Settlements, *Central Bank Survey of Foreign Exchange and Derivatives Market Activity 1998*. Basle: BIS, May 1999.

kets." Whereas, the infrequent interventions by individual European central banks in securities markets "tended to discourage the development of private securities markets and foster the predominance of bank-intermediated finance." The ECB has continued this practice of infrequent interventions. In general, it is active in securities markets only once per week.

For now U.S. financial markets continue to lead the world in both size and liquidity. As a result, the U.S. dollar remains the major currency in international bond markets. The euro, however, has already become a major player in these markets, and its use will likely expand as euro-area financial market integration proceeds. The development of a euro-area capital market similar to the U.S. market should provide benefits to both economies by increasing the options available to borrowers and lenders on both sides of the Atlantic.

Vehicle Currency

There are no direct data available on vehicle currencies, but this information can be gleaned from the shares of currencies in foreign exchange transactions, as shown in Table 8.[18] In 1998 the dollar was involved in 87 percent of all currency exchanges.[19] The euro legacy currencies were involved in 52 percent of all exchanges, with the Deutsche mark the most often traded of these currencies. The yen was used in 21 percent of all currency trades. The dollar's dominance was especially clear in forward and swap transactions. The dollar was involved in 81 percent of all forward trades compared with the mark's and yen's shares of 28 and 27 percent, respectively. In swaps the contrast was even greater. The dollar was involved in 95 percent of all swaps, with the mark and yen taking part in 20 and 17 percent, respectively, of all trades.

The use of the dollar in foreign exchange transactions was well above its use in international trade and debt contracts, indicating its role as a vehicle currency. The BIS (1999) notes that evidence of the dollar's role as a vehicle currency is provided by its use in seven of the ten most heavily traded currency pairs. The report also notes that it is standard practice for the dollar to be used as a vehicle currency in swaps, which explains the high percentage of swaps involving the U.S. dollar and the low use of the yen and mark in these trades.

The use of a currency as a vehicle currency is determined primarily by transactions costs. Transactions costs are inversely related to volume in each bilateral currency market.[20] This volume is in turn determined by a currency's share in international trade and capital flows. Thus, the use of a currency in invoicing international trade, in international capital markets, and as a reserve currency lowers the transactions costs associated with the use of that currency.

A vehicle currency emerges whenever the indirect exchange costs through the vehicle are less than direct exchange costs between two non-vehicle currencies. For example, given the depth of the exchange market for dollars, it may be less costly

[18] These data are gathered from a triennial survey of foreign exchange markets conducted by the BIS.

[19] Since there are two currencies involved in an exchange, the total share of all currencies traded on international exchanges will equal 200 percent. However, a single currency can, at most, be involved in 100 percent of all exchanges.

[20] The use of transactions cost theory to explain the rise of a vehicle currency was developed by Krugman (1980) and Chrystal (1984).

to exchange Mexican pesos for U.S. dollars and then exchange U.S. dollars for Korean won rather than to exchange pesos directly for won. Indeed, the existence of transaction costs may reinforce the use of the dollar as an invoice currency.

The extent of liquidity in asset markets also affects the development of a vehicle currency. Banks prefer to hold most of their foreign currencies in the form of interest-earning assets rather than cash. The liquidity of these assets is a key determinant of the transactions costs involved in switching from one currency to another. Liquidity is determined not simply by the size of a country's capital markets but also by the extent to which secondary markets operate.

The prospects of the euro becoming an important vehicle currency thus depend primarily on the transactions costs associated with euro exchanges. Clearly the size of the euro currency market relative to the markets for individual euro currencies will result in lower relative transactions costs for the euro. These transactions costs will also depend on the extent to which the euro is adopted as (1) an invoice currency, (2) a reserve currency, and (3) a prevalent currency in international capital markets.

Preliminary data indicate that the euro has not increased its role as a vehicle currency to a level beyond that of the mark. According to the BIS (2000a), the market share of the euro in currency markets during 1999 was close to the share of the Deutsche mark in 1998. Indeed, because a vehicle currency is no longer needed to facilitate exchanges among the euro currencies, the use of the euro as a vehicle currency has probably declined relative to that of the mark. Evidence on the limited use of the euro as a vehicle currency is also provided by data from foreign exchange markets in emerging market countries. The use of the euro in these markets during 1999 was concentrated in Eastern Europe, again similar to that of the mark in 1998. In Thailand and Korea for example, the euro was involved in less than 1 percent of local currency trades (BIS 2000a).

Substitute Currency

Another role that an international currency may play is as a substitute for domestic-currency transactions. Uncertainty surrounding the purchasing power of a domestic currency can lead to the use of a foreign currency as a unit of account, store of value, and medium of exchange in the domestic economy. This generally occurs as a result of hyperinflation and/or political instability.

In the decades prior to the creation of the euro, the dollar and the mark were the only currencies used extensively outside their respective borders, with the dollar being the predominate substitute currency. In part, this predominance of the dollar was a result of the links between the United States and countries using a substitute currency. Nevertheless, the ease of availability of the dollar, which both determines and encourages its other uses as an international currency, continues to facilitate the use of the dollar as a substitute currency.

Measures of the extent to which currencies are used as substitute currencies are not easily obtained. However, the best estimates indicate that about 55 percent of the total U.S. currency held by the nonbank public was held abroad at the end of 1995.[21] About 35 percent of Deutsche mark holdings were abroad (Seitz, 1995).

The use of the U.S. dollar as a substitute currency began in earnest in the 1920s as a result of hyperinflations in several European countries.[22] Its use in Latin America expanded in the 1980s also as a result of hyperinflation. Most recently, the collapse of the Soviet Union expanded the use of the dollar in that region.[23] Although the dollar is the preferred substitute currency in the former Soviet Union, the German mark is more prevalent in some Eastern European countries as well as in the former Yugoslav republics.

The use of the dollar as a substitute currency provides a direct benefit to the United States through seigniorage earnings. These earnings are generally estimated by calculating the amount the U.S. government would have to pay if, rather than holding cash, individuals in these countries held U.S. Treasury securities. The top panel of Figure 2 provides a rough estimate of the real seigniorage earned by the United States as a result of foreign holdings of U.S. currency during the period 1973-99.[24] In real terms, seigniorage revenues have averaged $8.7

---

[21] See Anderson and Rasche (2000) and Porter and Judson (1996). According to Anderson and Rasche, the share of U.S. currency held abroad increased throughout the 1970s and 1980s but fell slightly in the 1990s.

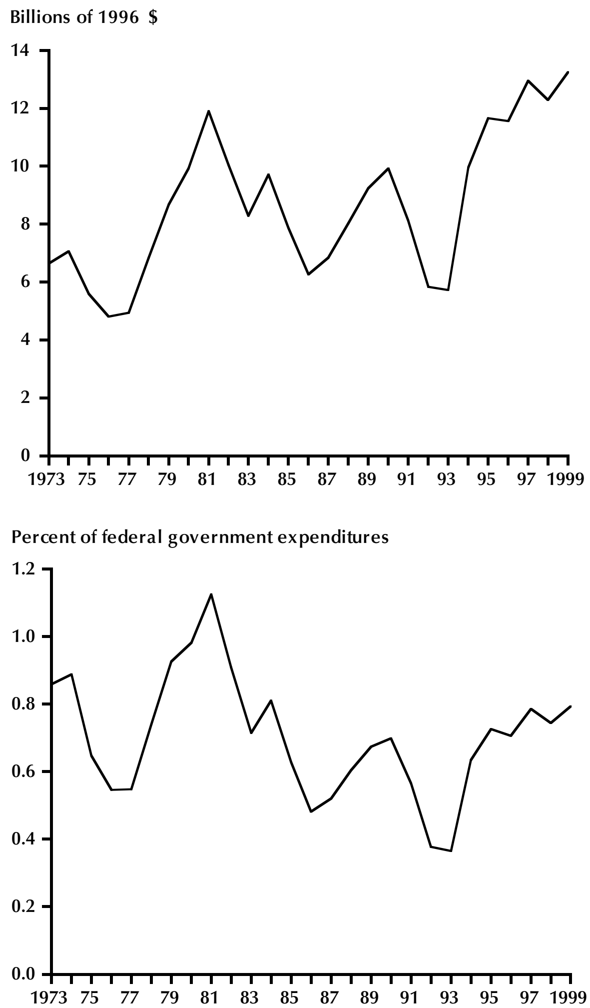
[22] The dollar was preferred to the British pound as the latter had yet to return to the gold standard after World War I.

[23] According to the U.S. Treasury (2000), Argentina and Russia are believed to have the largest holdings of U.S. currency outside the United States.

[24] These seigniorage revenues are estimated by using the interest rate on one-year Treasury bills and adjusting nominal revenues using the GDP deflator.

Figure 2

Seignorage Revenues from Foreign Holdings of U.S. Dollars



SOURCE: Department of Commerce, Bureau of Economic Analysis, and Board of Governors of the Federal Reserve System.

billion on a yearly basis over this period. One method of estimating the importance of these seigniorage revenues is to calculate the share of government expenditures accounted for by these revenues. This is shown in the bottom panel of Figure 2. On average less than 1 percent of the expenditures of the U.S. federal government have been financed by seigniorage revenues on currency held abroad.[25]

The euro is not likely to rapidly replace the dollar as the substitute currency of choice. In fact, the use of the euro as a substitute currency is likely to lag behind its use as an international currency. Foreign holders of a substitute currency want a stable, secure currency. Uncertainty surrounding the value of the euro, particularly given its decline against the dollar during the first two years of its existence, will limit the near-term attractiveness of the euro as a substitute currency.

If the euro does become increasingly used as a substitute currency, the seigniorage earnings of the ECB will rise. It is difficult to predict how large these revenues might be, as they depend on the world demand for substitute currencies, the shares of the euro and the dollar, and interest rate conditions. Emerson et al. (1992) estimated that these seigniorage revenues would, at most, amount to $2.5 billion a year for the ECB.

THE OFFICIAL USES OF AN INTERNATIONAL CURRENCY

Exchange Rate Peg

Under the Bretton Woods system that existed from 1946 to 1973, most currencies in the world were tied to the U.S. dollar. With the demise of the Bretton Woods system, many countries chose to let their currencies float while others set the value of their currency against that of another country. Of those countries choosing the latter option, most continued to peg their currency to the U.S. dollar. In 1975, 52 members countries (about 41 percent) of the International Monetary Fund (IMF) pegged their currency to the dollar, as shown in Table 9. The euro legacy currencies were the second most popular choice. The French franc was the peg for the African Financial Community (CFA) franc, the currency used by the then 13 members of the CFA; and the Spanish peseta was the exchange rate peg for the currency of Equatorial Guinea. The pound was the only other European Union currency to be used as an exchange rate peg.

Over time the popularity of currency pegs has declined. However, both the number and percentage of member countries pegging their currencies to the euro have risen. In 2000, 24 IMF member countries tied their currencies to the euro.[26] The 14

[25] The seigniorage benefits must be weighed against the problems the foreign holdings of currency create for monetary policy. As Porter and Judson (1996) note, if foreign demand for a country's currency is unrelated to domestic demand, then the interpretation of movements in monetary aggregates becomes more difficult.

[26] These 24 include San Marino, which uses the Italian lira as its currency, and Greece, which is now a member of the euro area.

Table 9

Currency Pegs

	U.S. dollar		Euro currencies		Other E.U.	
Year	Number	Percent	Number	Percent	Number	Percent
1975	52	40.6	14	10.9	8	6.3
1980	39	27.7	15	10.6	1	0.7
1985	31	20.8	14	9.4	1	0.7
1990	25	16.2	15	9.7	0	0.0
1995	22	12.2	17	9.4	0	0.0
2000	23	12.6	24	13.2	0	0.0

SOURCE: IMF, *Annual Report on Exchange Arrangements and Exchange Restrictions*, various issues.

CFA members continue to constitute the majority of countries whose currencies are tied to the euro. Most of the remaining 10 countries whose currencies are pegged to the euro hope to be in the first or second wave of enlargements of the European Union. In addition, Denmark, which is one of the three members of the European Union who are not currently members of the euro area, ties its currency to the euro through the Exchange Rate Mechanism (ERM) II.[27]

According to these data, the U.S. dollar is now the second most popular choice for a currency peg, with 23 countries officially tying their currencies to the dollar.[28] In practice, however, the dollar remains the currency against which most countries limit movements in their domestic currencies. For example, 20 countries in addition to those listed in Table 9 strictly limit the movement of their domestic currencies against the dollar. Some of these currencies are officially tied to another currency. Jordan, for example, officially pegs its currency to the SDR but in practice pegs to the U.S. dollar.

The primary reason countries choose to peg their currency to another currency is to reduce exchange rate risk and/or to control inflation. Keeping the currency stable against the peg, or setting limits on exchange rate changes, minimizes the risk to those borrowing or lending in foreign currencies or engaged in international trade. The unexpected failure of a currency peg, however, can produce sharp changes in the exchange value of the local currency and lead to losses on contracts priced in foreign currencies. Partly as a result, pegs have become less popular over the last 30 years.

For those countries who do peg, the currency choice is usually determined by trade and financial links. This explains why, among countries with currency pegs, Latin American and Caribbean countries are pegged to the dollar while most European and African countries peg to the euro. Likewise, because oil is priced in dollars on world markets, many oil exporting countries either officially or in practice limit the fluctuations of their currency against the dollar.

The introduction of the euro has not resulted in any countries shifting their peg from the dollar to the euro. Nonetheless, it is likely that the share of currencies pegged to the euro will rise as more of the countries hoping to be admitted to the European Union may peg their currencies to the euro. In addition, any European Union country wanting to enter the euro area will have to first peg to the euro.

Any effect on the euro area and the United States caused by an increase in the number of countries pegging their currencies to the euro relative to those pegging to the dollar will occur through the effects of these pegs on foreign currency reserves.

Reserve Currency

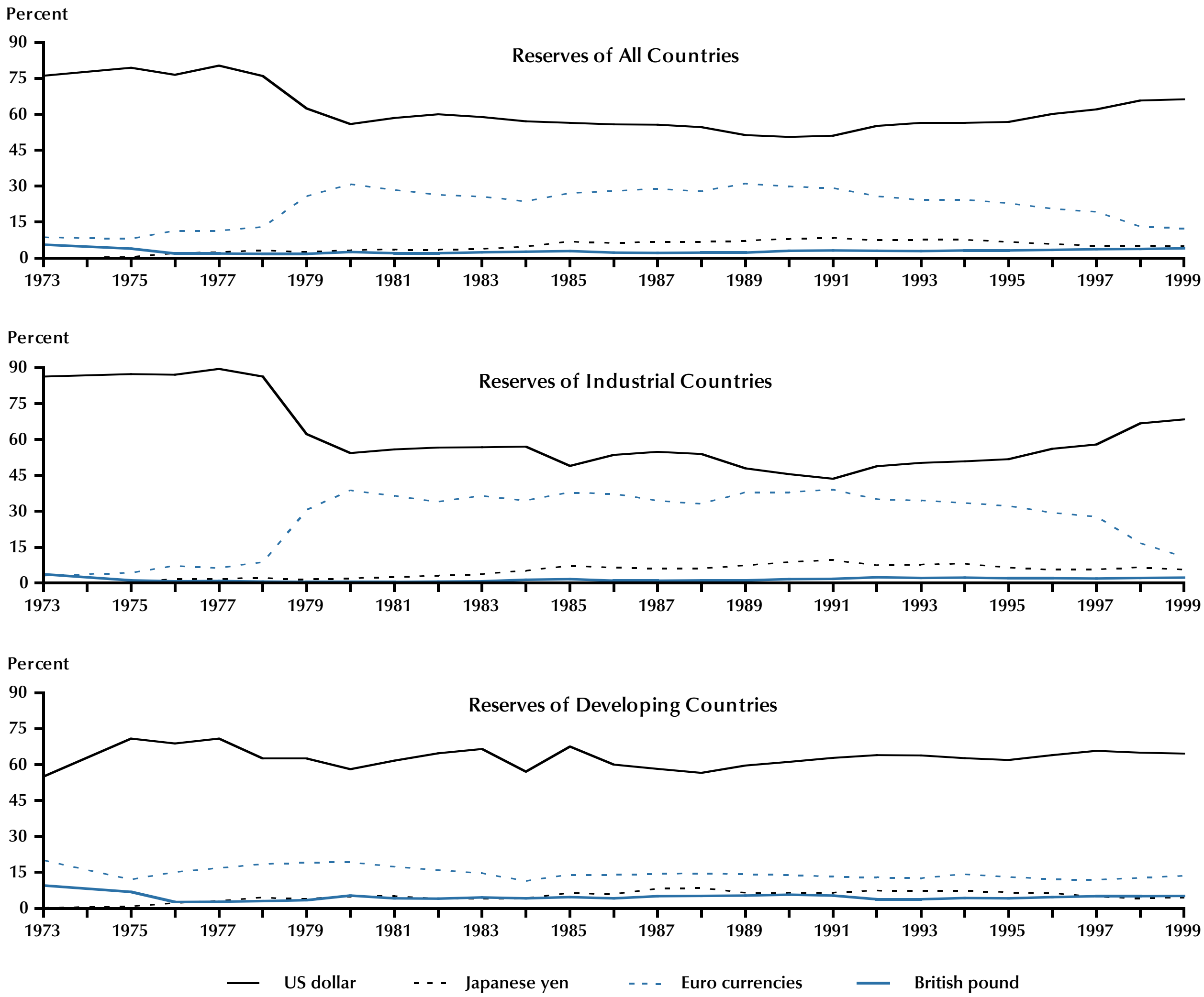
In 1973 the dollar accounted for 76.1 percent of the official foreign currency reserves held by the

[27] Established in 1979, ERM was the fixed exchange rate system of the European Monetary System. With the creation of the euro, ERM was replaced by ERM II, linking the currencies of Denmark and Greece (until January 2001) to the euro.

[28] These 23 include five countries (Ecuador, Marshall Island, Micronesia, Palau, and Panama) that use the U.S. dollar as the local currency. In January 2001, El Salvador (which is not included in the 23) also adopted the U.S. dollar.

Figure 3

Currency Composition of Foreign Exchange Reserves



SOURCE: IMF, *Annual Report* (various years).

member countries of the IMF, as shown in the top panel of Figure 3. The euro legacy currencies had an 8.7 percent share of foreign currency reserves, and the pound sterling had a 5.6 percent share. Holdings of yen were only 0.1 percent of total reserves.

The dollar's share in foreign currency reserves declined in the late 1970s as some countries diversified their holdings, shifting primarily into euro legacy currencies, particularly Deutsche marks. Although the dollar's share fell again in the late 1980s, it has increased somewhat since 1991 to stand at 66.2 percent in 1999.[29] The share of the euro currencies peaked in 1989 at 31.1 percent and has fallen steadily since then, standing at 12.5 percent in 1999. The share of the yen rose slowly through most of the 1970s and 1980s, reaching a peak of 8.5 percent in 1991. Since then the yen's share has fallen, reaching 5.1 percent in 1999.

[29] These shifts in holdings of reserves are affected both by changes in the physical holdings of currency and changes in exchange rates. Since the IMF measures reserve holdings in U.S. dollars, a rise in the exchange value of the dollar *ceteris paribus* will raise the dollar share of foreign exchange reserves.

Table 10

Currency Composition of Long-Term Debt in Developing Countries (Percent)

Currency	1970	1980	1990	1999
U.S. dollar	47.1	49.8	41.2	56.0
Japanese yen	2.3	6.9	10.5	12.6
Euro-area currencies	13.8	12.1	14.3	9.3
Pound sterling	11.2	3.4	2.3	1.2
Multiple currencies	11.6	10.9	14.7	8.2
Other currencies	14.0	16.9	17.0	12.7

SOURCE: World Bank, *Global Development Finance*, 2001.

In the 1970s the developing countries, as a group, had more diversified holdings of foreign currencies than did the industrial countries, as shown in the middle and lower panels of Figure 3. Throughout most of the 1980s and 1990s, however, the developing countries held a greater share of their reserves in dollars than did the industrial countries. Currently there is little difference in the currency composition of reserves across developing and industrial countries.These changes can be explained by examining why countries hold reserves. Governments and central banks hold reserves for three main purposes: (i) to finance imports; (ii) to finance foreign debt; and (iii) to intervene in currency markets to manage the exchange rate.[30] In advanced economies, private markets generally fulfill the role of financing trade and debt. Hence, reserves are held primarily for intervention purposes.

In developing countries all three purposes are important. The currencies in which imports are invoiced in developing countries is a key determinant of the composition of reserves. Similarly, because reserves also are important for financing foreign debt, the currency composition of this debt will affect the currency composition of reserves. As shown in Table 10, the long-term debt of developing countries is most commonly denominated in U.S. dollars.

Euro-area currencies are the next preferred choice, but this share has declined slightly over the past 30 years. Most noticeable has been the decline in the use of the pound in debt contracts of developing countries. This decline is partly reflected in the relative fall in pound reserves held by developing countries. In contrast, the rise in use of the yen in debt contracts between 1970 and 1990 is reflected in the rise in yen foreign exchange reserves.

The currency choice of reserves for intervention purposes depends in part on a country's exchange rate regime. Heller and Knight (1978) showed that, if a country pegged its exchange rate to a particular currency, that currency's share in its reserves rose. Dooley et al. (1989) showed that industrial economies with flexible exchange rates had a high share of dollar reserves and a low share of Deutsche mark reserves. Among industrial economies, the main fixed exchange rate regime was the ERM. The establishment of the ERM in 1979 coincides with the sharp rise in the share of euro legacy currencies (particularly marks) in the foreign currency reserves of industrial economies.[31] The importance of the exchange rate arrangement in determining the currency composition of a country's reserves is linked to the use of these reserves for intervening in the currency markets.

The risk and return on currencies is also a factor in determining the currency composition of reserves. Most reserves are held in the form of government securities. Thus, changes in the relative return on these securities in conjunction with the depreciation risk, particularly if sustained over a long period, may cause shifts in a country's composition of reserves. In addition, the liquidity of government securities markets is a factor in determining the choice of reserve currency because reserves may need to be sold quickly for intervention purposes.

[30] See Ben-Bassat (1980, 1984) and Dooley et al. (1989).

[31] Data in Masson and Turtelboom (1997) indicate that the European Union countries held 69 percent of the Deutsche mark reserves held by industrial countries in 1995.

What has been the initial effect of the creation of the euro on the currency composition of reserves? As Figure 3 indicates, the dollar's share has risen and the euro's share has fallen. This occurred for two reasons: the elimination of ecu reserves and the reclassification of intra-euro-area holdings of euro currency reserves.[32] At the end of 1997, ecu reserves accounted for 10.7 percent of the foreign currency reserves of industrial countries and 5.0 percent of the reserves of all countries. Most of these ecu reserves were claims on the European Monetary Institute, the precursor to the European Central Bank. They had been issued to the central banks of the European Union countries in exchange for gold and dollar deposits. In late 1998 the deposits were returned to these central banks and the ecu reserves were eliminated. This explains the sharp drop in euro legacy currency reserves in the industrial countries in 1998. With the advent of the euro in 1999, holdings by euro-area countries of the euro legacy currencies ceased to be foreign currency reserves. This led to a further decline in the share of the euro in the foreign currency reserves of industrial countries.

The importance of the transition to the euro in driving movements in the currency composition of worldwide reserves over the last two years is further indicated by looking at the developing countries. As the bottom panel of Figure 3 indicates, the euro share of reserves held by developing countries rose slightly in the last few years. In 1997 the euro legacy currencies accounted for 12 percent of the reserves of developing countries. At the end of 1999, the euro accounted for 13.6 percent of their reserves. Thus, while there is no evidence that the creation of the euro has led to a drop in the relative holdings of euros outside the euro area, neither is there evidence of a marked rise in these holdings.

The lack of a noticeable shift in the composition of world reserves is not surprising. The trade and debt financing needs of the developing countries remain primarily in dollars. Certainly, as the euro's use as an international medium of exchange rises, countries are likely to increase their holdings of euro reserves. It is also unlikely that the creation of the euro has had a noticeable effect on the demand for reserves for intervention purposes.[33] Central banks are unlikely to sell much of their dollar holdings to buy euros without good cause. The ECB notes "central banks traditionally refrain from abrupt and large changes in the level and composition of their foreign reserves" (ECB, 1999, p. 41). Johnson (1994) argues that as long as the Federal Reserve achieves an acceptable degree of price stability in the United States, changes in reserve holdings should occur gradually.

The implications of a shift in international reserves away from the U.S. dollar and toward the euro depend on the speed at which such a change would occur. A massive sale of dollars by central banks and the purchase of euros would cause a sharp drop in the value of the dollar relative to the euro. This shift would also raise interest rates on U.S. government securities since, as noted above, most reserves are held in government securities. In contrast, the euro would rise in value and interest rates in the euro area would drop. As discussed above, this scenario is improbable. The ECB (1999) asserts that portfolio shifts are "expected to take place at a slower pace in the central bank community than in the private sector." Indeed, despite concerns with the euro area over the decline in the foreign exchange value of the euro, the national central banks have not sold noticeable amounts of their substantial holdings of dollar reserves.[34]

A gradual shift in international reserves toward the euro is unlikely to have much effect on the United States or the euro area. Because nearly all international reserves are invested in government securities, the reserve currency country does not gain any seigniorage benefits. The most important benefit is the possibility that reserve currency status lowers the interest rate at which the government can borrow. Thus, it is argued that the euro area will benefit through a reduction in the interest rate at which governments can borrow while the U.S. government will see its borrowing costs rise.

A negative interest rate effect on the United States would require not simply a rise in the share

[32] The ecu, or more formally, European currency unit, was a weighted average of the European Union currencies. Although it never existed as a paper currency, it was used as the unit of account for official European Union activities and a small ecu private bond market existed. The ecu was superceded by the euro.

[33] Hong Kong, however, announced in late 1999 that it was increasing the share of the euro in its foreign currency reserves.

[34] The national central banks transferred a small portion of their reserves to the ECB upon its creation but kept most of the remaining reserves. As of September 2000, the foreign exchange reserves of the ECB were $43.7 billion while the reserves of the national central banks were $212.2 billion. In contrast, the United States held $31.2 billion in foreign exchange reserves. Although the national central banks may have wanted to hold on to their reserves to handle any possible crisis in the early years of the euro, the available pool of reserves is more than sufficient to handle any problems.

of reserves held in euros, but an absolute decline in holdings of dollar reserves. Given the trends in the growth of worldwide reserves, the latter change will take longer (if ever) to occur than the former. In addition, the extent of the interest rate benefit to a reserve currency is not well established. Blinder (1996) is skeptical of the importance of such a link. He argues that if such a benefit were significant then there should be a larger difference between interest rates on government and corporate bonds in the United States than in other major countries; yet he finds no evidence to support this argument. The euro area is more likely to see a fall in government borrowing costs from measures to standardize government bond markets than through an increase in the use of the euro as a reserve currency (BIS, 2000b).

Intervention Currency

A corollary to the dollar's role as the primary international reserve currency is its use as the main currency for intervening in foreign exchange markets. This latter role is also aided by the use of the dollar as a vehicle currency and by the liquidity of the U.S. bond market, as discussed earlier in this article. Although data on interventions are limited, it is believed that nearly all intervention in the currencies markets, with the exception of those undertaken by the United States, takes place in dollars.[35]

The most important determinants of the choice of intervention currency are liquidity and acceptability. In countries that peg their exchange rate, the currency peg will determine the intervention currency. Since countries prefer to hold their reserves in the form of interest-earning assets, the liquidity of these assets is extremely important. The relative illiquidity of the euro-area and Japanese bond markets gives the dollar an advantage over the use of these two currencies.[36]

The acceptability of an international currency is related to its role as a medium of exchange for private transactions. The more frequently a currency is used for private transactions the larger is the exchange market for that currency, which increases the ease with which a country can use the currency for intervention purposes.

CONCLUSION

Factors determining whether a country's currency will be used readily outside its border include the size and openness of its economy and financial markets as well as its macroeconomic policy environment. In the postwar period, these factors have favored the use of the U.S. dollar as the predominant international currency. In the early postwar period, there were few alternatives to the dollar in international markets as a result of restrictions on convertibility and limits on capital mobility. In the last several decades, as other major economic powers emerged (notably Germany and Japan) and markets opened, the dollar's dominance has been reduced. Nonetheless, the dollar has remained the most important international currency.

On January 1, 1999, the euro was created, linking an economic area nearly the size of the U.S. economy. The euro's impact will be felt in markets throughout the world economy. For the first time the dollar faces a potential challenge to its role as the world's major international currency.

In the first two years of its existence, the euro's presence has been felt most in international securities markets. Issues of euro-denominated foreign bonds surged in 1999. The euro legacy currencies accounted for 28.0 percent of new bond issues in 1998. The share of new issues denominated in euros was 38.3 percent in 1999. In international money markets, the euro's presence was even more obvious. International money market instruments denominated in euros in 1999 accounted for 32.9 percent of the market, well above the 17.2 percent share of the legacy currencies in 1998. Although the euro's share of international debt securities declined in 2000, the euro continues to be a widely used alternative to the dollar in these markets. Little change, however, has occurred in the use of the euro relative to the dollar in the other functions of an international currency.

In the short-term there is unlikely to be much change in this pattern. Over time, however, the use of the euro relative to the dollar will likely increase, particularly as euro-area financial markets become more integrated and more liquid. Nevertheless, the decline in the dollar's share and the rise in the euro's share in international transactions is likely to occur gradually. In part, this is because the more often a currency is used in international transac-

---

[35] Under the rules of the ERM, mandatory interventions (when the exchange rate reached its upper or lower limit) had to take place in one of the member currencies. Non-mandatory (intra-band) interventions could take place in any currency, and generally dollars were used. See Giavazzi (1989) for details.

[36] The existence of swap arrangements between central banks can offset some of these liquidity problems.

tions, the lower are the costs associated with using that currency and hence the more attractive is the currency for conducting international exchanges. Thus, there is much inertia in the choice of an international currency. The British pound, for example, continued to play a major role as an international currency long after its dominance of the global economy waned.

Policies on the part of the governments and central banks in the euro area and the United States will play a crucial role in the use of their currencies in international markets. The ability of the euro-area governments to foster sustained economic growth in the region is important. Equally important is the credibility of the ECB. The ability of the ECB to maintain a low inflationary environment in the euro area is a key factor in determining the use of the euro outside the region. In addition, concerns about the attachment of European governments and the public to a monetary union will undermine the use of the euro in international markets.

The ultimate determinants of the continued use of the dollar as an international currency are the economic policies and conditions in the United States. As Lawrence Summers noted when he was Deputy Secretary of the U.S. Treasury, "Ultimately, the dollar's relative standing in the international financial system will always depend more on developments here than on events elsewhere" (Summers, 1997). In the absence of an economic crisis in the United States, the dollar is not likely to lose its standing as the most popular international currency.

Any shifts in the roles of the dollar and euro will affect both the United States and the European Union. The extent to which a country benefits from having its currency used internationally is not clear. The use of a currency for invoicing may reduce the costs borne by that country's importers, but these costs may be small at best. The use of a currency as a reserve currency may reduce the borrowing costs of that country's government, but again the extent of this benefit is not known. The use of a currency as a substitute currency does provide seigniorage benefits but also complicates monetary policy. Moreover, if these seigniorage revenues arise as a result of an economic and/or political instability, the benefit to the country earning the seigniorage may be more than offset by the costs of the instability.

The creation of the euro has the potential to produce benefits to both the United States and the euro area that could far outweigh the effects of any shifts in international currency holdings. Developments in European financial markets alone should increase the investment options available to consumers as well as reduce the costs of borrowing for businesses. These developments will benefit those on both sides of the Atlantic.

REFERENCES

Anderson, Richard G. and Rasche, Robert H. "The Domestic Adjusted Monetary Base." Working Paper 2000-002A, Federal Reserve Bank of St. Louis, January 2000.

Bank for International Settlements. *BIS Quarterly Review*. Basle: BIS, February 2000a.

___________. *70th Annual Report*. Basle: BIS, June 2000b.

___________. *Central Bank Survey of Foreign Exchange and Derivatives Market Activity 1998*. Basle: BIS, May 1999.

Bekx, Peter. "The Implications of the Introduction of the Euro for Non-EU Countries." Euro Papers Number 26, European Commission, Directorate General Economic and Financial Affairs, July 1998.

Ben-Bassat, Avraham. "The Optimal Composition of Foreign Exchange Reserves." *Journal of International Economics*, May 1980, *10*(2), pp. 285-95.

___________ . "Reserve-Currency Diversification and the Substitution Account." *Princeton Studies in International Finance*, 1984, (53).

Bénassy, Agnès and Deusy-Fournier, Pierre. "Competition Among the World's Dominant Currencies Since Bretton Woods Collapsed." Unpublished manuscript, Centre for International Economics (CEPII), Paris, April 1994.

Bénassy-Quéré, Agnès; Mojon, Benoît and Schor, Armand-Denis. "The International Role of the Euro." Working Paper 98/03, CEPII, July 1998.

Bennett, Paul; Garbade, Kenneth and Kambhu, John. "Enhancing the Liquidity of U.S. Treasury Securities in an Era of Surplus." Federal Reserve Bank of New York *Economic Policy Review*, April 2000, *6*(1), pp. 89-119.

Bergsten, C. Fred. "The Dollar and the Euro." *Foreign Affairs*, July/August 1997, *76*(4), pp. 83-95.

Black, Stanley W. "The International Use of Currencies," in Yoshi Suzuki, Junichi Miyake, and Mitsuaki Okabe, eds., *The Evolution of the International Monetary System: How*

Can Efficiency and Stability Be Achieved? Tokyo: University of Tokyo Press, 1990.

Blinder, Alan S. "The Role of the Dollar as an International Currency." *Eastern Economic Journal*, Spring 1996, *22*(2), pp. 127-36.

Cecchetti, Stephen G. "Legal Structure, Financial Structure, and the Monetary Policy Transmission Mechanism." Working Paper No. 7151, National Bureau of Economic Research, June 1999.

Chrystal, K. Alec. "On the Theory of International Money," in John Black and Graeme S. Dorrance, eds., *Problems of International Finance*. New York: St. Martin's Press, 1984.

Cohen, Benjamin J. *The Future of Sterling as an International Currency*. London: Macmillian Press, 1971.

Dooley, Michael P.; Lizondo, J. Saul and Mathieson, Donald J. "The Currency Composition of Foreign Exchange Reserves." *IMF Staff Papers*, June 1989, *36*(2), pp. 385-434.

Emerson, Michael; Gros, Daniel; Italianer, Alexander; Pisani-Ferry, Jean and Reichenbach, Horst. *One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union*. Oxford: Oxford University Press, 1992.

European Central Bank. "The Euro Area One Year After the Introduction of the Euro: Key Characteristics and Changes in the Financial Structure." *ECB Monthly Bulletin*, January 2000, pp. 35-49.

___________ . "The International Role of the Euro." *ECB Monthly Bulletin*, August 1999, pp. 31-53.

Fleming, Michael J. "The Benchmark U.S. Treasury Market: Recent Performance and Possible Alternatives." Federal Reserve Board of New York *Economic Policy Review*, April 2000, pp. 129-45.

Giavazzi, Francesco. "The European Monetary System: Lessons from Europe and Perspectives in Europe." *Economic and Social Review*, January 1989, *20*(2), pp. 73-90.

Grassman, Sven. "A Fundamental Symmetry in International Payments Patterns." *Journal of International Economics*, May 1973, *3*(2), pp. 105-16.

Hartmann, Philipp. "The Future of the Euro as an International Currency: A Transactions Perspective." London School of Economics *Financial Markets Group Special Papers*, November 1996.

Heller, H. Robert and Knight, Malcom. "Reserve-Currency Preferences of Central Banks." *Princeton Essays in International Finance*, December 1978, (131).

International Monetary Fund. "Progress with European Monetary." *International Capital Markets: Developments, Prospects, and Key Policy Issues*, September 1999.

Johnson, Karen H. "International Dimension of European Monetary Union: Implications for the Dollar." *International Financial Discussion Paper* No. 469, Board of Governors of the Federal Reserve System, May 1994.

Kenen, Peter B. "EMU, Exchange Rates and the International Monetary System." *Recherches Economiques de Louvain*, 1993, *59*(1/2), pp. 257-81.

Kool, Clemens J.M. "International Bond Markets and the Introduction of the Euro," Federal Reserve Bank of St. Louis *Review*, September/October 2000, *82*(5), pp. 41-56.

Kregel, Jan A. "Can European Banks Survive a Unified Currency in a Nationally Segmented Capital Market?" Working Paper No. 305, Jerome Levy Economics Institute, July 2000.

Krugman, Paul. "Vehicle Currencies and the Structure of International Exchange." *Journal of Money, Credit and Banking*, August 1980, *12*(3), pp. 513-26.

Laxton, Douglas and Prasad, Eswar. "Possible Effects of European Monetary Union on Switzerland: A Case Study of Policy Dilemmas Caused by Low Inflation and the Nominal Interest Rate Floor." Working Paper WP/97/23, International Monetary Fund, March 1997.

Magee, Stephen, P. and Rao, Ramish K.S. "Vehicle and Nonvehicle Currencies in International Trade." *American Economic Review*, May 1980, *70*(2), pp. 368-73.

Masson, Paul R. and Turtelboom, Bart G. "Characteristics of the Euro, the Demand for Reserves, and Policy Coordination Under EMU." Working Paper No. 97/58, International Monetary Fund, May 1997.

Page, S. "The Choice of Invoicing Currency in Merchandise Trade." *National Institute Economic Review*, November 1981, *85*, pp. 60-72.

Pollard, Patricia S. "The Role of the Euro as an International Currency." *The Columbia Journal of European Law*, Spring 1998, pp. 395-420.

Porter, Richard D. and Judson, Ruth A. "The Location of U.S. Currency: How Much Is Abroad?" *Federal Reserve Bulletin*, October 1996, *82*(10), pp. 883-903.

Portes, Richard and Rey, Hélène. "The Emergence of the Euro as an International Currency," in *EMU: Prospects and Challenges for the Euro*. Oxford: Blackwell Publishers, 1998.

Prati, Alessandro and Schinasi, Garry J. "European Monetary Union and International Capital Markets: Structural Implications and Risks." Working Paper No. 97/62, International Monetary Fund, May 1997.

Santillán, Javier; Bayle, Marc and Thygesen, Christian. "The Impact of the Euro on Money and Bond Markets." Occasional Paper No. 1, European Central Bank, July 2000.

Seitz, Franz. "The Circulation of Deutsche Mark Abroad." Discussion Paper No. 1/95, Economic Research Centre of the Deutsche Bundesbank, May 1995.

Summers, Lawrence H. *Testimony Before the Senate Budget Committee*, 21 October 1997.

Tavlas, George. "The International Use of the U.S. Dollar: An Optimum Currency Area Perspective." *The World Economy*, September 1997, *20*(6), pp. 709-47.

United States Treasury Department and the Board of Governors of the Federal Reserve System. *The Use and Counterfeiting of United States Currency Abroad*. Washington D.C.: February 2000.

Reconsidering the Trade-Creating Effects of a Currency Union

Michael R. Pakko and Howard J. Wall

Countries select particular exchange rate arrangements for a variety of reasons. For example, the ability to conduct an independent monetary policy is often cited as the main advantage of having a floating exchange rate regime. Conversely, countries sometimes tie their exchange rate to that of a larger country—foregoing the ability to conduct independent monetary policies—to benefit from the relative stability of the foreign currency. This is the rationale for several Latin American countries that have recently adopted or are considering policies of dollarization.

A more prevalent rationale for adopting fixed exchange rates or even common-currency arrangements, however, is the notion that exchange rate volatility introduces uncertainty into cross-border transactions, reducing the volume of trade that would otherwise take place. Indeed, this argument played a key role in the decision of the European Union to embark upon plans for introducing the euro. As described in an early EU Green Paper on the subject:

> An exchange rate adjustment, even a moderate one, may substantially alter the balance of a contract between two European firms and at the same time affect the relative wealth of citizens and the purchasing power of consumers. Only a single currency covering the largest possible number of Member States can shelter firms and individuals from these disruptions. (European Commission, 1995)

Despite the firmly held convictions of many economists and policymakers that exchange rate volatility and uncertainty dampens trade, there has been little empirical evidence to support this premise.[1] Studies often find that the effect is of the wrong sign (Brada and Mendez, 1988), statistically insignificant (Belanger, Gutierrez, and Raynauld, 1992), or at best very weak (Frankel and Wei, 1993). Recent theoretical work also suggests that the association may not hold in the context of general equilibrium or for all forms of risk aversion (Bacchetta and van Wincoop, 2000, and De Grauwe, 1988).

In a drastic departure from past empirical studies that fail to find a significant link between exchange rate stability and trade, a recent set of papers by Andrew Rose and his colleagues find extremely large positive effects of common currencies on the volume of trade. The most dramatic, and widely cited, of his findings is that "two countries sharing the same currency trade three times as much as they would with different currencies" (Rose, 2000, p.7).

In related work, Rose and Engel (2000) found similarly large trade-creating effects by comparing the extent of integration between countries with common currencies to that of regions within the same country. Other work (Frankel and Rose, 2000) has combined estimates of the trade-creating effects of common currencies with evidence of a link between trade and growth, concluding that some countries could increase their per capita income by 20 percent over 20 years by dollarizing or adopting the euro. Most recently, Glick and Rose (2001) use a much larger data set and find that a common currency doubles trade.

Rose's estimates of the trade-creating effects of adopting common currencies are obtained using a "gravity model" in which bilateral trade is a function of the relative economic size and distance between two trading partners. In general, these simple factors can explain a great deal of observed trade patterns, and gravity models are generally deemed to be empirically successful. Rose's model also includes several variables that are intended to capture trading partners' cultural and historical links and membership in regional trading blocs. The key feature of Rose's gravity model is the inclusion of two monetary variables: a dummy variable to indicate whether trading partners use the same currency and a measure of the volatility of the bilateral exchange rate.

In this paper, we re-examine the trade-creating effects of common currencies, replacing Rose's equation with a more general functional form.

Michael R. Pakko is a senior economist and Howard J. Wall is a research officer at the Federal Reserve Bank of St. Louis. The authors thank Andrew Rose and Cheng Hsiao for their comments and suggestions. Much of this research was done while Wall was a visiting scholar at the Institute for Monetary and Economic Studies at the Bank of Japan, whose hospitality and resources are greatly appreciated. Rachel J. Mandal provided research assistance.

[1] See Côté (1994) for a comprehensive survey.

© 2001, THE FEDERAL RESERVE BANK OF ST. LOUIS

Specifically, rather than controlling for cultural, geographic, and historical factors by introducing particular variables, we allow for general fixed effects that are specific to each trading pair. Estimating this modified form of the model, we find that the trade-creating effects of common currencies found by Rose disappear. This suggests a tenuousness in the findings that should give one pause before concluding that the potential gains from adopting common currencies are as great as Rose indicates.

COMPETING GRAVITY MODELS

To obtain his benchmark results, Rose uses ordinary least squares (OLS) to estimate an equation that includes the typical gravity-model variables, as well as a list of dummy variables intended to control for common historical and cultural influences that might influence trade volumes. Specifically, he estimates the following equation:

(1)

$$\ln(X_{ijt}) = \beta_0 + \beta_1 \ln(Y_{it}Y_{jt}) + \beta_2 \ln(y_{it}y_{jt}) + \theta_1 \ln D_{ij} + \theta_2 Cont_{ij} + \lambda_1 Lang_{ij} + \lambda_2 ComNat_{ij} + \lambda_3 ComCol_{ij} + \lambda_4 Colony_{ij} + \omega FTA_{ijt} + \boldsymbol{\tau T'_{ijt}} + \gamma CC_{ijt} + \delta V(e_{ijt}) + \varepsilon_{ijt},$$

where X_{ijt} is the total real trade of country i with country j in year t. The usual gravity variables are Y_{it} and Y_{jt}, the gross domestic products (GDPs) of i and j; y_{it} and y_{jt}, their real per capita GDPs; D_{ij}, the great-circle distance between them; and $Cont_{ij}$, a dummy variable to indicate whether they are contiguous. The four time-invariant cultural and historical dummy variables take the value of 1 when the partners (i) have a common first language, $Lang_{ij}$; (ii) are part of the same nation (for example, if they are both French overseas departments), $ComNat_{ij}$; (iii) were colonies of the same colonizer after 1945, $ComCol_{ij}$; or (iv) if one was a colony of the other, $Colony_{ij}$. To control for the trade-creating effects of regional integration, the dummy FTA_{ijt} is equal to 1 when the partners are members of the same free trade area or other form of regional integration regime. The model also includes a vector of time dummies, $\boldsymbol{T_{ijt}}$.

The variables of most present interest are the two monetary variables: CC_{ijt}, a dummy that is equal to 1 if i and j use the same currency; and $V(e_{ijt})$, which is a measure of the volatility of the exchange rate between the currencies of i and j. The latter is the standard deviation of the first difference in the log of the bilateral exchange rate between i and j for the five years prior to the year of the observation.

We propose an alternative, more general specification of equation (1) that uses trading pair–specific fixed effects to control for time-invariant geographic, cultural, and historical factors. Rather than controlling for these factors with a list of particular variables, as Rose does, we use fixed effects that are specific to each of the trading pairs (see Bayoumi and Eichengreen, 1997, and Cheng and Wall, 2001).

The general advantage of this fixed-effects approach is that it avoids estimation bias that can arise because of misspecified or omitted time-invariant factors that are correlated with bilateral trade and some right-hand-side variables. For example, there may be some unobserved (or uncontrolled-for) factors that are responsible for both the level of trade between two countries and whether or not they have a common currency. If so, then any estimation that does not control for such factors would mistakenly attribute a correlation between trade and a common currency to a direct link between the two characteristics, rather than with the unobserved attributes. In the context of the present question, the fixed-effects approach has the additional advantages of not having to use distance to measure relative trading costs and of allowing for a better empirical representation of the dynamic link between common currencies and trade.

We use least squares with dummy variables (LSDV) to estimate the equation

(2)

$$\ln(X_{ijt}) = \beta_0 + \beta_{ij} + \beta_1 \ln(Y_{it}Y_{jt}) + \beta_2 \ln(y_{it}y_{jt}) + \omega FTA_{ijt} + \boldsymbol{\tau T'_{ijt}} + \gamma CC_{ijt} + \delta V(e_{ijt}) + \mu_{ijt}.$$

Note that β_{ij}, the trading pair–specific component of the intercept, incorporates all of the time-invariant factors that are included separately in specification (1); these include the distance and contiguity variables, as well as the time-invariant cultural and historical factors included in (1). More importantly, this fixed-effects term also controls for factors that are *not* included in (1). In other words, rather than explicitly controlling for the factors $Lang_{ij}$, $ComNat_{ij}$, $ComCol_{ij}$, and $Colony_{ij}$—and *only* those factors—we allow the data to identify common characteristics that influence the volume of trade between two countries.

RESTRICTED FIXED EFFECTS

The fixed-effects approach that we use is the most general that has been applied to the question of common currencies.[1] It assumes that, for each pair of countries, there is likely to be a unique set of reasons for trade volume to differ from the average. Unlike standard pooled cross-section estimation, it allows for the possibility that cultural or historical factors can explain why trade between the United States and the United Kingdom is so much greater than trade between, say, the United States and France. Although fixed effects have been applied to gravity models only recently, other fixed-effects specifications have appeared in the literature.

Mátyás (1997) and Egger (2000) specify two fixed effects for each country, one for when it is an exporter and one for when it is an importer. Applying this to equation (2) yields

(3)

$$\ln(X_{ijt}) = \beta_0 + \theta_i + \rho_j + \beta_1 \ln(Y_{it}Y_{jt}) + \beta_2 \ln(y_{it}y_{jt}) + \theta_1 \ln D_{ij} + \theta_2 Cont_{ij} + \lambda_1 Lang_{ij} + \lambda_2 ComNat_{ij} + \lambda_3 ComCol_{ij} + \lambda_4 Colony_{ij} + \omega FTA_{ijt} + \boldsymbol{\tau T'}_{\boldsymbol{ijt}} + \gamma CC_{ijt} + \delta V(e_{ijt}) + \varepsilon_{ijt},$$

where θ_i is the fixed effect for i when it is an exporter and ρ_j is the fixed effect for j when it is an importer. Because distance, contiguity, and language are not perfectly collinear with the fixed effects, unlike in (2), they need not be dropped from the regression. Note that equation (3) can be obtained by imposing the arbitrary restriction on (2) that $\beta_{ij} = \theta_i + \rho_j + Z_{ij}$, where $Z_{ij} \equiv \theta_1 \ln D_{ij} + \theta_2 Cont_{ij} + \lambda_1 Lang_{ij} + \lambda_2 ComNat_{ij} + \lambda_3 ComCol_{ij} + \lambda_4 Colony_{ij}$. Because this also means that $\beta_{ik} = \theta_i + \rho_k + Z_{ik}$, these restrictions on the trading-pair fixed effects imply the cross-pair restriction that $\beta_{ij} - \beta_{ik} = \rho_j - \rho_k + Z_{ij} - Z_{ik}$.

In this specification, the United States has two fixed effects: one to control for the factors that make its exports differ from the average and another to do the same for its imports. The trading-pair effect for U.S. exports to the United Kingdom is the sum of the fixed effect for U.S. exports and the fixed effect for U.K. imports. Similarly, for U.S. exports to France, the trading-pair effect is the sum of the fixed effect for U.S. exports and the fixed effect for French imports. Because the fixed effect for U.S. exports is part of both of these trading-pair effects, this specification imposes the arbitrary restriction on how the two trading-pair effects are related to each other and to all other trading-pair effects. As shown by Cheng and Wall (2001), these arbitrary restrictions result in poor in-sample predictions.

A more restricted fixed-effects specification than (3) was employed in Rose and van Wincoop (2001) and in a working paper version of Rose (2000) (< haas.berkeley.edu/ ~ arose/ >). In these papers, there is one fixed effect for each country, regardless of whether the country is the importer or the exporter, i.e., $\theta_j = \rho_j$. Applying this restriction, (3) becomes

(4)

$$\ln(X_{ijt}) = \beta_0 + \theta_i + \theta_j + \beta_1 \ln(Y_{it}Y_{jt}) + \beta_2 \ln(y_{it}y_{jt}) + \theta_1 \ln D_{ij} + \theta_2 Cont_{ij} + \lambda_1 Lang_{ij} + \lambda_2 ComNat_{ij} + \lambda_3 ComCol_{ij} + \lambda_4 Colony_{ij} + \omega FTA_{ijt} + \boldsymbol{\tau T'}_{\boldsymbol{ijt}} + \gamma CC_{ijt} + \delta V(e_{ijt}) + \varepsilon_{ijt}.$$

Using this specification of fixed effects, Rose found that a common currency led countries to more than double their bilateral trade.

[1] See Cheng and Wall (2001) for a discussion of the various fixed-effects specifications used in gravity models.

In equation (2), the trading-pair fixed effect is estimated using a separate dummy variable for each trading pair in the data set, so that we need at least two observations of each pair. Note also that we refer to our fixed effects as "general" so as to differentiate them from the restricted fixed effects that have been used in other gravity models in the literature. As we demonstrate in the insert, these specifications are special cases of (2) in that they can be obtained by imposing arbitrary restrictions on the general trading-pair effects.

The main benefit of the fixed-effects approach is that it addresses the possibility of omitted-variables bias by controlling for all factors that are fixed over the sample period, not only those included in the estimation. Because the time-invariant factors that these variables are meant to proxy for are often difficult to measure or are unobservable, it is difficult (if not impossible) to include enough variables to account for all of the important factors.

The list of variables included by Rose is as exhaustive as in any gravity model,[2] yet there is no variable, for example, that captures the unique historical relationships between the United States and Panama or the United States and Liberia. These three countries all use the U.S. dollar; and there are obvious historical reasons why they would (i) be more likely than others to share a currency and (ii) trade more than would be otherwise predicted. Because the model does not control for factors such as these, which are correlated with both trade and the likelihood of sharing a currency, it cannot help but provide biased estimates. It is not feasible to create variables that capture the unique historical relationships between these countries or, for that matter, between any pair of countries. One cannot create variables to control for every pair-specific factor in the universe of trading pairs.[3] The only sensible solution is to include a dummy variable for each pair that indicates trade between all pairs of trading partners, i.e., to create trading pair–specific fixed effects.

Fixed-effects estimation also addresses the possible problem of misspecification created by the distance variable, which is meant to reflect the relative costs of trading. However, distance is a notoriously poor measure of such costs (Plane, 1984), and examples of why this is so come readily to mind. First, the distance between single points within two countries (usually the national capitals or, as in the present case, the geographic centers) can be a poor indicator of the trading distance between people spread across millions of points within the countries. Second, even without this problem, in terms of trading costs, distance across land is not the same as distance across an ocean. And third, distance across relatively undeveloped countries is not the same as distance across developed ones. The distance between Italy and Spain is only slightly greater than that between Algeria and Niger, but it is difficult to believe that trading costs are lower for the latter pair. The misspecification of trading costs that distance introduces will bias empirical results because the error that it introduces will likely be correlated with one or more of the other right-hand-side variables, as well as with the level of bilateral trade.

The most important consideration in the present context is that fixed-effects estimation allows us to get much better estimates of the dynamic relationship between trade and common currencies. When considering the question of a causal link between adoption of a common currency and increased trade, an obvious approach would be an examination of bilateral trade time series, including both pre- and post-union observations. However, a relative lack of observations with typical time series makes this impractical for drawing any strong conclusions. A feasible alternative pools the data both cross-sectionally and over time, which can be used to estimate a simple gravity model.

One approach is to estimate a model such as the one specified in (1), controlling for as many of the time-invariant factors as possible and hoping that the estimates are not biased because one or more time-invariant factors are excluded or misspecified. The alternative that we propose captures the dynamic link between common currencies and trade by taking advantage of the fact that LSDV estimation is econometrically identical to OLS estimation of differences over time (see Hsiao, 1986, or Greene, 1999). Thus, by controlling for all time-invariant effects, our estimates should tell us the changes in trade that occurred alongside changes in common-currency status. Unfortunately, given the data set, which has very few observations for which there is a change in common-currency status over the sample period, this approach is not ideal.[4] Nonetheless, as we demonstrate, it is sufficient for identifying the source of Rose's result, as well as demonstrating its fragility: our empirical estimates suggest the possibility that a common currency may lead to significant *reductions* in trade.

THE DATA

Rose's data set—which is available on his Web site <haas.berkeley.edu/~arose/>—begins with

[2] In addition to the variables in equation (1), in other specifications Rose includes dummies to indicate whether trading partners are landlocked, are islands, or share the same head of state.

[3] For these three countries you could create two dummy variables: one for when the trading pair includes a country that built a canal through the other and another for when one was established by freed slaves from the other.

[4] Of the nearly 23,000 observations in the data set Rose used for his benchmark estimate, only 7 have a change in common-currency status.

33,903 observations of bilateral trade between various combinations of 186 countries, dependencies, territories, overseas departments, and other political units for the years 1970, 1975, 1980, 1985, and 1990. Of these observations, 330 are of trade between trading partners that use the same currency.[5] After eliminating the observations with incomplete data, Rose obtains his benchmark estimates with a pooled cross-section of 22,948 observations, 252 of which are of trade between countries that use the same currency.[6]

Our selection criteria are slightly more stringent than this because we need at least two observations for each pair of trading partners. After eliminating the observations that do not meet this additional criterion, we are left with 21,758 bilateral trade observations of 5,541 trading pairs, with 212 observations of trade between pairs that use the same currency.

One criticism of fixed-effects models is that their estimates reflect short-run relationships of a length defined by the time interval between observations, not the long-run relationships that pooled cross-sections are intended to reveal. In the present context, this view is of limited relevance because the long run, the period over which no factors related to trade are fixed, is a length of time that is of no interest to policymakers or anyone else. The relevant factors—distance, historical relationships, cultural links, etc.—are not likely to become variable at any time in the foreseeable future. Nevertheless, because the five-year interval in Rose's data set may be too short for the affected economies to adjust completely to adoption of a common currency, we also estimate our model using 10- and 20-year intervals.

Our second data set is a subset of the original data that uses observations for 1970, 1980, and 1990 only. After eliminating those trading pairs with only one observation in these three years, there are 11,520 observations of 4,392 pairs remaining, with 112 observations of trade between countries using the same currency. A third data set uses only data from 1970 and 1990, leaving 5,728 observations of 2,864 trading pairs, with only 35 observations of trade between trading partners using the same currency.

Although the first two data sets have roughly the same percentage of observations for which the partners use the same currency (just under 1 percent), the third one has a much smaller percentage (about 0.6 percent). Sample-selection bias therefore becomes a potential problem for the third data set: The country pairs for which data are less likely to be complete tend to be the poorer ones, and, as Rose points out, a disproportionate number of countries using common currencies are relatively poor.

THE EMPIRICAL RESULTS

Table 1 summarizes the regression results for the pooled cross-section and fixed-effects models for the three data sets. The results for the pooled cross-section model with five-year intervals are nearly identical to Rose's benchmark results, which were obtained with about 1,200 more observations. As with Rose's benchmark, our estimated effect of regional integration suggests that two members of such a regime trade about 2.5 times ($e^{0.91} = 2.5$) what two countries not in the same regime would—a huge effect that strains credulity. However, because membership in a regional integration regime might be correlated with missing or unobserved cultural or historical factors, this number likely suffers from the same estimation problems that we believe exist for the effects of a common currency (see Cheng and Wall, 2001). We also find, as did Rose, that countries with a common currency trade more than three times as much as they would if they had different currencies ($e^{1.173} = 3.2$).

The results of our estimation of the gravity model with trading-pair fixed effects and the same data with five-year intervals are dramatically different from the results for the pooled cross-section model. The estimated coefficient on the regional integration dummy shrinks to a statistically insignificant 0.08 percent. The estimated effect of a common currency indicates that two countries sharing the same currency trade only 69 percent ($e^{-0.378} = 0.69$) of what they would trade if they had different currencies, although this trade-reducing effect is not significantly different from zero statistically. Also, the estimated coefficient on exchange rate volatility shrinks to about one third of what the pooled cross-section model produced. In short, the startlingly large estimates of the effects of regional integration and common currencies produced by Rose's benchmark model disappear when trading-pair fixed effects are used to model time-invariant factors.

[5] See Rose (2000) for a complete description of the data set.

[6] He also estimated each year separately, finding little difference between the single-year cross-section and pooled cross-section results.

Table 1

Regression Results: Dependent Variable = Log of Bilateral Exports

	Five years between observations		Ten years between observations		Twenty years between observations	
	Pooled cross-section	Fixed effects	Pooled cross-section	Fixed effects	Pooled cross-section	Fixed effects
Intercept	–19.051 (0.264)	–33.342 (2.009)	–18.931 (0.359)	–38.566 (2.499)	–19.939(0.529)	–40.490 (2.880)
Product of GDPs	0.791 (0.006)	1.340 (0.094)	0.778 (0.008)	1.493 (0.116)	0.780 (0.012)	1.529 (0.141)
Product of per capita GDPs	0.665 (0.011)	–0.151 (0.093)	0.690 (0.016)	–0.152 (0.119)	0.733 (0.022)	–0.121 (0.141)
Distance	–1.081 (0.018)	—	–1.084 (0.024)	—	–1.059 (0.032)	—
Contiguity	0.507 (0.086)	—	0.488 (0.112)	—	0.343 (0.150)	—
Common language	0.392 (0.040)	—	0.457 (0.052)	—	0.456 (0.067)	—
Common nation	1.374 (0.276)	—	1.315 (0.366)	—	0.662 (0.647)	—
Common colonizer	0.663 (0.060)	—	0.717 (0.082)	—	0.887 (0.120)	—
Colonial relationship	2.164 (0.074)	—	2.098 (0.099)	—	2.100 (0.142)	—
Regional integration	0.912 (0.075)	0.079 (0.090)	0.756 (0.088)	0.048 (0.122)	0.698 (0.110)	0.059 (0.143)
Common currency	1.173 (0.143)	–0.378 (0.529)	0.902 (0.195)	–0.797 (0.421)	1.558 (0.370)	–1.174 (0.563)
Exchange rate volatility	–0.0183 (0.0022)	–0.0051 (0.0020)	–0.0157 (0.0025)	–0.0054 (0.0026)	–0.0100 (0.0028)	–0.0066 (0.0034)
Total observations	21,758		11,520		5,728	
Observations of common currency	212 (0.97%)		112 (0.97%)		35 (0.61%)	
Trading pairs	5,541		4,392		2,864	
$\bar{R}^2$	0.626	0.854	0.639	0.841	0.665	0.828
Root-mean-squared error	1.980	1.236	1.894	1.255	1.796	1.288
Log-likelihood	–38,184.43	–24,742.64	–19,701.53	–12,203.42	–94,88.98	–55,99.55

NOTE: Numbers in parentheses are White-corrected standard errors. Estimates of the year dummies and trading-pair fixed effects are suppressed for space considerations.

Independently, Rose (2001) obtains these same results using the general fixed-effects model. However, he rejects the findings on the grounds that the statistical insignificance of the common-currency dummy is due to a small number of switches in common-currency status. While it may well be true that the statistical insignificance of the common-currency dummy should not be taken to mean that the effect is not positive, this misses the point. A comparison of the two sets of results suggests that pooled cross-section estimates are not reliable because they are biased by the exclusion or mismeasurement of trading pair–specific variables. This is evident in the dramatically different coefficients on the GDP and per capita GDP variables that are found when using the two methods. In other words, the restrictions necessary to obtain the pooled cross-section specification from the fixed-effects specification are rejected, indicating that the fixed-effects specification is preferred.[7,8]

The difference between the two methods in their estimates of the trade-creating effect of a common currency is a separate issue. The proper conclusion to draw is that, when the statistically preferred fixed-effects specification is used, there is no statistically significant evidence of large trade effects (positive or negative). Although this means that Rose's results cannot be supported statistically, the small number of switches precludes us from saying much about the effects of common currencies on trade, although the tripling of trade found by Rose is well outside of a 95 percent confidence interval.[9]

As discussed above, the use of data with five-year intervals might be misleading because five years might not be a long enough period for the common currency to have its full trade-creating effect. Our results using data with 10- and 20-year intervals between observations, however, indicate that, if anything, the longer time interval magnifies the *trade-reducing effects* of a common currency. Using the data set with 10-year intervals, we find that countries using the same currency traded only 45 percent ($e^{-0.797} = 0.45$) of what they would if they had different currencies, an effect that is significantly different from zero at the 6 percent level. And finally, using the data set with 20-year intervals, we find that countries using the same currency traded only 31 percent of what they would if they had different currencies, an effect that is significant at the 4 percent level. Remarkably, we find that the trade-reducing effects in this data set are so consistent that the coefficients on the common-currency dummies are statistically significant despite there being so few switches into or out of common currencies.

OTHER RESULTS

Our results, although statistically persuasive, indicate only the source of Rose's findings with his original data set and are not necessarily useful for making out-of-sample predictions of the effects of a common currency. Using a new data set, Glick and Rose (2001) compare results obtained with pooled cross-estimation with those obtained with a general fixed-effects specification, just as we have done. Their data set has yearly observations of 230 countries from 1948 through 1997, with many more observations of switches into and out of common currencies; although, as in Rose's original data set, only about 1 percent of the sample covers country pairs with a common currency. Their pooled cross-section estimation using yearly observations indicates that a common currency leads to a quadrupling of trade, whereas their fixed-effects estimation indicates that trade will be doubled. Further, they find that this trade-creating effect is large even when longer intervals are used, which is in contrast to our results. They conclude that the fixed-effects estimation shows that the effect of a common currency on trade "is economically large, statistically significant, and seems insensitive to a number of perturbations in…methodology."

Rather than closing the book on the issue, these results actually point to the general sensitivity of the empirical approach. This is because the two sets of results, ours and those of Rose and Glick, were obtained with two equally reasonable data sets that nonetheless differ a great deal in their handling of common currencies. Many of the country pairs noted to share a common currency in one data set do not even appear in the other data set; and, even for the country pairs that do appear in both data

7 A likelihood ratio test easily rejects the hypothesis that the restrictions do not lead to statistically different results.

8 As suggested by Mátyás (1998) and Egger (2000), we tested whether the factors omitted from the pooled cross-section are random (uncorrelated with the independent variables) rather than fixed (correlated with the independent variables). A Hausman test easily rejects the random effects model. Given the discussion in Egger (2000) of the reasons why the fixed effects model is preferred a priori, this is not surprising.

9 The lower and upper bounds of the 95 percent confidence interval are that a common currency will lead countries to trade, respectively, 24 percent and 193 percent as much with each other.

sets, the data sets often disagree on whether the countries had a common currency. For example, of the 85 country pairs in the Rose-Glick data set that are described as having shared a currency in 1975, only 37 (44 percent) even appear in Rose's original data set, and 15 (41 percent) of these are indicated as having *different* currencies. Also, of the 52 country pairs in Rose's original data set that are noted to have shared a currency in 1975, only 26 (50 percent) also appear in the Rose-Glick data set, 5 of which (19 percent) are indicated as having different currencies.

CONCLUSIONS

Although economists have long considered exchange rate stability and common-currency arrangements to provide for enhanced trading opportunities, very little empirical support for this notion has been uncovered over the years. Rose's estimates of the trade-creating effects of common currencies are so provocative because they depart so dramatically from the dearth of evidence supporting this widely held belief.

Our results suggest, however, that the evidence is much weaker than indicated by Rose's estimates; we conclude that Rose's results are not robust with respect to a general specification of time-invariant determinants of trade volume. Although the robustness question may appear to have been settled by Rose's impressive array of alternative specifications, our results indicate otherwise. In short, Rose's remarkable finding that a common-currency arrangement triples the volume of trade is due to estimation bias arising from omitted or misspecified variables that are correlated with trade volume and with the likelihood that countries use a common currency.

Using three different subsets of Rose's data to estimate a generalized fixed-effects model, our point estimates indicate that common-currency arrangements are associated with *reduced* trade. Using the data sets with longer intervals between observations, these results are even statistically significant. The fact that the evidence supporting trade-reducing effects of a currency union strengthens with the lengthening of the interval may simply be an artifact of the paucity of time-series information in the data set. With such a limited number of regime switches represented in the data, it may not be possible for the gravity approach to answer the key question of what happens to trade between two countries after they adopt a common currency.[10]

Our results should not be interpreted literally as demonstrating that a common currency will lead to a much lower volume of trade, particularly in light of the findings of Glick and Rose (2001). Indeed, such a result may strain credulity as much as Rose's finding of a tripling of trade. At the very least, though, one should be cautious about drawing any broad conclusions about the effects of common currencies on trade given that such a wide range of values can be estimated using this data set, and that the opposite sign can be obtained using a different and equally reasonable data set.

REFERENCES

Bacchetta, Philippe and van Wincoop, Eric. "Does Exchange-Rate Stability Increase Trade and Welfare?" *American Economic Review*, December 2000, *90*(5), pp. 1093-109.

Bayoumi, Tamim and Eichengreen, Barry. "Is Regionalism Simply a Diversion? Evidence from the Evolution of the EC and EFTA," in T. Ito and A. O. Krueger, eds., *Regionalism Versus Multilateral Trade Arrangements.* Chicago: University of Chicago Press, 1997.

Belanger, Denis; Gutierrez, Sylvia and Raynauld, Jacques. "The Impact of Exchange Rate Variability on Trade Flows: Further Results on Sectoral U.S. Imports from Canada." *North American Journal of Economics and Finance*, Spring 1992, pp. 888-92.

Brada, Josef C. and Mendéz, José A. "Exchange Rate Risk, Exchange Rate Regime and the Volume of International Trade." *Kyklos*, 1988, *41*(2), pp. 263-80.

Cheng, I-Hui and Wall, Howard J. "Controlling for Heterogeneity in Gravity Models of Trade." Working Paper 99-010B, Federal Reserve Bank of St. Louis, March 2001.

Côté, Agathe. "Exchange Rate Volatility and Trade: A Survey." Working Paper 94-5, Bank of Canada, May 1994.

De Grauwe, Paul. "Exchange Rate Variability and the Slowdown in Growth of International Trade." *International Monetary Fund Staff Papers*, March 1988, pp. 63-84.

Egger, Peter. "A Note on the Proper Econometric Specification of the Gravity Equation." *Economics Letters*, January 2000, *66*(1), pp. 25-31.

[10] Our results and conclusions are similar to those of Persson (2001), who applies a novel "matching approach" to estimate a "treatment effect" (a methodology with its roots in medical research) from the Rose data set.

European Commission. "Practical Arrangements for the Introduction of the Single Currency." Green Paper, May 1995.

Frankel, Jeffrey A. and Rose, Andrew K. "Estimating the Effects of Currency Unions on Trade and Output." Working Paper No. 7857, National Bureau of Economic Research, August 2000.

Frankel, Jeffrey A. and Wei, Shang-Jin. "Trade Blocs and Currency Blocs" [NBER Working Paper No. 4335], in Guillermo de la Dehaza, Alberto Giovannini, and Richard Portes, eds., *The Monetary Future of Europe*. London: Centre for Economic Policy Research, 1993.

Glick, Reuven and Rose, Andrew K. "Does a Currency Union Affect Trade? The Time Series Evidence." Working Paper No. 8396, National Bureau of Economic Research, 2001.

Greene, William H. *Econometric Analysis*. Hemel Hempstead, UK: Prentice-Hall, 1999.

Hsiao, Cheng. *Analysis of Panel Data*. New York: Cambridge University Press, 1986.

Mátyás, László. "Proper Econometric Specification of the Gravity Model." *The World Economy*, May 1997, *20*(3), pp. 363-68.

___________. "The Gravity Model: Some Econometric Considerations." *The World Economy*, May 1998, *21*(3), pp. 397-401.

Persson, Torsten. "Currency Unions and Trade: How Large Is the Treatment Effect?" Presented at the *Economic Policy* panel meeting in Stockholm, 6-7 April 2001, forthcoming in *Economic Policy: A European Forum*.

Plane, David A. "Migration Space: Doubly Constrained Gravity Model Mapping of Relative Interstate Separation." *Annals of the Association of American Geographers*, 1984, *74*(2), pp. 244-56.

Rose, Andrew K. "Currency Unions and Trade: The Effect Is Large." Presented at the *Economic Policy* panel meeting in Stockholm, 6-7 April 2001.

___________. "One Money, One Market: The Effect of Common Currencies on Trade." *Economic Policy*, April 2000, *15*(30), pp. 7-46.

___________ and Engel, Charles. "Currency Unions and International Integration." Working Paper No. 7872, National Bureau of Economic Research, September 2000.

___________ and van Wincoop, Eric. "National Money as a Barrier to International Trade: The Real Case for Currency Union." *American Economic Review*, May 2001, *91*(2), pp. 386-90.

The Mechanics of a Successful Exchange Rate Peg: Lessons for Emerging Markets

Michael J. Dueker and Andreas M. Fischer

Exchange rate pegs collapsed in many countries in the 1990s, leading to dreary assessments of the merits of pegged exchange rate regimes. Whether one points to the failure of Mexico's peg in December 1994 or to the sharp devaluations in East Asia in 1997-98, in Russia in August 1998, and in Brazil in January 1999, the collapse of unilateral exchange rate pegs often preceded acute financial and macroeconomic crises. Despite recent failures, however, exchange rate pegs remain a prevalent policy choice. Calvo and Reinhart (2000) argue that the exchange rate volatility that accompanies a floating exchange rate regime is particularly onerous to emerging markets, and thus can be a worse policy choice than a peg that reduces the variability of the exchange rate, even if it does not attain the complete confidence of investors. Given the continued prevalence of pegs, it is worth seeking additional understanding of what makes a peg successful or not.

For this reason, we find it useful to study what was arguably the most successful unilateral exchange rate peg: Austria's peg to the Deutsche mark prior to Austria's entry into the European Monetary System in 1995. An estimated model of Austrian monetary policy mechanics helps identify salient features that made the Austrian peg credible to the public. We then apply the same model to monetary policy in Thailand: among the East Asian countries that eventually devalued, Thailand had maintained the tightest peg to the U.S. dollar prior to July 1997. The conventional wisdom is that the currency crisis in Thailand came without warning and caught financial markets by surprise (Corsetti, Pesenti, and Roubini, 1999, and Halcomb and Marshall, 2000). We investigate whether there were any contrasts between the Austrian and Thai pegs that would have hinted at problems for Thailand prior to July 1997.

The next section discusses alternative exchange rate regimes to put the unilateral peg in context. The third section presents an empirical model of monetary policy to describe the mechanics with which Austria pegged its exchange rate. The fourth section applies the same model to describe Thailand's monetary policy and the contrast with Austria.

Michael J. Dueker is a research officer at the Federal Reserve Bank of St. Louis. Andreas M. Fischer is an economic adviser at the Swiss National Bank, Zurich, Switzerland. Mrinalini Lhila provided research assistance.

ALTERNATIVE EXCHANGE RATE REGIMES

As a prelude to an analysis of the mechanics of a unilateral exchange rate peg, it is useful to describe the spectrum of alternative exchange rate regimes. In addition to unilateral exchange rate pegs, there are five other exchange rate regimes: a floating rate (including managed floats), multilateral exchange rate pegs, currency boards, dollarization, and currency union. We describe here where the unilateral peg lies along the spectrum. Since the end of the Bretton Woods system of fixed exchange rates in 1973, floating exchange rates have displayed a very high degree of variability without a corresponding increase in the variability of exchange rate fundamentals (Flood and Rose, 1999). Moreover, Hausmann, Panniza, and Stein (1999) have shown that emerging markets in Latin America that have attempted to allow their exchange rates to float have experienced greater interest rate volatility than fixed-rate regimes. For this reason, Calvo and Reinhart (2000) argue that floating exchange rates can have destabilizing effects on emerging markets.

For the next four regimes—all variants of fixed exchange rates—we start with the type of fixed rate that is closest to a float and move along the spectrum from there. In the first three regimes, a home country unilaterally fixes its currency to an "anchor" currency. The unilateral nature of the regime implies that the anchor country is not obligated to assist the home country if its currency comes under speculative attack. In a pegged regime, it is incumbent on the pegging country to set a monetary policy that always appears to currency traders to be consistent with the preannounced conversion rate. The best way to uphold this commitment is to run a monetary policy that is similar to that in the anchor country in terms of inflation rates and credit expansion. A pegging regime is more resistant to speculative attack if banks and other institutions hold an amount of foreign-exchange reserves that is at least as great as the quantity of short-term debt

© 2001, THE FEDERAL RESERVE BANK OF ST. LOUIS

that is denominated in foreign currencies. Taiwan, for example, was largely immune to the Asian crisis of 1997-98 due to its large holdings of foreign exchange reserves. Many other emerging markets, however, intend to be net borrowers in foreign currencies, and they attract foreign lending by establishing a peg and promising a stable exchange rate. The best way to keep this promise is to run a monetary policy that closely mimics that of the anchor country.

A currency board differs from a unilateral peg in that the home country no longer sets its own monetary policy. Instead, the size of the monetary base is determined by monetary policy in the anchor country and capital flows. The currency board arrangement leaves no room for policies that are inconsistent with the fixed exchange rate because the only policy is a commitment to adjust the monetary base in tandem with flows of foreign exchange reserves in and out of the central bank. As a consequence, the home country's central bank can no longer act as a lender of last resort to the domestic banking sector; thus, speculative attacks can take place against banks instead of the currency.

Dollarization represents the unilateral decision to enact two formal changes.[1] The first change is that all local currency in circulation plus vault cash in banks is redeemed for U.S. dollars at some announced conversion rate and is then destroyed. The second change involves transforming all contracts denominated in local currency into contracts in U.S. dollars at the conversion rate. Dollarization, which has recently taken place in Ecuador, has received increasing attention in academic and policy circles.

Exchange rates can also be fixed through multilateral arrangements, although these require more coordination and negotiation than unilateral pegs. Two multilateral systems are multilateral pegs and currency unions. In a multilateral peg, the distinction between the anchor currency and the pegging currency becomes blurred because the participating countries are obligated to take monetary policy measures to defend the exchange rate peg. The prime example of a multilateral peg is the European Monetary System prior to the adoption of a single currency in January 1999. A currency union, in contrast, consists of an agreement to merge several currencies to fix the exchange rates and unify their monetary policymaking permanently. The European Monetary Union, undertaken in 1999, is the most prominent currency union.

A MODEL OF MONETARY POLICY MECHANICS FOR A UNILATERAL PEG

In practice, nearly all central banks implement monetary policy by setting a short-term interest rate as a policy instrument. A central bank trying to maintain an exchange rate peg will focus on the interest rate differential between the short-term rate in its domestic currency and the prevailing short-term rate in the anchor currency. If the home currency comes under selling pressure, an increase in the interest rate differential can attract buyers by convincing them that higher domestic interest rates will keep domestic inflation in check, prevent a devaluation, and result in excess returns to the domestic currency relative to the anchor currency. In the long run, the pegging central bank must keep domestic inflation rates close to inflation in the anchor currency. By harmonizing the inflation rates, the central bank prevents the real exchange rate from appreciating to unsustainable levels at the pegged nominal exchange rate. Speculators often bet that central banks that have allowed substantial appreciation of the real exchange rate through relatively high domestic inflation will choose to break the peg and devalue, rather than let the domestic economy stagnate for a prolonged period with a high, uncompetitive real exchange rate.

We preface our presentation of a model of monetary policy mechanics by noting that monetary policy decisions do not strictly obey a particular formula or equation. Nevertheless, central banks do not have to implement in a literal fashion a model of monetary policy for the model to be useful. In fact, central banks often monitor such models themselves because these models provide useful information about the rate of inflation that is likely to result from recent policy decisions.

In our empirical model of monetary policy mechanics, we assume that a pegging central bank adjusts the policy instrument, i (the interest rate differential), according to a forecast of the relationship between the policy instrument and domestic price inflation, π:

$$\Delta i_t = E_{t|t-1}\left[\Delta i_t + \pi_t\right] - \pi_{0t}, \quad (1)$$

where π_{0t} is the desired inflation rate, which is presumably close to the rate of inflation expected in the anchor currency. Note that this use of a forecast

[1] The term *dollarization* pertains to adopting the U.S. dollar; however, another major currency could be adopted as well.

to choose the policy instrument setting is analogous to setting a money-supply instrument, m in logs, according to a velocity forecast:

$$\Delta m_t = \Delta y_{0t} - E_{t|t-1}\left[\Delta y - \Delta m\right], \tag{2}$$

where y is nominal gross domestic product (GDP) in logs and Δy_{0t} is the desired rate of nominal GDP growth at time t. One difference is that, in the latter formulation, the forecasted quantity, $\Delta y - \Delta m$, is a well-known relation (velocity growth), whereas in the former the forecasted quantity, $\Delta i + \pi$ is not.[2] In either case, if policy is set according to the forecast and the forecast is correct on average, then the desired inflation or nominal GDP growth rate will be achieved on average.[3]

For a pegging central bank, we add to equation (1) two feedback terms that indicate the response to an exchange rate gap and an inflation gap. The exchange rate gap, $(e - \tilde{e})$, is between the actual and target exchange rate. The inflation gap, $(\pi - \pi^f)$, is between inflation in the home country and the anchor country:

$$\begin{aligned} \Delta i_t &= E_{t|t-1}\left[\Delta i_t + \pi_t\right] - \pi_{0t} \\ &+ \lambda_1\left(\pi - \pi^f\right)_{t-1} + \lambda_2\left(e - \tilde{e}\right)_{t-1} + \varepsilon_t . \end{aligned} \tag{3}$$

Not all of these feedback terms will be significant for both Austria and Thailand, but we estimated identical models for both countries to highlight the differences between their policies and not different models of policy. An error term ε is added to equation (3) to indicate that no central bank follows such an interest rate rule perfectly. In practice, we assume the error term has a Student t distribution with n degrees of freedom to allow for occasions of large deviations between the actual and model-implied policy settings. The coefficients λ_1 and λ_2 indicate to what degree the respective gaps alter this period's desired rate of inflation from the baseline level of π_0.

The model of monetary policy must infer a target value of the exchange rate because central banks allow even strongly pegged exchange rates to drift a bit over long periods of time, and they do not announce precisely the extent to which the exchange rate target has incorporated this drift. In this model, the implicit target exchange rate that appears in the exchange-rate gap in equation (3) is a weighted average of last period's target and last period's actual rate (in logs):

$$\tilde{e}_t = \delta \tilde{e}_{t-1} + \left(1 - \delta\right) e_{t-1} . \tag{4}$$

Gradual rebasing of the target occurs for values of δ less than one. Small shifts in the exchange rate are gradually accommodated into the target rate. As δ decreases from one, the rate of accommodation increases. Because δ is an estimated parameter, the model infers a path for the exchange rate target that best explains the central bank's policy responses as measured by interest rate adjustments.

Applying the Model to Austria's Peg

In order to use this model as a device to describe monetary policy mechanics over a relatively long sample period, it is realistic to allow some of the parameters to vary across time. Therefore, we make several parameters subject to two-state Markov switching, which is a parsimonious way to introduce variation into the parameter values. For example, even if Austria were to harmonize its intended inflation rate with Germany's, we would not expect Austria's baseline inflation, π_0, to be constant over the entire sample period. The German Bundesbank's informal inflation target varied between 4.5 and 2 percent (or less) between 1975 and 1994, according to von Hagen (1995). Thus, we can expect that estimates of π_0 for Austria will switch between two values that lie roughly in this range. Other parameters are not expected to remain absolutely constant across the entire sample either. For example, the exchange rate target will sometimes be nearly constant, $(\delta = 1)$, whereas at other times it will adjust to accommodate changes in the prevailing exchange rate, $(\delta < 1)$. Markov switching is a method that lets economists use the data and model to infer when parameter shifts occurred, rather than impose their own judgment. Also subject to switching are the feedback parameters, λ_1 and λ_2, and the variance, σ^2. We use three different binary Markov state variables, $S1$, $S2$, and $S3$, with transition probabilities, (p_i, q_i), $i = 1,2,3$, where $p_i = \text{Prob}(Si_t = 0 | Si_{t-1} = 0)$ and $q_i = \text{Prob}(Si_t = 1 | Si_{t-1} = 1)$.[4] The first state variable governs switching in π_0. The second governs switching in the feedback parameters λ_1, λ_2, and δ.

---

[2] An equivalent set-up to equation (1) would be to forecast $\Delta i + \Delta\pi$ to target the *change* in inflation as $\pi_{0t} - \pi_{t-1}$.

[3] Dueker and Fischer (1998) discuss the forecasting of the ratio between the nominal target variable and the policy instrument.

[4] Technical details regarding the estimation procedure are in the Appendix and Dueker and Fischer (1996).

Figure 1

Inflation Targets

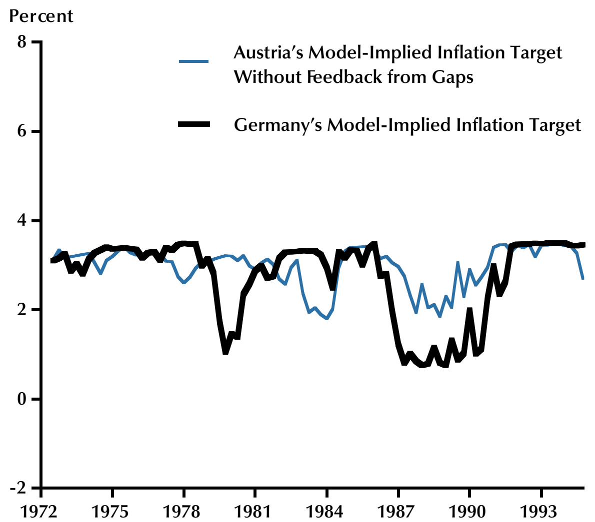


Table 1

Parameter Estimates for Austria

$\pi_{0a,b}$	1.740 (0.612)	3.494 (0.304)
$\lambda_{1a,b}$	0	0
p_1, q_1	0.887 (0.087)	0.941 (0.048)
$\lambda_{2a,b}$	1.124 (0.105)	0.338 (0.091)
$\delta_{a,b}$	1	0.823 (0.084)
p_2, q_2	0.231 (0.269)	0.743 (0.174)
$\sigma^2_{a,b}$	0.057 (0.028)	2.121 (1.074)
p_3, q_3	0.948 (0.041)	0.931 (0.578)
$1/n$	0.199 (0.161)	
Log-likelihood	–115.9	

NOTE: Standard errors are in parentheses; p_1, q_1 are transition probabilities for switching in π_0; p_2, q_2 are transition probabilities for switching in λ_1, λ_2, δ; p_3, q_3 are transition probabilities for switching in σ^2.

The third governs switching in σ^2, the variance of the error term. A more parsimonious model would tie all of these parameters to a single state variable, but it seems too restrictive to force the inflation target to move in tandem with the rebasing of the exchange rate target.

The data used to estimate the model are short-term interest rates and inflation rates for Austria and Germany, as well as the exchange rate between the Austrian schilling and the Deutsche mark. We use the three-month repurchase rates for Austria and Germany, which are the most representative short-term interest rates. The consumer price index (CPI) is the inflation measure. Our sample consists of quarterly data from 1972 to the end of 1994. On January 1, 1995, Austria officially entered the Exchange Rate Mechanism of the European Monetary System, whereupon the exchange rate became part of a multilateral peg.[5] Discussion of the construction of the forecasts, $E_{t|t-1}[\Delta i_t + \pi_t]$, and the likelihood function is included in the Appendix.

Parameter estimates for Austria from 1972:Q2 through 1994:Q3 are in Table 1, where subscripts a and b denote the pair of values of parameters subject to Markov switching. The a values correspond with the p transition probabilities, and the b values correspond with the q transition probabilities. Parameter values reported as equal to either zero or one converged arbitrarily close to those values and were not restricted in the estimation.

The estimates of Austria's baseline inflation rates, $\pi_{0a,b} = (1.74, 3.49)$, from Table 1 are quite close to the range of Germany's informal inflation targets of 4.5 to 2 percent or less.[6] The unconditional value of Austria's π_0 is 2.89. We call π_0 a baseline inflation rate because it would be the inflation target if both the exchange rate gap and the inflation gap were zero. To assess further whether Austrian monetary policy was aiming at a common rate of inflation with Germany, we estimated equation (3) for Germany, with the feedback coefficients λ_1 and λ_2 set to zero. The estimates of $\pi_{0a,b}$ for Germany are (0.71, 3.50), with an unconditional value of 2.86, which is extremely close to Austria's 2.89. Thus, Austria's monetary policymakers revealed through their interest rate instrument settings a preference for the same inflation rate as that of Germany, even in the absence of feedback from the exchange rate and inflation gaps.

Figure 1 shows a plot of the probability-weighted values of π_0 for Austria and Germany and shows a high degree of correspondence between the two. Austria's period-by-period inflation target, conditional on the inflation and exchange rate gaps, equals $\pi_{0t} - \lambda_{1t}(\pi - \pi^f)_{t-1} - \lambda_{2t}(e - \tilde{e})_{t-1}$.

[5] From 1974 to 1995, the Austrian National Bank unilaterally pegged the Austrian schilling to the Deutsche mark. This policy was known as the "hard-currency policy." Hochreiter and Winckler (1995) discuss this policy regime in detail.

[6] These results are presented in detail in Dueker and Fischer (2000).

Figure 2

Austria's Feedback Rule

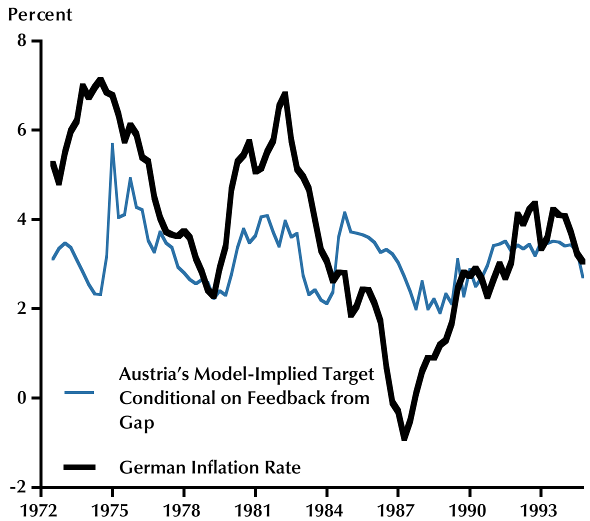
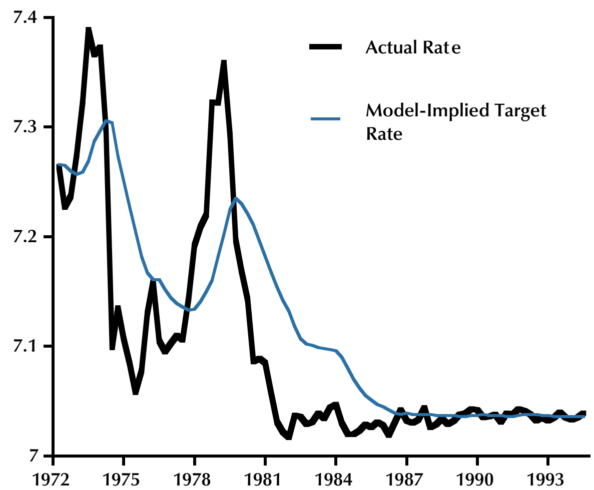


Figure 3

Schilling/Mark Exchange Rate



Since λ_1 equals zero in both states, Austria's monetary policy took feedback from the exchange rate only. One conclusion we can draw is that strong feedback from the inflation gap is not necessary for a peg to succeed, provided that the pegging country has chosen the same baseline inflation rates, π_0, as the anchor country.

Figure 2 shows Austria's period-by-period inflation target plotted against the actual rate of inflation in Germany calculated as the change in the CPI in the four most recent quarters. This chart suggests that Austria imported inflation from Germany during the two peaks in German inflation, the first in 1975 and the second in 1982. German inflation influenced Austrian monetary policy through the exchange rate because $e-\tilde{e}$ tended to be negative when German inflation was high. Figure 3 presents the model-implied exchange rate target, $\tilde{e}$, and the actual exchange rate.[7] In studying Figure 3, one must keep the scale in mind because the schilling fluctuated in a relatively narrow band throughout these 20 years. For most of the period, the exchange rate gap was negligible; therefore, Austrian monetary policy focused on keeping its inflation rate close to π_0, which Austrian policymakers had chosen to be close to Germany's inflation target. Nevertheless, the magnitude and significance of the feedback coefficients on exchange rate gaps, λ_2 in Table 1, indicate that Austrian monetary policy remained poised to act decisively to close any exchange rate gap that developed.

The Model of Peg Mechanics Applied to Thailand

Among the East Asian countries that were forced to break an exchange rate peg between 1997 and 1998, Thailand was the first, and perhaps the most surprising, to devalue. Prior to 1997, Thailand had maintained one of the tightest and most long-standing pegs in Asia. To understand the mechanics behind Thailand's peg of the Thai baht to the U.S. dollar, we estimate equation (3) for Thailand and compare the results with Austria. As with Austria, we used the three-month interest rate and the CPI along with the exchange rate. For Thailand, however, we used monthly data from January 1990 through June 1997, one month before the peg was broken.

Table 2 reports the parameter estimates: these show that Thailand's baseline inflation rate, π_{0t}, had an unconditional probability-weighted value of 6.5, which is well above the average level of U.S. inflation for that period, 3.1 percent. Hence the only way that Thailand's period-by-period inflation target could remain close to the U.S. rate would be through feedback from the inflation and exchange rate gaps. In contrast, Austria's baseline inflation rate closely matched the corresponding rate in Germany. Figure 4 shows that Thailand's inflation rate consistently

[7] In the graph the rates appear in levels, but they enter equation (3) in logarithms × 100.

Figure 4

Year-Over-Year Inflation Rates of Thailand and the United States

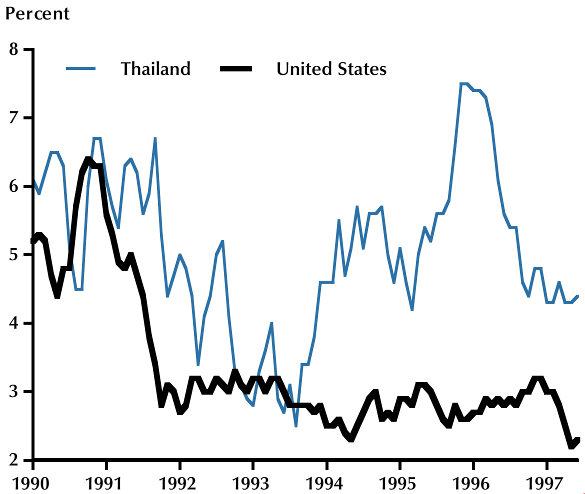


Table 2

Parameter Estimates for Thailand Monthly Data 1990:01 to 1997:06

$\pi_{0a,b}$	3.863 (2.102)	15.426 (3.882)
p_1, q_1	0.851 (0.139)	0.501 (0.018)
$\lambda_{1a,b}$	0	1.415 (1.422)
$\lambda_{2a,b}$	0	1.022 (0.532)
$\delta_{a,b}$	0.514 (0.074)	1
p_2, q_2	0.253 (0.368)	0.429 (0.264)
$\sigma^2_{a,b}$	2.917 (26.8)	2.993 (0.889)
p_3, q_3	0.207 (1.216)	0.998 (0.163)
$1/n$	0	
Log-likelihood	–197.1	

NOTE: Standard errors are in parentheses; p_1, q_1 are transition probabilities for switching in π_0; p_2, q_2 are transition probabilities for switching in λ_1, λ_2, δ; p_3, q_3 are transition probabilities for switching in σ^2.

exceeded the inflation rate in the United States, but by less than 3.4 percent (6.5 – 3.1), because of feedback from the inflation gap. Parameters p_2 and q_2 are the transition probabilities for switching in the feedback coefficients, λ_1 and γ_2, and both show very little persistence. In fact, since $p_2 + q_2 < 1$, the feedback coefficients show negative serial correlation, which implies oscillatory behavior in the period-by-period inflation target,

$$\pi_{0t} - \lambda_{1t}\left(\pi - \pi^{US}\right)_{t-1} - \lambda_{2t}\left(e - \tilde{e}\right)_{t-1}. \tag{5}$$

For Thailand, the feedback coefficients λ_{1b} and λ_{2b} imply strong responses to inflation and exchange rate gaps. For Austria, the feedback coefficients display no serial correlation—either positive or negative—because $p_2 + q_2$ is essentially equal to one; moreover, feedback from the gaps does not play an important role in determining Austria's interest rate.

Figure 5 shows that—after 1995 especially—Thailand's period-by-period inflation target, which is conditional on feedback from the gaps, appears to inherit negative serial correlation from switching in the feedback coefficients. Figure 6 plots the posterior probability of the high-feedback state and confirms that the fluctuation in the probability from month to month went from a relatively narrow range, between 30 percent and 60 percent prior to mid-1995, to a much greater range thereafter.[8] The discussion that follows centers on why Thailand's policy feedback coefficients became more volatile starting in mid-1995.

The exchange value of the U.S. dollar—to which the baht was pegged—reached a record low in May 1995 against the Japanese yen, at which time the dollar was also weak against other major currencies. Prior to May 1995, the dollar had depreciated consistently against the yen since early 1990 (as shown in Figure 7). Since Japan is both a major trading partner and a rival exporter with Thailand, the baht-dollar peg was able to sustain a rising real exchange rate with the dollar during the period that the yen was appreciating against the dollar.[9] In May 1995, however, the dollar-yen exchange rate peaked and the real exchange value of the yen began to depreciate against the dollar. To remain competitive in international markets, Thailand felt compelled at this juncture to prevent further appreciation of the real exchange value of the baht relative to the dollar. Clearly, it would have been difficult for Thailand if the real exchange value of the baht had been expected to continue to increase relative to the

[8] The posterior probability is the probability of a state at time t conditional on the data up to and including time t.

[9] The real exchange rate rises for Thailand if the inflation rate is greater in Thailand than in the United States and the nominal exchange rate (expressed in baht per dollar) does not increase by an equal magnitude.

Figure 5

Thailand's Feedback Rule

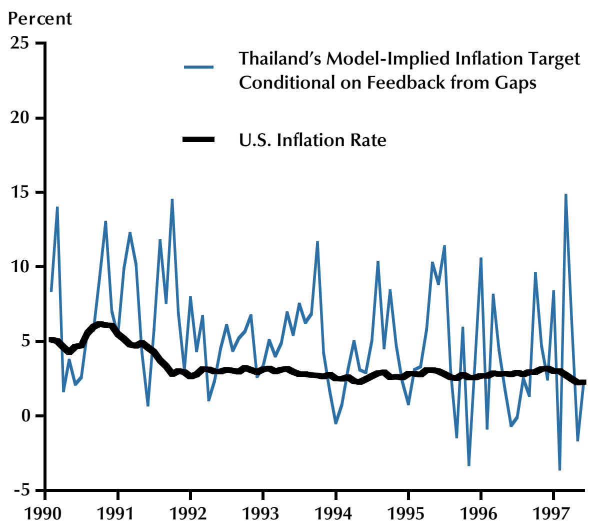
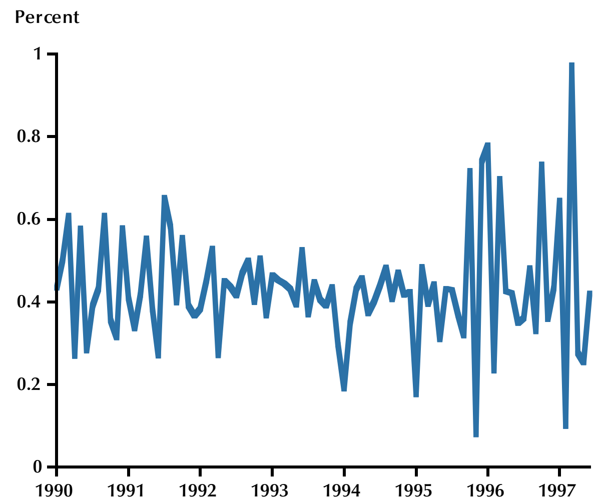


Figure 6

Thailand: Posterior Probability of the High-Feedback Coefficients on the Gaps



dollar at a time when the real exchange value of the dollar was rising relative to the world's other major currencies.

One key aspect of the credibility of an exchange rate peg is whether the market believes that the pegging country's economy remains competitive internationally, given any appreciation of its real exchange rate that has taken place during the peg. Thailand's appreciating real exchange value relative to the dollar may have appeared sustainable during a period when many of the world's other major currencies were appreciating relative to the dollar, but not when this course reversed. For this reason, it is not surprising that Figure 5 shows that Thailand's period-by-period inflation target was kept centered on a mean closer to the U.S. inflation rate after mid-1995. An obvious question, however, is why the inflation target was so volatile around this lower mean. The answer probably lies in the extreme inflows of foreign capital that Thailand was receiving at the time. On one hand, raising the short-term interest rate helped to reduce domestic demand and inflation. On the other hand, high interest rates helped spur additional flows of foreign capital to Thailand in search of high returns. In fact, the amount of foreign capital that flowed to Thailand in 1996 was massive, at a level equal to 13 percent of GDP (Grenville, 2000, p. 6). The tension between wanting to control domestic demand and inflation in the short run and worrying about the consequences of the huge capital inflows could explain the apparent stop-go behavior of Thailand's monetary policy after mid-1995. Such a balancing act—the rapid fluctuation of the feedback coefficients after 1995, shown in Figure 6—was not a sustainable policy for the long run. By July 1997, speculators had broken the exchange rate peg. Halcomb and Marshall (2000) review evidence that Thailand's

Figure 7

Yen/U.S. Dollar Exchange Rate

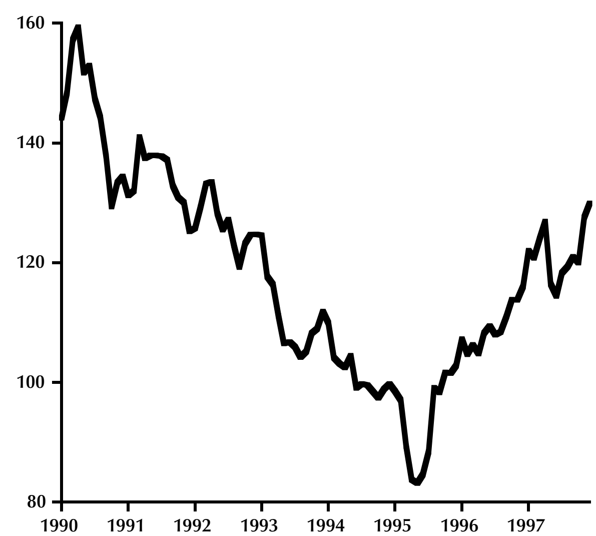


Figure 8

Baht/U.S. Dollar Exchange Rate

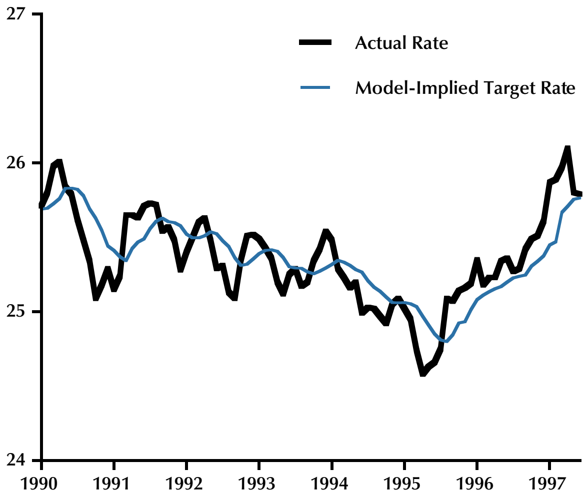
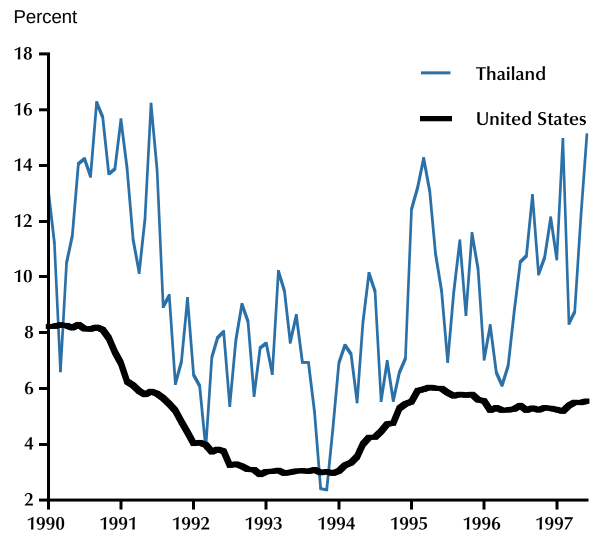


Figure 9

Short-Term Interest Rates in Thailand and the United States



devaluation of the baht in July 1997 was not widely anticipated in financial markets. They observe that the timing of a currency crisis can be difficult to predict, even if one knows that a peg is not on solid footing for the long run.

In the face of such massive capital inflows, it seems apparent in hindsight that Thailand probably should not have maintained such a hard peg. Instead, the monetary policy authority could have signaled by mid-1995 a greater degree of flexibility with respect to adjusting the peg. Indeed, the Bank of Thailand now practices inflation targeting with a floating exchange rate (Sonakul, 2000, p. 2). Figure 8 shows the baht-dollar exchange rate along with the model-implied target rate, $\tilde{e}$. This chart suggests that the Bank of Thailand allowed the baht to depreciate by about 4 percent in the 18 months prior to July 1997. Clearly this rate of depreciation was not enough to counteract the large interest rate differential shown in Figure 9. The size of the interest rate differential between Thailand and the United States in the early part of 1995 suggested that the Bank of Thailand might have signaled a willingness to let the baht depreciate at a rate of about 5 percent per year. Such a rate of expected depreciation also might have helped alleviate the capital inflows by discouraging domestic borrowers from taking dollar-denominated loans. Instead, the Bank of Thailand chose to defend the peg by squeezing speculators who tried to take short positions in baht by imposing high interest rates and pressure on domestic banks not to lend to off-shore currency traders (Halcomb and Marshall, 2000).

SUMMARY AND CONCLUSIONS

Our empirical results for Austria's successful exchange rate peg highlight the importance the Austrian National Bank placed on consistently maintaining Austria's inflation rate close to that of Germany. In so doing, Austria prevented the real exchange value of the schilling vis-a-vis the Deutsche mark from drifting far from its initial value. Furthermore, the Austrian economy had enough in common with the German economy that the Austrian National Bank was willing to let the real exchange value of the schilling experience the vicissitudes in the real exchange value of the Deutsche mark against other major currencies. One lesson for pegging countries is that they ought to behave like assiduous inflation targeters even when there is no pressure on the exchange rate. The key is that the inflation target should be the same inflation target used in the anchor country because the nominal exchange rate can no longer move to correct an overvalued real exchange rate. Feedback from the inflation and exchange rate gaps did not appear to play an important role in Austria's successful peg, given that Austria followed Germany's inflation target closely even before gaps developed. A second lesson is to take care in choosing an anchor currency because the major currencies experience wide swings against one another. It makes no sense to tie one's currency to the dollar if the fluctuations in the exchange value of the dollar against other major currencies are difficult to withstand.

Both of these lessons appear to apply to Thailand's peg to the U.S. dollar. The Bank of Thailand allowed the domestic inflation rate to exceed the U.S. inflation rate prior to mid-1995, based on the depreciation of the U.S. dollar against other major currencies, principally the Japanese yen. In fact, the estimates of Thailand's baseline inflation rate were more than twice the average U.S. inflation rate. If the Bank of Thailand truly had a long-term commitment to pegging its currency to the dollar, it would not have tried to take advantage of the depreciation in the dollar against the yen by inflating. This policy led to trouble when the U.S. dollar began to appreciate against the yen in the second half of 1995. At this point, Thailand's policy response to the inflation gap between Thailand and the United States was strong, but it was not implemented consistently. The model estimates reveal unstable, oscillatory behavior in the feedback from the inflation gap, probably due to the tension between the desire for high interest rates to control inflation and concern for the size of the capital inflows that high interest rates were attracting. In these circumstances, it would have been exceedingly difficult for inflation in Thailand to undershoot the U.S. inflation rate by a significant margin. The Bank of Thailand might have fared better by announcing gradual depreciation of the nominal exchange rate, starting in mid-1995, before speculators began to apply their own pressure. Since the crisis in 1997-98, the Bank of Thailand has announced a new inflation-targeting regime in place of an exchange rate peg. The Bank of Thailand believes that the new regime will be less prone to boom and bust cycles than was the peg to the dollar (Sonakul, 2000). Thus, Thailand is one emerging market that has decided that it can find greater stability by promising low inflation than by promising a particular exchange rate. Time will tell whether the disadvantages of floating exchange rates to emerging markets will weigh as heavily as Calvo and Reinhart (2000) suggest. What is clear from the results presented here is that Thailand's exchange rate peg prior to July 1997 never had the strong underpinnings that sustained Austria's peg to the Deutsche mark.

REFERENCES

Calvo, Guillermo A. and Reinhart, Carmen M. "Fixing for Your Life." Working Paper 8606, National Bureau of Economic Research, November 2000.

Corsetti, Giancarlo; Pesenti, Paolo and Roubini, Nouriel. "What Caused the Asian Currency and Financial Crisis?" *Japan and the World Economy*, 1999, *11*, pp. 305-73.

Dueker, Michael J. and Fischer, Andreas M. "Austria's Hard-Currency Policy: The Mechanics of a Successful Exchange Rate Peg." Working Paper No. 2479, Centre for Economic Policy Research, March 2000.

___________ and ___________. "A Guide to Nominal Feedback Rules and Their Use for Monetary Policy." Federal Reserve Bank of St. Louis *Review*, July/August 1998, *80*(4), pp. 55-63.

___________ and ___________. "Inflation Targeting in a Small Open Economy: Empirical Results for Switzerland." *Journal of Monetary Economics*, February 1996, *37*, pp. 89-103.

Flood, Robert P. and Rose, Andrew K. "Understanding Exchange Rate Volatility with the Contrivance of Macroeconomics." *Economic Journal*, November 1999, pp. F660-72.

Grenville, Stephen. "Exchange Rate Regimes for Emerging Markets." Bank for International Settlements *Review,* No. 97, 3 November 2000, pp. 5-14.

Halcomb, Darrin and Marshall, David. "A Retrospective on the Asian Crisis of 1997: Was it Foreseen?" *Chicago Fed Letter*, January 2001.

Hausmann, Ricardo; Panizza, Ugo and Stein, Ernesto. "Why Do Countries Float the Way They Float?" Working Paper 418, Inter-American Development Bank, May 1999.

Hochreiter, E. and Winckler, G. "The Advantage of Tying Austria's Hands: The Success of the Hard Currency Strategy." *European Journal of Political Economy*, 1995, *11*, pp. 83-111.

Sonakul, M.R. Chantu Mongol. "Inflation Targeting—A New Monetary Policy Approach for Thailand." Bank for International Settlements *Review,* No. 106, 27 November 2000, pp. 1-2.

Von Hagen, Juergen. "Inflation and Monetary Targeting in Germany," in Leonardo Leiderman and Lars E.O. Svensson, eds., *Inflation Targets*. London: CEPR Press, 1995.

Appendix

The forecasts for equation (3) are taken from a model that allows for two types of uncertainty. The first arises from heteroscedasticity in the error terms. This is modeled by a Markov switching process, which tries to match the persistence of periods of high and low volatility in the data. The second source of uncertainty arises as economic agents are obliged to infer unknown or changing regression coefficients.

The model generating the forecasts is

$$\text{(A1)} \quad \left(\Delta i_t + \pi_t\right) = \beta_{0t} + \beta_{1t}\Delta i_{t-1} + \beta_{2t}\pi_{t-1} + \beta_{3t}\Delta e_{t-1} + u_t,$$

$$u_t \sim \text{Normal}\,(0,h_t).$$

$$h_t = v_0^2 + (v_1^2 - v_0^2)R_t,$$

where R_t is 0 or 1

$$\text{Probability}\,(R_t = 0 \mid R_{t-1} = 0) = r_1$$

$$\text{Probability}\,(R_t = 1 \mid R_{t-1} = 1) = r_2.$$

Variable i is the interest rate differential, π is consumer price inflation, and e is the exchange rate in logs.

The time-varying coefficients assume that the state variables, β_t, follow a random walk process:

$$\beta_t = \beta_{t-1} + \upsilon_t$$

$$\upsilon_t \sim \text{Normal}\,(0,Q).$$

The random walk assumption suggests that agents need new information before changing their views about the relationships among the variables. Moreover, the time-varying structure of the forecasts allows it to adapt to structural breaks in the relationships between the dependent and explanatory variables.

The maximum-likelihood estimates reported in Tables 1 and 2 are the result of estimating the following density function, which includes three Markov state variables denoted $S1$, $S2$, and $S3$, where Y_{t-1} is all information available through time $t-1$:

$$\text{(A2)} \quad \sum_{t=1}^{T} \ln \left(\sum_{i=0}^{1}\sum_{j=0}^{1}\sum_{k=0}^{1} \text{Prob}\left(S1_t = i,\, S2_t = j, S3_t = k \mid Y_{t-1}\right) L_t^{(i,j,k)} \right).$$

The Student t densities are

$$\text{(A3)} \quad \ln L_t^{(i,j,k)} = \ln \Gamma\left(0.5\left(n+1\right)\right) - \ln \Gamma\left(0.5n\right) - 0.5 \ln\left(\pi n \sigma^2_{S3_t=k}\right) - 0.5(n+1)\ln\left(1 + \frac{\varepsilon^2_{S1_t=i,S2_t=j}}{n\sigma^2_{S3_t=k}}\right),$$

and Γ is the gamma function.

New Economy—New Policy Rules?

James B. Bullard and Eric Schaling

INTRODUCTION

The New Economy

United States economic performance during the latter portion of the 1990s far exceeded even optimistic forecasts. From 1996 through 2000, nonfarm business sector productivity grew by about 3.0 percent per year, on average. In the ten years previous to this period, from 1986 through 1995, it had increased at an average rate of only 1.4 percent per year. The late 1990s coincided with a spell of accelerated progress in computer technology and a widening adoption of the Internet by businesses and consumers. U.S. real output increased about 4.3 percent per year, on average, from 1996 through 2000, while, at the same time, inflation pressures remained rather subdued, with the personal consumption expenditures price index increasing at an average rate of only about 1.9 percent per year.

Economists in the United States have been cognizant of these changing trends. Many commentators have argued that technological change may be increasing American productivity, making it possible for the economy to grow at a faster rate without creating inflation. And, in fact, Federal Reserve officials have made many such arguments in recent years. Consider, for example, the May 6, 1999, Congressional testimony by Federal Reserve Chairman Alan Greenspan: "…the evidence appears to be mounting that, even if productivity does not continue to accelerate, the pickup already observed does seem to explain much of the extraordinary containment of inflation despite the ever-tightening labor markets of recent years." The next day the *Washington Post* reported: "Greenspan said the unexpected jump in productivity is the major reason that for the past three years so many forecasters, including those at the Fed, have underestimated economic growth while overestimating inflation."

This set of events is sometimes collectively called "the new economy," and we will use this meaning of the term for the purposes of this paper.

Optimal Monetary Policy Rules in the New Economy

The U.S. monetary policy debate has been importantly influenced by Taylor (1993), who argued that simple, nominal interest rate–based monetary policy rules might produce good stabilization performance.[1] Taylor's (1993) ideas were based on a given, constant inflation target for the monetary authorities and, especially important for this paper, a given, constant long-run level of productivity. Nearly all rules in this literature are then specified relative to these fundamental objects. In addition, Taylor's (1993) analysis was not of an optimal policy rule, but of an ad hoc rule that Taylor reasoned would perform well based on historical experience. Svensson (1997) showed how a version of the Taylor rule could be viewed as the *optimal* monetary policy rule in a simple dynamic macroeconomic model, again for a given inflation target and a given underlying level of productivity. In addition, the papers in the Taylor (1999) volume generally favor the idea that something close to optimal stabilization performance could be obtained by adhering to a Taylor rule, across a wide variety of macroeconomic models.

However, one of the key "new economy" events is the shift in productivity. It seems natural that a fully optimal monetary policy rule would take account of the changing nature of the supply side. Our main goal in this paper is to derive an optimal monetary policy rule in an environment with unobserved shifting productivity, so that the policy authorities must infer the underlying regime from observed data. We wish to accomplish this in the simplest possible framework, but one in which we are sure that a Taylor-type rule would be optimal were it not for the productivity changes. Accordingly, we adopt Svensson's (1997) model as a baseline, and we augment the model with two-state regime switching in the level of long-run productivity. We wish to understand how a Taylor-type rule would have to be altered to allow for the possibility that underlying productivity shifts may occur. Although

James B. Bullard is an assistant vice president and senior economist at the Federal Reserve Bank of St. Louis. Eric Schaling is a professor of economics at Rand Afrikaans University and thanks the reserve staff for their support during his visit to St. Louis. The authors also thank Michael Dueker, Franc Klaassen, and seminar participants at CentER, Tilburg University, for helpful discussions. Marcela Williams and Charles Hokayem provided research assistance.

[1] For some of the related recent research on monetary policy rules, see Taylor (1999), King and Plosser (1999), and Clarida, Gali, and, Gertler (1999).

© 2001, THE FEDERAL RESERVE BANK OF ST. LOUIS

we use this model to keep our exposition relatively simple, we also think that it is reasonably clear that the basic findings here would hold in far more elaborate models.

Main Results

Our main finding is that the optimal policy rule in an environment with unobserved productivity shifts involves important lagged terms in inflation and the output gap. The role of these lagged terms is to help the policy authority react with appropriate interest rate adjustments when unobserved shifts in underlying productivity occur. In certain special cases, our optimal policy rule collapses to Svensson's (1997) rule for the same model, which involves only contemporaneous data. These special cases occur when (i) the probability of remaining in each regime is exactly one-half, so that productivity regimes are not persistent and can be interpreted simply as noise, or (ii) when the levels of productivity in the two regimes approach one another, so that there is effectively no difference between the two regimes. Intuitively, we think our main finding is an important one that would extend to a wide variety of models: In the face of possible unobserved changes in regime, the policy authority must optimally consider recent trends in the data to infer whether the regime shift has occurred.

While our main results are analytical, we also consider a calibration of the model in order to fix ideas and provide illustrations of our findings. Adhering to a Taylor-type rule as derived by Svensson (1997) when there are, in fact, unobserved switches in productivity regimes implies significantly worse macroeconomic performance, relative to the optimal rule that we derive. Policymakers using a Svensson-Taylor rule would typically observe inflation that is persistently above or below target. This would appear to them to be due to unobserved special factors. But, with the optimal rule, inflation remains near target at all times and output fluctuates in response to the changes in productivity regimes and normal macroeconomic shocks. Thus the shift from low to high productivity in conjunction with a policy authority adhering to a Svensson-Taylor rule produces the events associated with the "new economy" as described in the opening paragraph: output persistently higher than expected, inflation persistently lower than expected, measured productivity higher, and policymakers arguing that a productivity shift has contained inflation. The reverse case, a regime shift from high to low productivity, generates some of the features of the stagflation of the 1970s.

The remainder of this paper is organized as follows. First, we describe the model we will employ. Then, we derive our optimal monetary policy rule when there are regime switches in productivity; in the next section we compare the economic performance of our simple macroeconomy under the Svensson-Taylor rule and under the optimal rule. Then we offer some closing comments and use two appendices to discuss mathematical details.

ENVIRONMENT

As in Svensson (1997), we assume that inflation and the output gap are linked by the following short-term Phillips curve relationship:

$$\pi_{t+1} = \pi_t + \alpha y_t - u_{t+1}, \quad (1)$$

where $\pi_t = p_t - p_{t-1}$ is the inflation rate from period $t-1$ to period t; p_t is the natural logarithm of the price level in period t; y_t is the natural logarithm of the output gap at t; and the parameter α measures the slope of the Phillips curve. We interpret u_t as a productivity (supply) shock, and we put more structure on it below. We normalize the natural level of output to zero, so that y_t is zero when output is at this steady-state or "trend" level. Following Svensson (1997, p. 1115), we assume that the output gap is serially correlated, decreasing in the short-term real interest rate and increasing in an exogenous shock to the gap:

$$y_{t+1} = \beta_1 y_t - \beta_2 (i_t - \pi_t) + x_{t+1}, \quad (2)$$

where $\beta_2 > 0$, $0 < \beta_1 < 1$, i_t is a short-term nominal interest rate controlled by the monetary authority, and x_{t+1} is a stochastic disturbance term. As can be seen from equations (1) and (2), the real interest rate affects the output gap with a one-period lag, and hence affects inflation with a two-period lag, which is the control lag in the model. The shock to the output gap is serially correlated and assumed to be subject to i.i.d. noise ε_{t+1}, with mean zero and variance σ_ε^2 according to

$$x_{t+1} = \rho x_t + \varepsilon_{t+1}. \quad (3)$$

We want to think in terms of persistent productivity regimes in which switches are relatively rare events, corresponding to the U.S. productivity experience in the postwar era. To study persistent changes in productivity, we extend this system with a stochastic process for productivity, u_t. We use a two-state process defined by

$$u_{t+1} = a_h s_{t+1} - a_\ell = \begin{cases} a_h - a_\ell & \text{if } s_{t+1} = 1 \\ -a_\ell & \text{if } s_{t+1} = 0 \end{cases}, \quad (4)$$

where $a_h > a_\ell > 0$. Under this specification, as $a_h \rightarrow 0$, there is no difference between the regimes, and so we think of a_h as scaling the effect of the productivity differences in the two regimes. The unobserved state of the system s_t takes on a value of zero or one and follows a two-state Markov process.[2] There is an associated transition probability matrix given by

$$T = \begin{bmatrix} p & 1-p \\ 1-q & q \end{bmatrix}, \quad (5)$$

where

$$\begin{aligned} &\Pr[S_{t+1} = 1 | S_t = 1] = p, \\ &\Pr[S_{t+1} = 0 | S_t = 1] = 1-p, \\ &\Pr[S_{t+1} = 0 | S_t = 0] = q, \end{aligned} \quad (6)$$

and $\Pr[S_{t+1} = 1 | S_t = 0] = 1-q$.

Thus, the probability of remaining in the high (low) state conditional on being in the high (low) state in the previous period is $p(q)$, the probability of switching from the high to the low state is $1-q$, and the probability of switching from the low state to the high state is $1-p$. Because we wish to think of persistent regimes, we restrict our analysis to the case where both $p \geq 1/2$ and $q \geq 1/2$.

As suggested by Hamilton (1989), the stochastic process for equation (6) admits the following AR(1) representation:

$$s_{t+1} = (1-q) + \gamma s_t + \upsilon_{t+1}, \quad (7)$$

where $\gamma \equiv p + q - 1$ and υ_t is a discrete, white noise process with mean zero and variance σ_υ^2. From equation (2) it follows that the unconditional mean steady-state level of output, $\bar{y}$, associated with a zero steady-state real interest rate is zero. To be consistent, we impose that this level from equation (1) should also be zero. This implies

$$a_\ell = \bar{p} a_h, \quad (8)$$

where

$$\bar{p} \equiv \frac{(1-q)}{2-p-q}.$$

We give the details of this calculation in Appendix A.

Monetary policy is conducted by a central bank that controls a short-term nominal interest rate, i_t, and that has an exogenously given inflation target, π^*. The authorities aim to minimize deviations of inflation from this assigned target, on the one hand, and fluctuations of output around its trend level (which is normalized to zero, i.e., $\bar{y} = 0$), on the other. Consequently, the central bank will choose a sequence of current and future short-term nominal rates to meet the objective

$$\underset{\{i_t\}_{t=0}^{\infty}}{Min}\ E_t \sum \delta^t \left[\frac{1}{2} \left(\pi_t - \pi^* \right)^2 + \frac{\mu}{2} \left(y_t - \bar{y} \right)^2 \right]. \quad (9)$$

Here $0 \leq \mu < \infty$ represents the central bank's relative weight on output stabilization, while the parameter $\delta \in (0,1)$ denotes the discount factor. The expectation is conditional on the central bank's information set in period t. This information set contains the current output gap, y_t, the current inflation rate, π_t, its forecast of the shock to the output gap, x_{t+1}, its forecast of the productivity shock—which depends on the unobserved regime s_{t+1}—and the structure of the economy as described by equations (1) through (8).

IMPLEMENTING INFLATION TARGETING

To get some straightforward results, we interpret inflation targeting as implying *strict* inflation targeting, in the sense that inflation is the only argument in the loss function (9). This means that we set $\mu = 0$.[3]

Applying $(1-\gamma L)$, where L is the lag operator defined by $L^j x_t = x_{t-j}$, to equation (1) and taking account of equation (4),

(10)

$$(1-\gamma L)\Delta\pi_{t+1} = \alpha(1-\gamma L)y_t - a_h(1-\gamma L)s_{t+1} + (1-\gamma)a_\ell.$$

Substituting for $(1-\gamma L)s_{t+1}$ from equation (7), we may rewrite equation (10) as

$$\pi_{t+1} = (1+\gamma)\pi_t - \gamma\pi_{t-1} + \alpha y_t - \alpha\gamma y_{t-1} - a_h \upsilon_{t+1}, \quad (11)$$

where we have used the fact that

[2] We adopt the usual convention that, for discrete-valued variables, capital letters denote the random variable and small letters a particular realization. If both interpretations apply we use small letters.

[3] In the case where $\mu > 0$, the intuition and main findings change little while the mathematics becomes considerably more complex. To keep our main points clear we have simply decided to omit analysis of this case. We discuss the $\mu = 0$ assumption in more detail near the end of the paper.

$$a_\ell = \left(\frac{1-q}{1-\gamma}\right) a_h .$$

Hence, in the absence of control, the combination of the Phillips curve (equation (1)) and the AR(1) representation of the productivity state (equation (7)) gives rise to a second-order stochastic difference equation for inflation. An important limiting case of equation (11) is when $p = q = 0.5$; that is, in each period either regime is equally likely to occur, regardless of the current state. In this case the productivity shock becomes serially uncorrelated and the reduced form parameter $\gamma \to 0$. When this occurs, the Phillips curve approaches the standard Svensson (1997) first-order form.

We have noted that in the above model the control lag is two periods. The *current* inflation rate and the *current* output gap are predetermined variables that cannot be influenced by policy. Therefore, the one-period-ahead inflation forecast is also predetermined[4] (independently of the current level of interest rates). However, by changing the current nominal interest rate, the policymaker can affect the one-period-ahead output gap forecast and thereby the one-to-two-period inflation forecast. Thus, i_0 affects $E_0 y_1$, which in turn affects $E_0 \pi_2$; i_1 affects $E_1 y_2$, which in turn affects $E_1 \pi_3$, and so on. The proper intermediate target for policy is thus the one-to-two-period inflation forecast, and the instrument (control) of policy is the nominal interest rate at time t, or equivalently the one-period-ahead output gap forecast.

When $\mu \to 0$, the above problem becomes straightforward. The monetary authority then needs to set $E_t y_{t+1}$ so as to ensure that (today's forecast of) the two-period-ahead inflation rate is equal to the inflation target. Thus, we have $\pi^* = E_t \pi_{t+2}$.[5] Leading the inflation equation (1) by one period and taking expectations at time t yields

$$(12) \qquad E_t \pi_{t+2} = E_t \pi_{t+1} + \alpha E_t y_{t+1} - E_t u_{t+2} .$$

Setting this expression equal to the inflation target and then rearranging gives the optimal value of the control:

$$(13) \qquad E_t y_{t+1} = -\frac{1}{\alpha}\left(E_t \pi_{t+1} - \pi^*\right) + \frac{1}{\alpha} E_t u_{t+2},$$

where the (predetermined) one-period-ahead inflation forecast is given by[6]

$$(14) \qquad E_t \pi_{t+1} = \pi_t + \alpha y_t - E_t u_{t+1}.$$

If $p = q = 1/2$, we get $E_t u_{t+1} = E_t u_{t+2} = 0$ and the policy rule (13) is identical to the optimal rule for the Svensson (1997) model (for the case of strict inflation targeting). This rule says that, if the one-period-ahead inflation forecast exceeds the target, *ceteris paribus*, the one-to-two-period inflation forecast will exceed the target. To compensate, the policymaker then needs to contract next period's forecast of the level of the output gap in the economy.

We now want to think of p and q as substantially greater than $1/2$, so that the model has persistent favorable or unfavorable supply side developments—regimes—which more closely approximate the postwar U.S. experience.

If the current-period forecast of next period's productivity state is favorable ($E_t u_{t+1} > 0$), this has two effects. In the first place it directly lowers the one-period-ahead inflation forecast (see equation (14)). This means that the central bank should allow next period's output gap to expand. The intuition is that, to prevent inflation from falling too far below the target, the demand side of the economy should move in tandem with the supply side. Thus, the sign of $E_t u_{t+1}$ in equation (13), through $E_t \pi_{t+1}$, is positive.

The second (or indirect) effect of a positive one-period-ahead productivity forecast is through its effect on the one-to-two-period productivity forecast. More specifically, any given productivity state is likely to persist into the future, so the expectation of a high state next period implies a similar outlook for the following period. In fact it can be shown that

$$(15) \qquad E_t u_{t+2} = \gamma E_t u_{t+1}$$

(see Appendix C for details on the optimal predictor for productivity). In turn, if $E_t u_{t+2} > 0$, the one-to-two-period inflation forecast falls (see equation (12)), allowing the central bank to expand next period's level of the output gap. Thus, the sign of $E_t u_{t+2}$ in equation (13) is also positive. Substituting the right-hand sides of equation (14) for $E_t \pi_{t+1}$ and equation (17) for $E_t u_{t+2}$ in (15) gives

$$(16) \quad E_t y_{t+1} = -\frac{1}{\alpha}\left(\pi_t + \alpha y_t - \pi^*\right) + \frac{1}{\alpha}(1+\gamma) E_t u_{t+1}.$$

The first part of the expression for the optimal

[4] This can be seen by taking expectations at time t of equation (11). This yields $E_t \pi_{t+1} = (1 + \gamma)\pi_t - \gamma \pi_{t-1} + \alpha y_t - \alpha \gamma y_{t-1}$.

[5] For a derivation of this condition, see Appendix B.

[6] This can be seen by taking expectations at time t of equation (1).

control, $(-1/\alpha)(\pi_t + \alpha y_t - \pi^*)$, is identical to the Svensson (1997) derivation. This term can be interpreted as the demand component of the inflation process. The second component, $(1/\alpha)(1+\gamma)E_t u_{t+1}$, is new and contains the central bank's optimal reaction to its assessment of the (dis)inflationary consequences of the future *supply side* of the economy on the one-period-ahead and two-period-ahead inflation forecasts (the terms $(1/\alpha)\,E_t u_{t+1}$ and $(\gamma/\alpha)\,E_t u_{t+1}$, respectively).

In Appendix C we show that the central bank's optimal predictor for productivity is a function of the lagged output gap and the current acceleration of the inflation rate. That is,

(17) $$E_t u_{t+1} = \alpha\gamma y_{t-1} - \gamma\Delta\pi_t,$$

where Δ is the backward difference operator. Thus, the central bank can use its observed values of y_{t-1} and $\Delta\pi_t$ to forecast next period's productivity level. Substituting (17) into (16), we obtain

(18)
$$E_t y_{t+1} = -\frac{1}{\alpha}\left(\pi_t + \alpha y_t - \pi^*\right) + \frac{1}{\alpha}(1+\gamma)\left(\alpha\gamma y_{t-1} - \gamma\Delta\pi_t\right).$$

The term $-\gamma\Delta\pi_t$ suggests that, if inflation accelerates, this is likely to be an indication of adverse developments on the supply side of the economy. Or, put differently, an accelerating inflation rate is a *leading indicator* of an adverse supply shock.

Similarly, the term $\alpha\gamma y_{t-1}$ suggests that if last period's output gap was negative—meaning that one period ago the economy was operating below its long-run potential—this is not an indication of lack of demand. Instead, it is indicative of the presence of an adverse *supply shock*. Under strict inflation targeting this means that the central bank demand should contract (its forecast of) the output gap. Otherwise, the policymaker risks further amplifying the inflation process. Similarly, if last period's output gap was positive, it indicates a positive supply shock, rather than excess demand. Now the central bank should allow the output gap to widen, since otherwise it risks creating disinflation.

Finally, using the fact that the one-period output gap forecast fulfills

(19) $$E_t y_{t+1} = \beta_1 y_t - \beta_2 r_t + r^*,$$

where $r_t = i_t - \pi_t$ is the real ex post short-term interest rate and

$$r^* \equiv \frac{\rho x_t}{\beta_2},$$

the central bank's optimal monetary policy rule (interest rate reaction function) can be written as

(20)
$$r_t - r^* =$$
$$\frac{1}{\beta_2\alpha}\left(\pi_t - \pi^*\right) + \frac{\left(1+\beta_1\right)}{\beta_2} y_t + \frac{\gamma(1+\gamma)}{\beta_2\alpha}\Delta\pi_t - \frac{\gamma(1+\gamma)}{\beta_2} y_{t-1}.$$

The first two terms in the rule, involving $(\pi_t - \pi^*)$ and y_t, are identical to those derived by Svensson (1997). These terms can be viewed as the demand components of the inflation process. The third and fourth terms, involving $\Delta\pi_t$ and y_{t-1}, are new and are leading indicators of future supply shocks.

An important limiting case of equation (20) is when $p = q = 1/2$. Then $\gamma \to 0$ and the supply-side terms drop out, so that the policy rule collapses to

(21) $$r_t - r^* = \frac{1}{\beta_2\alpha}\left(\pi_t - \pi^*\right) + \frac{\left(1+\beta_1\right)}{\beta_2} y_t,$$

which—as in Svensson (1997, p. 1119)—is essentially a version of the simple policy rule popularized by Taylor (1993).[7] Another special case, less obvious from equation (20), is when $a_h \to 0$; here there is still regime switching, but the two regimes approach the same productivity levels and so the switching does not have any effect.

We now turn to a calibrated case to illustrate some of the differences between these rules.

COMPARING THE RULES

Calibration

Table 1 summarizes the parameter values used in our calibrated economy. We use standard, illustrative values for α, β_1, and β_2. The shock to the output gap is quite persistent, with $\rho = 0.9$. We chose the shock ε from a uniform distribution with minimum value $-1/2$ and maximum value $1/2$. The value of a_h scales the size of the effects of a productivity regime switch on the deviation of inflation from the policymakers' target value. Our choice of $a_h = 1$ limits this effect to 1 percentage point, but we could scale it up or down by choosing other values. Finally, we want to consider systems with very persistent regimes, and so we set $p = q = 0.975$, meaning that the chance of switching out of a given regime is only 0.025 in any period.

[7] Taylor rules are often written in terms of nominal interest rates, but given the definition of r_t the rules in equations (20) and (21) can easily be interpreted in these terms.

Table 1

Parameter Configuration

Parameter	Controls	Value
α	Response of inflation to the output gap	0.5
β_1	Output persistence	0.7
β_2	Response of the output gap to the real interest rate	1
ρ	Serial correlation in the shock to the output gap	0.9
σ_ε^2	Variance of the shock to the output gap	0.084
a_h	Productivity scale factor	1
p	Probability of high productivity, given high productivity	0.975
q	Probability of low productivity, given low productivity	0.975
π^*	Policymaker's inflation target	2.5

NOTE: We illustrate our analytical findings using this calibration.

Table 2

Asymptotic Loss

Case	Svensson-Taylor rule	Optimal rule
Baseline…	0.996	0.138
…with $p=q=1/2$	0.521	0.521
…with $a_h \to 0$	0.021	0.021

NOTE: In the baseline case, there are quantitatively important, persistent regimes. The optimal rule performs significantly better in this case. If the regimes are not persistent (second line) or not very different (third line), then the two rules perform equally well.

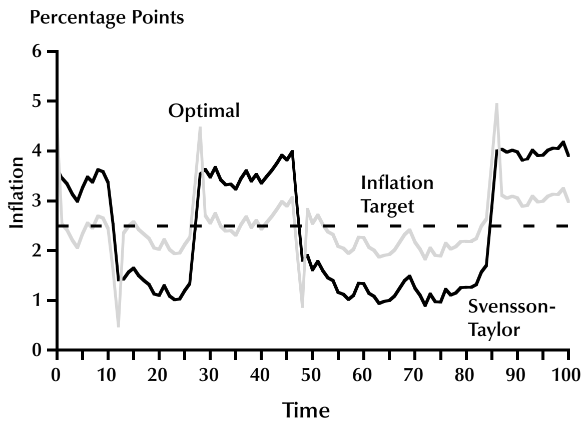
Optimality

We begin by demonstrating the superiority of the optimal rule given by equation (20) in the calibrated economy. Of course, in our derivation we assumed $\mu = 0$, meaning that the monetary authorities in the model economy direct policy solely toward keeping inflation near target because their objective function only involves inflation deviations. This was termed "strict inflation targeting" by Svensson (1997). Accordingly, we consider the asymptotic ($t \to \infty$) mean-squared inflation deviation from target for both the optimal rule given by equation (20) and for the Svensson-Taylor rule given by equation (21). We calculate the asymptotic mean-squared inflation deviation through a simulation using equations (1) through (3), and either (20) or (21), for a large enough number of periods that the mean-squared deviation no longer changes. Table 2 summarizes the results.

For baseline parameters, Table 2 indicates that the optimal rule clearly dominates the Svensson-Taylor rule, as expected, with an asymptotic mean-squared inflation deviation of only 0.138, versus 0.996 for the Svensson-Taylor rule. The Svensson-Taylor rule does not take account of the changing nature of the supply side of the economy, and thus policymakers using it would end up with a suboptimally high inflation variance. As we have emphasized, in two special cases the Svensson-Taylor rule and the optimal rule perform equally well. One of these occurs when the two productivity regimes are not persistent, so that $p = q = 1/2$, and other parameters are left as in the baseline case. In this situation, regime switches occur as often as non-switches, which merely adds to the noise in the system and leaves the "leading indicator" feature of the optimal rule impotent. The asymptotic loss is then equal for the two rules at 0.521, as shown in the second line of Table 2. The other special case is when the two regimes are not very far apart, which is the case when $a_h \to 0$ in our model, and all other parameters are again at baseline values (including p and q). Here, regime switches occur, but they are not quantitatively important because the productivity levels in the two regimes are not sufficiently different. The asymptotic loss is 0.021 for both rules, as shown in the third line of Table 2. This is much smaller than in the other cases because the lack of important regime switches reduces the overall variance in the economy dramatically.

Figure 1

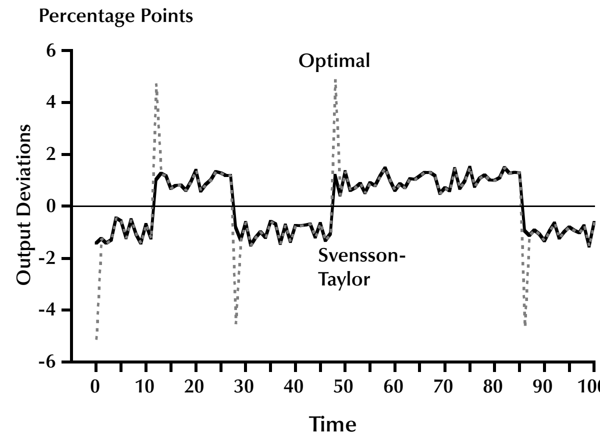
Inflation Stabilization Under Strict Inflation-Targeting Policies



NOTE: Inflation performance in model economies.

Figure 2

Output Performance Under Strict Inflation-Targeting Policies



We now turn to a particular realization of the model economy to illustrate some of the features of the optimal policy rule.

An Example

In Figure 1 we display the last 100 of 5,000 observations on inflation for simulated systems for both the optimal rule and the Svensson-Taylor rule. Both systems are calculated based on the same realized sequence of shocks. We use 100 observations to keep the Figure relatively clear. Figure 2 illustrates the implications for the output gap. Since our policymakers in these systems (under both policy rules) are strict inflation targeters ($\mu = 0$), they are of course only concerned with the inflation deviations as pictured in Figure 1.

In the Figures, regime shifts are realized in periods 0, 12, 28, 48, and 86. We think this provides enough switches to understand the main effects of the two rules. The primary feature of the optimal rule is that it tends to bring the inflation rate much closer to target following a productivity regime switch. The Svensson-Taylor rule, which leaves the policymakers without a response to the shifting productivity of the economy, does not bring inflation back toward its target; instead, regime shifts are associated with persistent movements in the level of inflation. In fact, inflation remains persistently above or persistently below target depending on the regime. Figure 1 clearly shows why the mean-squared deviation of inflation from target is higher for the Svensson-Taylor rule as compared with the optimal rule, as the systems are allowed to continue for a large amount of time.

It is interesting to see how the optimal rule fares in a period following an unfavorable supply disturbance, such as the regime switch realized in period 28 in the two Figures. As inflation starts to accelerate, the optimal rule fairly quickly infers the persistent change in the inflation environment and gets inflation back to target. This is in fact achieved by amplifying the structural economic slowdown, as shown in Figure 2. This is the correct policy response because a negative output gap in this case does not merely indicate lack of demand, but rather is indicative of the presence of an adverse supply shock. Thus, the optimal rule calls for contracting demand so as to avoid amplifying the inflationary effects of the low-productivity state. By way of contrast, the Svensson-Taylor rule fails to bring inflation down at all (even though the only goal here is to control inflation). In fact, inflation does not increase in response to the regime shift as much as under the optimal rule, but it stays persistently above target until the next regime shift is realized in period 48. Thus, a monetary policy response that is driven purely by demand factors amplifies the inflation problems associated with adverse supply shocks. We think that this “stagflation” example is reminiscent of the monetary policy responses of several

Organization for Economic Cooperation and Development (OECD) countries in the 1970s.

From the perspective of the "new economy," we can also consider the policy response to favorable supply shocks, such as those realized in periods 12 and 48 when the economy switches to a high-productivity state. Under the optimal policy the productivity shock drives inflation below target, but only temporarily. A few periods later inflation is back on target. The Svensson-Taylor rule, however, interprets the substantial increase in the output gap in these periods as evidence of excess demand. The central bank then responds by contracting aggregate demand. This in turn amplifies the downturn in inflation. As a result of systematically misreading the data, inflation falls below the target. Worse, it stays systematically below the target until the next regime switch.

As we have stressed, our exposition has been kept relatively simple by limiting the analysis to the strict inflation-targeting case ($\mu = 0$). The case when $\mu > 0$ is obviously an interesting extension in a quantitative sense, but we think our main points are better made in this simpler, strict inflation-targeting environment. If there are going to be unobserved shifts in productivity in the economy, then the optimal stabilization policy is naturally going to take these shifts into account. To accomplish this, an optimal policy rule will consider past data in addition to contemporaneous data in an effort to identify whether or not a regime shift has occurred. A policy rule that takes account of these factors is clearly going to perform better than one that does not. An optimal policy rule in the case with $\mu > 0$ will still have all of these features, except that it will mitigate output fluctuations to some extent at the expense of exacerbating fluctuations in inflation, as policymakers will in that case be attempting to optimally trade off these two types of fluctuations.

CONCLUDING REMARKS

In this paper we have investigated the implications of regime switching in productivity for optimal monetary policy rules. Our economy is simple and delivers a version of the Taylor rule as the optimal stabilization policy when there are no regime shifts in productivity. Thus, our analysis is able to isolate the additional components of an optimal policy rule in the face of persistent, unobserved productivity improvements or declines. We find that the optimal monetary policy rule in the regime-switching environment incorporates information about the changing nature of the supply side by considering lagged terms on inflation deviations and the output gap. We show that the optimal rule significantly outperforms a rule that ignores these terms in a quantitative simulation, provided the two regimes are persistent and sufficiently different. These conditions seem to characterize the postwar U.S. experience, as many analyses date a persistent productivity slowdown as beginning in the early 1970s followed by a "new economy" appearing in the 1990s.

We think our main findings are intuitively appealing and likely to carry over into more complicated environments, but this of course remains an open question, which we leave to future research.

REFERENCES

Berry, John M. "Greenspan Credits Technology; Fed Chief Cites Shift in Economy." *Washington Post*, 7 May 1999, Section A, p. 1.

Clarida, Richard; Gali, Jordi and Gertler, Mark. "The Science of Monetary Policy: A New Keynesian Perspective." *Journal of Economic Literature*, 1999, *37*(4), pp. 1661-707.

Greenspan, Alan. Congressional Testimony, 6 May 1999.

Hamilton, James D. "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle." *Econometrica*, March 1989, *57*(2), pp. 357-84.

King, Robert G. and Plosser, Charles I., eds. "Special Issue: Monetary Policy Rules." *Journal of Monetary Economics*, June 1999, *43*.

Svensson, Lars. "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets." *European Economic Review*, 1997, *41*(6), pp. 1111-46.

Taylor, John B. "Discretion Versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, pp. 195-214.

__________, ed. *Monetary Policy Rules*. Chicago: University of Chicago Press, 1999.

Appendix A

STEADY-STATE EQUILIBRIUM

The innovation sequence $\{V_t\}$ in equation (7) satisfies

$$\begin{aligned} &\Pr[V_{t+1} = (1-p) | S_t = 1] = p, \\ &\Pr[V_{t+1} = -p | S_t = 1] = 1-p, \\ &\Pr[V_{t+1} = -(1-q) | S_t = 0] = q, \\ &\Pr[V_{t+1} = q | S_t = 0] = 1-q, \end{aligned} \tag{22}$$

with $E_t V_{t+1} = 0$ and $\sigma_v^2 = E(V_t^2) = p(1-p)\bar{p} + q(1-q)(1-\bar{p})$, where we have used that[8]

$$\bar{p} \equiv \frac{(1-q)}{(1-p+1-q)} .$$

From equation (22) we see that $E_0 V_t = 0$ for all $t > 0$. Using this fact, and iterating equation (7) into the future, we can write

$$E_0 S_t = \gamma^t E_0 S_0 + \frac{(1-q)(1-\gamma^t)}{1-\gamma}, \tag{23}$$

where E_0 denotes the expectation conditional on information available at date zero (which need not include observation of S_0). Observing that $E_0 S_t$ can be interpreted as the probability that $S_t = 1$ given information at time zero (denoted $P_0[S_t = 1]$), equation (23) can be rewritten

$$P_0[S_t = 1] = \bar{p} + \gamma^t(\bar{p}_0 - \bar{p}), \tag{24}$$

where $p_0 \equiv P_0[S_0 = 1]$. From equation (24) we can see that for large t the economy will be in the high productivity state (state 1) with probability $\bar{p}$ in which case u would be $a_h - a_\ell$. Similarly, the economy will be in the low productivity state (state 0) with probability $1-\bar{p}$, in which case u would be $-a_\ell$. Hence, the *expected* long-run level of u (denoted as $\bar{u}$) is

$$\bar{u} = \bar{p} a_h - a_\ell . \tag{25}$$

From equation (2) it follows that the (unconditional mean) steady-state level of output ($\bar{y}$) associated with a zero steady-state real interest rate is zero. To be consistent, we impose that this level from equation (1) should also be zero. Taking account of (25) this implies

$$a_\ell = \bar{p} a_h, \tag{26}$$

which is equation (8) in the main text.

---

8 For more details see Hamilton (1989, pp. 360-63).

Appendix B

DERIVATION OF THE FIRST-ORDER CONDITION

The problem is to choose $\{i_t\}_{t=0}^{\infty}$ to minimize

(27) $$E_t \sum_{t=0}^{\infty} \delta^t \left[\frac{1}{2}\left(\pi_t - \pi^*\right)^2\right]$$

subject to

(28) $$\pi_{t+1} = \pi_t + \alpha y_t - u_{t+1}$$

and

(29) $$y_{t+1} = \beta_1 y_t - \beta_2\left(i_t - \pi_t\right) + x_{t+1}.$$

This problem can be reformulated by choosing $\{c_t\}_{t=0}^{\infty}$ to minimize

(30) $$E_t \sum_{t=0}^{\infty} \delta^t \left[\frac{1}{2}\left(E_t \pi_{t+1} - \pi^*\right)^2\right]$$

subject to

(31) $$z_{t+1} = z_t + c_t + \alpha x_{t+1} - (1+\gamma) a_h v_{t+1},$$

where $c_t = \alpha E_t y_{t+1} - E_t u_{t+2}$ is a new control variable and $z_t = E_t \pi_{t+1}$ is a new state variable.[9] We solve this problem using the method of Lagrange multipliers. We denote the Lagrange multiplier by λ and we write the Lagrangian as

(32)
$$\mathfrak{L} = E_t \sum_{t=0}^{\infty} \left\{\delta^t \left[-\frac{1}{2}\left(z_t - \pi^*\right)^2\right] - \delta^{t+1} \lambda_{t+1}\left[z_{t+1} - z_t - c_t - \alpha x_{t+1} + (1+\gamma) a_h v_{t+1}\right]\right\}.$$

The central bank's first-order conditions then take the form

(33) $$\frac{\partial \mathfrak{L}}{\partial c_t} = \delta^2 E_t \lambda_{t+1} = 0$$

and

(34) $$\frac{\partial \mathfrak{L}}{\partial z_t} = -\left(z_t - \pi^*\right) - \lambda_t + \delta E_t \lambda_{t+1} = 0.$$

Equation (33) implies $E_t \lambda_{t+1} = 0$. Using this in equation (34) yields

(35) $$\lambda_t = -\left(z_t - \pi^*\right).$$

Leading this expression one period and taking expectations implies that

(36) $$E_t \lambda_{t+1} = -\left(E_t z_{t+1} - \pi^*\right).$$

Since $E_t \lambda_{t+1} = 0$ and since $z_{t+1} = E_{t+1} \pi_{t+2}$, we conclude that the first-order condition for strict inflation targeting is given by

(37) $$E_t \pi_{t+2} = \pi^*,$$

which is the expression used in the text.

[9] This constraint is derived using the fact that π_{t+1}, y_{t+1}, and $E_{t+1} u_{t+2}$ can be written as $E_t \pi_{t+1} + (\pi_{t+1} - E_t \pi_{t+1})$, $E_t y_{t+1} + (y_{t+1} - E_t y_{t+1})$, and $E_t u_{t+2} + (E_{t+1} u_{t+2} - E_t u_{t+2})$, respectively.

Appendix C

DERIVATION OF THE OPTIMAL PREDICTOR FOR PRODUCTIVITY

Taking expectations at time t of equation (11) we obtain

(38) $$E_t \pi_{t+1} = \pi_t + \alpha y_t + \gamma \Delta \pi_t - \alpha \gamma y_{t-1}.$$

However, from equation (1) it follows that

(39) $$E_t \pi_{t+1} = \pi_t + \alpha y_t - E_t u_{t+1}.$$

Hence, consistency requires that $-E_t u_{t+1} = \gamma \Delta \pi_t - \alpha \gamma y_{t-1}$ or

(40) $$E_t u_{t+1} = \alpha \gamma y_{t-1} - \gamma \Delta \pi_t.$$

Along similar lines we can derive that $E_t u_{t+2} = \alpha \gamma y_t - \gamma E_t \Delta \pi_{t+1}$. Using equation (40), we find that

(41) $$E_t u_{t+2} = \gamma E_t u_{t+1} = \gamma\left(\alpha \gamma y_{t-1} - \gamma \Delta \pi_t\right).$$

All nonproprietary and nonconfidential data and programs for the articles written by Federal Reserve Bank of St. Louis staff and published in *Review* are available to our readers and can be obtained from three sources:

1. **FRED (Federal Reserve Economic Data),** a database providing U.S. economic and financial data and regional data for the Eighth Federal Reserve District. You can access FRED through the Internet at **www.stls.frb.org/fred.**
2. **Research Department,** Federal Reserve Bank of St. Louis, P.O. Box 442, St. Louis, Missouri 63166-0442. You can request data and programs on either disk or hard copy. Please include the author, title, issue date, and page numbers with your request.
3. **Inter-university Consortium for Political and Social Research (ICPSR).** Member institutions can request data through the CDNet Order facility. Nonmembers should write to: ICPSR, Institute for Social Research, P.O. Box 1248, Ann Arbor, Michigan 48106, or call (734) 998-9900.

ON THE INTERNET

www.stls.frb.org/research

THE FEDERAL RESERVE BANK of ST. LOUIS

Federal Reserve Bank of St. Louis
Post Office Box 442
St. Louis, Missouri 63166-0442