The costs of inflation

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This article surveys the academic literature on the costs of inflation. There are many well-established theoretical reasons why inflation—and uncertainty about future inflation—may reduce economic welfare. Moreover, there has recently been an expansion in empirical work on the relationship between inflation and growth, looking either at a single country or across countries. Most studies have found a significant negative correlation between inflation and growth. And at the broadest level, the article concludes, the available evidence supports the view that well-run economies with strong and efficient productive structures tend to exhibit both low inflation and high growth.

The article also briefly reviews the emerging literature on the costs of reducing inflation, which suggests that the short-term trade-off between unemployment and inflation is more pronounced in countries with low inflation.

In his 1992 LSE Bank of England lecture on the case for price stability,(1) the then Governor listed many of the costs of inflation, giving particular emphasis to those arising from unanticipated inflation. In addition to the costs that arise even if inflation is perfectly anticipated—as a result of the need to economise on real money balances and revise price lists, and of the less than full indexation of tax systems and debt contracts—there are important costs arising from unanticipated inflation. These include:

- the unplanned redistribution of income and wealth;
- additional uncertainty about future prices introduced into decisions about consumption, saving, borrowing and investment; and
- the higher costs of identifying changes in relative prices and allocating resources accordingly.

People may respond to these costs by attempting to predict future inflation or by searching out information on relative prices, but the allocation of increased scarce resources to such activities is costly for society as a whole (even if it may be privately profitable for those who undertake it).

This article expands on the Governor's remarks, looking at the growing theoretical and, especially, empirical literature on the costs of inflation, and in particular at the relationship between inflation and growth over the longer term.(2) It is not intended to provide a comprehensive survey of academic work in this area,(3) but rather to offer a selective review, particularly of recent empirical contributions.

The first two sections describe the main theories of the costs of anticipated and unanticipated inflation respectively, and some related empirical results. The third section considers recent empirical work on the determinants of economic growth over the longer term, in which the importance of inflation is assessed alongside that of variables such as investment, government spending and the presence of market distortions. The final section discusses the possible trade-off between the benefits of lower inflation and the costs of reducing inflation.

Anticipated inflation

The simplest conceptual model in which to analyse the costs of perfectly anticipated inflation is one of an economy in perfect competitive equilibrium and in which there are no distortions except for the non-payment of interest on notes and coin.(4) This can be used to illustrate the key issues, although it is clearly not a realistic description of the world. In such a model, inflation constitutes a tax on holdings of currency, and it imposes welfare costs as agents alter their behaviour in response. At their most basic, these take the form of 'shoe leather' costs: people will make more frequent trips to the bank to withdraw currency (if bank deposits pay interest or provide depositors with other services) and attempt to synchronise cash expenditures with the receipt of cash income.(5) These welfare costs would disappear if there was deflation at a rate sufficient to drive

(1) Published in the November 1992 *Quarterly Bulletin*, pages 441–48.
(2) The Governor discussed the short-run trade-off between inflation and unemployment—the 'Phillips curve'—in his lecture.
(3) There are a number of major survey articles in this area, including Driffill, Mizon and Ulph (1990), Fischer (1981a and 1994), Fischer and Modigliani (1975), Howitt (1990), McTaggart (1992), Orphanides and Solow (1990) and Woodford (1990).
(4) It would be possible (albeit at a cost) to pay something like interest on currency, for example—as discussed by Goodhart (1993)—through a lottery using the serial numbers on banknotes, and to remunerate banks' reserves held at the central bank. But if this was achieved, the optimal rate of inflation in this type of framework would become indeterminate.
(5) As described in Bailey (1956), pages 100–2.

the nominal interest rate on interest-bearing and riskless substitutes for cash down to zero, since people would then no longer need to economise on their holdings of cash.(1)

In this simple model, the cost of inflation depends on how much the demand for cash varies with the nominal interest rate. The cost will be positively related both to the rate of inflation (which will be reflected in the nominal interest rate) and to the sensitivity of the demand for cash to the interest foregone as a result of holding cash. Using such an approach, some estimates have suggested that even fully anticipated inflation may have large welfare costs.(2) But these estimates are very sensitive to the specification of the money demand function and to the chosen definition of money (in most developed economies, cash in domestic circulation is a fairly small proportion of national income).

In addition, the demand for money approach is incomplete, since real income, real wealth and the real rate of interest are assumed to be unaffected by inflation. And the approach is limited to a comparison of various rates of inflation (different nominal interest rates) rather than of different growth paths of the economy. In reality, inflation probably affects savings behaviour and capital accumulation, not least because any change in the real demand for cash represents a switch in the portfolio of assets held in the economy.

The implications of these points have been considered in a number of theoretical models, which generate a variety of outcomes.(3) In a simple neo-classical growth model, introducing real cash balances as the only alternative form of wealth can lead to the conclusion that higher inflation will be associated with increased physical capital but a slower rate of growth of output per head, as the economy moves towards its steady state. But if the level of wealth is made to depend on saving behaviour, which is in turn influenced by inflation, the result can be reversed.

The conclusions also depend on the assumptions made about the role played by money within the economy—for example on whether money is included in consumers' utility functions directly, or whether there is assumed to be a cash-in-advance constraint, so that purchases can take place only using money balances held for some time in advance.(4) And in models with more elaborate sectoral distinctions, inflation can result in an inefficient allocation of productive capital to the private financial sector.(5)

But it is difficult to identify an intuitively-appealing role for money within traditional growth models, and equally difficult to provide a rationale for the existence of money in a hypothetical economy in which the only distortion is the non-payment of interest on currency.(6) And once additional distortions are introduced, the optimal rate of inflation becomes more difficult to determine. For example, if non-distortionary lump-sum taxes and subsidies are not available to the government, then raising revenue through an inflation tax—seigniorage—may be no less desirable than other forms of taxation which distort economic behaviour.(7) Inflation will still be costly for the economy, and this will limit the extent to which it should be used as a source of revenue, but its optimal rate may still be positive.

Finally, the existence of tax systems that are not fully indexed and of contracts set in nominal terms (as, for example, for most mortgage borrowing) leads to further distortions from perfectly anticipated inflation. The true cost of inflation in this respect is the cost of adapting the tax system or financial contracts so that they are fully indexed, if that is possible, rather than the costs arising from a combination of inflation and non-indexation; but if non-indexation persists then inflation could be extremely damaging to an economy.

Unanticipated inflation

Redistribution costs

Unanticipated inflation leads to redistributions of income and wealth—in particular from creditors to debtors, when contracts are less than fully indexed, and from those with fixed nominal incomes to those who pay them. Such redistributions may be very costly for certain individuals and sectors of the economy. They may also undermine confidence in property rights. The difficulty of measuring the overall welfare costs here—not least because for every immediate loser there is an immediate gainer—should not obscure their importance.

Costs for decision-taking

Uncertainty about future price levels is likely to distort the allocation of resources in a number of ways. First, in the absence of index-linked assets, increased uncertainty may increase the attractiveness of real (as opposed to nominal) assets because they give a hedge against inflation. Second, uncertainty is likely to discourage agents from entering into long-term monetary contracts, thereby removing the assurance provided by longer-term contracts. This is likely to inhibit investments where the return is a long time ahead, and thus to reduce companies' investment rates and lead to investment in shorter-lived assets (which may represent a less efficient form of investment). Third, savers and lenders may respond to uncertainty by demanding a risk premium, so increasing the real cost of funds for borrowers. Fourth,

(1) As argued by Friedman (1969) in his derivation of the 'optimum' quantity of money.
(2) Bailey (1956) provides an early example of this, using Cagan's (1956) data on hyperinflation episodes. Fischer (1981a) and Lucas (1993) offer more recent analyses. The estimated cost of exceptionally high rates of inflation can be up to 50% of GDP, but even with low inflation a one percentage point increase in inflation is estimated to generate a welfare cost equivalent to up to 0.1% of output.
(3) These are described in the survey article by Orphanides and Solow (1990).
(4) Again, estimates of the cost of inflation can be derived from such models. They vary widely, but are generally smaller than those derived from measuring the area under a money demand curve; see the survey in Gomme (1993).
(5) For example, in Ireland (1994).
(6) As discussed by Hahn (1971, 1973).
(7) A point made by Phelps (1972, 1973). Cooley and Hansen (1991) calibrate a cash-in-advance model to assess the optimal distribution of tax on money, goods, labour and capital. But Kimbrough (1986a, 1986b) argues that since money balances are an intermediate good they should not be taxed.

capital will be misallocated if savers and investors form different expectations of inflation and thus different views of the *ex ante* real rate of interest.(1)

Uncertainty about future rates of inflation is likely to be greater at higher rates of inflation.(2) During a period of low inflation, the public may be reasonably sure that the authorities will be content with the situation and will attempt to prolong it. Following an inflationary shock, however, if the public are unsure about the preferences of the authorities, they will be uncertain how far the shock will be accommodated through monetary policy and therefore about the future rate of inflation.(3) The authorities themselves may be unsure what to do in a period of high inflation, because they face a dilemma: they would like to disinflate, but may be reluctant to do so because of the recession that would probably result over the short term. Disinflation will probably occur eventually, but its timing will be uncertain.(4)

But future inflation may be uncertain even when current inflation is low. The public may be unsure whether any future exogenous inflationary shocks (for example, adverse shifts in the terms of trade) will be accommodated by the authorities, or whether they might deliberately create an unexpected bout of inflation in an attempt to boost output and employment in the short term, perhaps for electoral reasons.

The earliest empirical work on the relationship between inflation and uncertainty used fairly simple measures of inflation variability, such as standard deviations around the average level of inflation over periods or across countries. The results suggested that there was a positive relationship between the variability and the level of inflation.(5) But there can also be considerable variability of inflation around a near zero mean, as was the case in many countries before the Second World War.(6)

Moreover, variability and uncertainty are not the same thing. Inflation might be highly variable, but if the processes generating it were understood there might be little associated uncertainty; and the costs of variable inflation will be lower if the variations are predictable. Attempts have been made to construct measures of uncertainty by adjusting measures of variability to take account of this, using either econometric models or survey data on inflation expectations to compare inflation outturns with predicted values.(7) Most of the results suggest a positive relationship between the rate of inflation and these measures of 'conditional' uncertainty, particularly for uncertainty over longer time horizons.

But some caution should be applied in interpreting these results. They depend not only on whether the equation for forecasting inflation is specified using a univariate or a structural model (and on whether models or survey data are used) but also on whether it allows for structural changes in the inflation process. In general, the relationship between inflation uncertainty and the level of inflation appears to be strongest when there is a change in the trend rate of inflation—or when there is uncertainty about the possibility of such a change—rather than when there is shorter-term variability in inflation around an unchanged trend rate. This is important if, as suggested above, inflation is most costly when the period of uncertainty stretches over a number of years rather than over shorter periods.

There may also be a causal link between the variability and the average level of inflation, at least if monetary policy is accommodating. For example, variable inflation might lead risk-averse workers to negotiate a nominal wage that incorporated a premium in case the price level proved higher than expected. This would tend to push up nominal and real wages. Moreover, if unanticipated inflation generated the illusion of a real increase in company profits—or even an actual increase, perhaps because firms had financed themselves earlier by borrowing at fixed nominal interest rates below current market levels, or were paying below current market rents on old leases—then firms might be prepared to concede higher wages.

Impact on relative price movements

The relationship between inflation and changes in relative prices has also been much studied. Changes in relative prices give signals which guide resource allocation in market economies. It is therefore an important question whether higher inflation makes it more difficult to perceive and to react to changes in relative prices, or causes relative price changes which would not otherwise occur.

Misperceptions of relative price changes are usually analysed using models that assume that expectations are rational and that the market-clearing process always functions smoothly, whereas unanticipated changes in inflation and increased relative price variability both result from unanticipated changes in the money stock.(8) In such models, a fully perceived change in the money stock has no effect on relative prices and there is no confusion between aggregate and relative price changes. However, a misperceived change leads to movements in prices in individual markets which participants regard, at least in part, as changes in relative prices. Assuming demand and supply elasticities in individual markets differ, these perceived

(1) There have been relatively few attempts to model formally the impact of uncertainty on economic welfare. Rankin (1994) surveys this area and suggests a model in which uncertainty about the future money supply—and so inflation—has a detrimental effect on the economy because risk-averse workers push up money wages and thus unemployment, and because of the increased variability of future prices and output.
(2) As argued by Friedman (1977) and Okun (1971).
(3) This is a familiar result in the 'rules versus discretion' literature, surveyed in Fischer (1990) and Cukierman (1992).
(4) Ball (1992) presents a model along these lines.
(5) See, for example, Foster (1978), Jaffee and Kleiman (1977), Logue and Willet (1976) and Okun (1971).
(6) Backus and Kehoe (1992) cite mean rates of inflation for the United Kingdom of 0.09%, -1.07% and 6.92% for the periods 1870–1914, 1920–39 and 1950–83 respectively, with standard deviations of 2.37, 6.86 and 5.05.
(7) Including Ball and Cecchetti (1990), Brunner and Hess (1993), Cukierman and Wachtel (1979), Engle (1983), Evans (1991), Evans and Wachtel (1993), Jansen (1989), Joyce (1994), McTaggart (1992) and Pagan, Hall and Trivedi (1983).
(8) Models of this type have been developed from Lucas (1973) and include Cukierman (1982 and 1984). It could be argued that the costs arising in these types of model represent the cost of money surprises rather than of inflation, but in practice the link between money and the aggregate price level is a convenience rather than a necessity, and the basic results carry across to any model in which market participants cannot distinguish perfectly between relative price changes and movements in the aggregate price level.

relative price changes result in changes in actual relative prices, which in turn cause a misallocation of resources. Such a misallocation arises from unanticipated inflation or disinflation.

As with uncertainty about future inflation, there may also be an intertemporal misallocation of resources. For example, where imperfect information creates a variety of expectations of inflation, resources will be inefficiently allocated over time because real rates of return are misperceived by at least some agents.

A second type of model has been built on the notion of 'menu costs'. This type of model was intended to explain the non-neutrality of money (why changes in the money supply may have effects on the real economy), at least over the short term, by providing an explanation for nominal price rigidity.(1) Menu costs—including the costs of changing price labels, gathering information about markets and taking decisions to change prices—cause prices to be adjusted infrequently, but more rapidly in response to large shocks than to small ones. Models of menu costs usually assume that firms adjust their prices either at fixed intervals(2) or whenever their relative prices move too far away from their correct levels.(3) In either case, the price level will usually not adjust immediately to a monetary shock, so money may not be neutral. When inflation increases, prices are changed more frequently, but not frequently enough to maintain the previous dispersion of relative prices. As a result, relative prices move out of line, leading to a misallocation of resources. The menu-cost approach relates increased relative price variability to inflation or deflation itself, rather than to unanticipated inflation, and so suggests a way in which even fully anticipated inflation entails costs.

Such models generally imply that the optimal rate of inflation, if one exists, is zero.(4) For example, Ball and Mankiw (1994b) presented a model in which firms change their prices only when induced to do so by a sufficiently large shock: they tolerate limited deviations of actual from desired prices. Positive inflation will then cause firms' relative prices to decline automatically between price adjustments. So when a firm wants to lower its relative price it may not need to pay the full menu cost, because inflation does some or all of the work. By contrast, inflation will widen the gap between desired and actual prices when a firm wants to increase its relative price. So shocks that raise firms' desired prices cause larger price responses than shocks that lower desired prices. (The opposite would be true if the general price level was falling—a firm wanting a lower relative price would have to pay the menu cost to jump ahead of the falling prices charged by other firms.)

Tobin (1972) used an assumption of downward price and wage rigidity to suggest that a positive rate of inflation could be optimal—a variant of the 'oiling the wheels' argument in favour of modest inflation. But his approach treated the asymmetry of price adjustment as exogenous whereas, as just outlined, in the menu-cost model of Ball and Mankiw it may be an endogenous response to inflation. In these models, inflation is costly because it creates inefficient relative price variability without any offsetting benefit.

If, however, the existence of menu costs means that prices adjust more rapidly at higher rates of inflation then the impact of certain types of shocks on quantities (such as real output and employment) could be mitigated through higher inflation. But this is an argument in favour of price flexibility rather than inflation itself; and given its other costs, it is unlikely that inflation is the best means of achieving such flexibility.

The impact of unanticipated inflation on relative prices is also crucial to the effect of inflation on what Laidler (1990) terms the *social productivity* of money. Even low rates of inflation may be costly because they undermine the usefulness of money as a unit of account and as a store of value, while high rates of inflation may also undermine its usefulness as a means of exchange. This cost cannot, by definition, be assessed using a model which implicitly treats the contribution of money to the functioning of an economy as negligible. If the use of money confers only small benefits then any damage that inflation might do must necessarily be minor. But if the social productivity of the monetary system is high, the disruption of that system by inflation is potentially much more serious.

Empirical work suggests that relative price variability and the rate of inflation have been positively related over a wide range of countries and over time in individual countries, and that relative price variability is positively related to the extent of unanticipated inflation.(5)

Again, however, questions about the direction of causation arise. Relative price variability might be exogenous, in which case an asymmetric response of prices to shocks could lead to inflation if some prices are inflexible downwards. This effect would diminish as inflation increased, unless there were some reason why prices rose more easily than they fell in relation to some core or expected rate of inflation. Price inflexibility might then lead to both higher inflation and resource misallocations.

Similarly, inflation and relative price variability might be positively related if both were affected by major supply shocks, if speeds of adjustment or short-run supply elasticities varied across industries, or if an accommodating monetary policy allowed major price shocks to lead to higher inflation. Or government policy might cause both inflation and relative price variability. For example, higher government spending might both increase inflation and change the composition of final demand and so relative

(1) Ball and Mankiw (1994a) provide a broad overview of the role of menu costs and of the various approaches adopted towards modelling them.
(2) Examples of this type include Blanchard (1983), Blinder (1991) and Taylor (1979).
(3) Models of this type include Ball and Mankiw (1994b), Barro (1972), Caballero and Engel (1992), Caplin and Leahy (1991), Caplin and Spulber (1987), Danzinger (1984 and 1987) and Sheshinski and Weiss (1977 and 1983).
(4) However, as discussed below, the non-neutrality of money may have implications for the costs of moving from positive to zero inflation.
(5) See Clare and Thomas (1993), Fischer (1981b), Jaffee and Kleiman (1977), Parks (1978), and Vining and Elwertowski (1976).

prices or, through indirect taxation, it might change relative prices directly.[1] Fischer (1981b) demonstrated that the relationship between inflation and relative price variability in the United States was mainly the result of food and energy price shocks after 1973, and that much the same had been true in West Germany and Japan. He also found a strong contemporaneous correlation between inflation and relative price variability, with no clear sequence. Studies using UK data show that, apart from oil price shocks, the major determinant of relative price variability has been changes in indirect taxation.[2]

So it is difficult to reach any firm conclusion that higher rates of inflation necessarily lead to greater relative price variability. Inflation and changes in relative prices could have a common cause; or relative price variability could be the cause of inflation. In each case, it would be wrong to conclude that higher inflation was itself the cause of increased relative price variability, or even that relative price variability necessarily involved a welfare cost.

Indexation

If many of the costs of inflation could be avoided using index-linked contracts, why is indexation not widespread? Institutional arrangements have tended not to adapt to take account of inflation (except in some countries experiencing very high inflation). This may be because the costs of indexation are relatively high. Indexation may also be inefficient because it inhibits changes in relative prices which would otherwise be desirable. And as it becomes a feature of an economic system, excess demand and other inflationary pressures will tend to be transmitted into prices more rapidly. So even if an indexed economy suffers fewer of the costs of inflation, it also tends to have higher inflation (since indexation may also reduce the counterinflationary resolve of the authorities). As a result, those costs which cannot be removed through indexation (in particular those relating to relative prices and to anticipated inflation) may become more severe.[3]

The effects of inflation on growth

The arguments presented above suggest that inflation and inflation uncertainty lead to a misallocation of resources; they are therefore likely to reduce the rate of growth of an economy. Attempts have been made to estimate by how much.

One possible starting-point is a neo-classical growth model. In this, an economy's growth rate is determined by technical progress and the growth rate of labour supply, both of which are assumed to be exogenous, but the level of output per 'effective' worker in steady-state equilibrium depends on a set of variables—which might include the rate of inflation—that determine the efficiency with which labour and capital are used. If returns to capital are diminishing, the growth rate will be slower the higher is the initial level of real output per head relative to the steady-state position. If all countries had the same steady-state position, poorer countries (defined by their initial stock of physical and human capital) would grow more rapidly until they caught up with the richer countries. But this 'convergence' hypothesis would not necessarily hold if national steady-state positions differed.

More recent growth models have focused on the determinants of technical progress, which include investment and the level and effectiveness of research and development expenditure. The rate of inflation (and other factors) may, by influencing these, be important in determining both the steady-state rate of growth and the path along which an economy approaches it.

Empirical work here has been conducted on a number of bases. First, some studies have used time-series data for individual countries, whereas others have adopted a cross-country approach in which the data for each country are averaged over extended periods. A further method is to use a panel of data which combines these two approaches.

Second, some studies include inflation as the only determinant of growth, while others include a range of other possible determinants, either to take account of one-off disturbances (such as oil price shocks) or in an attempt to model growth more comprehensively by testing the significance of other possible influences. Third, although growth per head is usually chosen as the dependent variable, some studies have focused on factor productivity or investment. And some have used both the rate of inflation and its variability (absolute or relative to a prediction) as explanatory variables.

Although a few studies have found no relationship between inflation and the growth rate, the general consensus is that growth is significantly and negatively related to inflation. In some cases, the correlation is estimated to be quite large, suggesting that a one percentage point reduction in inflation could be associated with an increase in the rate of growth by something between 0.1 and 0.5 percentage points. But it is recognised that this relationship is unlikely to be monotonic: the results do not imply that a move from stable prices to deflation would increase the growth rate. (There have been so few instances of sustained falling prices that the available data do not permit any reliable assessment of their effect.)

Time-series approaches

Beginning with single country time-series analysis, the simplest approach is to regress output growth on current and lagged inflation. Grimes (1991) ran such equations for 21 industrialised countries, including terms of trade and year-specific dummy variables to pick up supply-side shocks. He found a significant negative relationship for 13

(1) These possibilities are discussed in Fischer (1981b).
(2) See, for example, Mizon and Thomas (1988).
(3) Patinkin (1993) offers a vivid account of the problems faced by Israel under a system of widespread indexation.

countries, which implied that a sustained increase in inflation from 0% to 9% would lead to a full percentage point reduction in annual growth rates. In contrast, Stanners (1993) found only a weak (but negative) correlation between inflation and growth using time-series data for nine industrialised countries.

Simple equations regressing growth on inflation cannot, however, be expected to generate unbiased results. For one thing, in almost all countries there is a positive relationship, at least over the short run, between growth and inflation, with the direction of causation running from higher growth (at least in relation to productive potential) to higher inflation. In addition, single-country time-series observations that exhibit a negative correlation may be picking up the results of the authorities' reactions: a period of high inflation (or inflationary pressures) is likely to provoke a tightening of monetary policy, which in turn will cause both inflation and (in the short run) growth to decline.

Similar difficulties afflict studies which use time series from single countries to estimate the influence of inflation on productivity growth.(1) Some of them—for example Rudebusch and Wilcox (1994)—attempted to allow for the short-run trade-off between inflation and growth, and for reaction function considerations. Without any allowance for cyclical factors, they estimated a significant negative relationship between inflation and productivity growth in the United States, with a one percentage point reduction in inflation associated with an increase in annual productivity growth of 0.35 percentage points.(2) In addition, they found that inflation 'Granger causes' productivity growth (that is, productivity growth can be 'explained' in a statistical sense by lagged inflation terms, but inflation cannot be 'explained' by lagged productivity growth). But once a cyclically adjusted productivity growth series was used, the estimated relationship became much weaker. An alternative method of allowing for cyclical factors—by including the growth of real output as an additional variable—weakened the original results far less, so that a statistically-significant negative correlation between inflation and productivity growth remained; but Sbordone and Kuttner (1994) have shown that including the US federal funds rate as a further additional variable eliminates this correlation.

Jarrett and Selody (1982) also attempted to isolate the effects of policy reactions, in their case by including capacity utilisation as an additional explanatory variable. Their results, using Canadian data, were very close to those derived by Rudebusch and Wilcox using cyclically unadjusted data: a one percentage point reduction in inflation was associated with a 0.3 percentage point increase in productivity growth. However, an updating of their study by Fortin (1993) found that although inflation had a negative impact on productivity growth over a longer sample period, the result was no longer statistically significant.

A further problem with these results is that much of the negative correlation between inflation and output or productivity growth depends on a relatively small number of observations, in particular in the years immediately following the oil price shocks of 1972–73 and 1979, when inflation was relatively high and output and productivity growth relatively low. If these years were excluded, the results presented by Rudebusch and Wilcox would become less significant. So the conclusions depend heavily on how the evidence of the oil price shocks is interpreted. As the box on page 39 discusses, data for the United Kingdom reveal a similar difficulty.

The results are also based on a limited range of explanatory variables (partly because there are a limited number of data observations). This means that the estimated equations do not allow for the influence of many possible determinants of growth other than the rate of inflation, which may distort the results. One response—adopted by McTaggart (1992) and Smyth (1994)—is to estimate a production function including inflation as an argument. Both studies found that inflation had a negative impact on growth, but neither could identify the channels at work. Again, these regressions may have picked up short-run effects, rather than longer-term determinants of the growth rate. The results were broadly consistent with those for other time-series studies: for example, Smyth found that a one percentage point increase in inflation reduced the growth rate of private-sector output by 0.2 percentage points.

Some time-series studies have also assessed the importance of inflation *variability*. McTaggart (1992) found that inflation variability had a positive effect on the growth rate, but Jansen (1989) found that although inflation had a significant negative relationship with output growth, attempts to measure the effect on growth of the conditional variance of inflation yielded insignificant results.

It is also unclear why a change in inflation (or inflation uncertainty) should have as rapid an impact on output or productivity growth as some of the results suggest. It seems more plausible that productivity or output growth should respond favourably to a regime of low inflation (and low uncertainty about future inflation) extending over a much longer period, closer to a decade than a single quarter or year.

Cross-country approaches

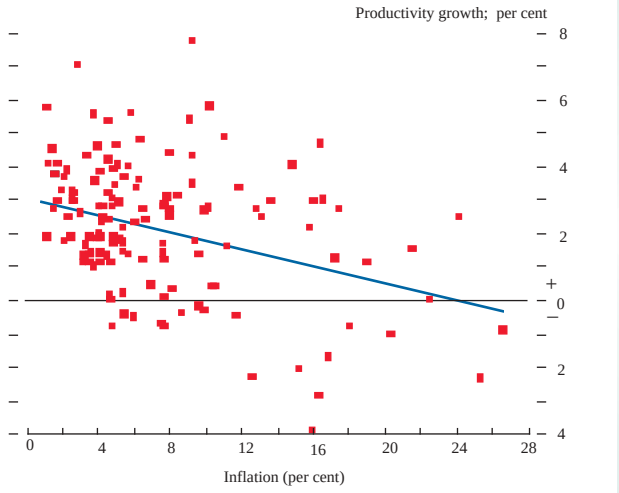
The other main method of estimating the effect of inflation on growth is to use cross-country data. The use of such data was helped by the work of the World Bank and of Summers and Heston (1988), who developed a database on growth rates and their possible determinants for 130 countries from 1950. This work has encouraged other researchers to construct consistent series for additional explanatory variables with a similar coverage. By averaging the data for each country in the sample over a number of years, it is

(1) Including Clark (1982), Jarrett and Selody (1982), McTaggart (1992), Rudebusch and Wilcox (1994), and Smyth (1994).
(2) They reported similar results for Canada and the United Kingdom, but much smaller and generally insignificant results for Japan, France, Germany and Italy.

The relationship between UK inflation and productivity growth

Time-series data on inflation and productivity growth in the United Kingdom and the United States are plotted in Charts 1 and 2 below. The charts suggests that in both countries there has been a negative relationship between the two variables in the post-war period; the line

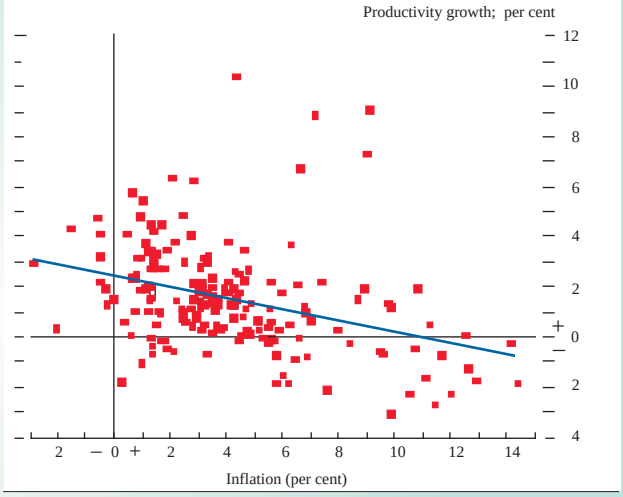
Chart 1
UK inflation and productivity growth



included in each case is drawn to provide a best fit to the data. In the United Kingdom, a one percentage point rise in inflation is associated with a reduction in productivity growth of 0.14 of a percentage point. A similar increase in US inflation is associated with a 0.22 percentage point reduction in productivity growth.

The results for both countries are, however, influenced by the particular conditions during the 1970s, when inflation was very high and productivity growth low. (Data for these years form a group in the bottom right-hand corner

Chart 2
US inflation and productivity growth



of each chart; these observations might be regarded as belonging to a different inflation 'regime'.) In the pre-oil shock period (before 1972), there was no significant correlation between inflation and productivity growth in the United Kingdom—the negative correlation is strongest after 1973.

The effect of adjusting the UK data for cyclical influences—by introducing real output as an additional variable—is to weaken the negative correlation between inflation and productivity growth. The same effect is obtained when adjusting the US data.

possible to avoid many of the problems of short-run trade-offs and policy reactions which arise when using high frequency data. However, statistical tests on the direction of causation cannot be applied to cross-sectional data.

One of the earliest cross-sectional studies was by Kormendi and Meguire (1985). Using data for 47 countries over the 1950–77 period and a wide set of explanatory variables—each averaged over six-year periods—they found that inflation had a significant negative correlation with output growth, apparently because of the negative association between inflation and investment. Their results suggested that one percentage point higher inflation was associated with a half-point reduction in the annual growth rate.

Grier and Tullock (1989) used pooled time series (five-year averages) and cross-sectional data between 1951 and 1980 for 113 countries to assess the impact of a range of variables on real output growth. They found that a single empirical model could not explain differences in growth among these countries and therefore presented different results for different country groups. For OECD countries, they found strong negative correlations between growth and the share of government spending in national income, and between growth and the variability of inflation, but no significant relation between growth and inflation. Elsewhere, the only significant relation between inflation and growth was a negative association in the African countries; and inflation variability had a significant negative relation with growth in the Asian countries.

De Gregorio (1992, 1993) used cross-sectional data for 12 Latin American countries to test the implications of an endogenous growth model in which the level and efficiency of investment are related negatively to the rate of inflation. He found that both inflation and its variance were negatively correlated with growth; the effect appeared to arise mainly because of a reduction in the efficiency of investment. His results suggested that a halving of the inflation rate in these countries between 1950 and 1985—from 34% to 17%—might have increased their annual growth rates by half a percentage point. However, he used only a limited set of

explanatory variables. Peng (1993) offered supporting evidence in a study of three Latin American countries, but found no significant relationship in three Pacific Basin economies. He attributed this difference to the persistence of high inflation in the Latin American countries. Alexander (1994) used a combination of time-series and cross-sectional data for 11 OECD countries, and found a significant negative relationship between growth and both the level and the rate of change of inflation, even having allowed for the growth in capital and labour. A one percentage point reduction in the rate of inflation would, according to these results, be associated with a quarter-point increase in real annual growth.

Fischer (1993) reported a study of the impact of inflation on growth using cross-sectional and panel data for 80 countries. He presented tests for the importance of macroeconomic stability—of which inflation is just one indicator—as a determinant of growth, and found that inflation was significantly negatively correlated with growth and also negatively, but less statistically significantly, related to the rate of capital accumulation and productivity growth. The results suggested that a one percentage point increase in inflation was associated with a decline in annual output growth of 0.04 percentage points. But the effect varied with the level of inflation: it was higher at lower rates of inflation (in the range of 0%–15% inflation, a one percentage point increase in inflation was associated with a reduction in annual output growth of 0.125 points). The negative relationship was obtained using data both before and after 1973, when supply shocks became more important.

Barro and Sala-i-Martin (1994) presented tests based on panel data for almost 100 countries, where the variables were averaged over the periods 1965–75 and 1975–85. They used a number of variables—including schooling, health and life expectancy—to capture the initial stock of physical and human capital in each economy, together with a wide variety of 'environmental' variables, which may be thought of as determining the steady-state level of output per 'effective' worker in a neo-classical growth model. The implication is that the higher this steady state, the more rapid will be a country's rate of growth from a given starting-point. So far as the 'environmental' variables were concerned, they found that higher government consumption as a proportion of national income had a negative impact on the growth rate, as did proxies for the extent of market distortions in an economy, such as the size of the black market premium on foreign exchange and of tariffs imposed on external trade. Similarly, a number of variables designed to pick up the impact of government-induced actions were statistically significant with the expected sign. These included a negative impact of political instability (used as a proxy for the security of property rights) and a positive impact of proxies for the rule of law. In subsequent research, not yet published, Barro has found a significant, negative relation across countries between inflation and growth when a variety of other influences are held constant.

Other recent examples of this approach focus on a variety of similar variables. Knight, Loayza and Villanueva (1993) considered both the openness of a country's trade policies (since the external trade sector can serve as a vehicle for technology transfer, a channel for promoting efficiency and a source of foreign exchange) and the stock of public sector infrastructure (which again could improve the efficiency with which factors of production are used). King and Levine (1993) concentrated on the role of financial institutions in evaluating prospective entrepreneurs and funding the most promising ones, on the assumption that this would lead to a more efficient use of capital and increase the probability of successful innovations. And Easterly (1993) looked at various types of price distortion, such as subsidies on input prices and investment goods, ceilings on nominal interest rates and the black market premium on foreign exchange. Each study found a number of proxies for the relevant variables to have a significant correlation (with the expected sign) with the rate of growth.

The apparent importance of a wide range of other factors (even if the results in relation to them are no more robust than those for inflation variables) makes it more difficult to gauge the significance and magnitude of the impact of inflation on growth. This is particularly so given that many of the other factors are likely to be related to inflation—either causally or because both are influenced by a third factor. But at the broadest level, the available evidence supports the view that well-run and well-governed economies with strong and efficient productive structures tend to exhibit both low inflation and high growth, though it is extremely difficult to identify and estimate the separate influence of inflation.

There are, however, a number of reasons to treat all of these results with some caution. First, some later studies have found that earlier results are sensitive even to fairly small changes in the sample period, the sample of countries used, the definitions of the variables and the specification of the estimated equation.(1)

Second, inflation and growth may be determined endogenously. One response to this possibility is to use an instrumental variable which is sufficiently correlated with inflation to generate reasonable estimation results and which is exogenous. Cukierman *et al* (1993) used a measure of central bank independence as an instrument for inflation, but other research has suggested that central bank independence and inflation may not be well enough correlated to justify this. Barro and Sala-i-Martin (1994) used lagged values of their 'environmental' variables, but admitted that this may be imperfect because their starting-point values may be determined by past growth performance, and because the prospects for growth in the future and the manner in which an economy is managed can become mutually reinforcing.

Even studies that use cross-sectional data could be invalidated if growth and inflation were determined by a

(1) See in particular, Levine and Renelt (1992) and Levine and Zervos (1993).

third variable. Researchers commonly cite supply shocks as a candidate for this, in particular the oil price shock in the early 1970s which lowered growth and raised inflation in most countries.(1) Some attempts have been made to allow for this by including terms of trade changes in the estimated equations(2) but this may not be an adequate proxy for all supply shocks. Fischer (1981b) concluded that 'since the inflation rate is not an exogenous variable to the economy, there is some logical difficulty in discussing the costs of inflation *per se* rather than the costs and benefits of alternative policy choices'.

Such considerations have led a number of commentators to express scepticism about the value of empirical work on inflation and growth (and indeed about tests of the determinants of growth generally). For example, Solow (1994) commented that although various political-economic factors 'might easily affect the growth rate if the growth rate were easily affected I do not find this a confidence-inspiring project. It seems altogether too vulnerable to bias from omitted variables, to reverse causation, and above all to the recurrent suspicion that the experiences of very different national economies are not to be explained as if they represented different points on some well defined surface . . . The introduction of a wide range of explanatory variables has the advantage of offering partial shelter from the bias due to omitted variables. But this protection is paid for. As the range of explanation broadens, it becomes harder and harder to believe in an underlying structural, reversible relation . . .'.

However, this scepticism may itself be overdone. Despite a number of shortcomings, the available evidence provides support for a negative relationship between inflation and growth, consistent with the predictions of the theoretical literature. But it would be still more convincing if a structured, micro-level testing of the hypotheses generated by the economic theory of the costs of inflation could be undertaken—and if this confirmed the negative relationship between inflation and growth.

Costs of disinflation

There are likely to be costs, in lost output and employment, attached to reducing the rate of inflation. For example, there are many different kinds of nominal rigidity—especially in the labour market, but also in debt contracts—which imply that it takes time for economic agents to adjust their behaviour if inflation is at an unexpected rate.(3) Unless economic agents anticipate inflation reductions—and have time to adjust their contracts accordingly—disinflation will lead to lost output and employment, at least over the short term. And it has been argued that such costs may persist over the medium term—if not necessarily permanently—particularly in the labour market.(4) Thus even though the efficiency gains from moving to an optimal rate of inflation will be permanent, whereas any costs of doing so will be temporary, the costs could still outweigh the benefits, depending on the rate of discount to be applied to the benefits. Theoretically, it might be better to accept a permanent modest rate of inflation than to pay the costs of reducing inflation to an even lower rate, although Okun (1971) doubted whether inflation could be held permanently at a modest level, describing this as the 'mirage' of steady inflation.

It is also important to consider the pace of adjustment, particularly because the costs of disinflation may be related to its speed. In some models of disinflation, the optimal approach is to reduce inflation slowly, because a sharp reduction may generate greater uncertainty—which is costly.(5) However, this result depends on assumptions about the information available to economic agents and the manner in which they form their expectations about inflation. And gradualism may not be an appropriate response to very high inflation, because the costs of a sharp reduction may be lower than those of continuing high inflation.

The costs of reducing inflation are no easier to calculate than the benefits of lower inflation. Indeed, the cost of reducing inflation by a percentage point may not remain constant as the rate of inflation falls towards zero. It may be, for example, that the credibility gained through achieving low inflation in the past (or through central bank independence) reduces the costs of subsequent policies designed to reduce inflation. Sargent (1982, 1983) suggested that since contracts denominated in nominal terms will be adjusted more promptly and more fully if the authorities announce a credible policy of disinflation, then such an announcement could reduce the rate of inflation with little cost in terms of output or employment. And Chadha, Masson and Meredith (1992) argued—on the basis of both theoretical considerations and a multicountry model developed by the IMF—that the output costs of a disinflationary policy will be smaller: if the policy is announced in advance and is phased in gradually; the more credible is the policy; and the greater are the importance of expected future inflation in determining current wage and price setting, and the responsiveness of wages and prices to demand conditions.

But others have suggested that the cost of reducing inflation is likely to be higher at lower rates of inflation. For example, as discussed earlier, Lucas (1973) argued that since inflation variability is likely to be lower at low rates of inflation, movements in prices are more likely to be regarded as relative price movements than as changes in the general price level. This may lead to larger adjustments in output and employment as individual firms respond to the price changes which they observe. Thus the short-run Phillips curve may be flatter at lower and less variable rates of inflation. Alternatively, Gray (1978) presented a model in

(1) Easterly *et al* (1993) present results which suggest that shocks, in particular terms of trade shocks, explain statistically as much of the variance in growth rates over ten-year periods as do country characteristics and policies.
(2) For example, Fischer (1993).
(3) The vast literature on this subject is surveyed by Blanchard (1990), Dixon and Rankin (1994) and Romer (1993).
(4) As discussed and assessed in Blanchard and Summers (1986) and Fortin (1993).
(5) As argued in Balvers and Cosimano (1994).

which lower and less variable inflation increased the optimal length of contracts and reduced the optimal degree of indexation. This in turn increased the extent of nominal wage rigidity and thereby increased the impact of nominal shocks on output and employment.

In Ball, Mankiw and Romer's (1988) menu-cost model, lower inflation leads to less frequent price changes for a given level of adjustment costs, so lessening the responsiveness of prices to nominal shocks, again leading to higher short-run output and employment costs. Finally, building on these earlier models, Walsh (1994) argued that greater central bank independence could increase the costs of disinflation, not only by creating lower and less variable inflation but also by reducing expectations of nominal shocks. The degree of central bank independence might reduce the cost of lowering inflation through Sargent's 'credibility bonus', but this might be more than offset by its impact on nominal rigidities.

The empirical evidence suggests that there is indeed a significant and negative correlation between the average level of inflation and the short-term output: inflation trade-off, although it is not possible to identify the cause of this correlation. The seminal results are those of Ball, Mankiw and Romer (1988), who found a strikingly large negative correlation.(1) Ball (1993) found that the negative correlation was lower when wage-setting was more flexible, and Walsh (1994) reported results (albeit based on a small sample of eight European countries) which suggested that the magnitude of the short-term output:inflation trade-off is related negatively to the rate of inflation and positively to the degree of central bank independence. Using data on 17 OECD countries, Posen (1994) also found that the costs of disinflation were positively related to the degree of central bank independence, but there did not appear to be any significant relationship between central bank independence and nominal wage rigidity.

On the optimal speed of disinflation, Ball (1993) found that the short-run costs of reducing inflation were inversely related to the speed of adjustment: a short, sharp shock was the best approach to reducing inflation. However, the results of Walsh (1994) could be interpreted as suggesting the opposite, at least if more independent central banks tend to introduce more rapid disinflations. And Yates and Chapple (1994) found it difficult to establish any clear relationship between the speed and the costs of disinflation. An important consideration for the authorities is that too blunt an effort to reduce inflation could undermine public support for price stability and therefore prove self-defeating.

Finally, the authorities may be able to influence the costs of reducing inflation, for example by establishing greater credibility, or by removing the micro-level rigidities which make the process of wage and price formation unresponsive to deflationary pressures. Even if the extent of nominal rigidities is itself a function of the inflationary regime, it may also be responsive to supply-side initiatives introduced by the authorities.

Conclusions

Economic theory suggests that inflation imposes costs on the economy through a variety of channels. And although the empirical evidence cannot be regarded as conclusive, it is broadly consistent with the theoretical results. This implies that there are advantages in achieving and maintaining price stability, even if these are difficult to quantify precisely.

(1) Cozier and Wilkinson (1990) found no such evidence for Canada, but Yates and Chapple (1994) found the negative correlation to be remarkably robust to changes in functional form, sample size and sample periods. However, although the sign and statistical significance of the negative correlation were robust, the magnitude of the coefficients on average inflation varied considerably across different specifications.

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