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In This Issue . . .

Recent increases in various measures of inflation have generated much commentary about the "acceptability" of the current inflation rate and prospects for future inflation. In the first article of this *Review*, "What is an 'Acceptable' Rate of Inflation?—A Review of the Issues," Michelle R. Garfinkel provides a primer on three issues that must be addressed in any analysis of what constitutes an acceptable rate of inflation. In discussing the first two issues, which concern the possible costs and benefits of inflation, she questions the validity of the idea that any positive inflation could be desirable as a long-run phenomenon. In discussing the third issue, which revolves around the costs of reducing inflation, however, Garfinkel points out that an inflation in excess of the long-run, desirable rate need not be unacceptable.

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The increase in the inflation rate from about 1 percent in 1986 to over 4 percent more recently has touched off a debate about its possible causes. One culprit often discussed is the decline in the foreign exchange value of the dollar since 1985. In the second article in this *Review*, "Does Dollar Depreciation Cause Inflation?" R. W. Hafer explores this connection.

The author notes that there are many facets to the dollar-inflation linkage. For example, does a change in the exchange rate lead or merely reflect events in the United States relative to other countries? Also, should one calculate the exchange rate bilaterally or multi-laterally. The procedure chosen, as Hafer shows, affects the analysis greatly.

Hafer also demonstrates that declines in the foreign exchange value of the dollar are not inflationary nor do they promote an upward spiral in future wages and prices. As the author shows, these relative price changes are, by definition, not inflation. In fact, the evidence suggests that, once the effects of domestic money growth are accounted for, changes in the exchange rate provide no additional explanation of inflation.

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Following nearly 50 years of convergence, state per capita incomes have risen faster in high-income than in low-income states since 1978, resulting in a substantial divergence of state per capita incomes. Historically, regional disparities in economic growth have been linked to the federal government's fiscal policies.

In the third article of this issue, "Has Federal Spending and Taxation Contributed to the Divergence of State Per Capita Incomes in the 1980s?" Cletus C. Coughlin and Thomas B. Mandelbaum analyze the flow of funds between the states and the federal government and conclude that changes in these flows have not been a major cause of the increasing inequality of state per capita incomes. More specifically, while federal transfer payments and taxes reduced the level of inequality, changes in their distribution did not contribute to the rising inequality. The evidence suggests, however, that changes in one major federal spending program—defense spending—may have been a minor factor contributing to the increasing inequality in this decade.

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Economists have long been interested in inflation's effects on real economic variables. In addition to effects arising from the impact of unexpected inflation, many hold that uncertainty about future inflation rates affects real variables. In the fourth article in this issue, "Does Inflation Uncertainty Affect Output Growth? Further Evidence," Dennis W. Jansen studies the hypothesized negative relationship between inflation uncertainty and output growth. Using a bivariate ARCH-M (Autoregressive Conditional Heteroskedasticity in Mean) model, the one-period-ahead conditional forecast error of inflation is taken as a measure of inflation uncertainty. Estimates of this model indicate that over the last several decades there is little evidence that inflation uncertainty influenced output growth.

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In the final article in this Review, "Tests of Covered Interest Rate Parity," Daniel L. Thornton investigates whether "covered interest parity" holds on average. Covered interest parity implies a certain linear relationship between domestic and foreign interest rates (for assets of a given maturity and risk) and spot and forward exchange rates, and is assumed to hold in many open-economy macroeconomic models. The author points out that, while previous tests have relied on the markets' reactions to specific news (usually money announcements), there is a more general test that can be applied to all observed exchange rate data, not simply data around the times when specific news is released. Thornton applies this test, as well as the usual test of market reactions to money announcements, to daily data for the United States, Canada, Switzerland, Germany, France, the United Kingdom and Japan for the period from October 5, 1979 through September 14, 1988. His results are consistent with the hypothesis that covered interest parity holds on average over this period.

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What Is an "Acceptable" Rate of Inflation?—A Review of the Issues

"Our strategy continues to be centered on moving toward, and ultimately reaching, stable prices, that is, price levels sufficiently stable so that expectations of change do not become major factors in key economic decisions."

Alan Greenspan, *Testimony to House Committee on Banking, Finance, and Urban Affairs*, January 24, 1989

RECENT fears of increased future inflationary pressures, heightened by high rates of capacity utilization, have generated a large body of commentary concerning what level of inflation would be desirable or at least acceptable.[1] While there appears to be a general consensus that a rise in the rate of inflation is not desirable, whether or not many would agree with Mr. Greenspan's statement above is not clear. Indeed, his statement makes a stronger suggestion that even the current rate of inflation is not acceptable.[2]

This article points out three central issues for determining what constitutes an "acceptable" rate of inflation. The first issue concerns the costs of inflation. The second issue is whether, despite these costs, inflation's benefits are sufficiently large to justify some positive rate of inflation. The final issue concerns the costs of reducing inflation. Even if there were convincing reasons for ultimately eliminating inflation, some analysts would argue that a positive inflation could be acceptable in the short-run; the optimal time path along which a long-run goal of zero inflation is achieved depends on the temporary costs of adjustment to reach that goal eventually.

WHAT ARE THE COSTS OF INFLATION?

Examining the effects of inflation sheds light on why price stabilization is a primary objective of monetary policy. This section focuses on

[1]See, for example, Clark (1989) and Stein (1989).

[2]Mr. Greenspan expressed this view more clearly in his testimony to Congress in February 1989: ". . . let me stress that the current rate of inflation, let alone an increase, is not acceptable, and our policies are designed to reduce inflation in coming years." [Greenspan (1989), p. 274.] Elsewhere, he has been quoted as suggesting that the ultimate objective of the Fed is to eradicate inflation [Murray (1989)].

Table 1
Some Effects of Inflation

Anticipated Inflation	Unanticipated Inflation
1. Inflation tax on money balances: transfers resources from money holders to government and reduces money demand.	1. Reduction in real value of gross return from holding nominal debt: transfers resources from net monetary creditors to net monetary debtors.
2. Inflation-induced increase in marginal income taxes: transfers resources from taxpayers to the government and reduces labor supply.	2. Reduction in real wages if wages are fixed in nominal terms: transfers resources from labor to employers.
3. Taxation of nominal interest income: transfers resources from savers to the government and reduced savings.	**Inflation Uncertainty**
4. Interaction with tax incentives: reduces cost of borrowing and increases debt finance.	1. Increase in reluctance to enter into nominal wage contracts and increase in cost of nominal wage contract negotiations: increases indexation of nominal contracts and reduces real economic growth.
5. Costs of price adjustments: produces excessive relative price variability and a misallocation of resources.	2. Increase in risk premia of longer maturity nominal bonds: causes a movement from longer to shorter term maturities and increases the real cost of capital.
	3. Increase in incentive to hedge against unanticipated inflation: transaction costs incurred in attempts to hedge against risk associated with inflation uncertainty and distortions in asset accumulation.
	4. Confusion about source of price movements: causes excessive relative price variability and a misallocation of resources.

some of the relevant effects given existing institutional arrangements in the United States.[3] These effects, as summarized in table 1, are organized by their source: the effects arising from anticipated (or expected) inflation and those arising from unanticipated inflation (or the difference between actual inflation and expected inflation) and the associated uncertainty about future inflation.

The Effects of Anticipated Inflation

Much of modern macroeconomic research has been devoted to examining how expectations affect economic decisions. In contrast to the idea that only "surprises" or unanticipated events can have real effects, economic theory suggests that even fully anticipated inflation can distort economic decisions. These "distortions" are said to be the costs of anticipated inflation. A useful way to focus solely on the effects of anticipated inflation is to assume that the future sequence of changes in the general price level is known in advance.[4]

Anticipated inflation influences the allocation of resources in the economy primarily through two types of tax effects. First, inflation effectively imposes a tax on money balances equal to the

[3]For a more exhaustive list and detailed analysis of the effects of inflation, see Fischer and Modigliani (1978). Also, Kessel and Alchian (1962) provide a useful discussion of inflation's consequences. For a survey of the earlier literature concerning the theory of inflation, see Laidler and Parkin (1975).

[4]This assumption is made purely for expositional ease. When uncertainty is introduced in the discussion, the effects of anticipated inflation mentioned in this section are simply added to those effects arising from the unanticipated component of inflation and those effects arising from uncertainty. It should be noted that the assumption of certainty does not preclude a variable inflation rate.

reduction of purchasing power of money holdings. For example, an individual holding $100 throughout 1988, when the inflation rate was around 4 percent, lost about $4 in purchasing power.[5]

Since inflation imposes a tax on money balances, it reduces individuals' demand for money.[6] Because individuals will attempt to economize on money holdings during periods of inflation by making extra trips to the bank or automatic teller machine, inflation is said to generate "shoe-leather costs." But the costs of the inflation tax are not merely the physical resources and time expended to avoid the inflation tax, as that term suggests. The total cost or the "gross burden" of the inflation tax more importantly includes the increase in the price paid to maintain real money balances and the value of lost services otherwise provided by money. Inflation, however, generates revenue to the government that indirectly accrues to individuals. The "excess burden" is the difference between the total costs and the government's revenues. Under some plausible assumptions, a rough estimate of this excess burden from a "small" inflation tax of 5 percent is about $13.4 billion or about 0.3 percent of gross national product (GNP) per year.[7]

The excess burden of the inflation tax on money balances is only part of the total welfare cost associated with inflation. The second type of tax effect arises as anticipated inflation interacts with the structure of the existing income tax system, exacerbating the distortions contained therein. Since the progressive income tax system is not completely indexed against increases in the price level, inflation will subject individuals' incomes to higher average and marginal tax rates. Even if wages fully adjust to inflation so that the real (before-tax) wage rate is approximately constant, an individual's real, after-tax income will decline.[8]

Although one would expect that, through the so-called "bracket-creep" effect, anticipated inflation would influence and distort individual's labor supply decisions, empirical evidence on the effects of marginal taxes suggests that anticipated inflation has little effect on aggregate

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[5]Inflation as measured by the consumer price index for all urban consumers was 4.4 percent during 1988, while other measures indicate that inflation was between 3.0 percent and 4.5 percent. The current dollar loss of purchasing power of $100 is calculated by the following equation:

$$P_{t+1}\left(\frac{100}{P_t} - \frac{100}{P_{t+1}}\right)$$, where P_t is the general price level in time t. Since the rate of inflation, π_t, equals $\frac{P_{t+1} - P_t}{P_t}$, the loss in purchasing power in current dollar terms equals 100 π_t. As noted below, the tax on money balances generates revenue to the government.

[6]Another way to see why inflation reduces the demand for money is by noting that inflation increases the opportunity cost of holding those balances. The opportunity cost is the revenue forgone by holding money rather than securities yielding a nominal interest rate, R. (The assumption that money does not yield interest is not important here. As argued by Tatom (1979), among others, even checkable deposits that pay interest are subject to the inflation tax.) Suppose, for example, that there is no expected future inflation. Then the nominal rate paid on a security is its real yield, r. An individual holding $100 in cash balances for transaction services forgoes the real interest payment, $100r, that would have been obtained if he instead bought a $100 bond. In this case, the opportunity cost of holding money balances is r per dollar. Now suppose that inflation, π, in the next period is expected to be positive. The nominal yield on the bond R, will increase roughly by the amount of expected inflation to compensate lenders for the expected loss in purchasing power of the initial loan; the nominal yield will equal the real rate plus an expected inflation premium. (Strictly speaking, $R = (1 + r)(1 + \pi)-1$. Simply adding the real rate of interest and the rate of inflation will be a reasonable approximation provided that the product of the real rate of interest and the rate of inflation, $r\pi$, is of a small order of magnitude.) The higher nominal rate forgone by holding money implies that the opportunity cost of holding money has increased.

[7]This estimate is intended to give only a rough order of magnitude of the excess burden of inflation. The estimate assumes that the current stock of money (M1) is about $780 billion and that the interest elasticity of the demand for money is -.15. This latter assumption means that when the opportunity cost of holding money increases 1 percent, the quantity of money demanded falls .15 percent. Thus, assuming the real rate of interest is 3 percent, the demand for money would increase by 25 percent to $975 billion if inflation were zero. It should be noted that the estimate of the welfare cost ignores the fact that total "tax" borne by the individual money holder does not go entirely to the government. Since the banking system receives part of the revenue from the inflation tax through money creation, the estimate above understates the excess burden. See Tatom (1976, 1979) and Fischer (1981b) for more detailed discussions of estimating the excess burden of the inflation tax on money balances.

[8]In a preliminary study, Baye and Black (1988) table II, p. 480, estimate that the "bracket-creep-induced inflation tax rate," defined as the difference between the rate of change in gross income necessary to keep utility constant and the associated rate of change in consumption expenditures, ranges from 0.2 percent to 2.4 percent between 1972 and 1981. Furthermore, they find that changes in the tax code during this period, intended to mitigate the bracket-creep effect, were largely offset by simultaneous increases in Social Security taxes (pp. 481-82).

labor supply.[9] Furthermore, to the extent that the current income tax system has become partially indexed by recent tax reform, the effects of inflation in terms of the bracket creep effect have been partially mitigated.[10]

Nonetheless, recent tax reform has not fully insulated individuals from the tax effects of anticipated inflation. Anticipated inflation produces an overstatement of interest income subject to taxation. The nominal interest rate required by lenders includes two components. The first component, r, is a payment to the lender for not consuming today and, hence, constitutes income. The second component, π, is a premium to compensate the lender for the anticipated lost purchasing power of the principal due to inflation. Because the latter component serves to preserve the value of the principal, it is not income in an economic sense. Yet, like income, it is taxed.

To see how an increase in anticipated inflation increases an individual's tax liability for a given before-tax real return, consider the following example. Suppose, first, that no inflation is expected and the marginal income tax rate is 25 percent. A one-year loan that yields a 3 percent (real) return to an individual before taxes generates an after-tax real return of 2.25 percent. If, instead, the anticipated rate of inflation were 2 percent, with the real interest rate on the one-year loan remaining at 3 percent, and the nominal yield rising to 5 percent (the real rate of interest plus the rate of inflation that would be required when abstracting from tax considerations), then the after-tax real rate of return to the lender would fall to 1.75 percent. A rise in the anticipated inflation rate to 5 percent would erode the expected (and actual) return dramatically to 1 percent.

Lenders will demand a nominal return higher than the original real interest rate plus the rate of inflation to be compensated for the increased future tax liability arising from an increase in anticipated inflation. In the example above, for the lender to supply the same dollar amount of loans as when expected inflation was zero, the same after-tax real return of 2.25 percent would be required; this, in turn, would require a rise in the nominal return from 3 percent to 9.67 percent when expected inflation rises to 5 percent. Hence, the nominal rate of interest must rise by more than the rate of inflation to induce the lender to forgo the same amount of current consumption. If, however, nominal interest rates did not rise enough to keep the after-tax real rate the same when inflation rises, savings would be reduced. It has been estimated that the distortionary effect of a 10 percent rate of inflation on savings over a 20-year period produces a total welfare loss (total cost net of additional revenues to the government in present value terms) of about 7 percent of current savings or, assuming that savings is 10 percent of GNP, about 0.7 percent of current GNP.[11]

Tax incentives combined with anticipated inflation distort financial decisions. Because nominal interest payments on debt are tax-deductible and dividends are effectively taxed twice, anticipated inflation will induce corporations to finance an expansion of their operations by creating debt rather than issuing additional stock. If nominal interest rates do not adjust to anticipated inflation enough to maintain a fixed, after-tax real rate of return, then an increase in anticipated inflation can induce individuals to finance a greater proportion of their consumption and asset purchases with debt.[12] This bias for debt finance, which increases with anticipated inflation, could be costly if, by increasing future debt obligation as a fraction of expected future cash flows, it increases the chances of future default.

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[9]See, for example, Hausman (1981), who finds that the tax-induced effects on wages do not significantly reduce aggregate labor supply. Inflation's effect on the marginal tax rate could similarly have an insignificant effect on labor supply.

[10]Tatom (1985) discusses the impact of the partial indexation of the income tax system on real tax liabilities. As discussed by Tatom, the currently used method of indexation does not fully mitigate the bracket creep effect because the indexation of tax brackets is calculated using past increases in the general price level. Furthermore, some deductions, credits and adjustments that can be made for tax purposes have maximum dollar limits or nominal ceilings that are not indexed. Even assuming a constant real income before taxes, an expected rise in the price level implies that a larger portion of real income will be subject to taxes. Without increasing the marginal tax rate, anticipated inflation increases the average tax liability.

[11]Fischer (1981b), p. 23. As he notes, however, the estimate is rough and could be as large as 2 percent to 3 percent of GNP under slightly different, although still plausible, assumptions.

[12]Even if nominal rates fully adjusted to increases in anticipated inflation so as to not affect the after-tax real return, an increase in anticipated inflation decreases the cost of debt finance to firms provided that the corporate marginal tax rate exceeds the individual marginal tax rate.

The impact of anticipated inflation on economic behavior is not restricted solely to inflation-induced tax effects. Specifically, by changing prices, some firms incur lump-sum or "menu" costs. Even if these costs are small, real-world price adjustments occur at discrete times rather than continuously. Assuming that price changes are not sychronized, anticipated inflation (and deflation) can generate relative price changes in the short run. Since these inflation-induced relative price changes do not reflect real, fundamental changes in the economy, they can create a misallocation of resources, resulting in a welfare loss in addition to the explicit costs of changing prices.[13]

The Effects of Unanticipated Inflation and Uncertainty

Unanticipated inflation also can result in a misallocation of resources. Its impact on individuals' behavior, however, is less obvious. In particular, although unanticipated inflation primarily redistributes wealth among people, it is the uncertainty associated with these possible future redistributions that distorts economic behavior. Before discussing these distortionary effects, this section focuses on the distributional effects of unanticipated inflation.

To examine the distributional effects, while initially abstracting from the effects of uncertainty *per se*, suppose there is a one-time shock to the level of inflation. The shock is temporary in the sense that, after one period, the rate of inflation will return to the previously expected time path.[14] This unanticipated inflation influences the distribution of wealth through contracts that fix future nominal cash flows, especially debt contracts.

When debt contracts are fixed in nominal terms, the main effect of unanticipated inflation is to redistribute real wealth to net monetary debtors at the expense of net monetary creditors.[15] Not suspecting the possibility of a divergence between actual and expected inflation, a lender would demand a rate of return that compensates him only for not consuming today and for the lost purchasing power of the initial borrowings due to anticipated inflation. When actual inflation exceeds anticipated inflation, the lender unexpectedly suffers a loss on his loan; the purchasing power of the return on the loan falls below that expected at the time the loan was made.

For example, suppose an individual, who expects zero inflation over the next period, requires a 5 percent nominal (and real) return next period in exchange for lending $100 today. Regardless of next period's inflation, the lender will receive $105 in the next period. If there is a 5 percent (unanticipated) inflation, then the purchasing power of the $105 payment to the lender is identical to that of the $100 lent. In this case, the real net return is zero.

Just as unanticipated inflation erodes the real purchasing power of the return from the loan, it reduces the real liability of the debtor. Along the same lines, if nominal wages specified in labor contracts are fixed for an interval of time, unanticipated inflation reduces an individual's real wage while increasing an employer's income net of the wage bill in real terms.

Although the redistribution of wealth due to unanticipated inflation is important to the individual before and after the fact, it is not easy to say anything meaningful about the welfare implications of the realized or *ex post* redistrib-

[13]Mankiw (1985) demonstrates that, in the presence of even small price adjustment costs, optimizing behavior by price-setting firms can produce sticky prices that are inefficient from a social welfare perspective in a deflationary period. He shows, however, that sticky prices in an inflationary period could be more efficient than fully flexible prices. Since price-setting firms produce at lower-than-socially-optimal levels, sticky prices in an inflationary period reduce the wedge between actual and socially optimal output levels.

[14]If the level of inflation were permanently increased above its previously expected and actual level, but the possibility of a future shock were arbitrarily close to zero, the discussion to follow is virtually unchanged. It should be noted, however, that the discussion implicitly assumes that, when contracts are signed, individuals do not perceive the possibility of shock in the future. Hence, the discussion is about a counterfactual and can be misleading. Specifically, if individuals suspected that such a shock might occur (with a positive probability), they would adjust their behavior, so that the terms of the contract reflect the possibility of a future shock. The implicit assumption is made for expositional purposes, and the possible adjustments in behavior are discussed in turn.

[15]A net monetary creditor's (debtor's) holdings of fixed nominally denominated assets are greater (less) than his holdings of nominally denominated liabilities. See, for example, Kessel and Alchian (1962). Alchian and Kessel (1959) present evidence that the market value of equity of firms classified as net monetary creditors tends to fall during inflationary periods. The converse holds for net monetary debtors.

utions.[16] The losses due to unanticipated inflation are matched by others' gains, so that there is no net change in wealth associated with the redistribution. In an expected or *ex ante* sense, however, the possible (and arbitrary) redistributions have aggregate welfare implications, because they distort behavior, especially that of individuals who dislike risk.

Uncertainty associated with inflation manifests itself quantitatively and qualitatively in both nominal and real contracts. In the presence of fixed nominal wage contracts, uncertainty associated with future inflation can depress the supply and demand for labor. As greater inflation uncertainty increases the difficulties and costs of forecasting future inflation, wage negotiations become more complex and costly. Consequently, without nominal wage indexation when future inflation becomes more uncertain, individuals and firms are less willing to lock themselves into fixed nominal contracts.

But the effects of inflation uncertainty will be partially alleviated as labor markets adjust. Greater uncertainty about future increases in the general price level gives risk-averse individuals and firms an incentive to increase the degree of indexation in wage contracts and to reduce the duration of the contract. The increased degree of indexation and the shortening of the length of the nominal contracts increases the responsiveness of nominal wages to unanticipated inflation.[17] Nevertheless, a recent empirical study, which accounts for the greater wage indexation induced by greater inflation uncertainty, indicates that an increase in inflation uncertainty similar to that which occurred roughly between the 1960s and the 1970s would reduce growth in real GNP in the long term by approximately 2 percent.[18]

Inflation uncertainty also affects the demand and supply of nominally denominated debt of different maturities. Risk-averse lenders might be less willing to purchase a long-term nominal bond over short-term nominal bonds. As forecasting future inflation becomes more difficult with longer time horizons, the opportunity cost of holding a longer-term nominal bond is more uncertain. In addition, a given permanent unexpected movement in the rate of inflation will have a greater impact on the market value of the longer-term bond and, consequently, a greater impact on the realized rate of return from selling that bond. To compensate lenders for taking on additional risk, the required nominal yield on a bond with a longer maturity will embody a greater risk premium.

The uncertainty associated with future inflation creates an element of uncertainty about real, future rates of return on all investments whose returns are not fixed in real terms. The more uncertain are the future rates of inflation, holding all else constant, the greater the risk premia for all bonds of any given maturity.[19] As the required nominal yields on instruments of all maturities increase with greater inflation uncertainty, the cost of capital financed by nominal debt increases. Not all investments, however, are fixed in nominal terms. The risk-averse individual can hedge, at least partially, against unanticipated inflation by investing in projects or holding financial instruments whose actual and expected real returns are relatively

[16]Such a value judgment would depend on the specified social welfare function—in particular, the relative weights assigned to each individual's utility. Nonetheless, the decline in wealth experienced by some in a period of positive unanticipated inflation does not necessarily provide sufficient justification, in terms of a Pareto efficient criterion, for a "forced" transfer of resources to restore the initial distribution of wealth.

[17]When the economy is subject to real as well as to nominal disturbances, however, complete wage indexation is not desirable. See Gray (1976) for example. Also, see Holland (1984b) for a more detailed discussion of the effects of inflation uncertainty on labor markets.

[18]Holland (1988), p. 478-80. This is a cumulative effect over a number of years (e.g. 2 to 6 years). In general, however, there is mixed evidence about the effects of inflation uncertainty on output growth. For example, Jansen (1989) finds that the conditional variance of inflation as a measure of inflation uncertainty has no significant impact on real output growth.

[19]Taylor (1981), among others, finds a positive relation between the average rate of inflation and the variability of inflation across nations and through time. This stylized fact, however, does not imply any causal link between the two. Moreover, greater variability does not imply greater uncertainty. Nevertheless, preliminary evidence indicates that inflation variability is positively related to uncertainty, as measured by the variance of the forecast errors from survey data or from an econometric model for predicting future inflation, or as measured by the dispersion of inflationary expectations within a survey. But Jansen (1989) recently found no statistical relation between inflation and the conditional variance of inflation. See Taylor (1981) and Holland (1984a), who review the existing evidence on the relations between average inflation, the variability of inflation and uncertainty.

independent of future rates of inflation, such as human capital, homes and corporate stocks.[20]

Even a complete hedge against unanticipated inflation would not eliminate the welfare costs of uncertainty, however. Substantial transaction costs can be incurred by those who attempt to eliminate the risk associated with future inflation from their portfolios. In any case, as individuals and firms attempt to hedge against unanticipated movements in the general price level, inflation uncertainty can distort asset accumulation and the aggregate allocation of resources.[21]

Another distorting feature of the uncertainty associated with price movements arises when information about the source of price movements is not available without costs. If information were costless to obtain, the appropriate response to a given increase in prices is clear. For example, an unanticipated temporary increase in observed prices correctly attributed to monetary policy (a nominal factor), rather than to an increase in demand for some goods relative to others (a real factor), would not alter the decisions of producers in the absence of nominal rigidities. If it is costly, however, to distinguish between general price movements produced by nominal factors from those created by real factors, price movements will be "noisy." Confusion about the source of a given price movement and the appropriate response will produce excessive relative price variability, resulting in a misallocation of resources.[22]

WHY NOT A ZERO RATE OF INFLATION?

While any positive inflation has a large number of distortionary effects, a zero inflation rate might not necessarily be desirable—even in the long run. First, the various measures of inflation (for example, the consumer price index and the GNP implicit price deflator) do not control perfectly for quality improvement of products over time. To the extent that the lower and higher quality versions of goods are treated as comparable, the difference in their prices will be measured as inflation; the resulting measure will tend to overstate the actual inflation rate. Given this positive bias in inflation measures, it has been suggested that a 2 percent inflation rate measured by the usual price indexes would be associated with roughly stable prices.[23] Moreover, some would contend that inflation also has some important benefits like providing a cheaper source of government revenue or creating higher output and employment, so that the long-run desirable rate of inflation is not zero, but positive.

Optimal Taxation

Some have argued that inflation is required for optimal taxation.[24] The inflation tax provides

[20]While homes appear to be good hedges against expected and unexpected inflation, the evidence for human capital is inconclusive, at least for the long run. Moreover, a puzzling negative relation between stock returns and expected as well as unexpected inflation has been widely documented, but not resolved. See, for example, Fama and Schwert (1977).

[21]See Jaffee and Kleiman (1977) for a more detailed discussion of the effects of inflation uncertainty on the allocation of resources.

[22]To be sure, relative price variability need not be a cost. To the extent that relative price movements signal real disturbances to the economy, those movements contain important information facilitating an efficient allocation of resources. Fischer (1981a) provides a summary of competing approaches to explaining the relation between the average inflation rate and relative price variability. Taylor (1981) and Fischer (1981b) do not find evidence indicating a causal relation between inflation and variability of relative prices. Rather, Taylor (1981) and Fischer (1981a) find evidence consistent with the notion that the positive relations between average inflation, the variability of inflation and relative price variability in the 1970s have been driven by supply shocks (for example, energy and food shocks). Taylor (1981) also finds that accommodative monetary policies aiming to stabilize output and employment in light of real disturbances to the economy contributed in a large part to the increased variability of inflation in the 1970s. Furthermore, Fischer (1981a) concludes that policy shocks that could have created confusion about the source of price movements do not appear to be associated with lower aggregate economic activity.

[23]Friedman (1969), p. 47. According to Friedman (1969), however, a negative inflation rate (about 2 percent deflation) correctly measured would be optimal. In this case, a zero inflation rate, as measured by the various price indices would be a desirable target. (See Alchian and Klein (1973) for a critical assessment of the appropriateness of the price indexes for policy.)

[24]See, for example, Phelps (1973). The government's revenue from the production of money is the nominal rate of interest times the stock of the monetary base (total reserves plus currency). Using the fact that the ratio of the monetary base to the money stock (M1) is about 40 percent and assuming that the real interest rate is about 3 percent, the revenue with a 5 percent inflation tax on a stock of M1 of $780 billion is about $25 billion per year in current dollar terms. The inflation tax alone generates $15.6 billion per year. It is important to note that unanticipated inflation implicitly generates additional revenue to the government (a net monetary debtor) through its effect on the real value of public debt. By reducing the purchasing power of interest payments on outstanding debt, unanticipated inflation lowers the real liability of the government and the amount of revenue to be raised through income taxes.

the government an alternative source of revenue to other explicit and distorting taxes—for example, income taxes.[25] The theory of optimal taxation suggests that, to finance a given level of public expenditures, the government should trade off the costs of distortions arising from inflation against those arising from other taxes.[26] From this perspective, the optimal inflation tax rate equates the marginal cost per dollar of revenue from the inflation tax and from other distorting taxes.

Recent empirical evidence on the marginal costs of the inflation tax and other taxes, however, casts doubt on the relevance of the optimal taxation theory to justify a positive rate of inflation. These studies suggest that the marginal cost per dollar revenue of the inflation tax at any positive rate of inflation exceeds that for alternative taxes set at plausible rates.[27] In other words, inflation does not necessarily provide a cheaper source of government revenue. Furthermore, the interaction between inflation and the distortions produced by the tax system suggests that the marginal cost of income taxes could be positively related to the rate of inflation; thus, lowering the inflation tax not only would reduce the welfare losses associated with the inflation tax, but make income taxation a cheaper source of government revenue.[28]

The Inflation and Unemployment Trade-off

The older argument used to justify positive inflation hinges on the so-called Phillips curve trade-off between inflation and unemployment. Figure 1, which depicts the apparent trade-off that emerged in the 1960s, could be interpreted as suggesting that, by tolerating a higher level of inflation, society could benefit from lower levels of unemployment.

One possible story behind such an interpretation is that an expansionary monetary policy that increases the general price level can increase output if nominal wages are relatively fixed. With fixed nominal wages, a rise in inflation can induce firms to increase output. This incentive arises because the firm's marginal profit—that is, the change in real revenues net of the change in the real wage bill realized by expanding output—increases with unanticipated inflation. If nominal wages were not fixed, they would adjust quickly to the increase in prices to maintain a given real wage rate; output and unemployment would be essentially independent of inflation. But, according to the trade-off view, the existence of nominal wage contracts means that, by generating inflation, the government can decrease the rate of unemployment and thereby enhance social welfare.

The possibility of exploiting the trade-off between inflation and unemployment with monetary policy, however, depends on the way in which inflationary expectations are formed and incorporated into nominal wages. If inflation is correctly anticipated and incorporated into wage contracts, then real output will be independent of inflation in the long run. Even if the government were to generate inflation un-

[25]If there were non-distorting taxes, then the excess burden of the inflation tax discussed above would render inflation an "inefficient" tax. But, in the absence of non-distorting taxes as a source of revenue to the government, the optimal rate of inflation could be positive. Browning (1987), table 1, p. 16, estimates that in 1984 the total welfare cost associated with the distortionary effects of the labor tax ranged from $55.9 billion to $212.6 billion under various assumptions. As a percentage of tax revenues from labor, the welfare loss ranged from 7.5 percent to 28.5 percent, well below the inflation-induced welfare loss as a percentage of revenues from the inflation tax (about 86 percent).

[26]In recent studies, Mankiw (1987) and Poterba and Rotemberg (1988) test the implications of the hypothesis that the government optimally trades off the distortions from explicit income taxes and inflation. While Mankiw finds preliminary evidence supporting the hypothesis for the United States, Poterba and Rotemberg, who look at different nations, do not find conclusive evidence. That the hypothesis is not fully supported by the data might be a result of the maintained assumption that the distortionary effects of the explicit tax system are independent of the distortionary effects of the inflation tax. Given the discussion above, this assumption seems inappropriate.

[27]For example, Tatom (1976), p. 20, shows that marginal cost per dollar revenue of the inflation tax, assuming that the elasticity of demand for money is −.15, is 44 percent. This estimate is not conditional on the inflation rate, but it is highly sensitive to the assumed elasticity of demand for money. For example, an elasticity of −.25 would imply a marginal cost of 83.33 percent. Browning (1987), table 2, p. 21, shows that the marginal welfare cost from taxes on labor earnings ranges from 9.9 percent to 33.2 percent under the assumption that labor supply is not highly responsive to the marginal income tax rate (see footnote 9).

[28]It should be noted, however, that since the marginal cost of taxes on labor earnings is positively related to the marginal tax rate, the theory of optimal taxation in light of the evidence on marginal welfare costs does not necessarily imply a zero rate of inflation. Nevertheless, if the marginal cost of the inflation tax were positively related to inflation, the optimal rate of inflation would more likely be zero.

Figure 1
The Inflation-Unemployment Trade-off

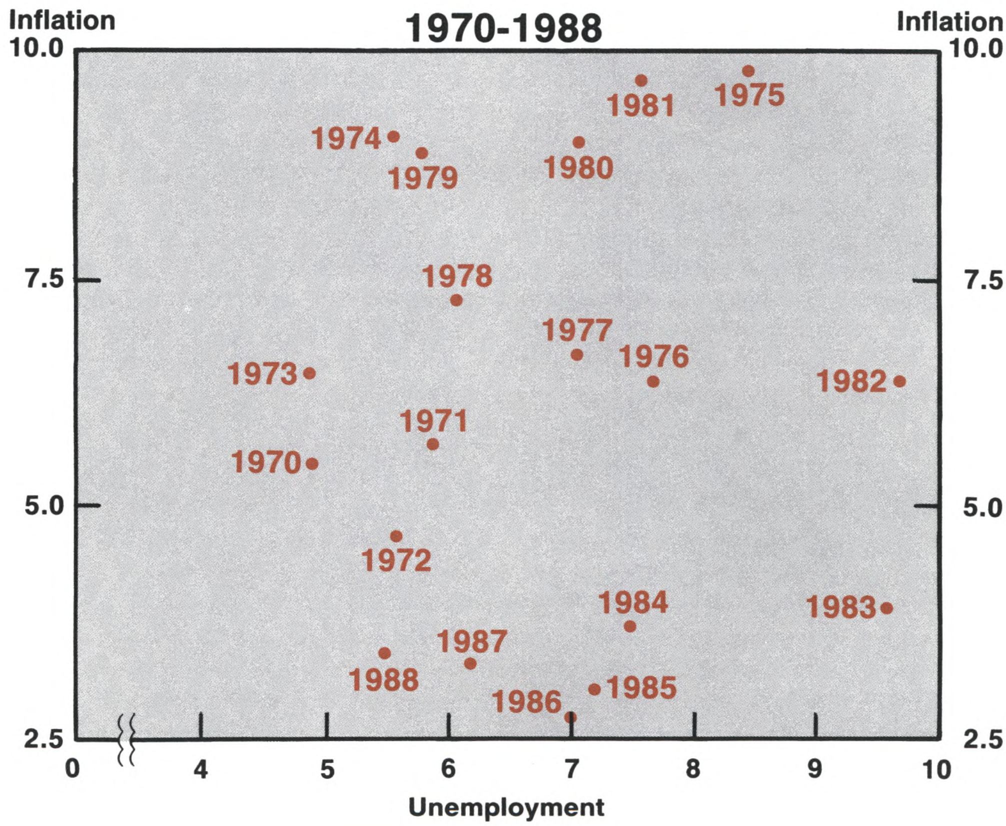
expectedly, the increase in output and decrease in unemployment would only be transitory. Subsequent wage changes would restore the original level of the real wage. As a consequence, the original profit rate would be restored, with output and unemployment returning to their original equilibrium or "natural" levels; the trade-off between unemployment and inflation would not exist in the long run.[29]

Indeed, figure 2, which plots the combinations of unemployment and inflation in the 1970s and the 1980s, does not support the existence of a long-run trade-off. While a short-run trade-off might exist, whether or not it is operative for the purpose of enhancing social welfare is unclear. Attempts to "fool" individuals systematically, by continuously creating surprise inflation so as to exploit the short-run trade-off, would not improve the welfare of all individuals because, although some individuals experience unexpected wealth gains, others suffer wealth losses. In addition, attempts to repeatedly fool individuals would increase the costs associated with inflation due to increased inflation uncertainty.

Moreover, as individuals and firms adjust to the higher inflation uncertainty, the trade-off becomes less favorable, because greater inflation uncertainty increases incentives for indexation. With greater wage indexation, a given

[29]See Fischer (1977), for example. The notion that real output and employment are independent of the inflation rate in the long run (a vertical Phillips curve) is known as the "Natural Rate Hypothesis."

Figure 2
The Inflation-Unemployment "Trade-off"



amount of surprise inflation will have a smaller transitory effect on output and employment as nominal wages become more responsive to actual inflation. Accordingly, the trade-off becomes steeper. If attempts to exploit the trade-off also increases average inflation, the trade-off shifts outward, so that a given rate of inflation will be associated with a higher rate of unemployment.

WHAT ARE THE COSTS OF REDUCING INFLATION?

The suggested benefits of inflation seem hardly compelling to justify any positive, sustained inflation. The long-run desirability of achieving stable prices, however, does not necessarily mean that the current rate of inflation is unacceptable. Specifically, the latter discussion suggests that policies to reduce inflation and ultimately achieve the long-run desirable inflation rate can be costly. That is, any short-run trade-off between inflation and unemployment implies that anti-inflationary policies will produce temporary increases in unemployment.

Are The Costs Too High?

Table 2 shows the inflation rate, as measured by the GNP implicit price deflator, and the civilian unemployment rate; it indicates that the large reduction in inflation from 1979 to 1988 was accompanied by significantly large rates of unemployment. These observed high rates of unemployment, however, can overstate the costs of the anti-inflationary policy. Regardless of the current inflation rate or its prospective

Table 2
Unemployment and Inflation, 1979-88

Year	Civilian unemployment	Inflation[1]
1979	5.8%	8.9%
1980	7.1	9.0
1981	7.6	9.7
1982	9.7	6.4
1983	9.6	3.9
1984	7.5	3.7
1985	7.2	3.0
1986	7.0	2.7
1987	6.2	3.3
1988	5.5	3.4

SOURCE: *Economic Report of the President* (1989) and *Economic Indicators* (January 1989).

[1]Percentage change from the previous year in the GNP price deflator.

path, temporary unemployment is an efficient response to fundamental changes in the economy, as individuals search for new jobs. Consequently, the "natural" rate of unemployment (the rate of unemployment consistent with a steady inflation) can be positive. It has been estimated that, assuming the natural rate of unemployment is 6 percent, the decline in inflation from 9 percent in 1980 to 3.2 percent in the middle of 1987 was associated with about 2.4 percentage points of "excess" unemployment per percentage-point reduction in inflation.[30]

Similarly constructed estimates have been used to suggest that reducing inflation is unacceptable on efficiency grounds:

> The damage that high unemployment does to economic efficiency is enormous and inadequately appreciated. By contrast, the harm that inflation inflicts on the economy is often exaggerated; and those costs which are not mythical can be minimized or even eliminated by indexing. Hard-headed devotion to the principle of efficiency thus argues for worrying less about inflation and running a high-pressure economy in which jobs are plentiful.[31]

By definition, excess unemployment is inefficient, because it implies that resources, otherwise available to increase consumption opportunities, have been wasted. But excess unemployment is only a transitional cost as the economy adjusts to the long-run desirable inflation rate. When the inflation goal is finally achieved and sustained, the excess unemployment will disappear. In contrast, the welfare costs associated with inflation are incurred indefinitely—that is, each year in which the economy's institutional features (for example, the explicit tax system) make the distortionary effects of inflation discussed above relevant.[32]

The Optimal Time Path of Reducing Inflation

Among the important questions that policymakers must face is the timing of anti-inflationary policy actions to reach the long-run desirable inflation rate. Given the initial inflation rate, the speed with which the desirable inflation rate is reached partly determines the cost of that policy.

One recent study shows that there are large differences in the costs of policies that vary with respect to their timing[33]. On the basis of various models, this study calculates the costs of several policies to bring inflation from 7.5 percent to zero. The costs of the policies are estimated in terms of output losses using a relationship known as Okun's law that translates each percentage point of excess unemployment into a 3.2 percent reduction in real output. For example, employing a Phillips curve model, this study

[30]Friedman (1988), p. 66. Each percentage point of unemployment above the natural rate (or that in a "fully employed" economy, with a steady inflation rate) constitutes a percentage point of "excess" unemployment. Of course, because the natural rate of unemployment is not observed and is subject to change during the evolution of the economy subject to permanent and transitory real shocks, one could argue that Friedman's estimate understates (or overstates, for that matter) the welfare loss associated with the reduction of inflation in the 1980s.

[31] Blinder (1987), p. 65.

[32]Of course, not all anti-inflationary policies can be justified. Rather, without a careful evaluation of the costs and benefits of reducing inflation, a monetary policy that produces an inflation above (or below) the optimal rate does not easily follow from an efficiency criterion. As pointed out by Meyer and Rasche (1980, p. 14), among others, however, if the benefits from eliminating inflation (or identically, the costs of sustaining inflation) increase at the same rate of real potential output, then any anti-inflationary policy would be justified, irrespective of the policy's costs, provided that the costs are finite and that the initial gain from such a policy is positive.

[33]Meyer and Rasche (1980).

found that a gradual policy to eliminate inflation over a 23-year period could generate a discounted cumulative output loss of $1 trillion (in 1972 terms), whereas a policy that reached the inflation goal in 11 years could result in a discounted cumulative output loss of $1.5 trillion.[34]

The relation between the time path and the costs of the policy depends on the dynamic relation between unemployment and inflation. In addition to the degree to which the economy is indexed, this dynamic relation depends on the credibility of the anti-inflationary policy and expectations about future inflation. If, as assumed in the Phillips curve model, expectations depend on past inflation, a given inflation-reducing policy will be more costly; with nominal rigidities in the economy and a sluggish adjustment of expectations, the short-term trade-off between inflation and unemployment can be large. To achieve a specific reduction in inflation over a given time span can require higher levels of unemployment and greater output losses. If inflationary expectations are forward-looking and the policy is credible, however, the link between inflation and unemployment is weaker; in this case, unemployment is less responsive to movements in inflation. Accordingly, credible anti-inflationary policies will be less costly in terms of output losses than incredible ones.[35]

The time path of the anti-inflationary policy is also important because it determines the speed with which the gains from such a policy are realized fully. For example, a gradual policy that eliminates inflation over 50 years might not generate significant output losses, but the present discounted value of the benefits from that policy could be infinitesimally small.

CONCLUSION

Analyses of the acceptability of any particular positive inflation should start by asking what is the optimal rate of inflation. In reviewing the various effects and costs of inflation, this article questions the validity of the notion that any positive inflation could be desirable as a long-run phenomenon. The surprisingly large number of distortionary effects resulting from inflation weakens the possible justifications for sustained positive inflation.

The long-run desirability of zero inflation need not imply, however, that a positive rate of inflation is never acceptable for any period. The transitional costs of reducing inflation over a short period could be considerably large relative to the benefits of quickly eradicating inflation. But the costs of fighting the current inflation do not preclude the desirability of an anti-inflationary policy, either. Indeed, the steady reduction in monetary aggregate growth since 1987 (measured by M1, M2 or the adjusted monetary base) suggests that the trade-off has been faced, at least implicitly. In any case, the acceptability of an inflation in excess of the long-run desirable rate depends on the appropriately measured net benefits of alternative paths to achieve the ultimate inflation goal.

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[34]Ibid., pp.7-8.

[35]Taylor (1983) shows that even if overlapping wage contracts temporarily fix nominal wages, a policy that gradually reduces inflation can be relatively costless provided that expectations about future inflation are rationally formed and everyone believes that the policy will actually be implemented. See Cukierman (1986) and references cited therein for analyses of the institutional and economic factors that tend to detract from the credibility of anti-inflationary policies. These analyses suggest that, without a perfect resolution of the credibility problem, the economy is likely to be characterized by an "inflationary bias." Fischer and Summers (1989) show how by decreasing the marginal costs of inflation, the government, recognizing the importance of its reputation, can reduce that bias. Without reputational considerations, however, reducing the costs of inflation can increase the inflationary bias.

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Does Dollar Depreciation Cause Inflation?

DURING the past few years, the rate of inflation has risen from 1.1 percent in 1986, measured by the consumer price index, to 4.4 percent in 1988. Though this rate of price increase pales in comparison to the double-digit inflation of the mid-1970s and early 1980s, it is high enough to cause concern among economic analysts, financial market participants and policymakers. Among the various explanations for the recent acceleration in inflation is the decline in the foreign exchange value of the dollar since 1985.[1] According to this view, the decline in the value of the dollar raises the dollar price of imported goods and, therefore, the prices paid by U.S. citizens as well. The consequence is inflation. Or is it?

The purpose of this article is to provide a framework in which to evaluate the claim that a decline in the dollar's foreign exchange value raises the rate of inflation in the United States.

THE RELATIONSHIP BETWEEN THE EXCHANGE RATE AND INFLATION

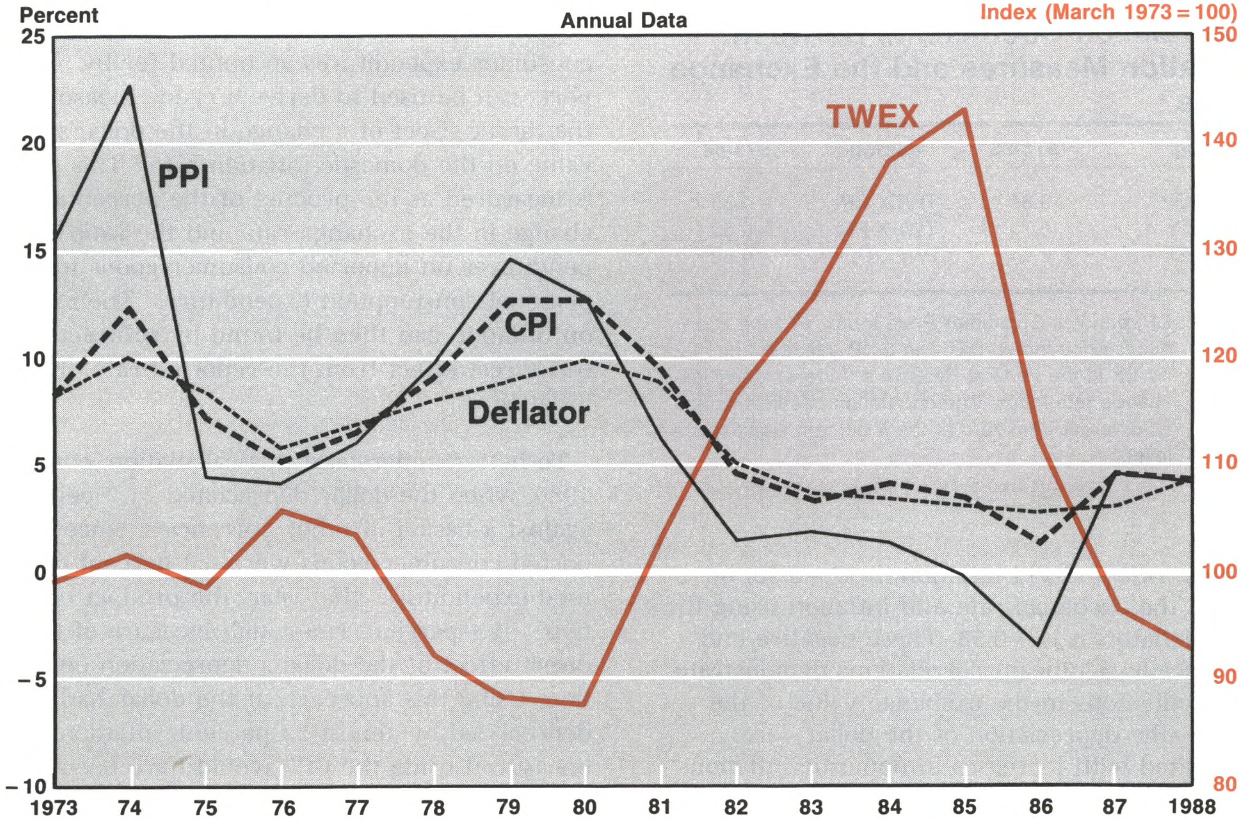
What is the foreign exchange rate? Simply put, the price of a unit of one currency in terms of another. Why would one want to purchase another currency? There are several reasons. One is the need of foreign currency to purchase foreign goods. Another is the need of foreign currency to trade in other countries' financial assets. Purchases of financial assets, like stocks or bonds, in another country can only be completed if one exchanges dollars for the foreign currency.

The dollar's foreign exchange value, commonly measured against a weighted average of foreign currencies, has varied considerably since 1973. To illustrate this, figure 1 plots the

[1]For example, John Paulus, chief economist for Morgan Stanley & Company, recently is quoted as saying that "the weak dollar is finally showing up as an inflation factor." (Uchitelle, 1989a) Lawrence (1989) attributes to two well-known economists the idea that without reducing the federal budget deficit and, therefore, the trade deficit, "a cheaper dollar would only bring higher U.S. inflation." Also, Boyd (1989) argues that "[w]hat the Fed thinks about the dollar feeds into its fight against inflation. . . ."

The behavior of the dollar also affects monetary policy discussions. For example, as stated in the Record of the Federal Open Market Committee's December 15-16, 1987, meeting, "[t]he members recognized that the performance of the dollar in foreign exchange markets might have a key bearing on policy implementation in this period. No member wanted to tie monetary policy exclusively to the dollar, but some strongly emphasized that further substantial depreciation in the dollar could have highly adverse repercussions on domestic financial markets and the economy." (*Federal Reserve Bulletin*, 1988). For a related discussion, see Furlong (1989).

Figure 1
Trade-Weighted Exchange Rate and Inflation Rates



Federal Reserve's trade-weighted exchange rate index (March 1973 = 100), which calculates the change in the value of the dollar against the currencies of 10 industrial countries.[2] As one can see, during the past 25 years the index has ranged from 87.4 in 1980 to a high of 143 in 1985. The 1980s have been characterized by two large swings: an appreciation of about 64 percent between 1980 and 1985, and a depreciation of about 35 percent since 1985. It is this recent downswing in the exchange rate that has sounded an inflationary alarm among some analysts.

One reason that the recent dollar decline has aroused inflation fears stems from the casual observation that the exchange rate and domestic inflation tend to move in opposite directions. To illustrate this negative correlation, figure 1 includes three commonly used measures of inflation: the Consumer Price Index (CPI), the Producer Price Index (PPI) and the GNP deflator. These three differ in that they measure price changes at different levels of aggregation (the GNP deflator being the broadest measure) and for different baskets of goods and services. While some differences in measured rates of inflation during certain periods are noticeable, they typically follow the same general pattern. The simple correlations between the different inflation measures, as table 1 reports, range from 0.64 for the PPI-GNP deflator to 0.81 for the CPI-PPI over the full period.[3]

More important to the current discussion is the fact that these inflation measures typically fall when the exchange rate is rising and rise when the exchange rate is falling. As table 1 reports, the correlation between the exchange rate and CPI inflation is −0.55; between the ex-

[2]The 10 countries are Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland and the United States.

[3]The correlations are based on quarterly data.

Table 1

Correlation Coefficients Between Inflation Measures and the Exchange Rate

Pairing	1973-88	Pairing	1973-88
CPI-DEF	0.81	TWEX-CPI	−0.55
CPI-PPI	0.73	TWEX-PPI	−0.50
PPI-DEF	0.64	TWEX-DEF	−0.58

NOTE: CPI denotes Consumer Price Index; PPI the Producer Price Index; DEF the GNP deflator; and TWEX is the Federal Reserve's trade-weighted exchange rate index. The correlation coefficients are all different from zero at the 5 percent significance level.

change rate and PPI inflation, it is −0.50; between the exchange rate and inflation using the GNP deflator, it is −0.58. These negative and statistically significant correlations demonstrate that reductions in the exchange value of the dollar—the depreciation of the dollar—are associated with increases in domestic inflation.

WHY SHOULD DEPRECIATION RAISE THE INFLATION RATE?

When the dollar depreciates relative to other currencies, the dollar prices of foreign goods increase relative to domestically produced goods, other things equal, making imports more expensive. Since imports make up part of the basket of goods purchased by consumers, measures of inflation based on that basket also will rise.

Measuring the Direct Effect

It often is argued that foreign exporters, facing higher dollar prices for their goods sold in the United States, will simply pass on some or all of the depreciation-induced price increase to their U.S. customers. This is referred to as the "pass through" effect. To get a rough idea of how much a change in the exchange rate can directly impact inflation, the percentage of total consumer expenditures accounted for by imports can be used to derive a crude measure of the direct effect of a change in the dollar's value on the domestic inflation rate.[4] This effect is measured as the product of the percentage change in the exchange rate and the ratio of expenditures on imported consumer goods to total personal consumption expenditures. The impact on inflation can then be found by subtracting this direct effect from the reported rate of inflation.

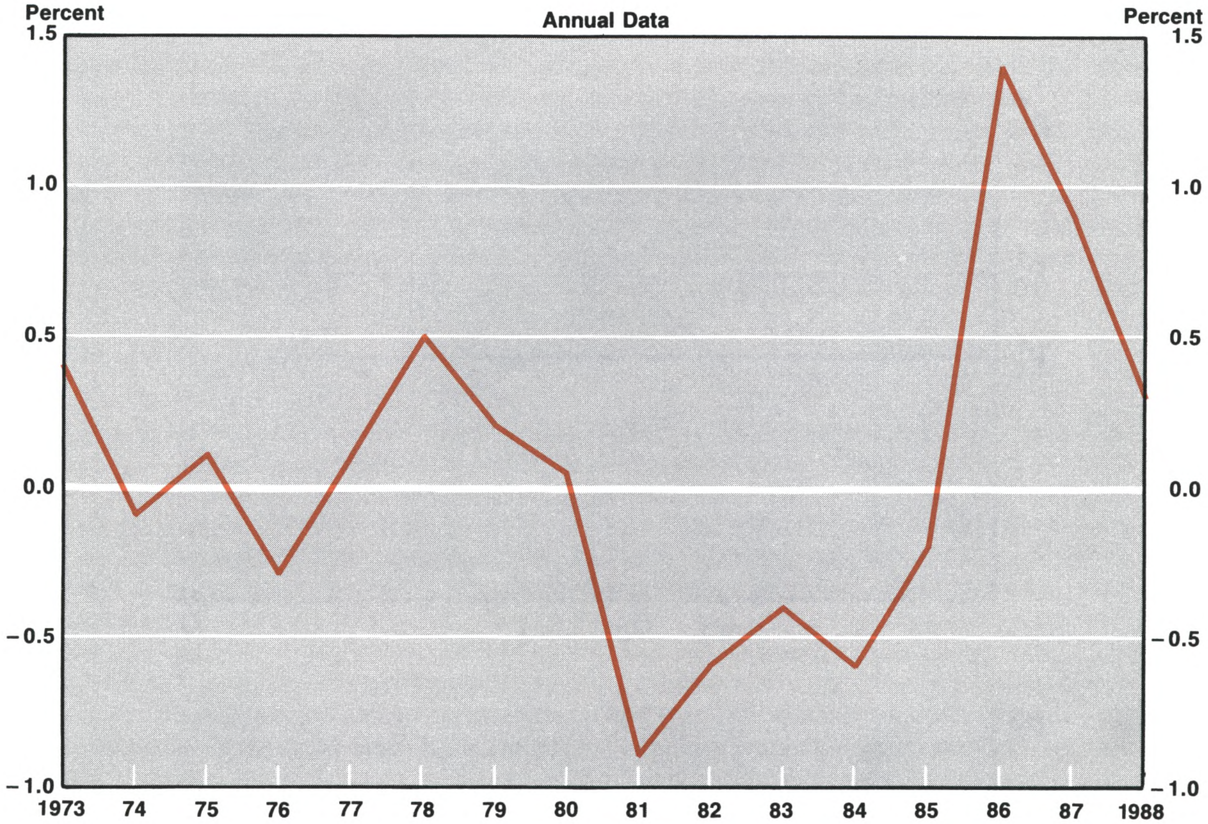
To better understand this calculation, consider 1986, when the dollar depreciated 21.7 percent against a basket of other currencies. Since imported consumer goods were 6.3 percent of total expenditures that year, the product of the two, −1.4 percent, is a rough measure of the direct effect of the dollar's depreciation on inflation. Using this approach, if the dollar had not depreciated by almost 22 percent, inflation (measured using the CPI) would have been closer to zero percent than the reported value of 1.9 percent. In other words, the falling value of the dollar accounted for much of the observed inflation.

To illustrate how much of a direct impact movements in the dollar may have had on domestic inflation over time, figure 2 plots the effect on domestic inflation from a change in the exchange rate. As the figure shows, during periods when the exchange rate is rising, such as 1980-85, inflation is lower than it would have been in the absence of the dollar's appreciation. During the recent fall in the value of the dollar, the effect has turned positive, pushing inflation higher than it otherwise would have been.[5]

[4]This approach has been used often. See, among others, Solomon (1985) or Blinder (1979). It may be argued that the personal consumption expenditure (PCE) deflator is the appropriate measure to use in this calculation. We use the CPI because it is more widely recognized and discussed. Moreover, since the correlation between the CPI and PCE measures of inflation is over 0.90 for the 1973-88 period, there is no loss of generality by using one measure or the other. The data used extend through the third quarter of 1988 because of availability.

[5]One aspect of figure 2 that deserves mention is the fact that, after the exchange rate has fallen to a new level, the direct effect on domestic inflation diminishes. In other words, once the foreign exchange value of the dollar has stopped falling, the direct effect on domestic inflation tends toward zero. This shows that exchange rate changes do not impart a permanent effect on the inflation rate, but cause only temporary changes.

Figure 2
Direct Exchange Rate Effect on Domestic Inflation



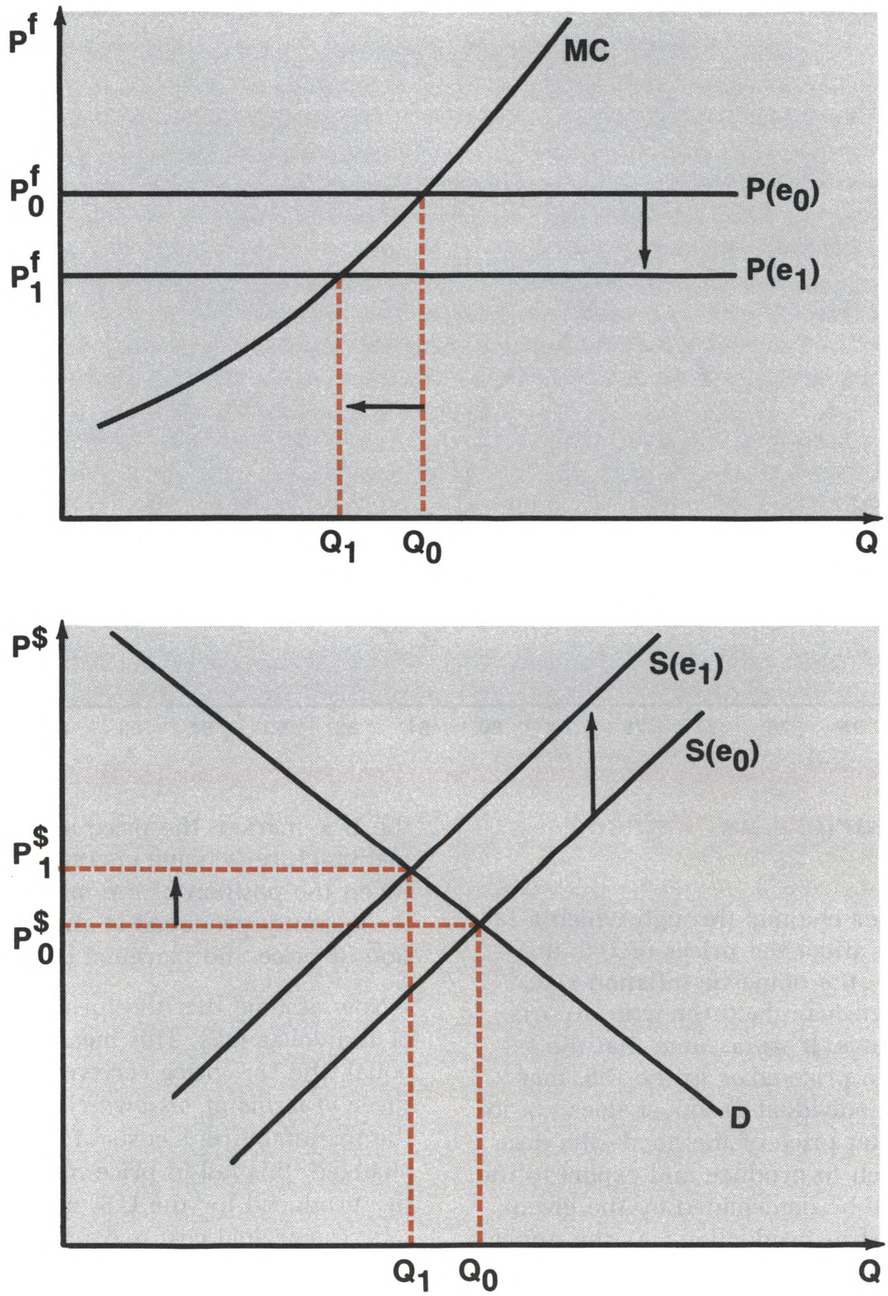
Foreign Exporters as "Price-Takers"

There is another channel through which a fall in the dollar can affect the prices of U.S. imports and, hence, the domestic inflation rate. Consider a foreign manufacturer who exports to the United States. If we assume that the manufacturer is a price-taker in the U.S. market—that is, the individual producer does not influence the market price of the good—the decision on how much to produce and export to the United States will be determined by the given price and the cost of production.[6] As the upper panel of figure 3 shows, this representative manufacturer has the usual upward-sloping marginal cost curve. Since he is a price-taker in the U.S. market, the price in terms of the manufacturer's home currency is set at P_0. Given the position of the marginal cost curve, the quantity produced is given by the intersection of price and marginal cost, or at Q_0.

Now assume that the foreign exchange value of the dollar falls. This means that, other things equal, the U.S. price received by the manufacturer *in terms of his own currency* falls to P_1. If the manufacturer's costs of production have not changed, this fall in price means that the quantity produced for the U.S. market falls to Q_1, where marginal cost is equal to the new price. The dollar's depreciation thus has reduced the supply of goods sent by this representative foreign manufacturer to the United States.

[6]For a recent analysis of this, see Knetter (1989). His evidence, based on industry analysis, suggests that exporters to the United States perceive U.S. prices as given. Based on his study, Knetter notes that "[t]he variation in the results across industries suggests that the link between currency values and domestic price levels is tenuous at best." (p. 209)

Figure 3
Price and Quantity Effects of a Decline in Dollar



The effect of this reduction in imported goods is shown in the lower panel of figure 3. Here the supply and demand curves for the U.S. market in which the foreign manufacturer sells is shown. The market supply curve drawn is the sum of domestic and foreign producers' individual supply curves. Other things the same, a reduction in the amount exported to the U.S. market results in a leftward shift in the supply curve. The effect on U.S. prices? Given the demand for the good, the price paid by U.S. residents increases from P_0 to P_1. In other words, a depreciation of the dollar increases the prices paid by U.S. residents for this good. Such an increase will result in a higher price level and, hence, at least a temporary increase in the rate of inflation.

Estimating the Total Effect

One problem with the preceding approach is that it relies solely on the direct effects of the dollar's depreciation. An increase in the price of some imported goods, such as those used in the manufacturing process, also may lead to indirect increases in the prices of domestically produced goods. Consequently, measuring only the direct effect may underestimate the total effect of a depreciation in the dollar on the domestic inflation. We will return to this subject later in the paper.

WHY DOESN'T DOLLAR DEPRECIATION CAUSE INFLATION?

The discussion thus far suggests that there is a direct relationship between a depreciation in the dollar and higher domestic inflation. Thus, if the prices of imports rise because of a fall in the value of the dollar, it is just arithmetic to show that U.S. inflation must increase. Unfortunately, while the simplicity of such a view is seductive, it is not correct. The reasons why are discussed in the remainder of this article.

What Causes the Exchange Rate to Change?

An observed exchange rate is determined by the demand for and the supply of a currency in international exchange. Movements in the exchange rate reflect relative economic conditions between countries that, in turn, influence the demand and supply of the currencies. Moreover, because exchange rates are forward-looking, their adjustments reflect changes in expectations about future economic conditions. Consequently, it may be incorrect to impart a causal role to exchange rate movements in explaining domestic economic activity when the exchange rate merely reflects the underlying economic conditions, actual and expected, in different countries.

Over long periods of time, one key factor that influences the level of the exchange rate between two countries is their relative price levels. When one price level changes, the exchange rate will adjust accordingly to equate prices.[7] This notion, referred to as purchasing power parity, means that similar bundles of goods have a common price across international boundaries. If prices increase in only one country, the exchange rate between that country's currency and all other currencies will fall, *ceteris paribus*. Since in the absence of exchange rate changes the same basket of goods can be purchased elsewhere for a lower price, the demand for the country's goods and for its currency declines.[8] In unfettered foreign exchange markets, changes in the exchange rate may simply reflect changes in the countries' price levels.[9]

Exchange rate movements also may reflect differences in countries' economic activity. Because increased demand for imported goods is often associated with an increased level of economic activity, those countries experiencing faster growth may also find that their currency is depreciating in foreign exchange markets. Recall that one use of foreign currency is to purchase foreign goods and services. If the United States is growing faster than other countries, and its demand for imports is likewise increasing, then the demand by U.S. residents for foreign currency also is increasing. Consequently, there is relatively more demand for other currencies and their value appreciates relative to the dollar. Thus, movements in the exchange rate also may reflect differences in the relative economic conditions of two countries.

[7]The exchange rate can be defined as the ratio of dollar prices to prices measured in some foreign currency unit. If the foreign price rises and the U.S. price remains constant, the exchange rate will fall.

[8]To illustrate, suppose that pencils with identical characteristics sell for 75 cents in the United States and 93 yen each in Japan. This implies that the exchange rate is about 124 yen per dollar. If the price of pencils in Japan should rise to 150 yen, the dollar-equivalent price of pencils in Japan is now $1.21. Unless the price in the United States changes, demand will shift to U.S. pencil manufacturers. This lowers the demand for Japanese pencils and, other things the same, causes the yen-dollar exchange rate to depreciate.

[9]To abstract from price level changes, real exchange rates often are used. The real exchange rate is defined as the nominal exchange rate times the ratio of the two price levels, or $e^r = e^n(P/P^f)$. Note that for this measure, if the nominal exchange rate (e^n) and the foreign price level (P^f) double, the real exchange rate will remain unchanged.

Movements in the exchange rate also reflect differences in interest rates across countries, a channel of influence thought to be most important in explaining exchange rate movements over short time spans. For example, suppose that from an initial point of equality, interest rates on identical financial instruments, say bonds, in the United Kingdom rise 5 percent while those in the United States are unchanged. Other things the same, investors prefer the U.K. bond's rate of return to the U.S. bond. Pounds, therefore, will be in increased demand in order to purchase the U.K. bond, and the result is a depreciation of the dollar relative to the pound.

This discussion points out that movements of the exchange rate can reflect changes in either key economic factors between two countries or people's expectations. In a very direct way, these factors are related to changes in money growth and the process by which such changes are transmitted to the economy. For example, consider the effects of an increase in the growth of the money supply. If we assume that prices react somewhat slowly at first to this change, the brunt of the faster money growth will be evidenced in faster economic growth and in lower nominal interest rates. As noted earlier, faster economic growth in the United States relative to other countries leads to a fall in the value of the dollar. The decline in interest rates here relative to abroad also reduces the relative demand for dollar-denominated financial assets and, hence, the dollar's value falls.

But, as economic theory predicts and much emprical research shows, an increase in the growth rate of the money supply ultimately leads to an increase in the inflation rate. This movement to a higher rate of inflation reflects the increase in money growth, but also will occur at the same time that the dollar's value is falling in foreign exchange markets. In other words, the decline in the value of the dollar and the increase in inflation are both manifestations of the same thing, namely, the increase in the growth rate of the money stock. Hence, it is incorrect to assign exchange rate changes an independent role in determining permanent changes in inflation once the effects of changes in money growth have been taken into account.

How Is the Exchange Rate Measured?

There are numerous exchange rate measures. As mentioned earlier, the one most often used in discussions of this issue is the Federal Reserve Board's trade-weighted exchange rate (TWEX). In calculating the change in the dollar's value against other industrial countries, the weight given each country in the index is the 1972-76 average world trade of that country divided by the average world trade of all countries combined. In this way, relatively large movements in the exchange rate between the United States and any one country are weighted by the size of the other country. Exchange rates also can be measured bilaterally, that is, the exchange rate between two countries only.

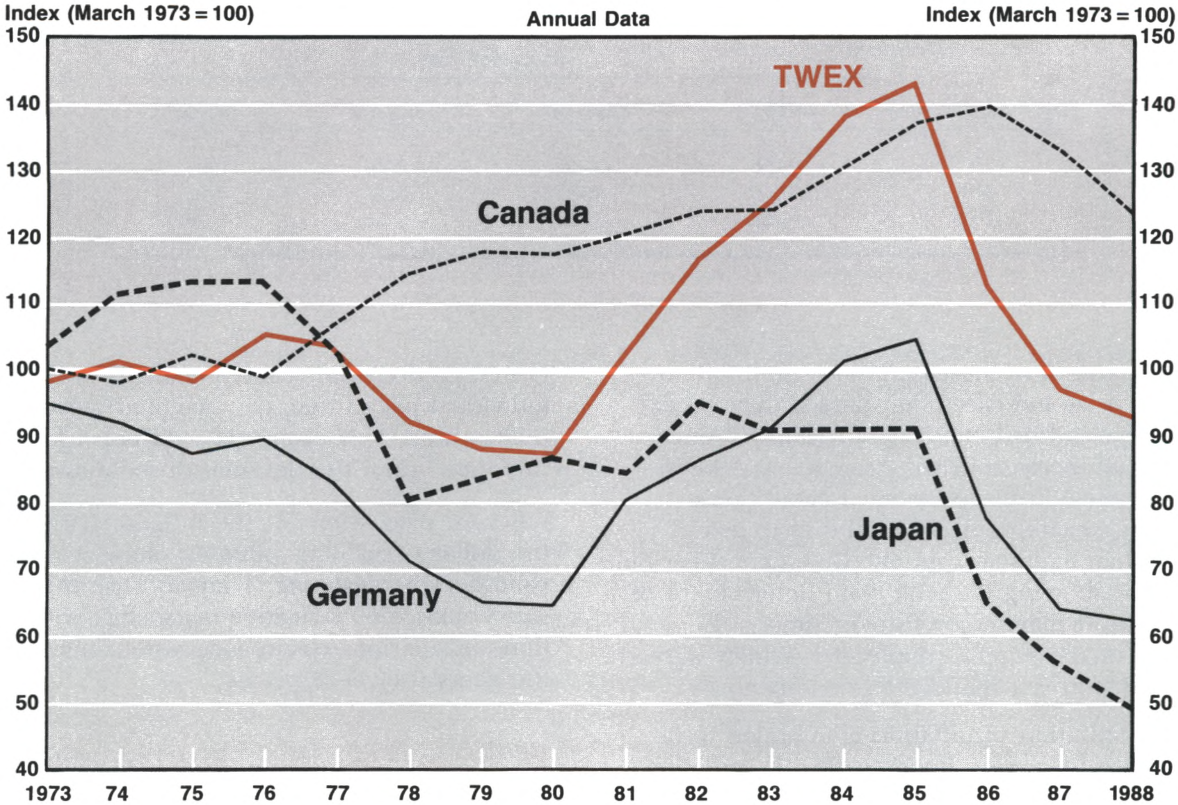
The fact that the exchange rate can be measured in different ways gives rise to different perspectives on exchange rate behavior. For example, consider figure 4, where the trade-weighted exchange rate and the bilateral exchange rates between the United States and three countries—Canada, Germany and Japan—are plotted for the period 1973 through 1988.[10] The TWEX declines from 1976 until 1980, when it begins to rise sharply. The appreciation of the dollar between 1980 and 1985 using this broad measure is 64 percent. Since 1985, however, the value of the dollar using the TWEX has declined about 35 percent.

How have bilateral exchange rates behaved relative to this overall exchange rate measure? The U.S.-Canadian exchange rate started appreciating in 1976, four years before the general upward movement in TWEX. Moreover, it has declined only since 1986. In percentage terms, the U.S. dollar was about 17 percent higher in 1985 than it was in 1980 against the Canadian dollar and has declined about 10 percent since then. These figures are much different from the measurement using the overall index.

The behavior of the U.S.-Germany and U.S.-Japan exchange rates also differs from the overall measure. During the first half of the 1980s, the dollar appreciated 62 percent against the German mark, but only 5 percent against the Japanese yen. Since 1985, the dollar has

[10]We use 1973 since it marks the beginning of the flexible exchange rate period. Also, March is the base period (i.e., = 100) for all exchange rates listed.

Figure 4
Trade-Weighted and Bilateral Exchange Rates



depreciated 40 percent against the mark and 46 percent against the yen. Thus, movements in the foreign exchange value of the dollar clearly differ among countries.[11]

Since it is the changes in bilateral exchange rates that influence the prices of exports in those countries, how are changes in the bilateral exchange rates related to domestic U.S. inflation? Table 2 reports the correlations between the exchange rates used in figure 4 and the three measures of inflation. The results show that the correlations between U.S. inflation and the U.S.-Canadian exchange rate are similar to those found using the TWEX; for the U.S.-Germany exchange rate, they are much smaller. The Japanese result, however, is somewhat puzzling: it shows a positive relationship, suggesting that a depreciation in the dollar relative to the yen is associated with a decline in inflation. The message from this comparison is that focusing on the TWEX-inflation connection may obscure bilateral relationships that influence import prices paid by U.S. residents.

Is It Really Inflation?

Suppose that the value of the dollar declines and the dollar price of imported goods subsequently increases. Will this lead to inflation? To answer this question, it is necessary to define carefully what is meant by the term "inflation." A pragmatic definition of inflation is a persistent increase in the general level of prices of goods and services. There are two key aspects to this definition. First, virtually all prices, not simply

[11]This is the premise upon which broader exchange rate indexes are often constructed. For a discussion and comparison of alternative measures, see, among others, Belongia (1986), Cox (1986), Rosenweig (1986) and Ott (1987).

Table 2

Correlation Coefficients Between Inflation Measures and Exchange Rates: 1973-88

	Exchange rate			
Inflation measure	**TWEX**	**Canada**	**Germany**	**Japan**
CPI	−0.55	−0.46	−0.24	0.30
PPI	−0.50	−0.56	−0.12	0.25
DEF	−0.58	−0.62	−0.14	0.38

one or two, have increased. Second, inflation defines price increases that persist over an extended period of time; it is not simply a once-and-for-all increase in the price level. A persistent increase in the price level occurs only when aggregate demand continues to grow faster than aggregate supply. Given considerable evidence showing that the main determinant of aggregate demand growth over time is the growth of the money supply, it is widely agreed that inflation is a monetary phenomenon.[12]

This definition of inflation is intended to be restrictive for a very good reason. If "inflation" is used to describe situations in which the price of only one good or a small set of goods increases, for example, import prices, the result will be a confusion between general inflation and relative price changes.

To see this, consider the fact that observed rates of inflation are measured as changes in an index of various prices. The price indexes used to measure inflation, such as the CPI or PPI, are a weighted average of prices covering a wide variety of goods and services. From one month to the next, some prices in the index inevitably will be rising while others will be falling. Because these price movements are weighted differently in the index, inflation measured as the percentage change in the index may reflect nothing more than relative changes in certain individual prices that are weighted more heavily than others. This clearly is a different kind of "inflation" than the definition used above.

Recent discussions of the inflationary effect of the dollar's declining value are subject to this invalid line of reasoning. They confuse the transitory nature of a relative price shift with inflation and do not explain a persistent increase in the general level of prices.

Is "Pass-Through" Simply "Cost-Push?"

Another way of interpreting the notion of the pass-through is in terms of so-called cost-push explanations of inflation.[13] According to this view, which focuses on the input costs of producing a product, if one of the input prices rises, then the price of the good must also. Hence, if depreciation of the dollar raises imported goods prices (in dollars), then prices on items produced with those goods also must rise. Since goods and services are more expensive, labor will demand higher wages which, being another cost of production, feeds into even higher prices. In this way, a fall in the value of the dollar, some argue, could start a process of

[12]The quantity theory equation written in logarithmic growth rate form is

$$\dot{M} + \dot{V} = \dot{P} + \dot{Q},$$

where M is the money stock, V is velocity, P is the price level and Q is the level of output. The dots above each letter denotes rate of change. According to this theory, because velocity and output are determined independently of money growth in the long run, there is a one-for-one relationship between changes in the growth rate of money and changes in the rate of inflation. For recent evidence on this relationship using a sample of 62 countries, see Dwyer and Hafer (1988).

[13]For a discussion of cost-push theories of inflation, see Batten (1981).

cost-push inflation, with wages and prices spiraling upward.[14]

The notion of cost-push inflation stemming from a depreciating dollar has little economic foundation. Suppose that a rise in import prices increases the measured rate of inflation and leads consumers to re-evaluate their current money holdings. With an increase in the measured price level, individuals will desire to increase their nominal money holdings to maintain current purchasing patterns. If the money supply is not increased, the increased demand for money will not be accommodated. As a consequence, the demand for goods and services, both domestic and imported, will fall, reducing the upward price pressures and returning the rate of inflation to that determined by the relative growth of money supply and demand.[15] Thus, the view that an increase in one price (imports) causes inflation again confuses a relative price change with a persistent increase in the general price level.

The extent to which this higher dollar cost is passed through to imported goods that compete directly with domestically produced goods depends on economic circumstances.[16] For example, recently it has been noted that the falling value of the dollar since 1985 has not led to the price increases for imported goods many thought would occur.[17] One reason often cited is that foreign competitors relinquished profit margins for market share built up during the 1980-85 appreciation of the dollar. In other words, importers held dollar prices of their goods to levels competitive with U.S.-produced goods to hold their share of the U.S. market.

An interesting aspect of this argument is that it has been used to explain both the relatively small impact of the dollar's appreciation on domestic inflation during the 1980-85 period, as well as the relatively small impact on domestic inflation of the dollar's fall since then. This suggests that the pass-through is not a reliable indicator of domestic price pressures stemming from exchange rate movements. Indeed, it recently has been estimated that less than one-half of one percentage point of the 4.4 percent rise in the CPI during 1988 is attributable to the pass-through from a falling dollar.[18]

What About Substitution Effects?

The cost-push view of the depreciating dollar's effect on domestic inflation also assumes that consumers do not reduce their purchases of the more expensive imported goods. Economic theory (and common sense) predicts, however, that they will buy more of the less-expensive, domestically produced items.[19] To examine whether there is a substitution effect at work, the percentage of total personal consumption expenditures spent on consumer imports was calculated.[20] This ratio is useful, because it allows us to determine whether consumers alter their consumption patterns of imports vs. domestic goods in the face of a change in the exchange rate.

In figure 5, we plot the ratio of consumer imports to total personal consumption expenditures along with the TWEX since 1973.[21] As one would expect, periods of an appreciating

[14]The notion of a wage-price spiral often is found in popular discussions. For example, Uchitelle (1989a), p. 1, states that "[i]nflationary spirals, however, cannot last long . . . unless they are fed by widespread wage increases that keep forcing up prices." Passell (1989) also has suggested that, on the basis of the nearly 12 percent PPI inflation rate in January 1989, "economists are shaken by the first signs of *self-perpetuating* cost push inflation." (italics added)

[15]For evidence that exchange rate movements have little effect on domestic prices once money supply and demand factors are accounted for, see Darby (1981).

[16]See, among others, Pigott and Reinhart (1985) for a discussion of this issue.

[17]For example, see Hooper and Mann (1987).

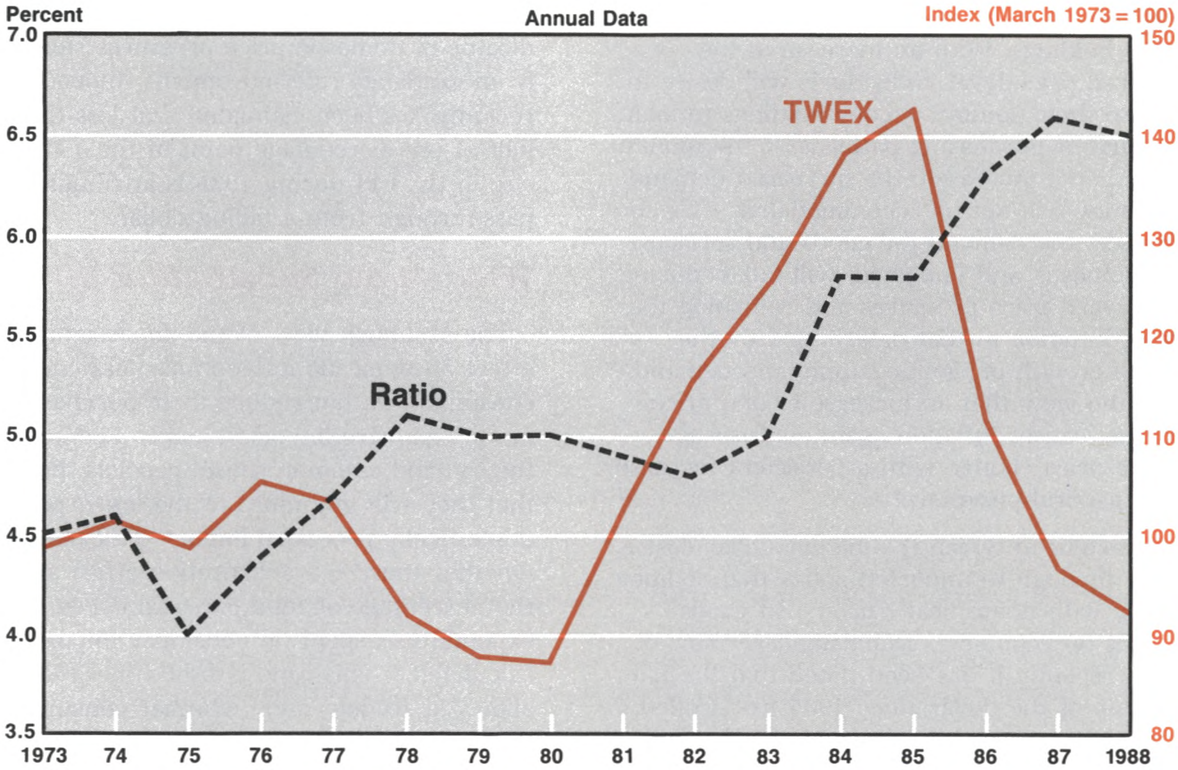
[18]This estimate was attributed to Catherine Mann, an economist at the World Bank, in Uchitelle (1989b).

[19]Since the evidence presented earlier shows that bilateral exchange rate movements may be quite different from changes in an exchange rate index like the TWEX, the substitution may be between domestically produced goods as well as between competing imported goods.

[20]For the purposes of this calculation, we follow Blinder (1979) and consider the following to be consumer imports: food, feed and beverages; passenger cars; other consumer merchandise; travel; passenger fares; and private payment for other services. Note that this measure probably overstates consumer spending. For example, passenger fares do not differentiate between pleasure travel and business travel—one the expense of consumers, the other of businesses. Also, the component, passenger cars, does not differentiate between business and private use. The source is *Survey of Current Business*, various issues. Values for 1988 are preliminary estimates.

[21]Nominal values of the measures are used since we use the nominal TWEX measure.

Figure 5
Trade-Weighted Exchange Rate and Consumer Imports as a Percent of Total Expenditures



dollar are associated with an increase in the ratio of consumer imports to total expenditures. Since a rising dollar may mean lower imported prices, consumers would be expected to purchase larger amounts of imports relative to domestic goods and services. Note that the adjustment of consumer expenditures does not occur simultaneously with exchange rate changes. From figure 5, it appears that the adjustment in consumer expenditures is delayed about two years after the exchange rate changes course.[22]

The figure also shows that the recently falling dollar is associated with a decline in the ratio of imported consumer goods to total expenditures. Since the relative price of imported goods has been rising since 1985, along with the fall in the dollar, the response by consumers—shifting away from imported goods to domestic goods—is precisely what economic theory predicts.

Moreover, the percentage of consumer imports to total personal consumption expenditures actually is quite small. On average, consumer imports have accounted for only about 5 percent of total personal consumption expenditures since 1973, reaching a maximum value of about 6.6 percent in 1987. This evidence suggests that the role of dollar depreciation in initiating an inflationary spiral is dubious.

EMPIRICAL EVIDENCE

To measure the complete effect of a change in the exchange rate on domestic prices, one strategy is to view the domestic price level as a function of wages, demand pressures and import prices.[23] In such models, changes in the exchange rate affect domestic prices through their effect on import prices. Hooper and Lowery

[22]This reflects the so-called J-curve phenomenon. See Meade (1988) for a discussion.

[23]Such price equations are oftentimes referred to as cost-markup models.

(1979) report that the various models they examined indicate that a 10 percent depreciation in the dollar, other things constant, produces a long-run increase in consumer prices on the order of 0.8 percent to 1.5 percent.

Another approach used by Whitt, Koch and Rosenweig (1986) is to regress the domestic price level on its own lagged values along with contemporaneous and lagged values of the exchange rate.[24] Based on this approach, the authors find that a 10 percent depreciation of the dollar produces a 1.6 percent increase in the price level after one year and a 4.6 percent increase after four years.

Other studies have attempted to capture the effects of a depreciation by developing structural models of the economy and gauge the effects of a dollar depreciation as it works through various channels, such as labor costs, input prices and economic activity. Hooper and Lowery (1979) also compare such models and find that a 10 percent dollar depreciation on average produces a 0.8 percent to 2.7 percent increase in consumer prices. Sachs (1985) estimates several versions of such a model, finding that a 10 percent depreciation leads to a 0.42 percent to 1.27 percent increase in the price level in the first year, and by the third year, a 1.67 percent to 2.56 percent increase. Compared with the direct effect approach used earlier, the results from these other procedures indicate that the inflationary effects of a dollar depreciation may persist for several years once the indirect effects are accounted for.

Some researchers have questioned the empirical effects of a dollar depreciation found in the preceding studies. For example, Woo (1984) argues that much of the inflation effect attributed to exchange rate movements really reflects oil price increases. These price shocks, which produce sizable but transitory increases in the inflation rate, follow periods of dollar depreciation. In contrast to the other findings, Woo estimates that, once oil price shocks are accounted for, a 10 percent depreciation in the dollar produces a mere 0.02 percent increase in the price level in the first year, with no longer-term effects. Glassman (1985) also argues that exchange-rate effects on changes in the price level are overstated because of the high correlation between exchange rate movements and oil price shocks. Like Woo, he finds that changes in the foreign exchange value of the dollar have no appreciable effect on U.S. inflation after oil price effects are considered.

There also are several general criticisms about relating changes in domestic prices to exchange rate movements.[25] The exchange rate often is regarded as an exogenous variable. As noted earlier, however, movements in the exchange rate reflect relative economic conditions between different economies. Moreover, since economic theory suggests that exchange rates are forward-looking, reflecting market expectations, a finding that exchange rate movements appear to statistically "cause" inflation is merely an indication that they respond faster to changes in the relative economic conditions than do observed price levels.[26]

Another criticism is that the dynamic adjustments that may occur when the relative prices of imports rise are sometimes ignored.[27] Other things the same, unless the domestic monetary authority accommodates the relative price increase by expanding the money supply, desired expenditures on both imported and domestic goods must fall, offsetting any long-term effect of a dollar depreciation on domestic inflation.

Finally, so-called cost-markup models, while relevant in explaining the transitory movements in inflation, are not useful for explaining the underlying determinants of persistent changes in the price level. In a study of the effects of exchange rate changes on domestic inflation, it has been demonstrated that, once the influence of domestic money growth is accounted for, changes in the effective exchange rate provide no additional explanatory power.[28]

[24]They also estimate an equation that regresses the exchange rate on its own lag values and those of the price level. These results indicate that the price level does not help explain movements in the exchange rate.

[25]The following criticisms also are found in Bilson (1979).

[26]For example, expansionary monetary policy in one country may lead to an immediate response in foreign exchange markets as these agents' expectations for future inflation differentials have been altered. The effect on actual inflation differentials, however, may not change for some time.

[27]This point also is raised by Darby (1981).

[28]See Batten and Hafer (1986). This result holds for the GNP deflator. They also report that, when the PPI is used, there is a statistically significant effect. This result is not surprising, however, given the large tradeable-goods component in the PPI index relative to the GNP deflator.

CONCLUSION

Does a falling foreign exchange value of the dollar mean higher U.S. inflation? Some commentators would argue in the affirmative. The analysis in this paper, however, indicates that this view is off the mark. Inflation is a persistent increase in the general level of prices. This definition provides a consistent framework in which to distinguish inflationary trends from transitory relative price shocks. While a depreciating dollar may cause an increase in the dollar price of some imported goods and services, these relative price increases are not inflationary nor do they promote an upward spiral of wages and prices in the future.

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Have Federal Spending and Taxation Contributed to the Divergence of State Per Capita Incomes in the 1980s?

FROM THE EARLY 1930s through the late 1970s, per capita incomes rose faster in low-income than high-income states, resulting in a substantial reduction in the inequality of state per capita income. This trend, however, has been reversed in the last decade (figure 1).[1] Per capita income inequality has risen gradually since 1978 and, by 1987, had returned to the levels prevailing in the mid-1960s.[2]

Historically, the federal government's fiscal policies have been linked to regional disparities in economic growth. During the 1970s, for example, it was alleged that federal spending had been biased in favor of the Sun Belt at the expense of the Frost Belt, resulting in more rapid Sun Belt growth and slower Frost Belt growth.[3] Given the levels of income in these two regions, this growth differential reduced income inequality across states. Two recent studies argue, however, that the distribution of grants-in-aid and procurement has shifted toward the New England and mid-Atlantic regions.[4] Such redistri-

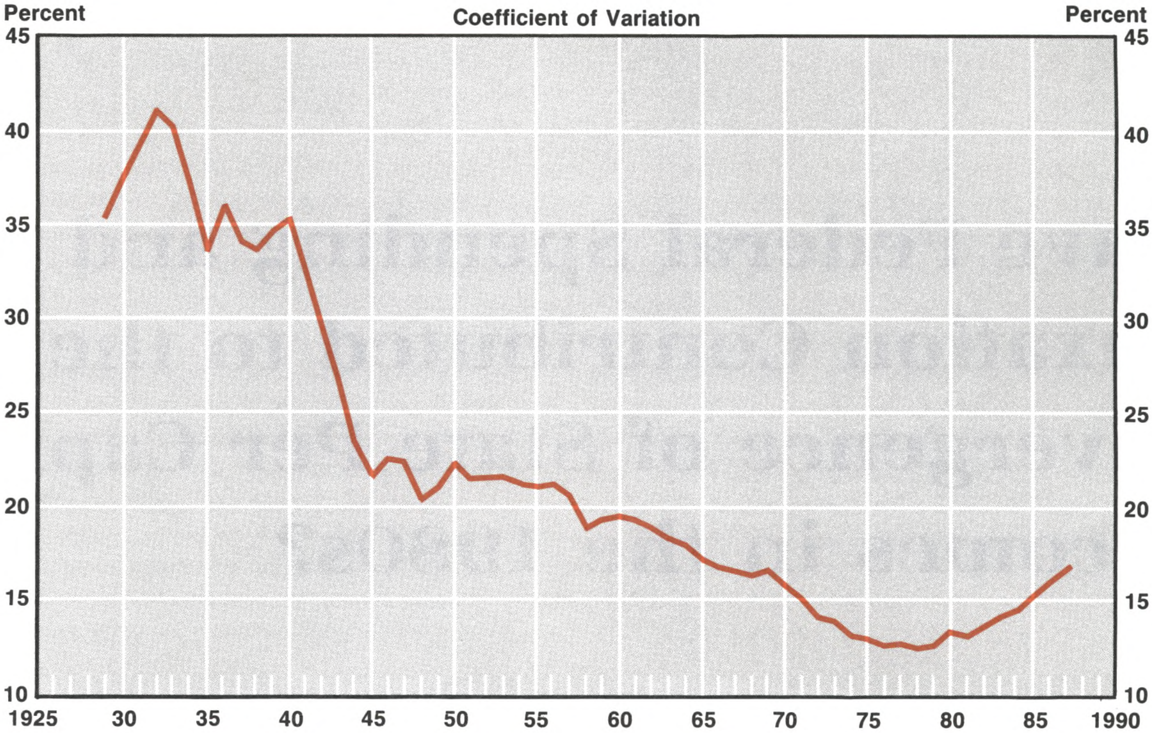
[1]The measure of income inequality used in this article is the coefficient of variation of annual state per capita income across the 48 contiguous states. For each year, the measure indicates the degree of dispersion of state per capita incomes about the mean state per capita income. Because we consider the state to be the appropriate unit of observation, each state is weighted equally in computing the inequality measure. However, Coughlin and Mandelbaum (1988), p.28, found this unweighted coefficient of variation to be closely correlated with a population-weighted coefficient of variation, and also closely correlated with another commonly used measure of inequality, the standard deviation of the ratio of regional to national per capita income.

[2]Ray and Rittenoure (1987) and the U.S. Department of Commerce (1988) document the rise of per capita income inequality between U.S. Census regions since 1979, while Coughlin and Mandelbaum (1988) show interstate income inequality has increased since 1978. Ray and Rittenoure (1987) concluded that changes in energy prices, agricultural prices and world trade patterns contributed to the increasing regional income inequality, while Coughlin and Mandelbaum (1988) concluded that changes in energy prices have contributed to the rise in inequality but that the farm crisis did not.

[3]See, for example, "The Second War Between the States (1977)" and "Federal Spending: The Northeast's Loss is the Sunbelt's Gain (1976)."

[4]See Weinstein and Wigley (1987) and Gross and Weinstein (1988).

Figure 1
Inequality of State Per Capita Income



bution could potentially increase income inequality by stimulating growth in relatively high-income states at the expense of growth in low-income states.[5]

Whether the rising inequality of state per capita income is really due to changes in federal spending and taxation is an unsettled issue, chiefly because there has been no thorough analysis of the effects of changes in the distribution of federal spending and taxation on state income inequality. In this study, we demonstrate that while the distribution of transfer payments and the federal tax burden alters the degree of inequality, no major changes in this relationship have occurred in the 1980s. Next, we describe and analyze the flow of funds between the states and the federal government. Changes in the size and distribution of these flows do not appear to have been a cause of the increasing inequality.

HAVE FEDERAL PERSONAL TAXES AND TRANSFERS AFFECTED INEQUALITY?

The income measure used in calculating the inequality measure (that is, the coefficient of variation) in figure 1 is total personal income. Total personal income is the sum of: 1) net earnings which are total earnings less personal contributions to social insurance, by place of residence; 2) dividends, interest and rent and 3) transfer payments, which are primarily Social Security and Medicare payments. The relative shares of these categories in terms of total per-

[5]Fierce competition among states for federally funded projects, such as the superconducting supercollider, suggests the importance of federal expenditures to state economies. Competing states spent millions of dollars preparing site studies and public relations campaigns to attract the $4.4 billion facility. Texas, which was awarded the supercollider in November 1988, offered $1 billion in bonds and services to persuade the U.S. Department of Energy that it should be chosen. See "U.S. Picks Small Town" (1988).

sonal income for 1969, 1978 and 1987 are listed in table 1. The share of net earnings declined from 77.4 percent in 1969 to 68.7 percent in 1987. Meanwhile, the shares of both dividends, interest, and rent and transfer payments increased.

Table 1 also shows two factors, personal contributions for social insurance and federal personal taxes, that are used below to adjust total personal income. Personal contributions for social insurance are subtracted from total earnings in computing total personal income. As a percentage of total personal income, these contributions rose from 3.4 percent in 1969 to 4.5 percent in 1987. Federal personal taxes, which include individual income, estate and gift taxes, declined from 12.3 percent of total personal income in 1969 to 10.8 percent in 1978, then exhibited little change in the 1980s. They represented 10.7 percent of total personal income in 1987.

To examine how personal taxes and transfers relate to the interstate inequality of per capita income, we compare the inequality (that is, the coefficient of variation) of total personal income with the inequality of income, assuming no federal taxes and no transfer payments exist. The latter measure of income, which we call private income, is derived by subtracting transfer payments from total personal income and adding personal contributions for social insurance. Thus, private income is the sum of total earnings and dividends, interest and rent.

Figure 2 reveals two noteworthy facts about the inequality of private income. First, its trend, generally decreasing through the late 1970s and increasing thereafter, is similar to the trend in the inequality of total personal income. Second, its level is consistently higher than the inequality of total personal income. This suggests that the combined effect of transfer payments and personal contributions for social insurance is to reduce income inequality.

Figure 2 also reveals that nearly all of the difference between the inequality of private income and that of total personal income can be accounted for by transfer payments. The addition of transfer payments to private income produces an inequality measure virtually identical to the inequality of total personal income. Consequently, the effect of contributions for social insurance programs (that is, Social Security, Medicare and unemployment insurance) on interstate per capita income inequality is negligible. Since most contributions for social insurance are proportional to earnings up to some maximum, this finding is not surprising.

Table 1
Income Components and Taxes as a Percent of U.S. Total Personal Income

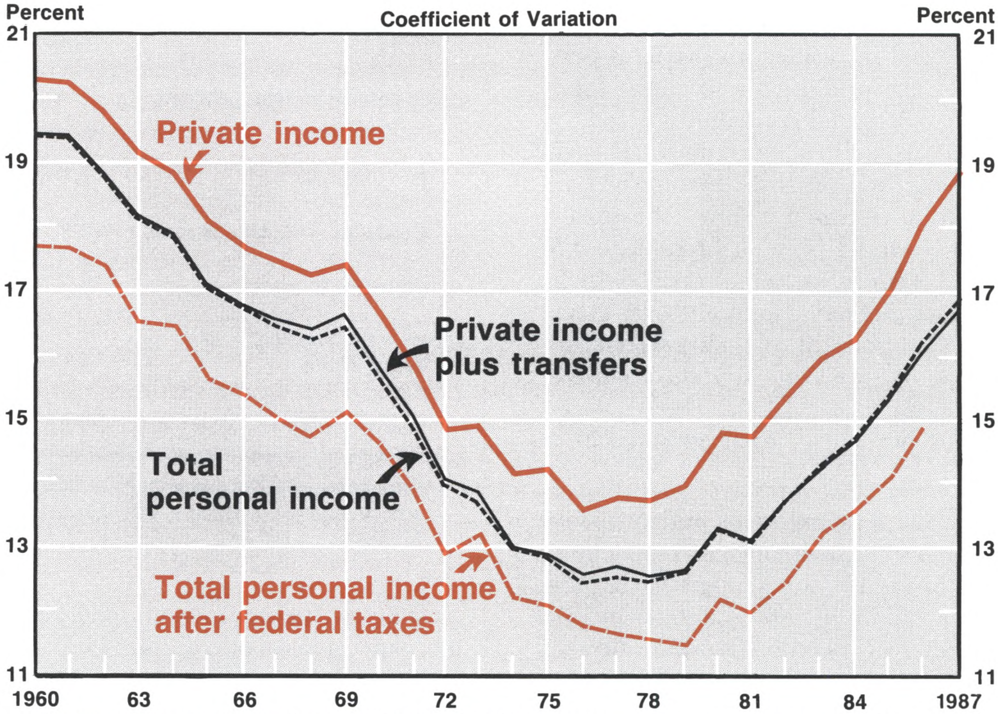
	1969	1978	1987
Components of total personal income			
Net earnings[1]	77.4%	73.4%	68.7%
Dividends, interest and rent	13.3	13.0	16.7
Transfer payments	9.3	13.6	14.6
Personal contributions for social insurance	3.4	3.8	4.5
Federal personal taxes	12.3	10.8	10.7

[1]Wage and salary disbursements, other labor income and proprietors' income minus personal contributions for social insurance.

Another factor that has potentially important implications for inequality is federal personal taxes. As figure 2 shows, the coefficient of variation of per capita state income after subtracting federal personal taxes increased at a rate similar to the other inequality measures since the late 1970s. The direct impact of federal taxation can be seen by the consistently lower level of income inequality after federal taxes are subtracted. The lack of a major change in the gap between the inequality measures before and after taxes suggests that changes in the distribution of federal personal taxes in the 1980s have not altered interstate income inequality substantially.

In summary, while the interstate distributions of the federal personal taxes and transfer payments have consistently reduced income inequality, they have had little effect on the change in inequality. Contributions for social insurance have had no substantial influence on either the level or the change in interstate income inequality. Thus, the evidence suggests that the increase in income inequality over the last 10 years is not due to changes in the

Figure 2
Interstate Inequality of Per Capita Income Measures



NOTE: The figure shows the coefficient of variation for four income measures. Total personal income is transfer payments, dividends, interest, rent and total earnings minus social insurance contributions. Private income is total personal income plus social insurance contributions minus transfer payments. Private income plus transfers is total personal income plus social insurance contributions. Total personal income after federal taxes is total personal income minus federal personal taxes.

distribution of transfer payments, social insurance contributions or federal personal taxes.[6]

FEDERAL FLOW OF FUNDS

The preceding analysis focuses on components of income that, in an accounting sense, can be either added or subtracted to produce different income measures. While this analysis is informative, federal fiscal policy entails numerous tax and spending programs that preclude a straightforward accounting analysis and that may have major income effects at the state level. These include federal corporate income taxes, excise taxes, federal grants to state and local governments and procurement contracts. This section considers the effects of the broader flows of funds between the federal government and the various economic actors in states including state governments, local governments, individual residents and corporations.

The flow of federal funds to and from a state is usually calculated as a ratio of a state's share of total federal expenditures to its share of total payments made to the federal government.[7] If the ratio is greater than unity, the state receives

[6]While the method used in this section suggests the direct impact that the distribution of transfer payments, social insurance contributions and federal personal taxes have on income inequality, it has limitations. If transfer payment programs or federal taxes actually were eliminated, shifts in production, consumption and investment eventually would take place that might lead to changes in interstate income inequality unlike those indicated in figure 2.

[7]Advisory Commission on Intergovernmental Relations (1980), Erdevig (1986), and Rymarowicz (1988), for example, use this ratio in examining the flow of federal funds to states.

a greater share of the national total than it pays to the federal government, a condition thought to stimulate the state's economy and raise per capita income. Conversely, a ratio less than one suggests a drain of state funds that potentially dampens the state's economic activity. See the shaded insert for a more complete explanation of how the federal funds ratio was calculated, what expenditures and tax payments are included and how the data were estimated.

The Conventional Wisdom: Economic Effects of Federal Funds

A larger federal funds inflow can stimulate regional economic growth by augmenting a region's productive capacity and by stimulating technological advances. Federal spending, such as defense procurement expenditures, may contribute directly to the stock of physical capital. Federal spending for educational programs may contribute to the growth of human capital. The case for federal spending stimulating technological advances is frequently illustrated by examining defense spending. In California and New England, generally acknowledged as leading innovation centers, defense spending is frequently said to have induced significant amounts of commercial innovation.[8] The importance of federal expenditures in adding to the capital stock and promoting technological advances across states has not been studied widely, however, so the final distribution of effects from federal funds flows, especially on state per capita income, remains uncertain.[9]

Even though a change in a state's federal funds flow has potential effects on its productive capacity, any discussion of the impact of the federal funds flow usually focuses on the demand side of a state's economy. If tax payments to the federal government were lower, a state's residents and businesses would retain more income that could be spent locally on consumption and investment goods or could be used to finance state and local government services. Similarly, the argument is made that higher federal expenditures in the state would directly boost state income and employment.[10]

For these reasons, a higher federal flow of funds ratio for a state is thought to be more stimulative than a lower one, other things equal.[11] In addition, this measure and its components (federal expenditures, federal tax payments) are the only available indicators of the comprehensive influence of the federal government on state economies and continues to be used by policymakers and researchers in evaluating how federal spending and taxes affect various states and regions.[12]

The following analysis of the association between federal fiscal policies and the increasing divergence of state per capita incomes proceeds in two steps. First, simple correlations of state per capita income with the federal funds ratio are discussed. Second, using a categorization of states according to how their growth rates and levels of per capita income affected the degree of inequality in the 1980s, we examine how federal fiscal policies have changed between 1981 and 1987 for states within these categories.

Federal Funds Ratio

Table 2 reports simple correlations of state per capita income with a state's federal funds ratio for the 12 periods for which data are

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[8]Barff and Knight (1988) argue that increasing federal military spending starting in the late 1970s precipitated New England's economic upturn. Browne (1988) found that, while defense spending apparently spurred commercial high-tech development in Massachusetts and California, the experience of these states is unique. More generally, she found that defense spending in a state has had little effect on commercial innovation and high-technology development.

[9]Research on the impact of defense procurement on regional per capita income has yielded mixed results. Rees, et al. (1988) p.17, conclude that slower growth rates of defense procurement in the Sun Belt states compared with other regions during the 1980s was a causal factor in that region's slower per capita income growth. The validity of this conclusion is questionable, however, because no controls were made for other influences on regional per capita income growth. Bolton (1966), p. 14, found a positive, though weak, relationship between defense spending and state income growth between 1952 and 1962 but no relationship between defense spending and state per capita income growth in the same period.

[10]The openness of a state's economy tends to reduce these effects. Although lower federal taxes or higher federal expenditures leaves more income in the hands of state residents, a portion of these funds are spent for goods and services from outside the state. For example, defense procurement contracts are credited to the state in which the bulk of production is located, but some of this production is subcontracted to other parts of the nation.

[11]Advisory Commission on Intergovernmental Relations (1980), pp. 82-83, reported a positive relationship between a state's flow-of-funds balance and its per capita income growth between 1950 and 1975.

[12]See, for example, Advisory Commission on Intergovernmental Relations (1980), Erdevig (1986), Rymarowicz (1988), Weinstein and Wigley (1987) and Northeast-Midwest Institute (1988).

What Do Federal Flow of Funds Data Measure?

The federal funds ratio (FF) compares the federal expenditures received by those in a state in a given fiscal year with their federal tax payments. Ratios of each state's share of national expenditures to its share of tax payments are used rather than each state's levels. For a given fiscal year, the federal funds ratio is calculated as follows:

$$FF_s = [(FE_s/FE_n) / (TP_s/TP_n)] \times 100,$$

where the subscripts s and n denote an individual state (48 contiguous states) and the continental U.S. total, respectively. FE refers to federal expenditures made in states and TP refers to tax payments to the federal government. If a state has a FF greater than (less than) 100, it receives a greater (smaller) proportion of the nation's expenditures than it pays in federal taxes.

Percentage shares, rather than levels, are used in computing the ratio to minimize distortions caused by changes in data coverage in different years. Expenditures data for years before 1969, for example, include payments on the national debt to states by the federal government whereas these payments are excluded in more recent data.[1] By using shares of national totals, each state's expenditures and payments are more comparable than if levels were compared. Also, considering ratios of shares ensures that the national ratio equals 100, eliminating confusion due to the gap between expenditures and tax payments. The analysis excludes the District of Columbia, Hawaii and Alaska because of their unique relationship to the federal government.

Tax Payments

Tax payments include personal income taxes, corporation income taxes, excise taxes and social insurance taxes and contributions. Social insurance taxes and contributions include Social Security, railroad retirement, federal and unemployment insurance taxes. The table shows the relative size of each of the major components in fiscal year 1987. Individual income taxes and social insurance contributions account for more than four-fifths of the total. Individual income and corporation income taxes have declined slightly in relative size during the 1980s, while social insurance contributions have increased 5 percentage points since 1980 to 35.5 percent in 1987.

To allocate tax liability by state, estimates from the Tax Foundation, Inc. (1988) were used.[2] Individual income taxes were distributed among the states according to a state's actual tax liability for the most recent prior tax year available, adjusted by changes in personal income by place of residence. Corporation income taxes were based on the distribution of personal income (50 percent) and property income (50 percent). Excise taxes were based on consumption and population data. Most of the social insurance taxes were distributed by the distribution of personal income and personal contributions for social insurance and unemployment insurance taxes.

Federal Expenditures

As shown in the table, federal expenditures distributed by state included 81.6 percent of the approximately $1 trillion in federal government outlays for fiscal year 1987. Of the federal expenditures that the U.S. Department of Commerce (1988) was unable to distribute among states, the largest category was net interest payments on the national debt. Of the procurement contracts not distributed by state, most were defense contracts of less than $25,000.

[1]Federal expenditure and tax payment data for the years prior to 1981 were from Advisory Commission on Intergovernmental Relations (1980). Later data were from U.S. Department of Commerce (1988), Tax Foundation, Inc. (1988) and for defense contract data, from U.S. Department of Defense (various years).

[2]Long and Settle (1982) found that the estimates from the Tax Foundation were "reasonably accurate indicators of the true distribution of financing burdens" (p. 459) and that, of the several methods tested, the Tax Foundation methodology minimized overall estimation error (p. 453). See Tax Foundation, Inc. (1988) for more detail concerning the methodology.

Federal Taxes and Outlays, Fiscal Year 1987

	Level (billions)	Percent Composition
Tax Payments (Receipts)	$ 854.1	100.0%
Individual income taxes	392.6	46.0
Corporation income taxes	83.9	9.8
Excise taxes	32.5	3.8
Other	41.9	4.9
Social insurance taxes and contributions	303.3	35.5
Total Federal Outlays	$1,003.8	100.0%
Net interest	138.6	13.8
Distributed to territories	7.3	0.7
Procurement contracts not distributed	19.5	1.9
Other outlays not distributed by state	19.6	2.0
Expenditures distributed by state	818.8	81.6
Direct payments	380.1	37.9
Procurement contracts	176.2	17.6
Defense department	132.5	13.2
Other	43.7	4.4
Salaries and wages	125.9	12.5
Grants to state and local governments	104.0	10.4
Other programs	32.6	3.2

Direct payments to individuals was the largest category of federal expenditures distributed by state. Most direct payments were for Social Security or Medicare. Three-fourths of procurement contracts, the next-largest category, were awarded by the Department of Defense. The Defense Department was also responsible for approximately half of all federal salaries and wages distributed among the states in 1987. The largest programs among grants to state and local governments in 1987 were Medicaid ($27.2 billion), the Highway Trust Fund ($11.2 billion) and Aid for Dependent Children ($10.5 billion). Almost half of the "other programs" category consisted of farm subsidy payments.

The Commerce Department was able to allocate federal expenditures among the states through reports from federal government executive departments and agencies. Procurement contracts are distributed according to the primary place of performance rather than the place of the prime contractor, but no adjustment is made for work performed in other states by subcontractors. Direct payments were allocated to the state in which the recipient resided, while salaries and wages reflect the state of employment.

available. A positive association, indicating that higher (lower) income states had larger (smaller) federal funds ratios, would be consistent with a federal tax and expenditure system that is contributing to divergent state incomes. The results indicate, however, a statistically significant negative association for all periods, suggesting that federal funds flow from higher to lower per capita income states.

It is possible, however, that federal fiscal policy could have contributed to the rising inequality if the degree of redistribution diminished in the 1980s. The evidence does not sup-

Table 2

Correlation Coefficients: State Per Capita Income with Various Fiscal Policy Measures

Year	Federal funds ratio	Expenditures[2]	Defense contracts[3]
1952	−0.64*	0.49*	
1959	−0.49*[1]	0.45*[1]	
1964			0.47*
1965	−0.62*[1]	0.15[1]	0.46*
1966			0.47*
1967			0.49*
1968			0.47*
1969	−0.60*[1]	0.29*[1]	0.47*
1970			0.43*
1971			0.42*
1972			0.36*
1973			0.38*
1974	−0.58*[1]	0.17[1]	0.35*
1975			0.33*
1976			0.29*
1977			0.30*
1978			0.30*
1979			0.34*
1980			0.38*
1981	−0.46*	0.32*	0.42*
1982	−0.45*	0.34*	0.46*
1983	−0.45*	0.37*	0.49*
1984	−0.46*	0.33*	0.53*
1985	−0.48*	0.34*	0.57*
1986	−0.58*	0.28	0.59*
1987	−0.57*	0.26	0.60*

[1]1959, 1965, 1969 and 1974 refer to three-year periods ending in years listed.

[2]Expenditures are per capita by state.

[3]Data are per capita by state and moving averages for the three years ending in year listed.

*Significantly different than zero at 0.05 significance level.

port such a conclusion. Rather than declining during the 1980s, the correlation coefficients in 1986 and 1987 are higher (in absolute value) than for the early 1980s and are roughly equal to earlier periods when the level of interstate per capita income inequality was declining.

For a closer examination of the distribution of federal funds in those states most responsible for the increasing per capita income inequality in the 1980s, we use a classification of states developed in an earlier article. The classification, presented in table 3, groups states according to their per capita income change between 1978 and 1987 and whether these changes tended to raise or lower per capita income inequality.[13] Ten states with above-average per capita income in 1978 experienced substantially faster growth between 1978 and 1987 than the average. We call these states "upwardly divergent." Ten states with below-average per capita income that experienced substantially slower growth than the average are called "downwardly divergent."

We have also identified 10 states whose income changes tended to reduce inequality. Four were states whose per capita incomes were below the average across states in 1978, but which have grown much faster than this average since then. These states are called "upwardly convergent." Six "downwardly convergent" states had per capita incomes above the average across states in 1978, but grew much slower than the average and thus contributed to reduced inequality. Finally, 18 states had relative per capita incomes that changed less than 5 percentage points between 1978 and 1987 and, therefore, had little effect on the recent changes in inequality.

We use these classifications to explore how the federal funds ratio has changed between 1981 and 1987 and whether the change is consistent with rising income inequality. The discussion will focus on federal funds flows in those 20 states in the two "divergent" groups because they were primarily responsible for the increase in inequality in the 1980s.

Table 3 reveals that the average federal funds ratio fell between 1981 and 1987 in upwardly divergent states (from 107.2 percent of the national average to 96.5 percent) and rose in downwardly divergent states (from 111 percent to 127.1 percent).[14] Neither of these changes is

[13]The footnotes in table 3 present the criteria for categorizing the states. See Coughlin and Mandelbaum (1988) for a more extensive explanation of the classification.

[14]Excluding New Mexico, in which extremely high levels of Energy Department contracts distort the data, the average federal funds ratio for downwardly divergent states rises from 102.6 percent of the U.S. average in 1981 to 119.7 percent in 1987. New Mexico received the highest per capita level of non-Defense Department procurement contracts of any state primarily because of the presence of the U.S. Department of Energy's Los Alamos and Sandia Research Laboratories. Since a portion of the funds go to subcontractors in other states besides New Mexico, the expenditure data probably overstate the amount spent in New Mexico.

Table 3

Federal Tax Payments and Expenditures by State

	Federal funds ratio		Per capita expenditures[1]		Per capita payments[1]		Per capita defense contracts[1,2]	
Upwardly Divergent[3]	**1981**	**1987**	**1981**	**1987**	**1981**	**1987**	**1981**	**1987**
Connecticut	105	83	134	124	128	148	389	301
Massachusetts	112	103	116	127	103	123	196	258
New Jersey	74	63	88	88	119	139	69	81
New Hampshire	99	75	96	84	97	111	101	95
New York	94	83	100	99	106	118	97	99
Virginia	146	154	141	155	97	101	180	199
Maryland	122	127	136	149	111	118	134	185
Rhode Island	111	101	109	102	98	101	72	80
Delaware	91	74	101	83	111	112	94	64
Florida	118	102	104	101	88	99	70	85
Group Average	107.2	96.5	112.5	111.2	105.8	117.0	140.2	144.7
Downwardly Divergent[4]								
Idaho	106	130	82	93	78	71	9	9
Montana	101	134	90	104	89	78	16	19
Louisiana	115	103	97	77	85	75	89	63
Utah	124	146	91	99	74	68	60	97
North Dakota	103	162	92	130	90	81	36	51
West Virginia	108	120	85	82	79	68	13	8
Oklahoma	99	106	91	90	92	85	46	35
Indiana	74	89	75	78	101	87	75	86
New Mexico	187	194	150	143	80	74	71	66
Texas	93	87	90	83	96	95	118	108
Group Average	111.0	127.1	94.3	97.9	86.4	78.2	53.3	54.2
Upwardly Convergent[5]								
Georgia	112	103	88	90	78	88	52	105
Maine	132	126	98	101	74	80	118	121
Vermont	111	92	88	79	79	85	76	44
North Carolina	99	93	76	76	76	81	35	30
Group Average	113.5	103.5	87.5	86.5	76.8	83.5	70.3	75.0
Downwardly Convergent[6]								
Wyoming	115	100	128	92	111	91	31	31
Nevada	96	97	104	100	108	103	24	31
Oregon	79	94	79	81	100	86	17	16
Iowa	70	105	69	88	99	84	30	36
Michigan	71	71	80	74	113	104	54	46
Washington	109	114	119	113	109	100	155	121
Group Average	90.0	96.8	96.5	91.3	106.7	94.7	51.8	46.8

(continued on next page)

Table 3 (cont'd)

Federal Tax Payments and Expenditures by State

	Federal funds ratio		Per capita expenditures[1]		Per capita payments[1]		Per capita defense contracts[1,2]	
No Substantial Change[7]								
Illinois	67	71	79	78	119	110	25	26
Ohio	79	89	82	85	103	95	50	80
South Dakota	116	154	92	110	79	71	14	21
Kentucky	102	114	81	81	80	71	22	23
Mississippi	161	164	103	97	64	59	110	95
Nebraska	83	112	81	98	98	87	19	24
Arkansas	122	131	86	89	70	68	18	59
Wisconsin	79	81	77	74	98	91	28	37
Kansas	89	106	94	103	106	97	99	130
Pennsylvania	93	96	93	93	100	97	54	61
Alabama	129	137	96	100	74	73	50	67
Colorado	101	109	101	109	100	100	63	113
Missouri	128	130	123	121	96	93	221	225
Arizona	118	124	101	108	85	88	93	142
California	104	97	115	106	111	110	177	180
South Carolina	124	124	88	89	71	72	34	27
Tennessee	118	116	95	92	80	80	33	35
Minnesota	83	92	83	91	100	99	77	100
Group Average	105.3	113.7	92.8	95.8	90.8	86.7	65.9	80.3

[1]Figures are indexed relative to a continental U.S. average of 100.

[2]Three-year moving average. Data for 1981 refers to three years through 1981, while 1987 figures are averages for 1985-87.

[3]States with above-average per capita income in 1978 and with a 5 or more percentage-point increase in per capita income as a percent of the state average. For Rhode Island, a state with below-average per capita income in 1978 and above-average per capita income in 1987, the rise in relative income resulted in the state's income absolutely further from the average in 1987 than in 1978.

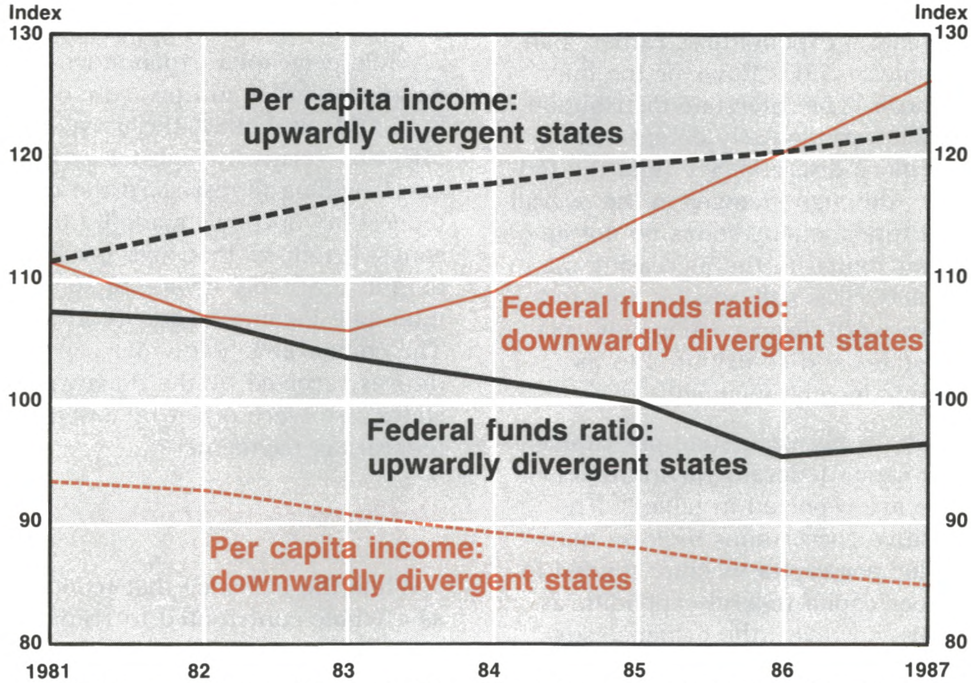
[4]States with below-average per capita income in 1978 and with a 5 or more percentage-point drop between 1978 and 1987 in state per capita income as a percent of the state average. For Indiana and Texas, states with above-average income in 1978 and below-average income in 1987, the drops resulted in the states' being absolutely further from average per capita income in 1987 than in 1978.

[5]States with below-average per capita income in 1978 and with a 5 or more percentage-point increase between 1978 and 1987 in state per capita income as a percent of the state average.

[6]States with above-average per capita income in 1978 and with a 5 or more percentage-point decline between 1978 and 1987 in state per capita income as a percent of the state average. For Wyoming, Oregon and Iowa, states with above-average per capita income in 1978 and below-average per capita income in 1987, the drop resulted in per capita income closer to the state average in 1987 than in 1978.

[7]States whose absolute percentage-point change in per capita income as a percent of the states was less than 5 percent between 1978 and 1987.

Figure 3
Per Capita Income and Federal Funds Ratios in Divergent States



NOTE: Per capita income is indexed, 100 = 48 – state average. For the federal funds ratio, 100 indicates that the share of federal expenditures received equals the share of federal taxes paid.

consistent with the hypothesis that changes in the distribution of federal expenditures and taxes have contributed to rising inequality. To be consistent with rising inequality, the federal funds ratios of upwardly divergent states would have risen, while that of downwardly divergent states would have fallen. In the upwardly divergent states, a rising federal funds ratio would have contributed to the relatively faster growth of these high-income states, resulting in greater inequality in per capita income. In the downwardly divergent states, a falling federal funds ratio would contribute to these states' relatively slow growth.

Figure 3 clearly shows the differing trends of the average federal funds ratio and per capita income in the two divergent groups of states. For the upwardly divergent states, the decline of the average federal funds ratio contrasts with the steady increases in per capita incomes. In downwardly divergent states, the federal funds ratio rose sharply since 1983, while per capita income fell relative to the state average.

Figure 3 also shows that the federal funds ratio is consistently higher in the downwardly divergent than in the upwardly divergent states. This is consistent with the negative correlations between state per capita income and the federal funds ratios indicating that states with lower per capita income tended to benefit more from the overall federal spending and taxation patterns than high per capita income states.

These findings suggest that neither the levels of, nor changes in, the overall flow of federal funds contributed to the divergence of state per capita incomes through their effects on the divergent states. In conjunction with the more general finding of consistently negative correlations between the federal funds ratio and state per capita income, this evidence suggests that, if it had any impact on per capita income growth, changes in the distribution of the federal funds flow reduced, rather than increased, per capita income inequality in the 1980s.

Federal Expenditures in States

Much of the concern about federal policies that influence state economies involves the distribution of federal expenditures rather than the pattern of federal funds flows or the burden of federal taxes. The interstate distribution of federal spending, particularly defense spending, is seen as more discretionary than the federal tax burden. Although changes in the overall flows of federal funds among states do not appear to have contributed to the increasing inequality in the 1980s, it is still possible that federal expenditures were disproportionately spent in high-income states and contributed to increasing per capita income inequality.

Simple correlations between state per capita income and per capita federal expenditures received in a state are reported in table 2. The consistently positive correlations indicate that states with higher per capita incomes tended to receive higher per capita federal expenditures. During the 1980s, however, the evidence suggests that this relationship, if it has changed at all, has weakened. In fact, for 1986 and 1987, the positive association is not statistically significant at the 0.05 significance level.

Doubts about federal spending contributing to divergence are heightened when the states are categorized by their contributions to rising inequality. Table 3 shows that, on average, the share of federal expenditures received by upwardly divergent states declined slightly from 112.5 percent of the national average in 1981 to 111.2 percent in 1987. The direction of this change does not suggest that changes in spending patterns contributed to increases in inequality. Per capita expenditures fell slightly, while per capita income was growing rapidly. In downwardly divergent states, the direction in the change of shares is also inconsistent with rising inequality: average per capita expenditures rose from 94.3 percent of the national average in 1981 to 97.9 percent in 1987.[15]

While per capita expenditures were above the national average in upwardly divergent states in both 1981 and 1987, these expenditures were offset by relatively high tax payments. Thus, if one is willing to disregard the consistently high federal tax outflows made by these high-income states, it follows that high levels of federal spending in upwardly divergent states contributed to interstate income inequality in a particular year. The comparatively low per capita federal expenditures received by the downwardly divergent states also were offset by low outflows of federal tax payments.[16]

Defense Procurement Contracts

While the evidence that federal expenditures as a whole contributed to rising inequality is negligible, there is another possibility. Assuming that different expenditures have different effects on growth, changes in the distribution of certain categories of expenditures may have contributed to rising inequality. Among the major categories of federal spending, only defense contracts are significantly linked to the level of state per capita incomes.[17] The potential impact of federal procurement contracts on interstate income inequality has been magnified by their rapid growth. Procurement has been a rapidly growing component of those federal expenditures distributed among states, expanding at a 6.9 percent annual rate between 1981 and 1987,

[15]In both years, the extremely high expenditures in New Mexico raised the average of downwardly divergent states. Nonetheless, excluding New Mexico does not alter the fact that the share of per capita expenditures in these states rose between 1981 and 1987. If New Mexico is excluded, per capita expenditures in downwardly divergent states averaged 88.1 percent and 92.9 percent of the national figures in 1981 and 1987.

[16]Correlation coefficients indicate a close relationship between per capita income and per capita federal tax payments. The correlation coefficients across the 48 states were high, positive and statistically significant for each of the 12 periods since 1952 for which data were available. In addition, the results suggest that the relationship has not changed substantially during the 1980s, as correlations ranged from 0.94 in 1981 to 0.98 in 1987.

[17]No significant correlations (0.05 significance level) were found between annual state per capita incomes and the other components of federal spending (per capita grants, per capita salaries and wages and per capita direct payments) for any period since 1972. The lack of systematic relationships between state per capita incomes and federal grants-in-aid suggests that the positive relationship between a region's federal grants-in-aid and its per capita income discussed by Gross and Weinstein (1988) and Weinstein and Wigley (1987) does not exist at the state level. Our finding, however, is consistent with the results of a study by the U.S. Department of the Treasury (1985), pp. 197-202, which found no statistically significant relationship between state per capita income and per capita grants-in-aid for 1983.

compared with 6.3 percent for total federal expenditures. The rapid defense build-up during the Reagan administration was largely responsible for the increase in procurement.

Evidence suggests that the distribution of defense contracts may have increased interstate inequality since 1978. Simple correlations for each period between 1964 and 1987 of state per capita income with state per capita defense contracts are reported in table 2.[18] The positive association for each period suggests that high-income states receive above-average amounts of defense contracts, which is consistent with defense spending contributing to divergence. The association has tended to strengthen since the mid-1970s, a fact that suggests the 1980s are a continuation of a longer trend.

As table 3 shows, the average of per capita defense contracts in upwardly divergent states was well above the national average during both periods and increased from 140.2 percent in 1981 to 144.7 percent in 1987. This increase, however, is relatively less rapid than the income growth of these states. The upwardly divergent states are far from homogeneous, as about half of the states received below-average levels during both periods.

On the other hand, table 3 shows that nine of the 10 downwardly divergent states received below-average defense procurement contracts in the three-year periods ending 1981 and 1987. Per capita defense contracts in downwardly divergent states averaged slightly more than half of the national average. More importantly, the share of these states changed little between 1981 and 1987, a fact suggesting no change in the effect of defense spending on inequality.

For the convergent states, the changes in the distribution of federal defense contracts appear to have reduced income inequality. For example, between 1981 and 1987, the share of the nation's per capita defense contracts received by upwardly convergent states rose from 70.3 percent of the U.S. average to 75 percent, while the share of downwardly convergent states declined from 51.8 percent to 46.8 percent.

Thus, at least in the upwardly divergent states, defense spending may have contributed to increasing inequality. In view of the evidence from the other state categories, however, the case for changes in defense spending contributing to increasing inequality is weak.

SUMMARY

Overall, federal fiscal policy does not appear to have been a cause of the increasing inequality of state per capita incomes in the 1980s. The distribution of transfer payments and the burden of federal personal taxes were shown to lower the interstate inequality of income consistently since 1958, while the burden of social insurance contributions apparently had little effect.

The absence of a consistent time series before 1981 on the distribution of federal expenditures and taxes among states, as well as other data limitations, preclude firm identification of causal factors, but the flows of federal funds generally were not distributed in a way that benefited rapidly growing high-income states. On the contrary, upwardly divergent states received lower net inflows of federal funds than downwardly divergent states, and their net inflows declined during the 1980s. While upwardly divergent states tended to receive slightly higher levels of per capita expenditures than downwardly divergent states (largely because of the distribution of procurement contracts), their tax payments were substantially higher as well.

The pattern of change in per capita federal expenditures between 1981 and 1987 was opposite to those one would expect if federal expenditures contributed to the increase in interstate per capita income inequality since 1978. The evidence, however, is consistent with the argument that one major federal spending program—defense spending—could have been a minor factor in the rising inequality of state per capita income this decade.

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[18]Defense contract data are expressed in terms of three-year moving averages because of the volatility of the data and because the contracts sometimes reflect multi-year obligations of up to three years in duration.

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Does Inflation Uncertainty Affect Output Growth? Further Evidence

ECONOMISTS have long been interested in the effects of inflation on real economic variables. In the past two decades, this line of research has expanded greatly, spurred on by the relatively high inflation rates in the developed economies beginning in the 1970s and the coincident slowing in the rate of output growth. One traditional and widely accepted notion is that anticipated inflation has little or no effect on real variables, except for those effects arising from institutional features such as incompletely indexed tax codes and zero interest payments on currency and reserves.[1] It is also widely accepted that unanticipated inflation affects real variables, at least in the short run.

Many analysts also hold that uncertainty about future inflation rates affects real variables. Indeed, Marshall (1886) expressed concern about the negative effects of an uncertain future value of the English pound on output over 100 years ago. More recent arguments in this spirit are contained in Okun (1971) and Friedman (1977), who argue that uncertainty about future inflation is detrimental to real economic activity.

Furthermore, they suggest that uncertainty about future inflation is linked to the mean rate of inflation by the policy environment. Friedman, in particular, argues that nations might temporarily pursue a set of goals for real variables (for example, output, unemployment) that leads to a high inflation rate. The high inflation rate induces strong political pressure to reduce it, leading to stop-go policies and attendant uncertainty about future inflation. Thus, high inflation coexists with increased inflation uncertainty, as individuals become less certain about the political choice over future inflation paths.

Friedman postulates a negative effect of a highly volatile inflation rate on economic efficiency for two reasons. First, increased volatility in inflation makes long-term contracts more costly because the future value of dollar payments is more uncertain. Second, increased volatility in inflation reduces the ability of markets to convey information to market participants about relative price movements. By reducing economic efficiency, greater inflation uncertainty should at least temporarily increase

[1]Surveys reporting on this general consensus are Taylor (1981), Cukierman (1983) and Fischer (1981).

the rate of unemployment and reduce economic growth.[2]

Though these theoretical concerns about the effect of inflation uncertainty seem reasonable and persist in economic discussions, existing studies provide only mixed support for them. This paper studies the relationships between the mean and variance of the inflation rate and output growth for the United States in another attempt to identify the hypothesized negative relationship of inflation uncertainty on output growth. To put this study into perspective, the following section briefly reviews the findings of several previous studies, with particular attention to the relationship between the measure of inflation uncertainty employed in each study and evidence about the link between inflation uncertainty and real economic variables.

A REVIEW OF THE RECENT LITERATURE

Empirical studies of the effect of inflation uncertainty tend to follow one of three broad approaches. The first is that used by Okun (1971), who gathers data for 17 developed countries over 17 years and calculates the mean and variance of the inflation rate for each country. By plotting the mean inflation rate vs. the standard deviation of the inflation rate for these countries, he finds that these two variables are positively related. Logue and Sweeney (1981) use Okun's methodology and find that both the mean and variance of inflation are positively related to the variance of output growth.[3]

This approach has been criticized largely on two grounds. First, the sample variance of the inflation rate for a country over 15 or 20 years is unlikely to be the best measure of uncertainty about future inflation rates, because the sample variance of inflation confounds predictable and unpredictable changes in the inflation rate. For example, if the inflation rate moves in a perfectly predictable way, inflation uncertainty is zero, but the computed sample variance of inflation would be positive. A second criticism is that this approach requires a certain homogeneity across countries to make valid inferences about the variation of inflation and output growth across those countries. Gale (1981) gives reasons to doubt that this homogeneity exists, including noncomparability of indexes and different levels of development across countries. Indeed, Katsimbris (1985) strongly rejects the hypothesis of homogeneity across countries.

A second approach allows the mean and variance of inflation to change within a country through time. Katsimbris (1985) does this for 18 OECD countries. He constructs proxies for the time-varying mean and variance of inflation and output growth as eight-quarter, non-overlapping, moving averages. He finds few countries for which the mean and variance of inflation are related in a statistically significant way and even fewer for which the variance of inflation and the mean or variance of output growth are related. In particular, he finds no significant relationship between inflation uncertainty and output growth in the United States. Thornton (1988), in a recent study employing this methodology, obtains the same results.

Katsimbris' study of individual countries is but one example of a number of studies that use this second approach. Their main feature is the construction of proxies for inflation uncertainty. In addition to Katsimbris' eight-quarter, non-overlapping, moving averages, others estimate time series models for the inflation rate and the real variables and use the residuals to construct overlapping moving-average measures to proxy for the time-varying variance of inflation.

All of these studies lack a parametric model for the time-varying variance of inflation. For instance, Katsimbris' moving averages for the mean inflation rate does not necessarily capture the predictable elements of the inflation process. Therefore, his measure of the variance confounds the uncertainty of future inflation with predictable changes in inflation. In contrast, studies using proxies for inflation uncertainty constructed from the residuals of a model

[2]Recent theoretical work demonstrates that, under plausible conditions, increases in inflation uncertainty lead to reductions in output. Surveys of the theoretical rationales underlying relationships between inflation uncertainty and real variables are contained in Taylor (1981) and Cukierman (1983). These surveys also discuss some of the extant empirical literature on this topic.

[3]Logue and Sweeney acknowledge in their text that an alternative to their approach is to use a time series approach that relates inflation and its variability to the variability of production. They write, "Unfortunately, a neat measure of the next period's uncertainty that might be suitable for use in such a time series test is not available" (p. 499). It is a contention of this paper that the ARCH-M model provides the requisite time series test.

for the inflation process can claim rightly that they are attempting to measure only unpredictable movements in inflation; but these studies are prey to an internal inconsistency. In particular, such an approach estimates a model of inflation under the maintained hypothesis of homoskedasticity and then estimates a proxy for the time-varying (heteroskedastic) conditional variance from the residuals.

A third approach to measuring inflation uncertainty uses survey data from individual inflation forecasts. A good example is Mullineaux (1980), who uses the standard deviation of individual inflation forecasts about the mean value to measure inflation uncertainty. He finds that the sum of current and lagged values of this measure of inflation uncertainty is significantly and positively related to the unemployment rate and significantly and negatively related to the level of industrial production. A more recent study by Hafer (1986) confirms these results with an alternative survey of inflation expectations.

A crucial problem with this approach, however, is that the inflation uncertainty measure actually measures the dispersion of point estimates of the inflation rate across individuals, which does not necessarily capture the degree of uncertainty about future inflation rates. Within a specific theoretical framework, Cukierman (1983) has shown that these two measures are related. It is clear, however, that the individual point estimates reported in the surveys do not indicate the certainty with which individuals make their forecasts, so that measuring inflation uncertainty by the dispersion of these estimates of the inflation rate across forecasters can be misleading.[4] Consider, for example, what would happen if all individuals surveyed reported the same forecast. Even if none of the individuals were very certain of the forecast, that is, if inflation uncertainty were considerable, the constructed measure would be equal to zero.[5]

ESTIMATION RESULTS

This study investigates the effects of inflation uncertainty by looking at a time series of data for the United States, following the second approach discussed above. Unlike most previous studies, however, this investigation uses a statistical technique, the ARCH model, that parameterizes the mean and variance relationships under investigation. This permits straightforward estimation and hypothesis testing in an internally consistent framework. The measure of inflation uncertainty employed here is the time-varying conditional variance of the inflation equation. A more detailed description of the class of ARCH models is provided in the shaded insert on pages 46 and 47.

We model the inflation, real output growth system over the I/1959-II/1988 period using seasonally adjusted quarterly data on real GNP and the GNP deflator. The regression model for the conditional means of inflation and output growth is a vector autoregression.

Preliminary diagnostic tests were conducted to check for unit roots and time trends in the variables. These are reported in table 1. Neither inflation nor output growth exhibited a time trend. For output growth, the null hypothesis of a unit root was rejected. Tests for a unit root in the inflation process are inconclusive: the Dickey-Fuller test rejected the unit root hypothesis, but the augmented Dickey-Fuller test failed to do so. It is well known that tests for a unit root have low power when the alternative is a root close to but less than one. Moreover, the augmented Dickey-Fuller test is more powerful when the time series in question is not white noise after differencing, a situation that appears to hold for the GNP deflator.[6] Additional infor-

[4]One well-known survey, the ASA-NBER survey of professional forecasters, makes an attempt to gather data on confidence bands corresponding to forecasts. These data are relatively crude, however, and are seldom used by authors investigating the neutrality of inflation uncertainty. See, e.g., Hafer (1986).

[5]This is not to say that the information in the dispersion of inflation forecasts across individuals is not useful. Such information is not captured by the assumption implicit in this paper that agents forecast the inflation rate based on common information. Moreover, other approaches have been employed to look at related aspects of the relation between inflation uncertainty and real variables. Blejer and Leiderman (1980) look at relative price variability, measured as the dispersion of price changes in a set of industries about the average price change of the industry. They test to see if real output and unemployment are adversely affected by increases in relative price variability. Notice that inflation uncertainty is not directly an issue in Blejer and Leiderman's work since they examine only the variability of relative prices. They report that relative price variability had significant adverse effects on real variables for the United States.

[6]It is also known, however, that the augmented Dickey-Fuller test has lower power than the unaugmented test when the series is white noise after differencing.

The ARCH Class of Models

In a series of papers, Robert Engle and his collaborators have developed a class of models that allow for explicit parameterization of the variance process for time series models. These models are known by the acronym ARCH, for autoregressive conditional heteroskedasticity, and by variants on that acronym such as GARCH (generalized ARCH) and ARCH-M (ARCH in mean).[1] In these models, the variance of a regression is allowed to change over time and, in particular, to vary with past realizations of variables, including the regression disturbances.

The motivation behind the development of the ARCH class of models derives from several empirical features of economic data. First, the restrictive assumption of homoskedasticity often is rejected by the data. The ARCH model permits a general form of heteroskedasticity that nests the homoskedastic model as a special case. In particular, the variance is allowed to depend on realizations of past variables including past disturbances. Second, consistent with observed data, the ARCH model allows for the clustering of forecast errors that is often observed in econometric models. Thus, the ARCH model permits the occurrence of a large forecasting error today to increase the probability of observing a large forecasting error tomorrow. Third, the ARCH model explicitly allows for the leptokurticity that economic data exhibits. Leptokurticity is the phenomenon that a distribution has "fat tails."[2] Finally, the more general ARCH-M models are especially useful for conducting hypothesis tests relating means and variances.

The basic structure of the ARCH model is fairly simple. The univariate ARCH model can be represented as follows:

(1) $y_t = x_t'b + \varepsilon_t$

(2) $\varepsilon_t | I_{t-1} \sim N(0,h_t)$

(3) $h_t = \alpha_0 + \Sigma_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2, \qquad \alpha_j > 0$ for all j.

Equation 1 represents a standard univariate equation with y_t as the dependent variable, x_t as the vector of predetermined variables which can include lags of the dependent variable, b as the vector of parameters to be estimated and ε_t as the stochastic disturbance term. Equation 2 describes the properties of ε_t *conditional on information known at time t-1,* represented as I_{t-1}. The disturbance ε_t is conditionally normal, with mean zero and variance h_t. Note the explicit dependence of h on time, as specified in equation 3, so that h_t is dependent on q lags of the squared realizations of ε_t. (The homoskedastic model is a special case of the ARCH model when the parameters $\alpha_j = 0$ for $j > 0$.)

Equation 3 allows the variance h_t to be a function of past realizations of the disturbances, whereby the analysis can capture explicitly the possibility of phenomenon such as the clustering in time of large forecast errors. Such a phenomenon would be implied by finding that large past values of ε_t lead to a higher variance, h_t, and hence to a greater likelihood of a further large value of ε_t in the future.

It is important to note that the unconditional distribution of ε_t is not normal. For instance, the unconditional distribution of ε_t can be leptokurtic. The conditional distribution of ε_t and hence y_t is assumed to be normal, however, and thus the joint density is merely the product of the conditional densities. The log likelihood function (aside from a constant term) is given by:

(4) $L_T(b,\alpha) = \Sigma_{t=1}^{T} l_t$, where

(5) $l_t(b,\alpha) = (-1/2)\,[\log(h_t) + \varepsilon_t^2 h_t^{-1}]$.

Estimation of the ARCH model proceeds by choosing parameters b, α, that give the max-

[1]These include, in addition to the ARCH model, the GARCH or Generalized ARCH model and the ARCH-M or GARCH-M for ARCH in Mean models. Relevant citations are to Engle (1983), Bollerslev (1986) and Engle, Lilien and Robins (1987).

[2]For instance, the t-distribution (with finite degrees of freedom) is leptokurtic, as the tails of the distribution contain more mass than the tails of a standard normal distribution.

imum value for $L_t(b,\alpha)$, given the sample of T observations. In other words, we search for parameters b and α that maximize the probability of having observed the sample. Estimation is carried out by a numerical optimization procedure. In the case of the ARCH model, estimation is simplified somewhat by the fact that the two sets of parameters α, b are asymptotically independent, thereby allowing for maximization of $L_T(b,\alpha)$ with respect to each set of parameters separately.

The parameters α are restricted to be positive. As mandated by theoretical considerations, these restrictions preclude large realizations of ε_t from driving the variance negative. For stability, we also require that the sum of the α's is less than one. This is a necessary condition for restraining the unconditional variance to be finite.

In actual applications, it is desirable to be able to test for ARCH before specifying and estimating a model with ARCH. This is especially true because estimation of a model with ARCH involves nonlinear methods. Engle (1982) provides a straightforward test, the ARCH test, based on the Lagrange multiplier principle. As such, it requires only estimates of the homoskedastic model. The null hypothesis is homoskedasticity. The test is conducted by squaring the residuals from the homoskedastic model and regressing the squared residuals on various lags of the squared residuals. The test statistic is the sample size times the R^2 from this auxiliary regression, distributed as chi-square with degrees of freedom equal to the number of lags of the squared residuals included in the auxiliary regression. Large values for the test statistic lead to rejection of the null hypothesis of homoskedasticity and motivate estimation of an ARCH specification.

An important generalization of the ARCH model that we will employ in this paper is the ARCH-M model, that allows for the variance term h_t to enter the regression equation for y_t. The ARCH-M model is given by

$$(1')\ y_t = x_t'b + h_t^{.5}d + \varepsilon_t$$

$$(2')\ \varepsilon_t | I_{t-1} \sim N(0,h_t)$$

$$(3')\ h_t = \alpha_0 + \Sigma_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2, \qquad \alpha_j > 0 \text{ for all j.}$$

In equation (1'), d, a parameter to be estimated, measures the effect of the conditional variance on y_t. The term $h_t^{.5}$ entering equation 1 permits the conditional variance of the disturbance ε_t to affect the conditional mean of y_t. The form of the likelihood function for this model is the same as that given in equations 4 and 5 above, though clearly the parameter estimates will differ between the two models.

The ARCH-M model, by explicitly incorporating variance measures in the equation describing y_t, facilitates estimation and statistical inferences about the effects of variances on means.[3] For our purposes, the ARCH model allows the explicit parameterization and estimation of time-varying inflation uncertainty, defined as the conditional variance of the disturbance to an equation for the inflation rate. Further, with the ARCH-M generalization, we can estimate and test hypotheses about the effect of the time-varying inflation uncertainty on the conditional means of macroeconomic variables such as the inflation rate itself and the rate of growth of output.

[3]This model has been used by Engle, Lilien and Robins (1987) to estimate a model of the term structure in which the risk premium is modeled as time-varying and in which the risk premium affects the holding-period yield. The ARCH specification provides a way of estimating the time-varying risk premium, and the ARCH-M specification adds the ability to estimate the effect of the risk premium on the expected yield.

Table 1

Trend and Unit Root Tests
Sample: I/1960-II/1988

A. Unit root tests. Null hypothesis: Variable has a unit root.

Variable	Dickey-Fuller test t-ratio	Augmented Dickey-Fuller test t-ratio
log(p)	2.87	0.13
log(q)	−1.29	−1.06
log(m)	5.99	3.43
log(v)	−2.75 *	−2.10
△log(p)	−4.16 ***	−2.18
△log(q)	−8.09 ***	−5.11 ***
△log(m)	−6.41 ***	−4.23 ***
△log(v)	−7.52 ***	−4.39 ***

Approximate critical values for rejecting null hypothesis:

Significance	Critical value
10%	−2.58 *
5%	−2.89 **
1%	−3.17 ***

B. Tests for time trends. Null hypothesis: Variable has a unit root *and* no trend.

Variable	Dickey-Fuller Φ-statistic
log(p)	4.26
log(q)	2.98
log(m)	7.43
log(v)	1.41

Approximate critical values for rejecting null hypothesis:

Significance	Critical value
10%	5.47
5%	6.49
1%	8.73

mation on the hypothesis of a unit root in the inflation rate can be garnered from the empirical distributions of the Dickey-Fuller test statistic when the series has non-zero drift. These distributions have been tabulated by Schmidt (1988). For the inflation rate, the drift component would lead to a modification of the critical values tabulated by Dickey-Fuller, so that the 5 percent critical value is -2.11 and we reject the hypothesis of a unit root in the inflation series.[7]

The lag structure of the model was specified with the aid of the FPE (or Final Prediction Error) procedure.[8] Estimates of the model chosen under the assumption of homoskedasticity are provided in table 2. Diagnostic tests reported in table 3 indicate no statistically significant serial correlation and no significant evidence for a structural break in 1973, the approximate midpoint of the sample.[9] The ARCH test, also reported in table 3, rejects the null hypothesis of homoskedasticity for the inflation equation. There is little evidence for rejecting either a constant conditional variance of the disturbance to the output equation, or a constant covariance of disturbances to the output and inflation equations.

Given that the results of our specification tests indicated ARCH, at least for the inflation equation, we proceed to specify and estimate such a model. Since our concern is the effect of the variance of inflation on output growth, we allow the variance of inflation to enter the equations for inflation and output growth. As a further check of the specification, we also allow the variance of output growth to enter the inflation and output growth equations. That is, we specify an ARCH-M model. We can then directly estimate and test the hypotheses of interest.

Table 2

VAR Model of Output Growth and Inflation
Sample: I/1960-II/1988

$$DQ_t = .00909 + .164\,DQ_{t-1} + .144\,DQ_{t-2} - .310\,DP_{t-1}$$
$$\quad (4.15)^{**} \quad (1.74) \quad (1.57) \quad (2.40)^{**}$$

$$DP_t = .00173 + .413\,DP_{t-1} + .219\,DP_{t-2} + .232\,DP_{t-3}$$
$$\quad (2.05)^{**} \quad (4.46)^{**} \quad (2.21)^{**} \quad (2.50)^{**}$$

where the variance-covariance matrix of the disturbances is estimated to be

$Var(eq) = 1.86 \cdot 10^{-5}$
$Cov(ep,eq) = -7.92 \cdot 10^{-7}$
$Var(ep) = 8.73 \cdot 10^{-5}$

and the log likelihood value is 830.1.

** indicates significance at the 5 percent level

The bivariate ARCH-M model for inflation (dp) and real output growth (dq) that we estimate is given as:[10]

$$(1)\ dp_t = \beta_{10} + \beta_{11}dp_{t-1} + \beta_{12}dp_{t-2} + \beta_{13}dp_{t-3} + \beta_{14}H_{p,t} + \beta_{15}H_{q,t} + \varepsilon_{p,t}$$

$$(2)\ dq_t = \beta_{20} + \beta_{21}dq_{t-1} + \beta_{22}dq_{t-2} + \beta_{23}dp_{t-1} \quad \beta_{24}H_{p,t} + \beta_{25}H_{q,t} + \varepsilon_{q,t}$$

where

$$(3)\ H_{p,t} = \alpha_{10} + \alpha_{11}\,[\,\Sigma_{i=1}^{4}(5\text{-}i)\varepsilon^2_{p,t-i}\ /10] + \alpha_{12}\,[\,\Sigma_{i=1}^{4}(5\text{-}i)\varepsilon^2_{q,t-i}\ /10]$$

[7]Further evidence may be obtained by looking at related series. Money and velocity are related to the inflation series and output growth in a known way. We present evidence in table 1 that M1 money growth and velocity growth (defined as the first difference of the log of nominal GNP minus the log of M1) do not contain a unit root. Since the growth rate of velocity is, by definition, output growth plus inflation minus money growth, the growth rate of velocity should exhibit the properties of the component series. As Engle and Granger (1987) write, "Because of the relative sizes of the variances, it is always true that the sum of an I(0) and an I(1) will be I(1)" (p. 253). Thus, velocity growth as a linear combination of inflation, money growth and output growth should be I(1), or integrated of order 1, if any of the component series are I(1). Since the evidence indicates that the growth of velocity does not contain a unit root, i.e., is I(0), this is indirect evidence that inflation is also I(0). The only exception would be if the variables money, output and inflation were cointegrated. Tests of cointegration failed to detect such a relationship. Thus, we find that the inflation series is highly persistent, but not nonstationary.

[8]This approach was first suggested by Akaike (1969). Hsiao (1981) presents a strategy for applying the technique in a multivariate setting.

[9]This year also approximately divides the sample into the fixed or managed exchange-rate period before 1973 and the relatively flexible exchange-rate period after 1973, as well as dividing the sample into the pre-1973 period of no oil price shocks and the post-1973 period marked by a number of oil price shocks, both positive and negative.

[10]A dummy variable for the price-control period, taking the value of 1 when the controls were in place during III/1971-I/1973, was found to be statistically insignificant.

Table 3
Diagnostic Tests on VAR
Sample: I/1960-II/1988

A. Test for serial correlation

Order of serial correlation	Output growth equation: Test statistic	Output growth equation: Marginal significance	Inflation equation: Test statistic	Inflation equation: Marginal significance
1	0.15	.70	1.29	.26
2	0.15	.93	1.61	.45
3	2.22	.53	2.18	.54
4	2.33	.68	2.18	.70

B. Test for ARCH
Single equation tests

Order of ARCH	Output growth variance: Test statistic	Output growth variance: Marginal significance	Inflation variance: Test statistic	Inflation variance: Marginal significance	Covariance, output growth and inflation: Test statistic	Covariance, output growth and inflation: Marginal significance
1	0.05	.82	0.31	.58	0.02	.88
2	0.07	.96	0.33	.85	2.01	.37
3	1.45	.69	12.96	.00	2.05	.56
4	2.07	.72	13.24	.01	2.05	.73
6	2.21	.90	15.84	.02	3.22	.78
8	9.59	.30	17.05	.03	4.11	.85

C. Test for structural change
Subsamples: I/1960-IV/1973, I/1974-II/1988

Likelihood ratio test statistic: 4.1 $\sim x^2$ (8) Marginal significance .85

$$(4)\ H_{q,t} = \alpha_{20} + \alpha_{21}\ [\ \Sigma_{i=1}^{4}(5\text{-}i)\varepsilon^2_{p,t-i}\ /10]$$

$$+\ \alpha_{22}\ [\ \Sigma_{i=1}^{4}(5\text{-}i)\varepsilon^2_{p,t-i}\ /10]$$

and

$$h_t = \begin{vmatrix} H_{p,t} & H_{pq} \\ H_{pq} & H_{q,t} \end{vmatrix}$$

This specification of the variance process, with the conditional variance modeled as a declining lag structure in the squared residuals, has been employed extensively in applications of the ARCH model, but it is restrictive. For example, this specification allows just one free parameter to be estimated on the four lagged squared residuals and imposes a linearly declining lag structure. Therefore, other specifications of $H_{p,t}$ and $H_{q,t}$ were tried. One alternative specification had separate coefficients on each of the four lags of $\varepsilon^2_{p,t}$ and $\varepsilon^2_{p,t}$. This alternative did increase the estimated log likelihood, but only the coefficients on $\varepsilon^2_{p,t-3}$ and $\varepsilon^2_{q,t-3}$ were statistically significant. Further, a likelihood ratio test between the model with only $\varepsilon^2_{p,t-3}$ and $\varepsilon^2_{q,t-3}$ affecting the variance of inflation and output growth, respectively, and a model with all four lags of $\varepsilon^2_{p,t}$ and $\varepsilon^2_{q,t}$ in the respective variance equations, indicated no support for the additional lags. Also, lagged $H_{p,t}$ and $H_{q,t}$ were added to the variance specifications (yielding the generalization of the ARCH model called GARCH) and again the estimated log likelihood function did not increase significantly.

Table 4

ARCH-M Model of Output Growth and Inflation Sample: I/1960-II/1988

$$DQ_t = \underset{(.54)}{-.0109} + \underset{(2.33)}{.172}\, DQ_{t-1} + \underset{(2.33)}{.149}\, DQ_{t-2} - \underset{(3.55)}{.410}\, DP_{t-1} + \underset{(.93)}{2.53}\, Var(eq)^{.5} - \underset{(.13)}{.46}\, Var(ep)^{.5}$$

$$DP_t = \underset{(.38)}{-.0027} + \underset{(5.17)}{.384}\, DP_{t-1} + \underset{(2.79)}{.205}\, DP_{t-2} + \underset{(3.63)}{.245}\, DP_{t-3} + \underset{(.20)}{.188}\, Var(eq)^{.5} + \underset{(.48)}{.696}\, Var(ep)^{.5}$$

where the variance-covariance matrix of the disturbances is estimated to be:

$$Var(eq_t) = 6.99 \cdot 10^{-5} + \underset{(1.85)}{.131} \sum_{i=1}^{4} [(5-i)eq^2_{t-i}/10] + \underset{(.72)}{.203} \sum_{i=1}^{4} [(5-i)ep^2_{t-i}/10]$$

$$CoV(ep_t, eq_t) = 3.39 \cdot 10^{-7}$$

$$Var(ep_t) = 1.40 \cdot 10^{-5} + \underset{(2.67)}{.244} \sum_{i=1}^{4} [(5\text{-}i)\, ep^2_{t-i}/10] + \underset{(.00)}{.0000} \sum_{i=1}^{4} [(5-i)eq^2_{t-i}/10]$$

and the log likelihood is 835.9.

Likelihood ratio test against homoskedastic VAR: 11.6 $\sim X^2(8)$ (Marginal significance .17)

Estimates of the model in equations 1-4 are reported in table 4.[11] The coefficients on the conditional variance terms entering the output growth and inflation equations are insignificant at the 5 percent level. In addition, the lags of the output growth residuals have an insignificant coefficient in the inflation variance equation. Moreover, the lags of the inflation residuals have an insignificant coefficient in the output variance equation. Finally, a likelihood ratio test of the model reported in table 4 against the homoskedastic model reported in table 2 indicates that the null hypothesis, that the homoskedastic model is a valid restriction to the ARCH-M model, cannot be rejected at any reasonable significance levels. These results indicate that inflation uncertainty, measured as the conditional variance of inflation from an ARCH specification, does not have a significant effect on output growth.

To determine the sensitivity of the results to the model specification, we modified the model to include only the third lag of the squared inflation residual in the inflation variance equation and only the third lag of the squared output growth residual in the output variance equation. This specification was chosen from a preliminary model including separate coefficients on each of the four lags of the squared residuals in each variance equation. Estimates are reported in table 5. The estimated log likelihood function of this specification is nearly equivalent numerically (and certainly not statistically distinguishable) from the more general model. A likelihood ratio test against the homoskedastic VAR model leads to rejection at the 5 percent significance level of the null hypothesis that the homoskedastic VAR restrictions are correct relative to the ARCH-M alternative.[12]

[11]To estimate the ARCH-M model, indeed all the ARCH estimates reported in this paper, the ARCH parameters α_{11}, α_{12}, α_{21} and α_{22} were restricted to be non-negative. The shaded insert discusses the rationale for this restriction.

[12]One caveat to the interpretation of the likelihood ratio tests reported here, indeed to most of the statistical inference drawn in this paper, is that considerable pretesting was done in specifying both the VAR and ARCH models. This greatly complicates the inference problem. A good introduction to this issue is provided in Judge, et al (1988).

Table 5

ARCH-M Model of Output Growth and Inflation
Sample: I/1960-II/1988

$$DQ_t = -\underset{(0.89)}{.0186} + \underset{(2.00)}{.136}\, DQ_{t-1} + \underset{(2.01)}{.125}\, DQ_{t-2} - \underset{(4.29)}{.384}\, DP_{t-1}$$

$$+ \underset{(1.22)}{2.98}\, [Var(eq_t)]^{.5} + \underset{(0.46)}{.474}\, [Var(ep_t)]^{.5}$$

$$DP_t = \underset{(0.89)}{.0047} + \underset{(5.73)}{.345}\, DP_{t-1} + \underset{(4.01)}{.248}\, DP_{t-2} + \underset{(4.61)}{.296}\, DP_{t-3}$$

$$- \underset{(0.98)}{.582}\, [Var(eq_t)]^{.5} + \underset{(1.23)}{.493}\, [Var(ep_t)]^{.5}$$

where the variance-covariance matrix of the disturbances is estimated to be

$$Var(eq_t) = 7.45 \cdot 10^{-5} + \underset{(2.82)}{.100}\, eq_{t-3}^2$$

$$Cov(eq_t, ep_t) = 1.16 \cdot 10^{-6}$$

$$Var(ep_t) = 1.26 \cdot 10^{-5} + \underset{(6.31)}{.301}\, ep_{t-3}^2$$

and the log likelihood value is 840.9.

Likelihood ratio test against homoskedastic VAR: 21.6 $\sim X^2(6)$ (Marginal significance .001)

Likelihood ratio test against ARCH VAR: 4.0 $\sim X^2(4)$ (Marginal significance .21)

The estimated parameter values and the asymptotically valid t-statistics reported in table 5 provide further information about the hypotheses of interest. Table 5 shows that the variance of inflation had a positive but statistically insignificant effect on the rate of growth of output and a positive but statistically insignificant effect on the rate of inflation. These results provide no support for the hypotheses under investigation. We also find that the variance of output has an insignificant positive effect on the rate of growth of output and an insignificant negative effect on the rate of inflation.

Table 5 also reports estimates of the variance process. The third lag of squared realizations of the stochastic error in the inflation equation has a statistically significant effect on the conditional variance of the inflation error. In contrast, the lagged squared realization of the stochastic error in the output growth equation has a statistically insignificant effect on the conditional variance of output growth.

Table 5 provides no support for the hypotheses that inflation uncertainty, measured as the conditional variance of inflation forecast errors, has a negative effect on output growth. Indeed, of the six coefficients estimated for the ARCH-M model that were not estimated for the homoskedastic VAR model, five were statistically insignificant, including all of those measuring the effect of the conditional variance of inflation on the inflation rate and the rate of output growth. This observation leads to the suspicion that it is only the ARCH process itself that is important in the rejection of the VAR restrictions by the likelihood ratio test, a suspicion confirmed by estimation of an ARCH variant of the model in table 6. The ARCH model includes the conditional variance specification as in table 5, but does not allow the conditional variance to affect the conditional mean of the inflation process or the rate of output growth. Estimates of this model are reported in table 6.

In table 6 we see that the likelihood value is almost as high as that reported in table 5. A likelihood ratio test does not reject the null hypothesis that the ARCH model is a valid restriction to the ARCH-M model. Moreover, a likelihood ratio test of the null hypothesis of the

Table 6

ARCH Model for Output Growth and Inflation

$$DQ_t = .00947 + .157\, DQ_{t-1} + .129\, DQ_{t-2} - .353\, DP_{t-1}$$
$$(6.55) \quad (2.42) \quad (2.09) \quad (3.97)$$

$$DP_t = .00147 + .352\, DP_{t-1} + .262\, DP_{t-2} + .268\, DP_{t-3}$$
$$(2.67) \quad (5.84) \quad (4.26) \quad (4.24)$$

where the variance-covariance matrix of the disturbances is estimated to be

$$Var(eq_t) = 7.43 \cdot 10^{-5} + .125\, eq_{t-3}^2$$
$$(2.32)$$

$$Cov(eq_t, ep_t) = 1.10 \cdot 10^{-6}$$

$$Var(ep_t) = 1.30 \cdot 10^{-5} + .285\, ep_{t-3}^2$$
$$(5.76)$$

and the log likelihood value is 838.9.

Likelihood ratio test against homoskedastic VAR: 17.6 $\sim X^2(2)$ (Marginal significance .0001)

homoskedastic VAR model against the ARCH alternative leads to a strong rejection of the null. It seems that the inflation-output growth process has ARCH disturbances, but that the changing conditional variance does not feed back to the inflation rate or the rate of output growth.

FURTHER PROBLEMS AND PROSPECTS

The evidence presented here lends no support to the hypothesis that uncertainty about the future inflation rate leads to a reduction in the rate of output growth. Further, this evidence, in accord with that provided by both Katsimbris and Thornton using an alternative methodology, casts doubt on the existence and relevance of the hypothesized positive relation between the rate of inflation and the uncertainty about future inflation.

One possible explanation for this lack of support is that the inflation rate was largely predictable over our sample. Indeed, it is difficult to detect much of an ARCH effect in the inflation data over this span, especially when the inflation forecasting equation is supplemented with other exogenous variables, most notably relative energy prices. Several recent studies, including Engle (1983), Holland (1984), Cosimano and Jansen (1988), and Rich, Kanago and Raymond (1988), all report either difficulty in detecting ARCH in the inflation equation or estimates of the ARCH conditional variance that are very flat over this period. This study identifies an ARCH inflation process, but the process may not have been sufficiently variable to generate precise measures of the effect of the conditional variance of inflation on output growth.

Because this study is limited to investigating the first two moments of the bivariate inflation rate-output growth rate process, it abstracts from some potentially important issues, one of which is the importance of relative energy prices after the 1973 oil price shock. Of perhaps more importance is the neglect of a measure of the mean and variance of the policy stance of the monetary authority. Uncertainty about the future inflation rate can arise from several sources, including uncertainty about future government policy or future values of exogenous variables impinging on the inflation rate. A measure of government policy, perhaps by some monetary aggregate, might be useful to supplement results from the bivariate system reported here.

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Tests of Covered Interest Rate Parity

RECENTLY there has been considerable interest in and investigations of whether the covered interest parity (CIP) holds. At the microeconomic level, CIP is important because is it a direct consequence of covered interest arbitrage. Its failure to hold would suggest 1) that markets are inefficient in the sense that traders do not take advantage of known profit opportunities, 2) that legal restrictions and regulations, such as capital controls, exist or 3) that costs have been unaccounted for, such as individual borrowing constraints or differences in political risks across countries.[1]

At the aggregate level, CIP is important because it implies that interest rates and spot and forward exchange rates are related in a particular way. Indeed, this relationship is frequently imposed in open-economy macroeconomic models. Finding that the relationship among these variables implied by CIP does not hold would leave their relationship uncertain.[2]

Generally, there have been two types of empirical investigations of CIP. The first are designed to determine whether markets are efficient in the sense that all known profit opportunities are arbitraged.[3] These tests investigate whether the actual forward premium deviates from that implied by CIP by more than the transaction costs using the most efficient arbitrage. The issues are whether the forward premia ever exceed estimates of the transaction costs and, if they do, whether they persist. The

[1]In a sense, there are no tests of covered interest arbitrage. It is axiomatic! If tests revealed that CIP was violated so that known riskless profit opportunities were being ignored for long periods of time, such results would undoubtedly be explained in various ways, such as alleging that relevant costs were ignored.

[2]If CIP does not hold, it does not necessarily mean that there is no other exact linear relationship among these variables or their subsets. It only means that the nature of the relationship would be uncertain.

The policy implications of CIP may be especially important for small open economies where the U.S. interest rate can effectively be taken as exogenous. If CIP holds, attempts by such countries' policymakers to move their domestic interest rates will immediately get translated into their exchange rates and vice versa. This is particularly true if the forward rate is an efficient predictor of the future spot rate. Even if this is not the case [for example, see Chrystal and Thornton (1988)], both forward and spot rates would likely be affected since they tend to move together. Furthermore, if CIP holds, such economies may be influenced more by external events, such as changes in U.S. monetary policy, than if CIP does not hold. See Dufey and Giddy (1978) and Kubarych (1983) for a discussion of some of the policy implications.

[3]For example, see Deardorff (1979), Callier (1981), Bahmani-Oskooee and Das (1985) and Clinton (1988).

evidence is that frequent violations of CIP occur, but do not persist.[4]

The second tests are designed to examine whether CIP holds on average.[5] Specifically, they test whether domestic and foreign interest rates and spot and forward exchange rates respond in a way consistent with CIP to economic news that affects each market individually.

This article provides a generic representation of the latter tests and shows that, under appropriate conditions, similar tests can be performed that do not require testing the markets' response to particular sets of information. In so doing, this article extends empirical investigations to a larger set of countries and over a longer time period.[6]

DOES CIP HOLD ON AVERAGE?

CIP is a direct consequence of covered interest arbitrage.[7] In the absence of transaction costs, the CIP condition requires that

$$(1)\ \ln(1+i_t) - \ln(1+i_t^*) - \ln F_t + \ln S_t = 0,$$

where i^* and i are the foreign and U.S. interest rates, respectively, and F_t and S_t are the forward and spot foreign exchange rates (dollars per unit of foreign currency), respectively.[8] The maturity of the U.S. and foreign assets and the forward contract are identical. Moreover, foreign and U.S. securities are assumed to be identical except for the currency in which future payments are denominated.

The Markets' Reactions to Economic News

Equation 1 asserts that a particular linear combination of these variables is zero in the absence of transaction costs. Other linear combinations of the variables need not equal zero. Tests of CIP that rely on the markets' reactions to economic news or events make use of the fact that the particular linear combination of asset prices implied by CIP is zero. To see this, assume that U.S. and foreign interest rates and the spot and forward exchange rates can be represented by the following equations:

$$(2)\ \Delta\ln(1+i_t) = a_1 + b_1 n_t,$$

$$(3)\ \Delta\ln(1+i_t^*) = a_2 + b_2 n_t,$$

$$(4)\ \Delta\ln F_t = a_3 + b_3 n_t, \text{ and}$$

$$(5)\ \Delta\ln S_t = a_4 + b_4 n_t,$$

where n_t denotes the new information that becomes available in the interval over which the t^{th} observation is made. Each asset may respond differently to the same news.

Investigations of CIP rely on testing the markets' responses to specific information by identifying a particular component of n_t and by making an assumption about the stochastic properties of the rest. One approach is to estimate the equations

$$(6)\ \Delta\ln(1+i_t) = a_1 + d_1 I_t + e_{1t},$$

$$(7)\ \Delta\ln(1+i_t^*) = a_2 + d_2 I_t + e_{2t},$$

$$(8)\ \Delta\ln F_t = a_3 + d_3 I_t + e_{3t}, \text{ and}$$

$$(9)\ \Delta\ln S_t = a_4 + d_4 I_t + e_{4t},$$

where I_t denotes specific information that becomes available during the period in which the t^{th} observation is made, and $e_{it} = (b_i e_t)$ denotes an individual market's response to all other information made available during the in-

[4]Much of this literature shows that the difference between the actual forward premium and that implied by CIP often falls outside of the neutral band given by transaction costs, e.g., see Bahmani-Oskooee and Das (1985) and Clinton (1988). For example, Clinton finds "that while the longest sequence of profitable trading opportunities is five observations [days], the most common run does not extend beyond a single observation. Thus, in general, profit opportunities appear to be both small and short-lived, even though they are not rare." See Clinton (1988), p. 367. He suggests, however, that it is unlikely that the quality of the data will ever be sufficient to provide a rigorous test of market efficiency, i.e., that there are no unexploited profit opportunities.

[5]To date, this work has relied exclusively on investigating markets' responses to money announcements. See Roley (1987), Husted and Kitchen (1985) and Tandon and Urich (1987).

[6]Roley (1987) considers Japan and only the Gensaki rate, while Husted and Kitchen (1985) use data for Canada and Germany. Roley's data covers the period from October 6, 1977, through May 30, 1985, while Husted and Kitchen's data covers the period from February 8, 1980, through August 27, 1982.

[7]Deardorff (1979) shows that covered interest arbitrage requires that the forward rate deviate from that implied by CIP by no more than $|t + t^* + t_s + t_f|$, where t, t^*, t_s and t_f are the transaction costs (proportional to the size of the transaction) in the United States and foreign securities markets and the spot and forward foreign exchange markets, respectively. He also shows that the "neutral band" is narrower than this if "one-way" arbitrage is considered. This band has been further narrowed by Callier (1981), Bahmani-Oskooee and Das (1985) and Clinton (1988).

[8]$\Delta\ln F_t$ and $\Delta\ln S_t$ are weighted by an annualizing factor equal to 12 divided by the number of months in the forward contract.

terval, e_t.[9] Estimating this equation system involves the additional assumption that $E(e_t)=0$. Equations 6-9 are estimated and the restrictions $d_1 - d_2 - d_3 + d_4 = a_1 - a_2 - a_3 + a_4 = 0$ are tested. If CIP holds, the intercept and slope coefficients of equations 6-9 will satisfy the particular homogenous linear restriction implied by CIP.

An asymptotically equivalent test can be performed by estimating the equation

(10) $\Delta\ln(1+i_t) - \Delta\ln(1+i_t^*) - \Delta\ln F_t + \Delta\ln S_t = a + dI_t + f_t,$

and testing the hypothesis that $a = d = 0$. In this form, the error term, $f_t = e_{1t} - e_{2t} - e_{3t} + e_{4t}$, vanishes under the null hypothesis that the markets respond to the new information in a way consistent with CIP, that is, $b_1 - b_2 - b_3 + b_4 = 0$. A more satisfactory interpretation of f_t, therefore, comes from recalling that equation 1 holds identically only in the absence of transaction costs, so that f_t represents the change in the log of these costs.[10]

Another interpretation of f_t stems from the fact that the observations used to examine CIP generally are not taken at the same time. To illustrate the effect of this, assume that observations on U.S. and foreign interest rates are taken at 3 a.m. EST, while the observations on the spot and forward exchange rates are taken at 11 a.m. EST. The change in interest rates is measured from 3 a.m. before the release of the specific information to 3 a.m. after the information is released. The change in the exchange rates is defined similarly. Under these assumptions, changes in the interest and exchange rates reflect information that is common to both, as well as the information unique to each. For example, changes in the interest rates will reflect the markets' reaction to information between 3 a.m. and 11 a.m., but this information will not necessarily be reflected in the change in the exchange rates. Likewise, changes in the exchange rates reflect the markets' reaction to information from 3 a.m. to 11 a.m. the next day, but this information will not be reflected in the changes in the interest rates. Consequently, the error term of equation 10 comes potentially from differences in the information in the asset prices due to non-synchronous data, as well as from changes in the log of transaction costs.[11] It could not come from the common information because, as we have already noted, this component of the error term vanishes under the null hypothesis.[12]

Tests of the Linear Restrictions Implied by CIP

A comparison of equations 6-9 and equation 10 reveals another interesting aspect of these tests. The hypothesis that $a = 0$ is a test that the linear combination implied by CIP, but not accounted for by I_t, is zero. If CIP holds, this will be true at all times, not simply when the

[9]This specification assumes that there is no idiosyncratic information that affects one market but not the others. It is difficult to see how such idiosyncratic information could exist in the reduced-form equations 6-9, or how such an assumption could hold under the null hypothesis. For a model that looks at the implications of non-synchronous trading using the assumption of idiosyncratic information, see Lo and MacKinlay (1989).

[10]If transaction costs vary symmetrically around a non-zero mean, the change in the log of transactions costs will not vary symmetrically around zero. This stems directly from the concavity of the log function. This means that if the distribution of transactions cost is symmetric, the distribution of the log of the change in the transaction costs will be asymmetric.

[11]Since the markets may eventually respond to all information, the non-synchronous data implies that changes in asset prices taken at different periods of time will be serially correlated. In terms of equations 6-9, this means that the error terms will be cross-sectionally autocorrelated. In terms of equation 10, this implies that f_t will be serially correlated. Indeed, when equation 10 was estimated using all of the daily data, this was the case. The results reported in this paper are for estimates of equation 10 only on days when the specific information was available. Not surprisingly, in nearly all cases, these error terms were serially independent.

[12]For simplicity, let $\Delta i_t = \Delta\ln(1+i_t^*) - \Delta\ln(1+i_t^*)$ and $\Delta R_t = \Delta\ln F_t - \Delta\ln S_t$, so that CIP implies that $\Delta i_t - \Delta R_t = 0$, under the simplifying assumption of zero transaction costs. Now let $\Delta i_t = \alpha_0 + \alpha_1 SI_t + \delta_0\varepsilon_t + \delta_0\eta_t$ and $\Delta R_t = \beta_0 + \beta_1 I_t + \delta_1\varepsilon_t + \delta_1\omega_t$. Here, ε_t denotes the information not contained in I_t that is reflected in both interest rates and exchange rates. η_t denotes the information reflected in Δi_t that is not reflected in ΔR_t and ω_t denotes the information reflected in ΔR_t that cannot be reflected in Δi_t. Since there is little justification to do otherwise, it is assumed that Δi_t responds the same to ε_t and η_t; likewise, the response of ΔR_t is the same for ε_t and ω_t. Note that if the response of these markets to information is consistent with CIP, i.e., $(\alpha_0 - \beta_0) = (\alpha_1 - \beta_1) = (\delta_0 - \delta_1) = 0$, $\Delta i_t - \Delta R_t$ differs from zero by $\delta_0\eta_t - \delta_1\omega_t$, the response to the non-synchronous information. [Estimation requires a normalization; however, this does not affect the conclusion].

Roley (1987), p. 65, asserts that, "when testing whether the responses of these variables to a specific piece of new information are inconsistent with covered interest parity, the exact alignment of the data is not necessary." The above illustration demonstrates that this is not necessarily the case. The error term of equation 10 and, hence, the precision with which the parameters can be estimated is clearly dependent on the degree to which the data are synchronous.

markets react to specific information. Tests of CIP using the markets' response to specific information generally are performed using data only for days when the information is released; however, evidence on CIP can be obtained directly from the changes in these four asset prices even if information that the markets respond to is not identified or is not available.

Rejecting the hypothesis that this linear combination of changes in asset prices is zero is strong evidence against CIP. A failure to reject the null hypothesis is not strong evidence in favor of it, however, because the same could be true for other linear combinations of these asset prices. If asset prices follow a random walk without drift, the same could be true for any linear combination of the change in these asset prices, not simply for the linear combination implied by CIP. Consequently, stronger evidence consistent with CIP would be obtained if the null hypothesis is not rejected for the linear combination implied by CIP, but is rejected for other linear combinations.

EMPIRICAL EVIDENCE

Tests of CIP using the markets' response to specific information have relied exclusively on their response to money announcements. In this section, the broader test outlined above is applied to daily data for the period from October 5, 1979, to September 14, 1988. Tests of CIP using the markets' response to information in the form of money announcements also are undertaken. The reported tests using money announcements are only for days on which there was an announcement.

The data used in this study are one-, three-, six- and twelve-month Eurocurrency rates for the United States (U.S.), United Kingdom (U.K.), Canada (CA), Germany (GR), Switzerland (SW), France (FR) and Japan (JA), the corresponding forward exchange rates and the spot exchange rates. Anticipated changes in M1 are the median forecasts from the Money Market Services survey, and the forecast error is the difference between the forecasted change and the change in first-announced M1. The interest rates are reported as of 3 a.m. EST and the exchange rates are reported as of 11 a.m. EST. The interest rates are bid rates from the Bank of International Settlements.[13] The exchange rates are the average of bid and ask rates from the London foreign exchange market.

The test of CIP using money announcements involves estimating the equation

$$(11)\ \Delta\ln(1+i_t) - \Delta\ln(1+i_t^*) - \Delta\ln F_t + \Delta\ln S_t = a + d_1 UM_t + d_2 ME_t + e_t.$$

Both anticipated money, ME, and unanticipated money, UM, are included because, as a number of researchers found, these asset prices responded in a statistically significant way to both anticipated and unanticipated changes in the money stock.[14] The finding that the individual markets respond significantly to ME is, itself, frequently taken as evidence that the markets are informationally inefficient.[15] For the purpose of testing for CIP, however, the only relevant issues are whether the markets respond to ME and whether the responses net out in a way consistent with CIP.

It has been common to estimate equations like 6-9 or equation 11 over different subsamples to see if the markets' response to money announcements changes in response to changes in the Federal Reserve's operating procedure.[16] Since the interest here is only in testing for CIP, however, there is no need to split this sample for this purpose: the difference in magnitude of the market's response is unimportant.

It is important to split the sample for another reason, however: the null hypothesis that $d_1 = d_2 = 0$ will not be rejected either if the markets do not respond to money announcements or if

[13]The interest rates are from the BIS data tape at the Board of Governors of the Federal Reserve System. These are bid rates taken from several markets. The Money Market Service survey data through 1986 were provided by Graig Hakkio.

[14]For example, this is true of Tandon and Urich (1987), Husted and Kitchen (1985) and Belongia and Sheehan (1987). Deaves, Melino and Pesando (1987), however, show that the significance of expected money on U.S. interest rates is due to a few outliers, while Belongia, Hafer and Sheehan (1986) have shown that the response of U.S. interest rates to anticipated money is very sensitive to the sample period. In any event, the presence or absence of ME from equation 10 is likely to have little bearing on the test because ME and UM are nearly orthogonal. Furthermore, while the evidence on the importance of ME may be weak, the cost in terms of lost efficiency for including it is small.

[15]While this type of test is generally valid, there are some important limitations. For a discussion of these, see Pesaran (1987), especially chapter 8.

[16]In October 1982, the Fed switched from a nonborrowed-reserves to a borrowed-reserves operating procedure. See Thornton (1988a) for a discussion of the borrowed-reserves operating procedure.

Table 1

General Tests for CIP; October 5, 1979, through September 14, 1988

Country	One Month			Three Month			Six Month			Twelve Month		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
CA	−.00	−.27	−.39	.02	−.45	−.46	.01	−.45	−.52	.01	−.20	−.41
SW	.02	−.12	−.01	.01	−.34	−.03	.02	−.32	−.06	.00	−.32	−.09
GR	.05	−.26	−.18	.03	−.42	−.21	.04	−.46	−.24	.05	−.46	−.28
FR	.01	−.10	−1.23	.00	−.23	−1.26	−.00	−.29	−1.30	.00	−.28	−1.31
UK	−.01	−.21	−.77	−.02	−.37	−.79	.00	−.38	−.82	−.00	−.32	−.84
JA	.03	−.21	1.57	.00	−.27	1.56	.01	−.40	1.55	.00	−.01	.10

T_1: $\Delta \ln(1+i_t) - \Delta \ln(1+i_t^*) - \Delta \ln F_t + \Delta \ln S_t = 0$

T_2: $\Delta \ln(1+i_t) + \Delta \ln(1+i_t^*) + \Delta \ln F_t - \Delta \ln S_t = 0$

T_3: $\Delta \ln(1+i_t) + \Delta \ln(1+i_t^*) + \Delta \ln F_t + \Delta \ln S_t = 0$

their response is consistent with CIP on average.

It is well-documented that the markets, especially U.S. interest rates, responded in a statistically significant way to unanticipated changes in the money stock through the early part of 1984. Their response after early 1984 is more problematic, however. Consequently, the period was divided into two subperiods: October 5, 1979, to January 29, 1984, and January 30, 1984, to September 14, 1988.[17] Equations in the form of 6-9 were estimated for both periods, and both anticipated and unanticipated changes in the money stock had a statistically significant effect only during the first subperiod.[18] Consequently, estimates of equation 11 are presented only for the period ending in 1984. Results for the more general test are presented for the entire period.

THE RESULTS

Table 1 reports t-statistics for tests of various linear combinations of changes in U.S. and foreign interest rates and spot and forward exchange rates, including the linear combination implied by CIP. The t-statistic for the linear combination implied by CIP is denoted T_1; t-statistics for two other linear combinations of the changes in these asset prices are denoted T_2 and T_3. The alternative linear combinations are interesting because T_2 is the t-statistic for a test of a linear combination of changes in these asset prices that is correlated with that implied by CIP, while T_3 is the t-statistic for a test of a linear combination that is orthogonal to that implied by CIP.[19] Consequently, if the null hypothesis that CIP holds cannot be rejected, it would not be surprising to find that $T_3 > T_2 > T_1$.

[17]For example, Dwyer and Hafer (1989) found that essentially there was no statistically significant response of U.S. interest rates to money announcements after July 1984. More importantly, estimates of equations of the form of 6-9 found no statistically significant response to either anticipated or unanticipated changes in the money stock during the second subperiod.

[18]Estimates of equations like 6-9 for the first subperiod indicate that the markets frequently responded significantly to anticipated changes in the money stock. This was the case for U.S. and Canadian interest rates at all maturities, except the 12-month maturity for Canada, and is generally true for both the forward and spot exchange rates. It is not true for other foreign interest rates, with the exception of the one-month Euroyen rate.

[19]Let R_1, R_2 and R_3 denote the three restrictions on the vector of changes in asset prices that correspond with T_1, T_2 and T_3, respectively, e.g., $R_1 = (1, -1, -1, 1)$. Then the correlation between R_1 and R_2 is −.50, while R_1 and R_3 are uncorrelated.

In every instance, the t-statistics for the test of CIP are extremely small, suggesting that CIP holds on average over the sample period. While supportive of CIP, the fact that the null hypothesis cannot be rejected is not compelling evidence because the same could be true of other linear combinations of these variables. Tests of other linear combinations produce t-statistics that are considerably larger than those for that implied by CIP, although in no case was the null hypothesis rejected. In the majority of cases, however, $T_3 > T_2$.

Tests of the Response to Specific Information

Estimates of equation 11 along with the t-statistics for tests of linear combinations of the changes in these variables for the period from October 5, 1979, through January 29, 1984, are presented in table 2.[20] Two F-statistics are reported. F_1 is a test that all of the coefficients are zero. F_2 is a test that the two slope coefficients are zero.

There were four instances in which the coefficient on unanticipated changes in money was statistically significant at the 5 percent level and three instances in which the null hypothesis that both slope coefficients are zero is rejected. In no instance was the coefficient of anticipated money alone significant at the 5 percent level.

The occasional statistically significant response to unanticipated changes in the money supply is odd given the general lack of such responses. Even more surprising, one of these occurs at a maturity of six months while the other three occur at a maturity of 12 months, despite the fact there was no statistically significant response at shorter maturities.[21] This fact along with the extremely low adjusted R-squares leaves open the possibility that the statistically significant responses are due to the influence of a relatively few observations.[22]

Scatter plots of the dependent variable and unanticipated changes in the money stock for the four instances in which the coefficient on UM was statistically significant are presented in figures 1-4. In the case of the six-month maturity for Japan shown in figure 1, it appears that two extreme observations (see arrows) could account for the significant positive coefficient on UM. The same two observations appear as extreme observations for the 12-month maturity for Japan in figure 2. To see if the results for Japan are sensitive to these observations, they were deleted and the equation was re-estimated. In both instances the coefficient on UM was no longer statistically significant at the 5 percent level.[23]

The remaining scatter plots reveal no similarly dramatic outliers. They do indicate what the low adjusted R-squares suggest: a relatively weak relationship between the dependent variable and unanticipated changes in the money stock.[24] Given the spherical nature of the scatter plots and the extremely low adjusted R-squares, these results do not represent a serious challenge to the null hypothesis that CIP holds on average.

Tests of linear combinations of changes in these variables reported in table 2 are similar to those for the entire period reported in table 1. The major difference is the T_3 statistic is significant at the 5 percent level for Germany, France and the United Kingdom for all maturities.[25] This provides strong evidence that CIP holds on average during the period. This finding is consistent with that of Clinton (1988) who found that, even though there were numerous instances when deviations from interest rate parity were larger than those implied solely by transactions costs, no profitable arbitrage opportunities exist on average.

Unlike Roley (1987) who rejected CIP for Japan, these results suggest that it holds for the

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[20]France devalued its currency three times during this period, causing excessively large movements in the Eurofranc rate. These observations were deleted from tests involving money announcements for France. They were October 5, 1981, June 14, 1982, and March 21, 1983.

[21]Most of the empirical evidence suggests that the response of U.S. interest rates to money announcements is the strongest at the short-term maturities. For example, see Dwyer and Hafer (1989) and Hafer and Sheehan (1989).

[22]Thornton (1988b, 1989) has shown that some of the reported statistically significant responses of U.S. interest rates, exchange rates and stock prices to unanticipated changes in the money stock are due to relatively few observations.

[23]The observations are March 7, 1980, and June 10, 1983. The t-statistics for the coefficient on UM are 0.97 and 1.69 for the six- and twelve-month maturities, respectively.

[24]Given the results reported here, there is little reason to perform formal statistical tests for the stability of the coefficients. In any event, such tests likely will be of low power given the low adjusted R-squares for these equations.

[25]Separate tests indicate that many of these asset prices do not follow a random walk.

Table 2

The Markets' Reaction to Money Announcements: October 5, 1979 - January 27, 1984

Maturity/ Country	Constant[1]	UM[1]	ME[1]	SEE[1]	R^2	F_1	F_2	T_1	T_2	T_3
	Estimates of Equation 7							Test of Linear Combinations		
ONE MONTH										
CA	–.103*	–.022	.030	0.394	.016	6.69*	2.87	–.03	–.19	–.82
	(3.78)	(1.86)	(1.67)							
SW	–.103*	.006	.022	0.642	–.006	1.85	0.33	.04	–.14	–1.37
	(2.34)	(0.29)	(0.73)							
GR	–.029	.004	.026	0.478	–.002	0.62	0.75	.06	–.20	–2.12*
	(0.81)	(0.21)	(1.12)							
FR	.457*	–.019	–.007	3.155	–.009	1.54	0.02	.01	–.08	–3.09*
	(2.11)	(0.19)	(0.04)							
UK	.026	.016	.023	0.603	–.002	0.84	0.80	.03	–.16	–2.08*
	(0.62)	(0.88)	(0.83)							
JA	–.125	.019	.011	0.970	–.007	1.22	0.25	.05	–.19	–.23
	(1.86)	(0.65)	(0.24)							
THREE MONTH										
CA	–.022	–.010	.019	0.230	.012	2.06	2.39	–.03	–.33	–.91
	(1.36)	(1.38)	(1.81)							
SW	.022	–.001	.001	0.266	–.009	0.52	0.01	.01	–.32	–1.42
	(1.21)	(0.10)	(0.05)							
GR	–.017	–.001	.007	0.212	–.007	0.52	0.27	.01	–.31	–2.20*
	(1.13)	(0.11)	(0.73)							
FR	.065	.002	.009	0.943	–.009	0.41	0.03	.02	–.19	–3.16*
	(1.00)	(0.06)	(0.21)							
UK	–.009	–.012	.001	0.230	.005	1.25	1.52	–.05	–.29	–2.14*
	(0.59)	(1.74)	(0.11)							
JA	–.031	.010	–.001	0.354	–.005	0.79	0.47	.01	–.20	–.25
	(1.29)	(0.97)	(0.05)							
SIX MONTH										
CA	–.031*	.001	.007	0.213	–.007	1.54	0.28	–.03	–.34	–.99
	(2.14)	(0.21)	(0.69)							
SW	–.026	.006	–.004	0.305	–.007	0.68	0.26	.04	–.34	–1.48
	(1.22)	(0.67)	(0.30)							
GR	–.036*	.003	.010	0.192	–.001	2.62	0.86	.03	–.35	–2.33*
	(2.73)	(0.47)	(1.18)							
FR	.056	–.001	–.032	0.584	–.003	0.93	0.72	.01	–.25	–3.26*
	(1.40)	(0.07)	(1.19)							
UK	–.040*	–.000	.000	0.221	–.009	2.45	0.00	–.06	–.31	–2.23*
	(2.63)	(0.07)	(0.02)							

Table 2 (Continued)

The Markets' Reaction to Money Announcements: October 5, 1979 - January 27, 1984

	Estimates of Equation 7							Test of Linear Combinations		
Maturity/ Country	Constant[1]	UM[1]	ME[1]	SEE[1]	R^2	F_1	F_2	T_1	T_2	T_3
JA	–.050*	.021*	–.024	0.337	.019	3.86*	3.12*	.00	–.32	–.29
	(2.18)	(2.08)	(1.56)							
TWELVE MONTH										
CA	–.043*	.004	.004	0.220	–.006	2.77*	0.30	.01	–.28	–.91
	(2.87)	(0.59)	(0.45)							
SW	.014	.006	–.007	0.288	–.006	0.39	0.35	.00	–.27	–1.49
	(0.69)	(0.68)	(0.54)							
GR	–.021	.011*	–.005	0.174	.010	2.33	2.12	.04	–.31	–2.38*
	(1.75)	(2.02)	(0.56)							
FR	.003	.026*	–.019	0.364	.019	2.16	3.22*	.02	–.23	–3.21*
	(0.10)	(2.36)	(1.15)							
UK	–.032*	.000	–.003	0.230	.009	1.56	0.03	–.04	–.25	–2.24*
	(2.03)	(0.05)	(0.24)							
JA	–.073*	.029*	–.021	0.377	.023	5.08*	3.58*	.01	–.27	–.31
	(2.83)	(2.49)	(1.20)							

[1]Actual coefficient is 10^{-2} times the reported coefficient.

* Indicates statistical significance at the 5 percent level.

T_1: $\Delta\ln(1+i_t) - \Delta\ln(1+i_t^*) - \Delta\ln F_t + \Delta\ln S_t = 0$

T_2: $\Delta\ln(1+i_t) + \Delta\ln(1+i_t^*) + \Delta\ln F_t - \Delta\ln S_t = 0$

T_3: $\Delta\ln(1+i_t) + \Delta\ln(1+i_t^*) + \Delta\ln F_t + \Delta\ln S_t = 0$

Euroyen rate. Roley used the Gensaki rate and attributed his failure to support CIP to capital controls. Since the Eurocurrency rates used here are not affected by capital controls, the results are not inconsistent with Roley's. Together, however, they suggest that there should be relatively weak substitutability between the Euroyen and Gensaki rates.

Conflicting Results for the T_1 Statistics and the Estimated Intercept Coefficients

The T_1 statistics reported in table 2 are much smaller than the t-statistics for the intercept terms, some of which were significant at the 5 percent level.[26] One explanation for this, which

[26]Equation 11 was also estimated using all of the daily data, not simply for days when there was a money announcement. Not surprisingly, the t-statistics for the intercept terms were not much different from the t-statistics for the linear combination of these asset prices implied by CIP reported in table 2.

Figure 1
Scatter Plot For Japan: Six-Month Maturity

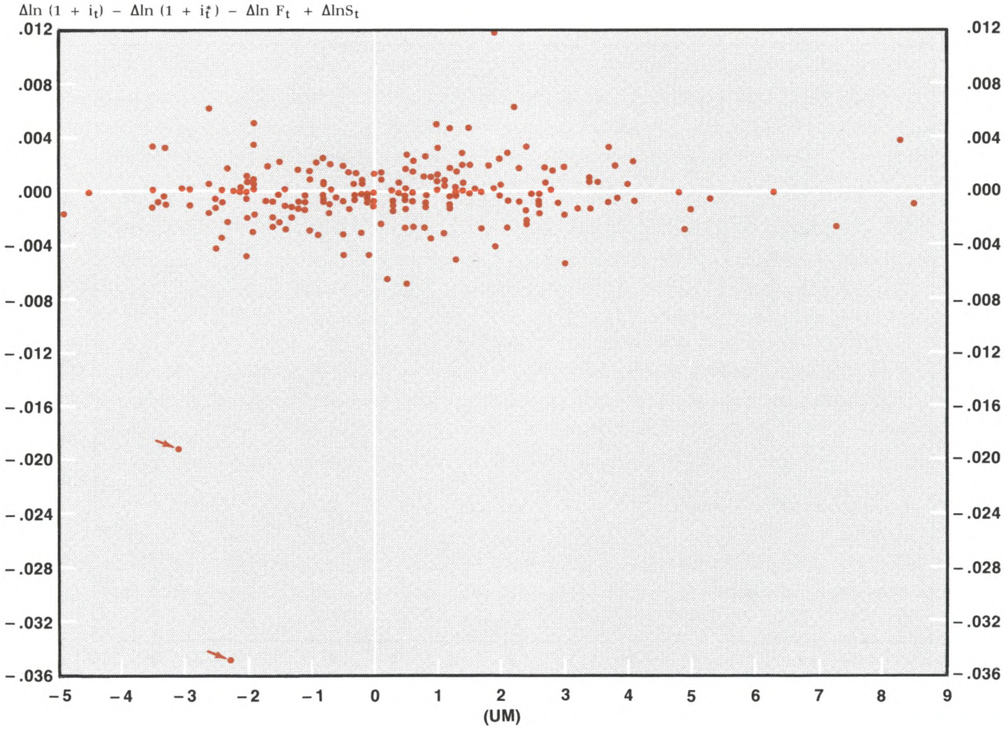


Figure 2
Scatter Plot For Japan: 12-Month Maturity

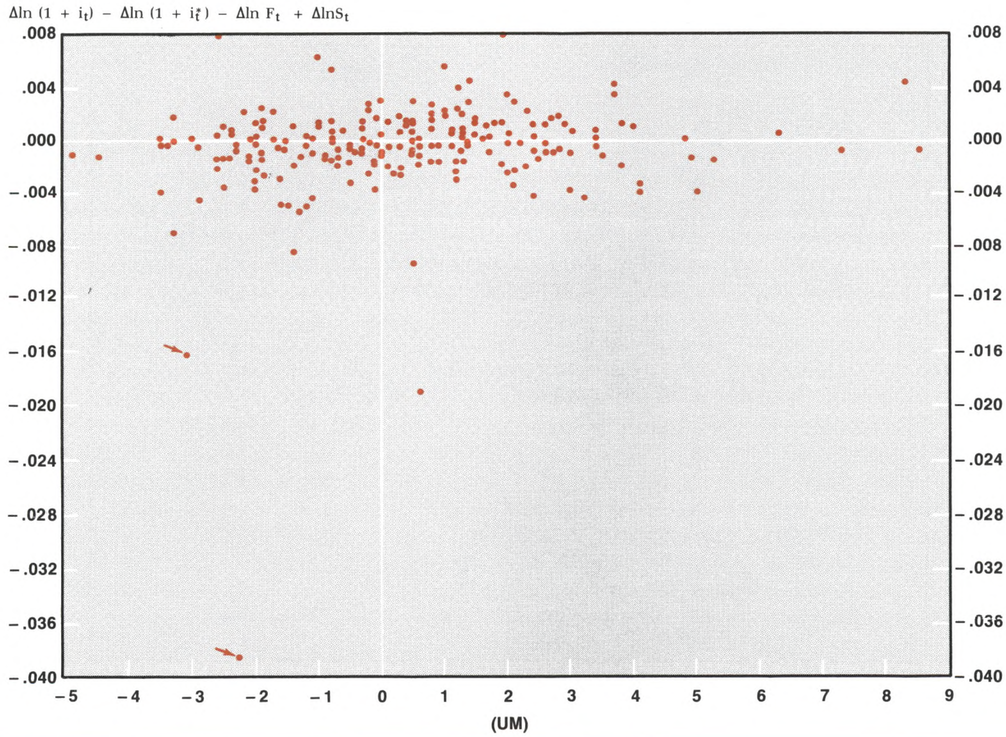


Figure 3
Scatter Plot For Germany: 12-Month Maturity

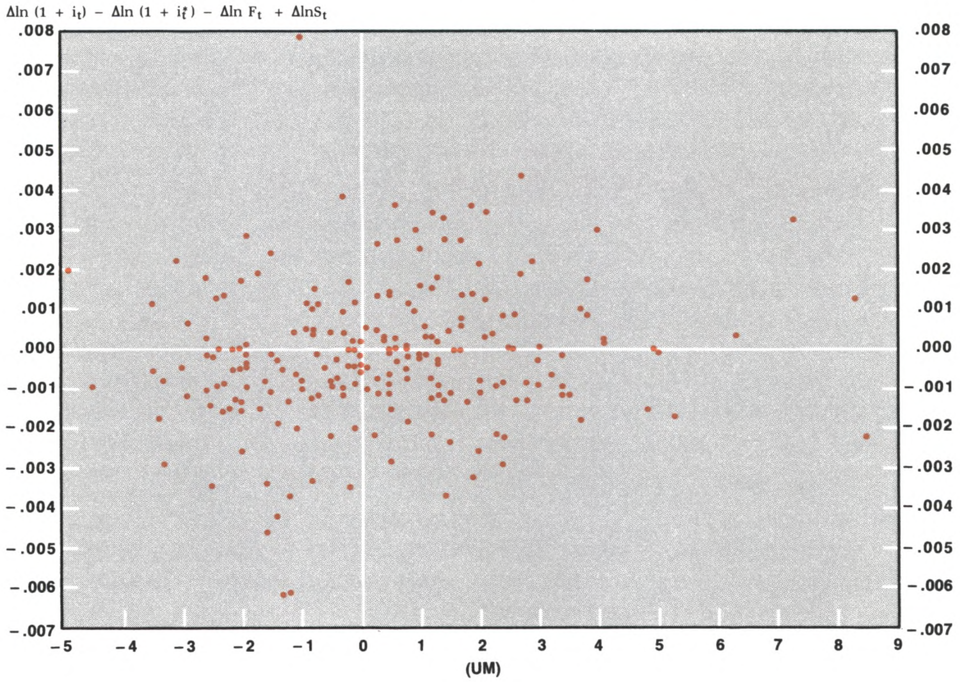
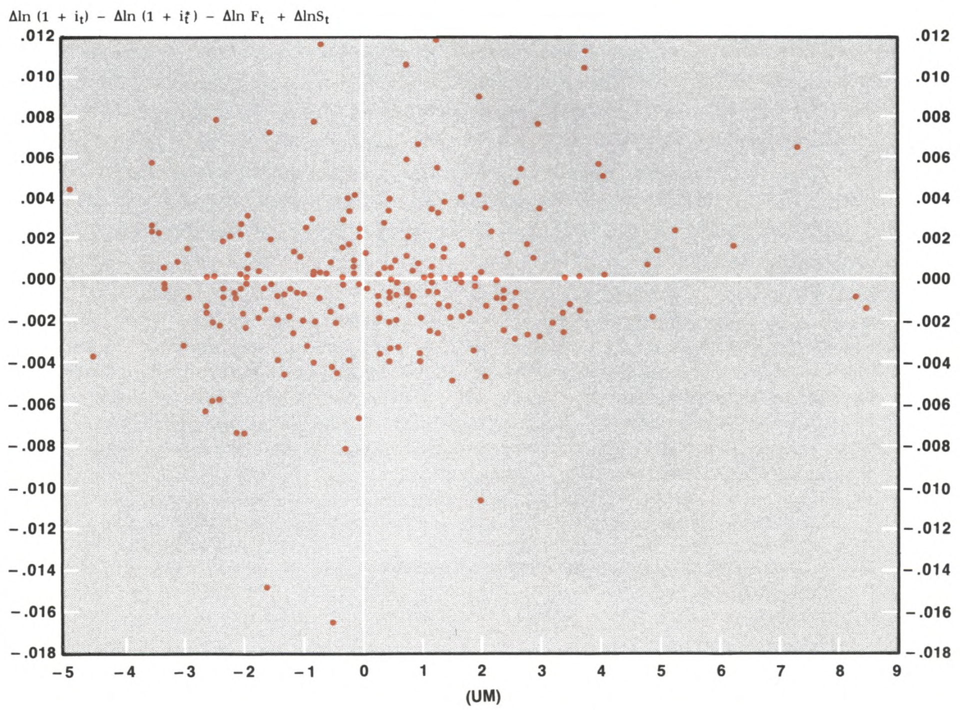


Figure 4
Scatter Plot For France: 12-Month Maturity



is consistent with the frequent—though not persistent—violations of CIP using transaction cost data, is that shocks to the market in the form of money announcements are destabilizing, causing large deviations from CIP on these days.[27] If this is the case, deviations from CIP should be larger on money-announcement days. Consequently, not only will the means be larger, but the variance of the dependent variable in equation 11 should be larger on money-announcement days as well.[28]

Table 3 reports test of the equality of the variances of the dependent variable of equation 11 against the alternative that the variance is larger on money-announcement days. These tests are performed only for the period ending in 1984 because, as has been noted, the individual markets do not respond significantly to unanticipated changes in the money stock thereafter.

In general, the results are not consistent with the hypothesis that the variance is larger on money-announcement days. There are six instances in which the null hypothesis of the equality of the variances is rejected in favor of the alternative at the 5 percent significance level, but there are seven instances in which the variance of the dependent variable is significantly lower on money-announcement days.[29] Moreover, two of the former cases are for the six- and 12-month maturities for Japan. Since the previous results for these maturities were strongly influenced by these observations, they were deleted and the tests repeated. When this was done, the null hypothesis was no longer rejected in favor of the alternative in either case.[30] Consequently, the occasional significant intercept term and the occasional significantly larger variance on money-announcement days are not strong evidence against CIP holding on average.

Table 3
Tests of Equality of Variance

	Maturity			
Country	One Month	Three Month	Six Month	Twelve Month
CA	0.57	0.94	1.09	0.97
SW	0.19	0.70	1.58*	1.79*
GR	0.24	0.32	0.90	1.07
FR	2.76*	1.05	1.17	0.78
UK	0.47	0.52	0.97	1.31*
JA	1.02	0.16	1.80*	2.39*

*indicates statistical significance at the 5 percent level.

CONCLUSIONS AND IMPLICATIONS

Despite a few occasions in which there was a statistically significant response to unanticipated changes in the money stock, the results of tests of the markets' response to economic news are consistent generally with the hypothesis that CIP holds on average. In two of the four instances in which there was a significant response to unanticipated changes in the money stock, the results appeared to be due to the nature of the data and the sensitivity of least-squares to extreme observations. Also, the few instances in which the means of the dependent variable implied by CIP were significantly different from zero on money-announcement days do not constitute strong evidence against CIP.

[27]Another is that the difference in these results are due to the distributions of the dependent variable. Though not reported here, the distributions of the dependent variable have their probability mass more highly concentrated about the mean and have thicker tails than normally distributed random variables. Consequently, sample means vary considerably, even in what conventionally would be large samples. The evidence of this is obtained from tests derived from histograms constructed by dividing the interval from ± 2.33 standard deviations around the mean into 11 equal-length groups centered on the mean. The first and last group were open-ended, theoretically containing 1 percent of the sample in each. These histograms were created for all observations and for days when there were and were not money announcements for the first subperiod. In nearly all instances, the actual frequency in the first and last group exceeded—in many cases, greatly exceeded—the expected frequency. But even in those instances where this was not the case, the actual frequency in the first and last group exceeded the actual frequencies in the second and third and 11th and 12th groups. The null hypothesis of normality was rejected in every case at very low significance levels by formal chi-square goodness-of-fit tests.

[28]One way to conceptualize this is simply to note that there is an extra source of variation on money-announcement days. For an example, see Thornton (1988b).

[29]This may not be too surprising given the transaction-cost interpretation of the error term because Bahmani-Oskooee and Das (1985) report that their estimates of transaction costs were highly unstable.

[30]The F-statistics for the six- and 12-month maturities are 0.72 and 1.14, respectively. Indeed, for the six-month maturity, the variance is significantly smaller on money-announcement days.

This is so because the hypothesis that the mean of the dependent variable implied by CIP is zero was never rejected for larger samples using all of the daily observations.

There is no evidence that the data are consistently more variable on money-announcement days. Furthermore, the t-statistics for tests that linear combinations other than that implied by CIP were zero were much larger than those for that implied by CIP and, in several instances, the null hypothesis was rejected during part of the sample period. Hence, CIP appears to hold on average for these data.

There are several policy implications of the finding that, on average, an exact linear relationship exists between the U.S. and foreign interest rates and the spot and forward exchange rates. For example, if the U.S. interest rate is taken as exogenous, foreign central banks cannot independently and simultaneously control both their interest rates and their exchange rates. This means that small open economies are susceptible to exogenous changes in U.S. monetary policy. Finally, the results indicate the CIP assumption used in many theoretical models is appropriate, so long as it is not required to hold at every point in time. These results, however, do not provide evidence for the question of market efficiency which characterizes many discussions of CIP and covered interest arbitrage.

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