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On the Believable Benefits of Low Inflation

by
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Acknowledgements

Abstract

This paper reviews the existing theoretical and empirical literature addressing the benefits of low inflation. The ultimate goal is to arrive at a set of benefits in which a monetary authority can have genuine confidence. I argue that the current state of economic research—both empirical and theoretical—provides little basis for believing in significant *observable* benefits of low inflation such as an increase in the growth rate of real GDP. Moreover, what observable benefits do exist are unlikely to justify a policy of disinflation, even if the transitional costs of disinflation are quite moderate. I conclude that defending a policy of moderate disinflation requires more attention to be paid to the benefits of low inflation that are *unobservable* in familiar aggregate data. This naturally poses some policy challenges to central banks contemplating a disinflation.

Résumé

L'auteur fait un survol des travaux théoriques et empiriques consacrés aux avantages d'un bas niveau d'inflation. L'objectif ultime de ces travaux est d'établir l'existence d'avantages dans lesquels les autorités monétaires puissent avoir pleinement confiance. Selon l'auteur, l'état actuel des recherches — tant empiriques que théoriques — ne permet pas de conclure qu'un bas niveau d'inflation présente d'importants avantages *observables*, comme une hausse du taux de croissance du PIB en termes réels. En outre, les avantages que l'on observe effectivement ne semblent pas suffisants pour justifier une politique de désinflation, même si les coûts d'une telle politique durant la période de transition se révèlent peu élevés. L'auteur conclut que, pour parvenir à justifier une politique de désinflation modérée, il faut se pencher de plus près sur les avantages qui *ne sont pas observables* dans les données globales les plus couramment utilisées, ce qui pose bien sûr plusieurs défis aux banques centrales qui envisagent d'adopter une politique de cette nature.

1.   Introduction

The costs associated with reducing inflation are widely known and have received much attention in the academic literature. There is widespread agreement among professional economists that the deliberate reduction of inflation generates costs in the form of reduced output, increased unemployment, and a higher incidence of bankruptcy. These costs are also known, in general terms, to members of the public through their exposure to the media (which is often well informed about economic events) or perhaps from some mostly long-forgotten training in an introductory economics class. They may not possess a well-articulated model of the economy or have a tight grasp of the precise mechanism linking monetary policy to events in the real economy. But they have some experience with unemployment, high real interest rates, and bankruptcies.

The benefits of a low-inflation environment are much less obvious. Though there is a consensus among economists and the general public that low inflation is desirable, there is no consensus about *why* this is so. Non-economists typically argue—and in so doing appear to suffer from money illusion—that inflation is undesirable because it represents a reduction in their real purchasing power. Economists use different arguments in stating their case against inflation. Some emphasize the benefits of low inflation that are, at least in principle, observable in conventional macroeconomic data, such as a higher level or growth rate of real output. Others stress the benefits of low inflation that are unobservable but nonetheless real, such as an increase in the efficiency of the price system.

There is broader agreement that the benefits of low inflation are more dispersed across the economy than are the costs of disinflation. This naturally makes the policy of reducing moderate inflation—for example, a reduction of inflation from 8 per cent to 2 per cent—a difficult policy to defend in public debate. The costs of disinflation are sharp and obvious; the benefits are diffuse and subtle. This dilemma, of course, is not unique to the conduct of monetary policy; policies that involve "short-term pain for long-term gain" are usually difficult to push through the political system.

This paper examines the existing theoretical and empirical literature on the possible benefits of low inflation. The ultimate goal is to arrive at a set of benefits in which a central bank can have genuine confidence, rather than simply hopeful optimism. In practical terms, this means a set of benefits that central banks can defend in (well-informed) public debate.

The emphasis on benefits of low inflation that can survive public debate recognizes the fact that in most countries support for central bank policies comes ultimately from the electorate. Even in those countries where the day-to-day management of monetary policy is conducted independently by the central bank, the electorate—via the current body of elected

representatives—stands as the ultimate judge of central bank behaviour. It is therefore important for the central bank to be able to defend its actions to the public.

The only benefits to be considered in such a political exercise ought to be *believable* ones; it is thus worthwhile stating how I use the concept of believability in this paper. I consider a potential benefit of low inflation to be believable if it satisfies at least one of two *sufficient* conditions. First, a particular benefit is believable if it has at its basis some solid theoretical reasoning. It is not sufficient that this reasoning be merely logical; it must also be sensible in the context of modern moderate-inflation economies, such as those in the United Kingdom, Canada, or the United States in recent years. Furthermore, such a theoretical basis is sufficient for believing in a benefit even in the absence of any empirical evidence that such a benefit exists. This condition simply recognizes the difficulty in detecting convincing causal relationships in empirical macroeconomics.

Second, a particular benefit of low inflation is believable if there is robust empirical evidence of its presence, even if there is currently no solid theoretical understanding for the phenomenon in question. By robust, I mean that the evidence must be relatively insensitive to changes in sample periods, frequency of data, or in the sets of conditioning information— assuming throughout, of course, that only valid statistical methods are employed. This condition recognizes that there are many facts for which we lack adequate theoretical explanations, and it would be inappropriate to ignore the presence of robust empirical relationships simply for lack of theory.

In defining what I mean by believability, it is obvious that some judgment is necessary, in assessing both how "sensible" the theory is and how "valid" the statistical methods. However, for the task at hand—assessing the policy relevance of the literature on the benefits of low inflation— the use of such judgment is unavoidable. Just how carefully this judgment is applied will become clear as the paper proceeds and will obviously be left to the reader to evaluate.

It is also necessary to be clear about some issues that this paper does *not* address. Two issues deserve mention. First, this paper does not discuss the benefits of reducing inflation from very high levels (such as 100 per cent or more) down to moderate levels. The relevant policy question for most industrialized countries in recent years concerns the benefits from reducing inflation from "moderate" levels (such as 8 or 10 per cent per year) to "low" levels (such as 2 or 3 per cent per year). It is well known that the role of money changes dramatically in high-inflation economies and the effects of demonetization are often severe. But these problems have not been relevant in the industrialized economies over the past two decades; since 1980, the relevant issue has been the benefits of disinflation from only moderate levels.

Second, this paper does not address short-run or transitional costs associated with reducing inflation from moderate to low levels, focusing only on the long-run benefits of low inflation. This does not reflect a belief that the short-run costs are unimportant; quite the contrary. I take this

approach only because it helps to sharpen the focus of the paper. This paper therefore addresses only half of the overall cost-benefit analysis that presumably accompanies any central-bank decision to disinflate. One thing I conclude, however, is that a thorough taxonomy of the benefits of low inflation helps considerably when thinking about such a cost-benefit analysis.

The paper is organized as follows. Section 2 examines the familiar literature relating to inflation and the demand for real cash balances. Section 3 addresses the potentially most significant observable benefits of low inflation—the effect on the economy's growth rate of real output. The discussion begins by examining some of the theoretical links between inflation and economic growth. I then examine the evidence for such a relationship in the data. Section 4 looks at the interaction of inflation and an imperfectly indexed income-tax system, an issue that has received increasing attention in recent years. Section 5 examines the unobservable benefits of low inflation—benefits not directly observable in the type of aggregate data that macroeconomists typically examine. I discuss the likely relationship between inflation and allocative efficiency, as well as the direct effect of inflation on individuals' welfare as inflation destroys the use of currency as a stable unit of account.

Section 6 contains a summary of benefits of low inflation in which central banks in moderate-inflation countries can sensibly believe. Section 7 argues that, if central banks were prepared to emphasize only the observable benefits of low inflation, a disinflation from moderate levels would rarely be a defensible policy. I thus conclude that the *unobservable* benefits of low inflation are central to defending the case for disinflation. This clearly makes disinflation a "tougher sell" since the unobservable benefits, by definition, are less tangible and thus harder to explain to members of the public. This dilemma naturally leads to two policy challenges, both of which ought to be taken up by any central bank contemplating a policy of moderate disinflation.

2.   Inflation and real cash balances

The classic starting point for examining the benefits of low inflation has been the public finance view of inflation as a tax on real balances, dating back to Bailey (1956). This same approach formed the basis for Friedman's (1969) famous argument that the optimal rate of inflation is such that the nominal interest rate is driven to zero.

The basic approach is well known and does not merit a detailed explanation here. It is sufficient to say that a reduction in inflation, by lowering nominal interest rates, reduces the opportunity cost of holding real balances. This, in turn, increases the amount of real balances held and thus confers benefits to money holders in the form of additional consumer surplus. Following Bailey (1956), the size of this benefit can be estimated by the size of the triangle under the money demand curve. Note that a permanent reduction in inflation generates this benefit as an ongoing flow; even a small annual benefit may therefore represent substantial gains in a present-value sense.

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Using Bailey's approach, the annual benefit (expressed as a fraction of GDP) from reducing inflation from some positive rate to Friedman's optimal value can be approximated by

$$\text{disinflation benefits } = \frac{\eta \cdot \Pi^2}{2v}$$

where η is the interest semi-elasticity of money demand, v is the velocity of money, and Π is the initial inflation rate.

It is worth emphasizing that the Bailey approach is a partial-equilibrium one and thus is only a comprehensive measure of the benefits of disinflation under some fairly restrictive assumptions. First, money must be super-neutral, so that the reduction in inflation has no effect on real output or the real interest rate. In this case, the Fisher effect holds exactly so that nominal interest rates fall one-for-one with inflation. Any non-super-neutralities imply that (a) the observed change in inflation differs from the change in the nominal interest rate (and it is the change in the nominal interest rate that matters); (b) the money demand curve is not stable; or (c) both conditions apply. Second, since the reduction in inflation (with inelastic money demand) implies a reduction in seigniorage revenues for the government, it must be the case that the government has access to non-distorting taxes to make up the revenue shortfall. The reduction in inflation would otherwise be accompanied by increases in distortionary taxes, and the resulting excess burden would then offset the direct welfare benefits of the increase in real balances. A third assumption is that "money" in this analysis must be non-interest-bearing money. As the definition of money changes, so too does the appropriate measure of velocity, and thus the estimate of the benefits of disinflation.

Fischer (1981a) estimates the benefits of disinflation for the United States by assuming super-neutrality and non-distortionary taxes, and by using the monetary base as the definition of money. He assumes that η (for base money) is 0.25 and finds that the benefits of reducing inflation from 10 per cent to zero amount to 0.3 per cent of GDP. Fischer's estimate is well within the ballpark of most other estimates. Lucas (1981) arrives at a similar estimate. The more recent estimate by Carlstrom and Gavin (1993) is also of this approximate size. Lucas (1994) uses the same general approach but emphasizes that, when using a log-log specification for money demand—which appears to fit the U.S. data more closely than the semi-log specification—the reduction of nominal interest rates from 3 per cent to zero increases the benefits disproportionately. Even then, however, he estimates the benefits of a 10 percentage point disinflation to be only about 1 per cent of GDP.[1]

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1. Note that Lucas (1994) is examining a more dramatic policy experiment than Fischer (1981a). Fischer contemplates inflation falling from 10 per cent to zero whereas Lucas imagines nominal interest rates falling from 3 per cent to zero and thus has *inflation* falling to Friedman's optimal level of perhaps -3 per cent. It is only when inflation becomes negative that Lucas' results begin to differ significantly from the existing literature.

There are two reasons why Fischer's estimate may be a significant overestimate of the actual benefits from a 10-point disinflation. First, some of the monetary base is in the form of commercial-bank reserves. But there is no reason why such reserves could not earn interest; and if they did, they would no longer be included in the appropriate definition of money for the Bailey thought experiment. As Fischer points out, it is purely an institutional convention that explains why bank reserves do not earn interest. And since this convention is (in principle) avoidable, it is not clear that the avoidance of the inflation tax on commercial-bank reserves should be considered a genuine benefit of reducing inflation. As an indication of how much this matters, note that commercial-bank reserves are currently about 10 per cent of total currency in circulation. Following Fischer's logic, therefore, such a correction would reduce the size of the benefits by about 10 per cent.

More important, since the U.S. dollar is actively used outside the United States, both as a reserve currency and as a medium of exchange in dollarized economies, Fischer's estimate of 0.3 per cent of GDP overstates the benefits *to the United States* from the proposed 10-point disinflation. In the case of other industrialized countries, whose currencies are much less widely held as reserve currencies, Fischer's experiment would yield a much smaller estimate of the benefits of disinflation.

This point is supported by Howitt's (1990) estimate of the benefits for a Canadian disinflation. Using the same approach, Howitt estimates a benefit of only 0.1 per cent of GDP from a 9-point reduction in inflation. It is worth noting that Howitt obtains a considerably smaller estimate of the benefits of disinflation despite his assumption of a much larger interest elasticity, 0.73 rather than 0.25. His estimate is also based on M1 rather than the monetary base, and since M1 is almost three times larger than the monetary base ($82 billion as compared to $30 billion in early 1998), his estimate of the benefits based on the monetary base would be more than cut in half, to roughly 0.04 per cent of GDP.

What should be concluded from these estimated benefits from low inflation? As Lucas (1994) argues, the small number of hours that each of a large number of individuals in an inflationary environment spends on managing cash balances are "simply thrown away, wasted on a task that should not have to be performed at all." In his view, even 0.1 per cent of GDP per year gained from a 10-point reduction in inflation is considerable. Apparently in contrast, Summers (1991) argues that Bailey's optimal-tax approach "has little or nothing to do with sensible inflation policy," adding further that "the magnitude of this deadweight loss is small relative to any other consequence of monetary policy."

Despite the apparent contradiction, both Lucas and Summers are probably right. Lucas is surely correct that, if a 10-point reduction in inflation brings about a permanent annual flow of benefits of even 0.1 per cent of GDP, these benefits should not be disregarded. They should certainly not be ignored in the politically charged cost-benefit analysis that accompanies the

decision to engineer such a disinflation. But Summers is also correct that, if the *only* benefits of low inflation were the reduction in the tax on real balances, there could never be a sensible case made for a disinflation of any size; the transitional costs of the disinflation would surely exceed even the present value of the permanent stream of benefits. For the serious benefits of low inflation, we need to look elsewhere.

3.   Inflation and real output growth

Considerable recent effort has been devoted to establishing the nature of the link between inflation and economic growth. Such a link offers the largest potential benefits from low inflation. Even if lower inflation has only a small positive effect on the annual growth rate of real GDP, the present value of such gains may be very significant when considered over a long horizon.

This section contains two main discussions. The first examines the theoretical link between inflation and growth. Permanent effects of inflation on the growth rate of real output require a model in which growth is endogenous; the neoclassical growth model with an exogenous growth rate cannot sensibly be used to address this issue.[2] The second main discussion examines the empirical evidence between inflation and growth. I review two different approaches to the issue— the single-country time-series approach and the multi-country cross-section approach.

3.1   Inflation and growth in theory

Recent research on the determinants of economic growth has focused on models in which the steady state is characterized by a non-zero growth rate of per capita output and in which this growth rate is endogenous. This literature can probably be dated from Romer (1986) and has grown substantially in the past decade; see Barro and Sala-i-Martin (1995) and Aghion and Howitt (1998) for general reviews of the issues and modelling approaches. The focus in this paper is on how this literature generates a link between inflation and the growth rate of real output.

In order to model the relationship between inflation and economic growth theoretically, the model must satisfy two characteristics. First, the growth rate must be endogenous to the model. Second, money must have some purpose in the model, so that a change in the sustained rate of inflation—ultimately caused by changes in the growth rate of money—can operate through some mechanism to affect real variables in the model.

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2.   The neoclassical growth model, however, does allow the possibility that inflation affects the economy's *level* of steady-state output through the Tobin (1965) effect. For the sake of brevity, this paper does not address the relationship between inflation and the level of output. Note, however, that many of the problems that plague the inflation-growth literature are also present in the literature examining the effects of inflation on the level of output. See, for example, Dornbusch and Frenkel (1973) and Stockman (1981) for discussions of the theoretical ambiguities, and Cozier and Selody (1992), Rudebusch and Wilcox (1994), Sbordone and Kuttner (1994), and Bullard and Keating (1995) for some indication of the fragility of the empirical results.

3.1.1 Mechanisms for endogenous growth

There have been several approaches to building models in which the growth rate of real output is endogenous. These approaches share the feature that the marginal product of capital is somehow bounded away from zero as capital continues to accumulate. This ensures that the law of diminishing returns does not eventually lead to a steady state in which the capital stock (or the per capita capital stock) is constant, as is the case in the neoclassical growth model. In endogenous-growth models, some element of the model ensures that the marginal product of capital remains "high" so that investment continues indefinitely. In steady state, real per capita output grows at a rate different from zero.

One broad finding from this endogenous-growth literature is that, despite the several approaches at achieving endogenous growth—such as constant returns to physical capital (the "Ak" model), human-capital accumulation (Lucas 1988), or positive externalities from the process of capital accumulation (Romer 1986)—the broad conclusions appear to be similar. There are differences in details, but the various approaches are simply different ways of keeping the marginal product of capital bounded away from zero so that the growth rate of per capita output exceeds zero in the steady state. Any exogenous event that changes the returns to either physical or human-capital accumulation will potentially affect the steady-state growth rate.

3.1.2 Money in endogenous-growth models

Given this broad similarity in the structure of the various endogenous-growth models, our focus can turn to the role of money in these models. In this respect, the literature offers even less variation than in the models' underlying structures. As noted by Chari, Jones, and Manuelli (1995), most endogenous-growth models that address the issue of inflation do so by incorporating either a cash-in-advance (CIA) constraint, as in Gomme (1993), or a more general transactions-cost (TC) function, as in Black, Macklem, and Poloz (1994).

In either case, the CIA constraint or the TC function plays a central role in creating a transactions demand for real balances. A CIA constraint simply requires individuals to hold real balances in an amount no less than the value of their intended real consumption. That is, consumption is financed by previous money holding. In the case of a TC function, the individual requires real resources to make transactions, and the real value of this resource cost declines in the real value of the individual's money holdings.

In an endogenous-growth model containing either a CIA constraint or a TC function, the basic linkage between inflation and economic growth is as follows. Individuals derive utility from consumption but they hold money in order to purchase consumption goods.[3] Moreover,

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3.   In some models, such as DeGregorio (1993), this also applies to firms.

individuals hold money from period t to period $t+1$ in order to purchase goods dated $t+1$. Individuals therefore hold money across time, and since cash balances do not earn interest, inflation increases the cost of holding such money. Since money must be held in order to buy consumption goods, however, an increase in inflation is tantamount to a tax on consumption. Furthermore, since all income is ultimately for consumption purposes, it follows that higher inflation lowers the after-tax real return from investments in either physical or human capital. An exogenous increase in inflation therefore lowers the flow of investment in either type of capital and thus lowers the economy's steady-state growth rate.

The relationship between inflation and growth in endogenous-growth models relies on the strength of this particular linkage. The empirical significance of this linkage is questionable, however, especially in modern moderate-inflation countries. There are two reasons. One involves the changing nature of financial transactions and what this implies about the costs associated with holding money. The second involves the necessary elasticities of behavioural variables (such as work effort or human-capital accumulation) to changes in income and/or relative prices.

Costs of Holding Money. Note that inflation reduces growth in these models by increasing the cost of holding money. This cost, in turn, is only present because people are constrained to hold money over time in order to finance their consumption. In the modern era of electronic banking, however, these costs are unlikely to be significant.[4] If inflation were high *and* people held currency over significant intervals of time, there might then be an empirically meaningful link between inflation and the cost of money holding. But the discussion in this paper is about the benefits of low inflation relative to moderate inflation, not to very high inflation. Moreover, the cost of withdrawing and transferring money is now so low that individuals can make their desired transactions while holding only small amounts of money for very short periods of time. It is unlikely that people hold enough money for long enough periods of time to make the tax from moderate inflation even noticeable, not to mention significant.

This point is demonstrated in Cooley and Hansen (1989), albeit in a slightly different setting. They show in a standard real-business-cycle model with a CIA constraint that when individuals are constrained to hold money for three months, the welfare cost of a 10 per cent inflation is 0.4 per cent of GDP. With a holding period of one month, the welfare cost falls to 0.1 per cent of GDP. But one month is still a significant overestimate of the average money-holding period in a modern industrialized economy.

Elasticities. In endogenous-growth models with CIA constraints or TC functions, the inflation-generated cost of money holding acts as a tax, and individuals respond to this higher tax by reducing work effort, reducing the accumulation of physical capital, or reducing the acquisition of human capital. In order for this to be an empirically meaningful mechanism for

4. By electronic banking, I mean nothing more than the use of ATM machines and bank card purchases that permit people to withdraw or transfer cash very easily and at low (or zero) cost.

decreasing the economy's growth rate, the tax increase and the response to it must both be significant. I have argued that the inflation tax itself is likely to be very small in a modern moderate-inflation economy. If this is indeed the case, the inflation-growth link then relies on the presence of very substantial elasticities for work effort or capital accumulation. There is little reason, however, to think that these elasticities are so large, especially the elasticity of work effort. The empirical labour literature certainly suggests very low wage elasticities for labour supply—see, for example, the exhaustive surveys by Killingsworth and Heckman (1986) and Pencavel (1986). And though casual evidence confirms that university enrolments are indeed sensitive to employment prospects, it is doubtful that the acquisition of human capital would respond significantly if at all to the very small costs that moderate inflation presents as a tax on cash balances.

There is one final point about investment and the inflation tax that should be noted. In endogenous-growth models, there is typically no distinction between firms and individuals; the representative agents in such models are both consumers and producers. But in practice, of course, it is firms—not individual consumers—that carry out the vast majority of investment in plant, equipment, and other physical capital. This distinction matters, because the mechanism that links inflation and growth in these models relies on the inflation tax on real balances, real balances that are typically *not* held to a significant extent by firms. Firms with significant cash flow have strong incentives to economize on their cash balances, holding their short-term assets in the form of treasury bills and other short-term (interest-earning) securities. Thus, the inflation tax on firms' cash balances is a very unlikely mechanism through which inflation might reduce investment and economic growth. This is not to argue, however, that inflation has no effect on investment; as we will see in Section 4, there is a very plausible linkage from inflation to growth provided by the income-tax system.

3.1.3 Assessment

The focus of this paper is on the benefits of reducing inflation from *moderate* levels. However, the linkage between inflation and economic growth in the current generation of endogenous-growth models, despite its logical coherence, offers an implausible channel through which disinflation from moderate levels can influence the rate of growth of real output. The combination of moderate inflation, very short holding periods for money, and low elasticities of work effort suggest that this linkage from inflation to economic growth is likely to be very weak.

With this in mind, the simulation results in Chari, Jones, and Manuelli (1995) are hardly surprising. They show in a broad class of endogenous-growth models—each calibrated with moderate elasticities and individuals assumed to hold money for six weeks—that the *maximum* effect of a 10 percentage point decrease in the inflation rate is for the growth rate of real output to rise by 0.027 percentage points. Even this small effect should probably be viewed as an upper

bound; with smaller elasticities and a more realistic holding period for money, the effect on growth would be even smaller.

3.2   Inflation and growth in the data

The empirical literature examining the relationship between inflation and economic growth has taken two paths. One focuses on the time-series relationship between inflation and growth within a country. This literature probably dates from Jarrett and Selody (1982). More recently, and largely due to the rebirth of growth theory in the past decade, a second approach has evolved that examines data from a large cross-section of countries. Kormendi and Meguire (1985) are an early example; Fischer (1993) and Barro (1996a; 1996b) are more recent ones.

3.2.1 *The time-series approach*

Jarrett and Selody (1982) examine the link between inflation and (labour) productivity growth in Canada using quarterly data for the years 1963 to 1979. Their study places less emphasis on what the structural relationship between these two variables might be and instead focuses on the time-series link in a reduced-form econometric model. In both their bivariate and trivariate specifications (in the latter they include the growth of hours), they find evidence of a strong two-directional relationship between inflation and productivity growth. Specifically, they find that a permanent reduction in inflation by 1 percentage point increases the annual growth rate of labour productivity by 0.23 percentage points. Their concluding sentence captures the full extent of their interpretation: "The increased inflation rates of the 1970s are sufficient to explain virtually the entire recent slowdown in productivity growth" (p. 367).

Novin (1991) extends the sample to the end of 1988 and repeats the exercise, albeit with some changes in the details of the approach. On the basis of finding a cointegrating relationship between inflation and growth, he finds roughly the same result: a permanent reduction in inflation by 1 percentage point increases the annual growth rate of (total factor) productivity by 0.3 percentage points.

There are reasons to be sceptical about these results. First, the suggested causal effect of inflation on productivity growth is so large as to be literally incredible. In a world where 2.5 per cent is perhaps a generous estimate of the long-run average annual growth rate of productivity, it is difficult to believe that a 1 percentage point reduction in inflation could possibly raise the growth rate by 0.25 points. This is especially clear when we consider, for example, the Canadian disinflation from 1990 to 1996, from a reasonably steady 5 per cent to a reasonably steady 2 per cent. Is there a believable mechanism at work that could convert this 3-point disinflation into a permanent increase in the productivity growth rate of three-quarters of a percentage point?

It is too easy, of course, to dismiss the results simply because they do not accord with one's prior beliefs. Some greater precision is required if serious doubt is to be cast on these results. There are three relevant points.

Robustness. Cameron, Hum, and Simpson (1996) argue that the Jarrett and Selody results are not robust. Using data from the past four decades for the United Kingdom, United States, Germany, and Canada, they argue that the inflation-growth relationship observed by Jarrett and Selody (which they replicate for each of the countries) is a spurious correlation. In particular, they show that, for the countries and sample periods chosen, both inflation and productivity growth are non-stationary but are integrated of different orders. Such a difference indicates that inflation and productivity growth *cannot* be cointegrated, thus casting doubt on the strong interpretations provided by Jarrett and Selody (1982) and Novin (1991).

Cointegration versus structure. The work by Cameron, Hum, and Simpson (1996) points to the potential fragility of any observed inflation-growth relationship. But it seems to miss a more fundamental point. The bivariate (or sometimes trivariate) approaches of Jarrett and Selody (1982) and Novin (1991) are based on the detection of a cointegrating relationship between inflation and productivity growth. As is often the case with time-series studies, however, there is no economic structure included in the analysis. For example, there are no controls for variables that might reasonably be viewed as influencing growth in the long run, such as levels of human capital, past rates of investment in plant and equipment, or expenditures on research and development.

In the absence of such structure, a sensible interpretation of the results is very difficult. Does an observed long-run relationship between inflation and growth indicate causality? Or are the actual determinants of growth some omitted variables that, over the sample period examined, have combined their distinct effects in such a way to create the illusion of a stable inflation-growth relationship? The implicit assumption in these studies is that inflation is viewed as the *only* variable that affects long-run productivity growth. Given this assumption, the authors are simply uncovering the size of the effect. But it is the assumption itself that is problematic.

Cyclical versus long-run relationship. The lack of structure in time-series studies manifests itself in many ways. One difficulty in interpreting the time-series results is that it is not clear to what extent the observed relationship between inflation and productivity growth is simply reflecting a "natural" relationship between the two variables over the course of the business cycle. Sbordone and Kuttner (1994), in their response to the finding by Rudebusch and Wilcox (1994) of a significantly negative relationship between inflation and productivity growth in the United States, make this point. Sbordone and Kuttner argue that it would be natural to expect a negative relationship between inflation and productivity growth at cyclical frequencies if firms hoard labour in response to short-run reductions in demand and if monetary policy affects output faster than inflation. The story is straightforward. Suppose that the monetary authority detects pressures

in the economy that will soon push up inflation. In response, monetary policy is tightened and output (or its growth rate) is reduced. But as firms initially hoard their labour, measured productivity falls, just as inflation begins to rise. This behaviour generates a negative relationship between inflation and productivity growth over the cycle, even though there may be no long-run relationship whatsoever.

This concern leads Fortin (1993) to estimate a time-series regression of productivity growth on inflation, using annual Canadian data from 1964 to 1991. In his first specification, he finds a negative coefficient on lagged inflation, suggestive of a relationship comparable to that found by Jarrett and Selody (1982). When he includes the capacity utilization rate as an additional regressor, however, the coefficient on inflation falls sharply in magnitude and it is not possible to reject the hypothesis (at standard levels of significance) that the coefficient is zero. Selody (1990) has done a similar correction and finds that, despite a smaller effect of inflation on productivity growth, the effect does seem to be significantly different from zero. The contrast between Fortin's and Selody's results reveals, once again, the fragility of the empirical findings in this literature.

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The foregoing discussion suggests that the single-country time-series approach to uncovering the link between inflation and growth faces two very serious challenges. The first is to incorporate more structure into the analysis rather than to examine time-series relationships between two or three (endogenous) variables. Even if a robust cointegrating relationship were found to exist between inflation and growth, this information would not contribute significantly to policy-makers' understanding of the benefits of low inflation. Without knowing the nature of the causal relationship, the mere knowledge that inflation and growth happened to move together in the past in no way indicates what the effects of future disinflation are likely to be.

The second challenge faced by the time-series approach is to separate the long-run inflation-growth relationship from the much noisier short-run relationship. The relevant policy issue (in this paper) is the long-run relationship. As discussed above, however, it is easy to imagine an economy that generates a negative short-run relationship between inflation and growth even when there is no long-run relationship. One option, as taken by Fortin (1993) and Selody (1990), is to introduce more structure into the estimation equation in an attempt to control for some of the short-run business-cycle phenomena. Another option is to avoid the use of quarterly or annual data and, instead, to use only longer-period averages. In this way, there is some reasonable hope that whatever relationship is observed between inflation and growth will not be the result of business-cycle dynamics. The obvious problem with this option, which probably explains why it has not been used, is that the use of five- or ten-year averages drastically reduces the number of usable observations, thus making the single-country time-series approach unworkable. This naturally takes us to the multi-country cross-section approach.

3.2.2 The multi-country cross-section approach

The underlying logic of using data from many countries over many years is that inflation is a sufficiently universal phenomenon that, if there is indeed a causal link from inflation to growth, we should be able to detect it when examining a sufficiently broad collection of countries. This enables us to take advantage of the considerable cross-sectional variation in inflation experiences, ranging from Japan and Germany to Israel and Turkey. The challenge, of course, is to account suitably for all the non-monetary aspects that vary across countries and also influence economic growth.

An important advantage of this approach is that it lends itself well to asking the question of the *long-run* effect of inflation on growth while avoiding the complications arising from business-cycle dynamics. As long as the sample of countries is large enough, we are able to consider long-period averages of inflation and growth within each country without encountering problems caused by small samples. We can then be fairly confident that any observed inflation-growth relationship is not the result of things such as labour hoarding and the timing of monetary policy.

There has actually been a subtle change in this multi-country cross-section approach over the past decade. Beginning with Kormendi and Meguire (1985), the approach was to assemble data on many countries and many years, but to base a pure cross-section regression on country averages of all relevant variables.[5] Mankiw, Romer, and Weil (1992) and Cozier and Selody (1992) also use a pure cross-section approach in their extensions of the Solow growth model. Though this method is very effective at avoiding the business-cycle issues, one clear disadvantage is that *all* time-series variation within any particular country is sacrificed. As Bruno and Easterly (1996; 1998) argue, however, some of this time-series variation is crucial. For example, consider two countries with the same average annual rate of inflation over a 30-year sample period. One has moderate and stable inflation; the other has low inflation followed by an inflation "crisis" followed by a return to low inflation. It is probably unreasonable to expect the same effect of inflation on growth in these two countries.

Reflecting the importance of examining both time-series and cross-section variation, some recent research considers a large sample of countries but retains some of the time-series variation within each country. Barro (1996a; 1996b) is perhaps the most important example. In what follows, I focus on Barro's work but it should be kept in mind that Barro's results are broadly consistent with those of other researchers, including those that focus purely on cross-sectional variation between countries.

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5. Kormendi and Meguire (1985) actually examine the relationship between output growth and the *change* in inflation. Their results would therefore appear to be more relevant to the discussion of the effect of inflation on the *level* of output, rather than on its growth rate.

Barro (1996a; 1996b) begins with the Summers and Heston (1993) data set and ends up with a sample of over 100 countries from 1960 through 1990. The basic approach involves estimating the following simple regression:

$$g_{it} = \alpha + \beta X_{it} + \gamma \Pi_{it} + \varepsilon_{it} \qquad\qquad (1)$$

where g is the rate of growth of real per capita output, Π is the rate of inflation, X is a collection of non-monetary variables that are likely to affect a country's growth rate, and ε is the error term. Each variable is indexed with a time period, t, and a country, i. Each time period t refers to a decade, so that growth rates, inflation rates and other variables (X) are averaged over the decade for each country. Each country therefore contributes three observations to the sample. In this way, Barro is arguably able to focus on the long-term effects of inflation on growth, abstracting from any business-cycle relationship, while also taking some advantage of the time-series variation existing within individual countries. This goes about as far as is practically possible towards addressing the concerns raised by Bruno and Easterly (1996; 1998). The X variables include the level of GDP in 1960 (to examine the convergence hypothesis), variables reflecting the extent of human capital in the population, investment and public expenditure as shares of output, proxies for the extent of government intervention in the economy, such as trade restrictions and capital controls, and proxies for the rule of law and the extent of democratic institutions.

Barro's focus is on the estimate of γ. An estimate of γ significantly less than zero is interpreted as evidence that an exogenous reduction in inflation increases the growth rate of (real per capita) output. Barro finds a negative and statistically significant relationship between a country's average inflation rate and its average growth rate of real per capita GDP. Specifically, the estimated value of γ is about -0.025. His interpretation is that a policy-induced disinflation of 10 percentage points would raise the growth rate of real per capita output by 0.25 percentage points.

Note first that Barro's suggested effect of inflation on growth is an order of magnitude smaller than the effect suggested by Jarrett and Selody (1982) and Novin (1991), although admittedly using very different samples and methods. The results from Jarrett and Selody suggest that a 1 percentage point reduction in inflation would raise the growth rate of output (productivity) by 0.23 percentage points. For Barro's results, this amount of stimulus to the growth rate requires 10 times the magnitude of inflation reduction. Even Barro's more modest estimate, however, probably overstates the magnitude of the inflation-growth link for moderate-inflation countries.

There are two concerns raised by Barro's analysis. The first relates to the identifying assumptions necessary to support Barro's interpretation of a causal link from inflation to growth. The second relates to the very different types of countries in the sample.

Endogeneity of inflation. An important problem with estimating a regression like Equation (1) is that inflation is an endogenous variable and is thus determined simultaneously with real

output growth. In other words, it may not be legitimate to think of a change in inflation as an exogenous policy choice by the monetary authority. Endogeneity can lead to false inferences about the direction of the causal relationship between inflation and growth.

Barro addresses the general problem of endogeneity by attempting to find valid instruments for inflation. He tries three different instruments: the first is an index of a country's central-bank independence; the second is lagged inflation; the third is a set of dummy variables indicating the colonial status of the country. He finds that the results are not particularly sensitive to the use of an instrumental-variables procedure, though only the set of dummy variables reflecting the colonial status of the country perform adequately as an instrument.

Barro recognizes that his instruments are not particularly convincing, as is often the case in empirical macroeconomics. The challenge is to find a variable correlated with inflation that at the same time does not deserve to be included in its own right as an independent variable in Equation (1). But such instruments are very difficult to find. It is sufficient to say that Barro's choice of instruments would not convince a sceptic—and indeed convinced neither Sims (1996) nor Kocherlakota (1996) in their reviews of his paper. For Sims, the basic problem with Barro's interpretation of the results is that the experiment of a policy-induced reduction in inflation, if it is to affect the growth rate, must also affect some other endogenous variables along the way. But with Barro's single-equation approach, these other variables are implicitly being held constant. Sims argues the need for a multi-equation approach and thus a more structural analysis.

High-inflation and low-inflation countries. Even if one were convinced that the endogeneity problems inherent in Barro's approach were small (or adequately addressed through the use of instrumental variables), there is a second problem. The sample contains countries with widely divergent inflation experiences. There are countries like Canada, the United States, and the United Kingdom, all of which can be viewed as moderate-inflation countries. But the sample also contains countries such as Israel, Brazil, and Turkey that, over many years in the sample, had much less stable economies, and this instability was reflected in their extreme inflation experiences.

Of course, the existence of this wide range of inflation experiences is one of the benefits of using the cross-country approach. After all, it is precisely this variation that is used to pin down the relationship between inflation and growth. However, the wide range of inflation experiences also suggests a need to think more carefully about the underlying meaning of a statistical population when doing regression analysis. As Levine and Zervos (1993) argue:

> Regression analysis presupposes that observations are drawn from a distinct population, but . . . Zimbabwe, Greece and Bolivia may have little in common that merits their being put in the same regression. Thus, the statistical basis upon which we draw inferences from cross-country analyses may be in doubt (p. 426).

In other words, the wide range of inflation experiences in Barro's sample should lead one to wonder whether the inflation-growth link that Barro uncovers is dominated by the inflation-growth link in high-inflation countries. As was argued in this paper's introduction, it is easy to believe that countries with very high inflation rates experience lower growth rates because of the dramatic demonetization that extreme inflation typically causes. Does Barro offer any evidence in support of an inflation-growth relationship among moderate-inflation countries?

As it turns out, the inflation-growth link that Barro finds is the result of the high-inflation countries. Barro chooses a cut-off rate of inflation, Z, and then estimates Equation (1) only for those country-decade combinations that have inflation rates less than Z. He finds that Z must be 50 per cent per year in order to find a significant inflation-growth link. If we confine our attention only to those countries with moderate inflation (even defined quite liberally as inflation up to 20 per cent per year), there is no evidence that inflation and growth are related.

This non-linearity in the inflation-growth relationship, moreover, does not just appear in Barro's results. It is also found in recent papers by Sarel (1996) and Judson and Orphanides (1996), both of which use data from a large sample of countries. Sarel estimates the cut-off inflation rate to be at 8 per cent per year; Judson and Orphanides estimate the cut-off to be at 10 per cent. It should be borne in mind, however, that both studies suffer from the problem of not adequately avoiding the inflation-growth correlation over the business cycle: Sarel uses 5-year periods whereas Judson and Orphanides use annual data.

General fragility of results. Plaguing this body of empirical work is a problem that is perhaps the most serious of all. Even if sensible instruments are found, and even if the inflation-growth relationship appears to exist for moderate-inflation countries, there is still a sense that any particular set of results is somehow special, and therefore not robust. Levine and Renelt (1992) make this argument very forcefully. Using data from a large collection of countries, they show that, of the many growth determinants suggested in the literature, each backed up by simple cross-section regressions, almost *none* of these determinants is robust to small changes in the conditioning set of variables. That is, even sensible changes in the set of right-hand-side variables can have, and typically do have, significant effects on the estimated coefficients on the variables of interest. Changes in statistical significance are commonplace, and changes in sign are not uncommon. They find that the *only* robust relationship that appears to exist in such cross-section studies is that countries with higher investment rates tend to have higher growth rates. All other alleged determinants of growth are found to be unrobust. The effect of inflation on economic growth appears to be one of the more fragile.

3.2.3 Summary of the evidence

The time-series evidence bearing on the inflation-growth relationship is not compelling. This is more true of the general approach than of any individual paper, however. The collection of

results reveals primarily one thing: the time-series evidence about the inflation-growth relationship is very fragile. Perhaps more important, however, is the maintained assumption that runs through most of this work—that inflation is the only long-term influence on growth. The analysis cries out for a more structural examination of the data, paying serious attention to the many other variables that may reasonably affect productivity growth.

This lack of structure in the time-series approach is corrected to some degree with the international cross-section approach. Though the methods have their own problems, the approach itself seems more able to identify any link that might exist between inflation and growth. Such a link, however, appears to exist only for countries with high and very high rates of inflation, and the relevance of these countries' experiences for moderate-inflation countries is questionable.

Ambler and Cardia (1998) have expressed concerns about the interpretations of both the time-series and the cross-section results. For reasons similar to those given by Kocherlakota (1996) in his comments on Barro's cross-section results, Ambler and Cardia argue that shocks in exogenous variables will, through the simple quantity equation, tend to produce a negative relationship between inflation and growth even when such a causal link does not exist. Ambler and Cardia (1998) conclude that, at best, the existing empirical results "can be seen as uncovering the conditional correlation between inflation and growth, with no meaningful interpretation and little or no implications for monetary policy or welfare."

It is worth noting an additional reason for thinking that the inflation-growth relationship found in these studies—as small and fragile as it is—may be an overestimate of the true relationship. Though the literature examining the effect of inflation on the *level* of output is by no means unambiguous in its predictions,[6] there seems to be some consensus that, through a mechanism such as the Tobin (1965) effect, inflation should be expected to increase the steady-state capital stock and thus increase steady-state output. If such a relationship actually holds, but the effect on output of a change in inflation appears only with a lag, then some of the observed inflation-growth relationship may merely be capturing inflation's lagged effect on the level of output. If this is true, then disinflation has even less to offer in terms of higher growth rates.

In summary, the empirical evidence about the inflation-growth relationship is quite tenuous. Not surprisingly, someone who wants to believe in a negative relationship between inflation and growth can find the sample period and regression equation supporting that belief. But a more compelling test is to ask whether a sceptic would be convinced by the existing body of evidence. And even a mild sceptic is unlikely to be convinced; the mild sceptic is much more likely to claim that the existing evidence is unable to support the existence of any relationship between inflation and growth, except perhaps in high-inflation countries.

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6.   See, for example, Dornbusch and Frenkel (1973) and Stockman (1981) for an indication of how inflation could either raise or lower steady-state output.

Of course, a committed believer could argue that the growth effects of inflation have not yet had time to occur, and that such effects will be observable only in the future, as long as inflation remains low. This may be correct. But until there exists some compelling—and therefore robust—evidence that inflation and growth are related, claims of an inflation-growth link will be based more on optimism than on a serious appeal to the evidence.

4.   Inflation, taxation, and investment

This section of the paper examines the possible interactions of inflation and the income-tax system and is divided into three broad discussions. First, I discuss Feldstein's (1982) idea that inflation, when combined with an imperfectly indexed corporate income-tax system, leads to an increase in the after-tax cost of capital and thus a reduction in the flow of investment. This could have an effect on either the steady-state level of output or the steady-state growth rate of output, depending on one's view of the growth process. Next is Howitt's (1996) idea that inflation also interacts with the tax system in such a way that the "quality" of investment is reduced, even if the quantity of investment may not be. Finally, I discuss the important difference between the direct burden and the excess burden of this inflation-tax interaction. Both burdens are relevant to the welfare benefits of disinflation. The larger is the direct burden coming from this interaction, the more government tax revenues will fall when inflation is reduced. This creates a need to increase other (distortionary) taxes, thus reducing the overall benefits of the disinflation.

4.1   Inflation and the quantity of investment

Feldstein (1982) was probably the first to stress the importance of the tax system when thinking about the effects of inflation. He notes that, in Irving Fisher's ideal world, the presence of lump-sum taxes means that a 1 percentage point increase in inflation will lead to a 1 percentage point rise in the nominal interest rate, thus leaving the real interest rate unchanged. In such a world, inflation has no (direct) effect on the flow of investment or saving.

A different picture emerges with distortionary taxes that are imperfectly indexed to inflation. Feldstein emphasizes two channels through which inflation can affect the real return to investment. First, firms' nominal interest costs on debt are fully deductible, even though some of the nominal interest rate reflects inflation. This leads to an overstatement of firms' real expenses and thus a reduction in the effective corporate tax rate. Working in the opposite direction is the fact that savers, who receive those nominal interest payments, pay taxes on the full nominal amount. The net effect on the after-tax return and thus on the overall flow of saving and investment depends on, among other things, the extent of integration of the corporate and personal income-tax systems.

The second channel is potentially much more important. For tax purposes, a firm's depreciation and inventory expenses are computed on a historical-cost basis rather than on a replacement-cost basis, and it is the latter that more truly captures the notion of economic cost.

With the use of historical costs, general price inflation implies that deductions for inventory investment and depreciation are included at too low a real price, leading to an overstatement of corporate profits and thus to an increase in the effective corporate tax rate above the level that would exist in the absence of inflation. Since inflation behaves in this setting like a distortionary tax on investment, the cost of inflation can be viewed as a deadweight loss.

Feldstein (1996) uses this idea to think about the benefits of reducing inflation and thereby avoiding the deadweight loss caused by the interaction of inflation and the unindexed tax system. Not surprisingly, his results are sensitive to his assumptions regarding the interest elasticity of the supply of saving. When he chooses a relatively low interest elasticity for saving—between 0 and 0.4—Feldstein estimates that a reduction of inflation from 2 per cent to zero improves welfare directly by between 0.7 and 1 per cent of GDP. He then notes that, even though the benefit is on the level of GDP (he implicitly does not have an endogenous-growth model in mind), the fact that GDP continues to grow over time implies that this benefit will also grow (in absolute terms). Assuming that GDP grows at an unchanged annual rate of 2.5 per cent and that the discount rate is 5 per cent, a 1 per cent benefit of GDP has a present value of 40 per cent of GDP. For Feldstein, the direct benefits of even a small disinflation are enormous.

4.2   Inflation and the quality of investment

Howitt (1996) is also concerned with the interaction of inflation and the tax system. Howitt agrees with Feldstein that the inflation-tax interaction may lead to a reduction in the flow of investment, but he emphasizes a different problem. Howitt argues that the presence of inflation will lead to the "wrong" investment—that is, to a cross-firm or cross-industry pattern of investment different from the pattern that would exist in a non-inflationary world.

Howitt's argument is also based on the fact that depreciation and inventory expenses are treated on a historical-cost basis rather than a replacement-cost basis. Specifically, firms that have higher inventory-sales ratios and firms that have higher proportions of depreciable capital will face a larger overstatement of their corporate profits and thus face a higher effective tax rate. Even a perfectly constant and known inflation, when combined with the imperfect tax system, distorts the *relative* returns for investment among different types of firms. After-tax returns will be distorted in such a way that capital will flow towards firms with low depreciable capital and low inventory-sales ratios. The effect of this inflation-created distortion is to reduce the efficiency of the allocation of capital. As Howitt says, a reduction in inflation should lead to

> . . . more capital going into real depreciable assets and inventories,
> and less into the kinds of capital that has historically been financed
> by large amounts of debt . . . and simple economics suggests that
> there should be an overall efficiency gain from this reallocation
> (p. 10).

For Howitt, the cost of inflation is not so much in a reduced *quantity* of investment, but rather in a reduced *quality* of investment as resources flow in response to differential accounting rates of return rather than in response to differential economic rates of return. Presumably this would be evident in terms of reduced future output, even though the current flow of investment may not be affected.

4.3   Excess versus direct burdens

The welfare benefits of low inflation relate to the excess burden of the interaction of inflation and the tax system. Specifically, to the extent that this interaction leads to a change in investment behaviour—either less investment overall or a change in the pattern of investment across firms—there will be a deadweight loss created. It follows that reducing inflation, and thus reducing the extent of this interaction, will generate direct welfare benefits. Furthermore, since the existing distortions in the tax system imply that the starting point for such a disinflation is not a first-best outcome, the disinflation-generated benefits may well be significant. From Feldstein's (1996) estimates, at least, these benefits are very substantial.

It is worth noting, however, that disinflation is not the only way to generate these welfare benefits. If the fundamental problem is that inflation combines with the unindexed tax system to generate welfare costs, then an alternative solution is to index the tax system. Feldstein (1996) is quite pessimistic about the possibilities for such tax reform. He discusses both technical and political issues that make indexation difficult or unlikely. In principle, however, such indexation could be achieved. It may not be perfect, but it could be designed to remove the lion's share of the harmful inflation-tax interaction. This issue is revisited in Section 7.

There is also a direct burden arising from the interaction of inflation and the tax system. Not only does this interaction distort investment decisions, but it also raises revenue for the government. If a disinflation reduces this tax revenue, the government will be forced to replace those revenues from other sources. And since real-world governments typically do not have access to (or are unwilling to use) lump-sum taxes, the increase in distortionary taxes will incur welfare losses.[7] This introduces the possibility that a policy to reduce inflation may generate direct welfare gains but also indirect welfare losses arising from the need to replace revenues.

This is exactly the issue addressed by Cooley and Hansen (1991) and Black, Macklem and Poloz (1994), and also incorporated in Feldstein (1996). Cooley and Hansen (1991) build a dynamic general-equilibrium model that incorporates distortionary taxation but in which the tax system is fully indexed. They examine the welfare effect of reducing inflation. On the benefit side, they note that a reduction in inflation reduces the inflation tax on real balances. On the cost side,

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7.   Another alternative is that the government responds to the loss of revenues by reducing expenditures. Analyzing the welfare effects of expenditure cuts, however, is probably more complicated than examining the welfare effects of tax increases.

the loss of seigniorage revenue forces the government to raise other distortionary taxes. They find that the costs of reducing inflation may well exceed the benefits.

An important limitation of the Cooley and Hansen (1991) model is the importance placed on replacing the government's seigniorage revenues, typically a very small fraction of overall government revenue. In contrast, the analyses by Black, Macklem, and Poloz (1994) and Feldstein (1996) explicitly take account of the incomplete indexation of the tax system. This extension cuts both ways, however. On the one hand, an imperfectly indexed tax system means that inflation can generate all the welfare costs discussed by Feldstein (1982; 1996), and thus a disinflation may generate considerable benefits. On the other hand, to the extent that this inflation-tax interaction also raises government tax revenues, there are more revenues that must be replaced when the disinflation occurs, and thus there is more room for welfare losses coming from the induced increase in distortionary taxes.

In Feldstein's (1996) analysis, the direct welfare gain (between 0.7 and 1 per cent of GDP) discussed above is offset by an indirect welfare loss of between 0.4 and 0.8 per cent of GDP. In the case where the supply of saving is completely interest inelastic, the net welfare effect is zero. In the case where the interest elasticity of saving is 0.4, there is a net welfare gain of about 0.6 per cent of GDP.

Black, Macklem, and Poloz (1994), following Cooley and Hansen (1991), build a dynamic general-equilibrium model that can be calibrated for running simulations. Unlike Cooley and Hansen, however, they incorporate into their model much of the realism of the Canadian tax system, including the use of historical cost for inventory and depreciation expenses. They find the same basic result that the direct benefits of disinflation—including fewer distortions on investment and less tax on real balances—are reduced by the government's need to replace the lost tax revenues. But they also show how the net welfare effect depends on which tax the government uses to replace the lost revenue. Their simulation results suggest that, if the government raises the personal income-tax rate to replace the lost revenues, then overall welfare rises by about 2 per cent of GDP. If the consumption tax is used, the welfare gain rises to 5 per cent of GDP. But if the corporate income-tax rate is used, welfare falls by about 0.5 per cent of GDP.

5.   The unobservable benefits of low inflation

The previous three sections discussed the possible benefits from low inflation that might be observable in the sort of aggregate data that macroeconomists usually examine—the quantity of real cash balances, the growth rate of real output (or productivity), and the level and rate of return on investment. In contrast, this section focuses on the benefits from low inflation that are unobservable in such aggregate data. Unfortunately, the literature has not progressed very far in this direction and, as a result, the discussion here is loosely intuitive rather than based on the results from formal models. Furthermore, due to the nature of the benefits under consideration,

there is little in the way of empirical work, though some attention is paid to recent survey evidence.

The section examines two broad ideas. I begin with the idea that inflation generates noise in the economy and, through this channel, causes a reduction in allocative efficiency. The second idea is that inflation causes a direct loss of utility for individual decision makers.

5.1   Inflation, noise, and allocative efficiency

It is often said that inflation introduces noise into the price system, and this noise leads to decisions that, *ex post*, are mistakes that would not have occurred in the absence of the inflationary noise. Lucas' (1972) famous "islands" model, for example, is based on this idea. The claim that inflation adds noise to the price system, however, cannot be based on the view of inflation as a uniform and perfectly anticipated phenomenon, for such a pure inflation would not lead to any mistakes. In order for inflation to introduce noise into the price system, inflation must carry with it some uncertainty about static and/or intertemporal relative prices.

There is considerable evidence that inflation and inflation uncertainty appear to travel together. This evidence begins with Okun (1971), Logue and Willett (1976) and Foster (1978). More recent and formal econometric approaches include Engle (1983) and Evans and Wachtel (1993). Though these studies may disagree in some details, there does appear to be a consensus that inflation and inflation uncertainty are positively correlated. In addition, as Fischer (1981b) and Domberger (1987) show, there appears to be a strong correlation between the level of inflation and the volatility of static relative prices. To the extent that these correlations between inflation and relative-price changes represent causal linkages, it follows that inflation adds noise to the price system. I proceed under the assumption that inflation brings with it greater uncertainty in static relative prices and greater uncertainty in inflation itself.

5.1.1 Inflation and resource allocation

Inflation injects noise into the smooth functioning of the price system and thus influences households' and firms' decisions. With this added noise come decisions that are mistakes— decisions that would not have been made in the absence of the inflation-induced uncertainty. Households end up saving too much or too little, employees end up working too much or too little, and firms end up producing too many of some goods and too few of others. Inflation therefore leads to a different pattern of consumption and production than would otherwise take place. In this sense, inflation is like a distortionary tax and thus causes a reduction in the economy's allocative efficiency.

Moreover, if without inflation the economy does not achieve a first-best outcome—for reasons of imperfect competition or incomplete information—then these inflation-induced mistakes, even if small for the individuals and firms involved, may represent first-order welfare

losses for the economy as a whole. Thus the allocative costs caused by inflation's noise may be quantitatively very important. Indeed, Thomas Melzer (1996), President of the St. Louis Federal Reserve, appears to take this view when he says

> . . . in my judgment, the number-one cost of inflation, even low inflation, is unnecessary confusion in the relative price system. It is important for the sake of efficient functioning of markets to let relative prices give the clearest possible signals in terms of credit markets, commodity markets, labor markets and in general any market where today's prices depend on perceptions of tomorrow's value of money (p. 3).

That inflation adds noise to the price system and causes a harmful misallocation of resources is a fairly abstract argument and certainly a tough point to get across to members of the public. The argument refers to shifts in resources that would not otherwise have occurred but is not specific about which resources get shifted. However, as long as inflation leads to uncertainty, and uncertainty leads to mistakes, it is clear that welfare losses will follow, and these losses take the form of deadweight losses. Economists are generally comfortable with an argument based on such deadweight losses even though there is often no clear implication for aggregates such as output and employment. But for members of the public, who have less of a sense of how distortions stand in the way of the free market's potential, the real costs of "resource misallocations" are not very clear. For most non-economists, there is little in Melzer's words that is tangible.

The basic argument can be made more accessible to a lay audience. One example of the general point, made by both Summers (1991) and Howitt (1996), is that inflation and its accompanying uncertainty leads to resources being devoted to "dealing with" inflation rather than being devoted to things that we "really care about." We therefore get more inflation forecasters and indexation specialists than we otherwise would have; we also get fewer bridge engineers and piano teachers. A specific example from Summers (1991) is that, as inflation rises, we get recipients of cheques lobbying for faster cheque-clearing services and the writers of cheques doing the opposite. The private gain from such rent seeking is obvious, but the net social gain, since real resources get expended in the process, is surely negative.

In general, then, inflation leads to a shift of resources towards socially wasteful activities and away from producing "real things" that we care about. Leijonhufvud (1977) also makes the point:

> Being efficient and competitive at the production and distribution of "real" goods and services becomes less important to the real outcome of socioeconomic activity. Forecasting inflation and coping with its consequences becomes more important. People will reallocate their effort and ingenuity accordingly. . . . In short, being good at "real" productive activities—being competitive in the ordinary sense—no longer has the same priority. Playing the inflation right is vital.

5.1.2 A shred of evidence

The problem with such inflation-generated resource shifts, despite the considerable losses in efficiency they may entail, is that these resource shifts are generally not observable in aggregate data. This is not an empirical statement but a theoretical one. Since inflation forecasters and bridge engineers both produce value added and thus both contribute to measured GDP, an inflation-induced resource shift away from "dealing with inflation" towards "real productive activities" will not change measured GDP in any predictable manner. Real GDP may rise or fall as a result of these resource shifts; this ambiguity is only exacerbated if inflation carries with it changes in static relative prices. Furthermore, since we could never arrive at a sensible list of those things that we "really care about," it would be a daunting task to examine disaggregated data in search of inflation-induced resource shifts.

One approach at determining the extent of the resource shifts involved with "playing the inflation right" is followed by English (1996).[8] English uses a sample of 75 countries to examine the relationship between inflation and the size of the financial sector, as measured by that sector's share of GDP (or total employment) in 1985. For inflation he uses the country's average annual inflation rate from 1975 to 1985. His estimates suggest that a 10 percentage point reduction in inflation reduces the size of the financial sector by about 1 per cent of GDP.[9]

There are two difficulties in interpreting English's results. First, as was the case for the international cross-section evidence on the inflation-growth relationship, English's results appear to be driven by the experience of countries with very high rates of inflation. In particular, when Brazil, Israel, Argentina, Bolivia, and Peru are removed from the sample—still leaving behind a sample of over 60 countries—the empirical relationship between inflation and the size of the financial sector disappears. For the same reason that extreme inflation is expected to accompany low growth, it is also expected to accompany expansion of the financial sector. The process of severe demonetization not only makes transactions and production more difficult, thus affecting output, but it is also accompanied by a dramatic increase in the need for financial alternatives to money. It is unclear, however, how relevant the inflation-induced expansion of Israeli's financial sector during the early 1980s is to a discussion of the benefits of low (as opposed to moderate) inflation in countries like the United States, the United Kingdom, Germany, or Canada.

There is another reason to be sceptical of the view that inflation-induced increases in the size of the financial sector necessarily represent welfare costs. Inflation, like war, may spawn

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8. Using a different data set, Frenkel and Mehrez (1996) address the same issue in a similar way and find broadly similar results.

9. English notes that Aiyagari, Eckstein, and Braun (1995) show that the size of the financial sector is closely related to the area under the money demand curve, and thus English's estimates of the effect of inflation can be interpreted as the Bailey-style welfare cost of inflation. It is interesting that English's indirect approach yields estimates that are very close to the more direct estimates of Fischer (1981a) and Lucas (1994).

innovations that are useful even after the "battle" is over. It is self-evident that the Second World War was undesirable, but it is equally evident that there were countless technical innovations—largely due to the war itself—that are viewed as clear benefits today. Radar, communications technology, and jet aircraft are just a few examples. Similarly, the innovations in financial instruments developed largely in response to high and uncertain inflation may be very useful in different settings after the passing of inflation. In this perspective, some of the resources that flow into the financial sector, and thus reduce our current consumption of the things "we care about," should be treated as beneficial investment rather than as pure deadweight loss.

The problem with this line of reasoning is that it is not obvious how far it can be pushed. This reasoning does suggest, however, that we must be careful about interpreting all increases in the size of the financial sector as pure welfare costs, even if such increases are causally linked to inflation. This does not undermine the basic argument that inflation and the uncertainty that accompanies it adds noise to the price system and thus generates efficiency losses for the economy. But it does cast doubt on the idea that it might be straightforward to measure these costs by examining resource shifts in disaggregated data.

5.2   Inflation as a direct utility loss

If private agents dislike inflation, for whatever reason, then inflation imposes a welfare cost even if it does not affect employment or output or investment or any other observable variables. After all, the ultimate goal is (unobservable) utility, not (observable) output.

Economists are understandably wary of such arguments. Once we start including variables in an ad hoc manner in individuals' utility functions, nearly any behaviour can be explained. For example, models in which a transactions demand for money is generated by having money enter directly into individuals' utility functions have never been fully satisfying to monetary economists. Similarly, a model in which individuals "dislike" imports would never be seriously used to provide a rationale for protectionist policies. So there is justifiably some pressure for economists to present some solid reasons why people might dislike inflation.

I discuss three reasons why inflation probably generates a direct utility loss. The first relates to the greater uncertainty that inflation brings to economic life. The second and third rely only on inflation itself, even a constant and perfectly anticipated inflation.

5.2.1 Inflation-induced uncertainty

It is common to view individuals as being risk averse. Risk-averse individuals, when faced with the choice of receiving *X* dollars with certainty or playing a lottery that pays *X* dollars only in expected value, strictly prefer the sure thing. Any exogenous increase in the amount of uncertainty—such as an increase in the variance of the possible payoffs in the lottery—reduces

the utility of risk-averse individuals, even though the greater uncertainty may not affect the expected payoff.

If it is indeed the case that higher inflation brings with it greater uncertainty, perhaps of static relative prices or perhaps of inflation itself, then higher inflation also generates a direct utility loss for individuals. In this view, inflation simply increases the extent to which risk-averse individuals are forced to take part in a lottery they would rather avoid.

The uncertainty associated with inflation generates another cost as well, though this one applies more to society as a whole than to individuals. If higher inflation means more uncertain inflation, then *unanticipated* inflation will be a more important phenomenon during periods of high inflation than low inflation. Unanticipated inflation leads to unforeseen redistributions between workers and firms as real wages diverge from their intended path, and between creditors and debtors as real interest rates change in unexpected ways. Such unforeseen and unplanned income redistributions imply that the government's tax-and-transfer policies geared at altering the income distribution must be constantly on the alert. The higher and more unpredictable is inflation, the more vigilant such policies must be.

5.2.2 Money illusion

A second reason people may suffer a direct utility loss from inflation is that people may suffer from money illusion. Even though their nominal receipts may rise in tandem with their nominal expenses during a constant and fully anticipated inflation, they *feel* like they are losing. Perhaps they view the increases in their nominal earnings as the result of their own hard work and diligence but view the increases in prices as a persistent and unavoidable tax on the fruits of their labour. It is beside the point that people are in fact not losing real purchasing power in such situations. The relevant thing is simply that they feel they are losing. A world with constant nominal wages and prices may provide more utility to private agents than a world with the same real variables but steadily increasing nominal wages and prices.

This argument has few supporters among the mainstream economics profession that tends, instead, to believe that agents can easily pierce the informational veil of a perfect and steady inflation. But there is nonetheless some evidence that such money illusion exists.

A recent paper by Shafir, Diamond, and Tversky (1997) presents survey evidence showing that people think in both real and nominal terms. When asked questions that involve a transparent need to compute real purchasing power, the majority of respondents seem to have no difficulty in computing real changes from the underlying nominal changes in wages and prices. Yet when asked "real life" questions about how economic decisions would be made in various situations, nominal comparisons appear to be more important than real ones. In many situations, such "nominal thinking" leads the survey respondents to make decisions that are clear mistakes when

viewed in real terms. Shafir, Diamond, and Tversky (1997) argue that many people suffer from money illusion, not because they are unable to distinguish real and nominal values, but because making nominal comparisons is easier and more instinctive than making real comparisons.

Shiller (1996) also presents survey evidence about the extent of money illusion. Moreover, Shiller's evidence illustrates interesting differences in the views of economists versus non-economists. His question B17 is as follows:

> Do you agree with the following statement? "I think that if my pay went up I would feel more satisfaction in my job, more sense of ful-fillment, even if prices went up just as much."

Among the members of the general U.S. population, 28 per cent of the respondents fully agreed with this statement; among economists, *none* of the respondents agreed. A slightly more dramatic question is B6:

> Do you agree with the following statement? "When I see projec-tions about how many times more a college education will cost, or how many times more the costs of living will be in coming decades, I feel a sense of uneasiness; these inflation projections really make me worry that my own income will not rise as much as such costs will."

Among the members of the general U.S. population, 66 per cent of the respondents fully agreed with this statement; among economists, 5 per cent agreed.

One can argue that such survey evidence is of limited value. It is an artificial situation rather than a real-world one, and thus we are not sure whether people are being accurate in their responses. It is also not always clear how the answers to specific survey questions should be interpreted. In Shiller's question B17, for example, some respondents may not interpret the price increases as applying to the goods that *they* purchase, only the goods purchased by others. In question B6, perhaps the respondents actually have a well-informed concern about the likely future increase in the relative price of education and actually suffer no money illusion. There are many possible interpretations. But such survey evidence is at least suggestive; and in the absence of an alternative method of gauging the extent of money illusion, the survey evidence should probably be taken as seriously as other empirical evidence in economics.

5.2.3 *Losing the nominal anchor*

A third reason why people dislike inflation is that inflation destroys the concept of a nominal anchor, of a stable unit of account. The idea that money is useful as a unit of account, and that stable money is more useful, may be the reason that Shafir, Diamond, and Tversky (1997) find that survey respondents instinctively employ nominal rather than real comparisons. Since

money is the numeraire in our economy, it makes day-to-day comparisons of value more difficult if the real value of that numeraire is changing. It is worse if the value is changing quickly and in uncertain ways. Of course, it does not make such comparisons impossible; people can spend a little time to think, compute, re-adjust, and then make their consumption and production decisions. But it does take real resources to do so, and these resources, when added up over millions of households and millions of firms, may be quite significant.

Summers (1991) puts this point nicely:

> . . . standards should remain standard. Imagine the following conceptual experiment: depreciate the pound—not the British currency, but the American weight measure—by 10 percent each year so that what is a pound today would be 14.4 ounces next year and 12.96 ounces two years from now, and so forth. Some might contend that allowing the pound to lose value steadily wouldn't make a difference. Only real things matter, and you could just redenominate the units and all the contracts could be written to be time contingent. . . . But it would be costly to get organised to write those contracts (p. 626).

This is a compelling argument, and it is more compelling the more it is the case that inflation and inflation uncertainty travel together. Not only do people dislike the need for continuous mental re-adjustments, they dislike even more the uncertainty surrounding the mental re-adjustments that must be made. John Crow (1988), the Governor of the Bank of Canada who oversaw Canada's disinflation in the early 1990s, appears to be making the same point when he says:

> The fundamental case for pursuing price stability thus rests on the benefits of a trustworthy monetary standard in an economy based on money. In the debate about monetary policy that is always going on inside Canada with more or less intensity, this basic consideration seems to be not so much challenged as ignored (p. 3).

Crow actually makes two points. The first is the general point that a trustworthy monetary standard is desirable in its own right. The second is that the first point is typically ignored. One presumes that this follows largely from the fact that the benefits of a trustworthy monetary standard are not easily observable, not tangible. But they are surely no less real than benefits that are more easily measured.

6.   A summary of believable low-inflation benefits

The literature on inflation and economic growth provides no compelling evidence that disinflation leads to an increase in the growth rate of real output. The mechanisms that exist in the current generation of endogenous-growth models are logically coherent, but it is unlikely that these mechanisms can be empirically relevant in modern, moderate-inflation economies.

Furthermore, neither the time-series evidence nor the international cross-section evidence is robust. There is a robust negative relationship between inflation and growth in high-inflation countries, but this evidence will hopefully remain irrelevant for the industrialized countries for some time to come.

That inflation generates costs through a tax on real balances seems indisputable (assuming that money demand is not perfectly interest inelastic). Moreover, as Lucas (1994) argues, in some general-equilibrium models, the costs of inflation are actually very close to the Bailey-style partial-equilibrium estimates. The Bailey approach does admit some variation in the estimated benefits of low inflation, but a generous estimate is that even a 10 percentage point disinflation generates a permanent flow benefit of only 0.1 per cent of GDP.

Unquestionably the largest of the observable benefits of low inflation arises from the interaction of inflation with an unindexed tax system. The use of historical cost rather than replacement cost in arriving at inventory and depreciation expenses raises the effective corporate tax rate. To the extent that the flow of investment is sensitive to the after-tax rate of return, the inflation-induced effects on investment may be substantial. For Feldstein (1982; 1996), these effects are predominantly on the level of aggregate investment; for Howitt (1996), the more important effects may be on the pattern of investment across firms and industries. In both cases, however, the interaction of inflation and the tax system generates deadweight losses.

As damaging as this inflation-tax interaction may be, however, it does raise the government's tax revenues. The thought experiment of disinflation must therefore include an increase in some distortionary taxes in order to replace the lost revenue. The effect of the disinflation is thus no longer a pure benefit; the direct benefits from a change in investment must be weighed against the indirect losses from the distortionary taxes. Though a sceptic could rightly argue that there ought to be no presumption that the direct benefits outweigh the indirect costs, the simulations by Feldstein (1996) and Black, Macklem, and Poloz (1994) are revealing: only in a minority of the reported simulation reports is there an overall welfare cost from disinflation.

There are two important benefits of low inflation that are unobservable. The first relies on the relationship between inflation and relative-price uncertainty. If inflation is associated with more uncertainty about either static or intertemporal relative prices—and the available evidence seems to suggest that it is—then inflation introduces noise into the price system, and this noise results in individuals and firms making decisions that they would not otherwise have made. As a result, resource allocation suffers. Though there is no presumption that this resource misallocation ought to translate into less output, there is surely a reduction in overall welfare. If one believes that inflation and relative-price uncertainty really do go hand in hand, and that relative prices are central in the allocation of resources, such welfare costs could be substantial.

The second unobservable benefit of low inflation relies only on the presence of inflation itself. Inflation reduces money's value as a unit of account and thus removes the nominal anchor

that individuals and firms use in their day-to-day decision making. Individuals and firms do not judge prices as being low or high based on the real price of the good or service in question; they evaluate prices based on the intrinsic value of the nominal unit of account—the intrinsic value of the dollar. And since inflation changes the real value of this standard, decisions are made more difficult. This problem is made worse if high inflation is also associated with more uncertain inflation, so that individual decision makers are unsure about how much the standard is changing. This inflation-induced change in money's value as a standard makes day-to-day decisions more difficult and thus imposes a direct welfare cost. Though some economists might argue that such costs could only exist if individuals suffer from an "irrational" money illusion, this is probably too narrow a view. Inflation introduces real complications and annoyance to day-to-day living, and these are direct utility losses for individuals.

The fact that such costs are based on abstract notions of allocative efficiency and welfare rather than on tangible concepts such as output and consumption in no way makes them less real. The question is not whether they are real, but whether they are significant. This leads to the final section of the paper, where I discuss some policy challenges.

7.   One conclusion and two policy challenges

From the list of observable benefits of low inflation, two stand out as being compelling. The first is the welfare gain arising from the reduction in the tax on real money balances. Though this is a genuine benefit, there are solid reasons for believing the benefit to be quite small. Surely more significant is the second compelling benefit, the welfare gain that comes from the reduced distortions caused by the interaction of inflation with the tax system. Indeed, if the estimates of Feldstein (1996) or Black, Macklem, and Poloz (1994) are to be taken seriously, this welfare gain is very substantial.

That is the end of the list of the observable benefits of low inflation. The other benefits, which may be quite substantial, are unobservable in familiar data. The welfare gains associated with an improvement in resource allocation and the direct utility gains from low inflation are the two I have discussed.[10] The nature of these benefits suggests one important conclusion and two policy challenges.

7.1   The importance of unobservable benefits

The small size of the inflation tax on real balances implies that, to a first approximation, the observable benefits of low inflation come only from the avoidance of the inflation-tax interaction. An important conclusion for the conduct of monetary policy follows from this observation: The

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10.   I have ignored some other unobservable benefits of low inflation. Mishkin (1996) and Chari, Jones, and Manuelli (1995) argue that the financial system operates more efficiently when there is lower inflation, even though this may be difficult to detect in standard types of data.

case for disinflation, in a cost-benefit sense, can only reasonably be made when the *unobservable* benefits of low inflation are emphasized. To put it differently, a central bank that tries to build a case for disinflation around the observable benefits of low inflation—giving short shrift to the hard-to-explain unobservable benefits—will find it extremely difficult, and probably impossible, to defend a disinflation policy.

To understand this argument, consider a world in which the only observable benefits are from the avoidance of the inflation-tax interaction, and in which the central bank ignores any unobservable benefits in considering the case for disinflation. Furthermore, these observable benefits can be *arbitrarily large*. The key point is that the government has two alternative methods of reducing the costs due to the inflation-tax interaction. One method is to reduce inflation. An alternative is to index the tax system, especially by moving from the historical-cost method to the replacement-cost method of deriving depreciation deductions. The choice between these alternatives is then very simple: the government should choose the method of avoiding these costs—disinflation or indexation—that is itself the least costly.[11] In such a comparison, however, the cost of disinflation could hardly ever be less than the resource costs involved in indexing the tax system. The relevant exercise is to estimate the short-run transition cost of reducing inflation and to compare it with the one-time cost of making appropriate reforms in the tax system. What are these costs?

There is widespread agreement that the transitional costs of disinflation are substantial, though the precise estimate of these costs depend on one's view of the sacrifice ratio. From Ball (1994), a typical estimate of the sacrifice ratio is about 2, implying that each percentage point decline in inflation generates a present-value cost of approximately 2 per cent of GDP. Putting this cost in Canadian-dollar terms in 1998, each percentage point of disinflation costs about $17 billion in foregone output.

The resource costs involved in designing and implementing significant tax reform are also likely to be substantial, though I have never seen any estimates of this. In the Canadian case, if such tax reform required the resources of the *entire* federal Department of Finance working for three years to design and implement tax reform, the direct resource cost would be nowhere near $17 billion; a closer estimate might be $500 million.[12] Even this estimate is probably very generous and allows for much of the private sector resources that would be devoted to understanding the new (indexed) tax system. But even if this simple estimate is too low by an

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11. Note that when either inflation is reduced or the tax system is indexed, the reduction in the effective income-tax rate implies a reduction in government tax revenues that must be replaced by increasing other taxes. Since these other taxes will likely be distortionary, there will be costs generated from these new distortions. But since these costs will be present in either case, they do not enter the decision of which policy to choose.

12. In both towers of L'Esplanade Laurier (Department of Finance plus the Treasury Board), there are at most 2,160 employees (36 floors x 60 employees per floor). At the generous average annual salary of $80,000, this amounts to $172 million per year, or a little over $500 million for three years.

order of magnitude, the estimate is still considerably less than $17 billion. Furthermore, note that the $17 billion figure is the output cost of reducing inflation by only 1 percentage point. If the thought experiment is a 5-point reduction in inflation, the sacrifice costs get scaled up accordingly. In contrast, the direct resource cost associated with tax reform is independent of the current rate of inflation and of the size of the potential disinflation.

One conclusion appears inescapable: If only the observable benefits of inflation are emphasized by the central bank in building a case against inflation, and avoidance of the inflation-tax interaction represents the lion's share of the observable benefits, then a policy of disinflation is impossible to defend. As complex as indexation might be, indexing the tax system is surely a less costly method of obtaining these benefits.

In order for a policy of disinflation to be defensible, either additional observable benefits must be found or emphasis must be placed on some of the unobservable benefits of low inflation. This leads naturally to two policy challenges for the monetary authority.

7.2   Challenge 1: Search for other compelling observable benefits

One challenge is to come up with a larger list of compelling and observable benefits of low inflation. Only with such an expanded list can a central bank base a policy of disinflation only on observable benefits. I am not here suggesting that the research departments of central banks in moderate-inflation countries "invent" benefits that appear compelling. Rather, I suggest that more effort be spent at examining the issue both theoretically and empirically.

This is no small task. As argued above, the main problem with the theoretical literature on the inflation-growth relationship is that money does not enter these models in a sensible way for examining the effects of moderate inflation on growth. And a satisfactory way of having money enter a complete model economy has eluded economists for many years. Thus, finding a role for money in a general-equilibrium model that provides a sensible link between inflation and growth may well solve the much bigger (or at least older) problem central to monetary economics.

Perhaps less ambitious is to push forward on the empirical side. Ultimately, of course, even if a robust empirical relationship between inflation and output is found, the link will have to be understood—and thus developed theoretically—before it is fully convincing. But there is certainly considerable value in the empirical research even if the theory is not yet fully understood.

My impression is that further work using the single-country time-series approach holds very little promise; the inherent lack of structure is likely to preclude this approach from generating convincing or robust results. The international cross-section approach is much more promising. This approach allows the economist to exploit the wide range of inflation and growth experiences across many countries. Furthermore, as Barro (1996a; 1996b) showed, using long-period averages

from the post-war period permits some time-series variation within each country while avoiding the confounding business-cycle issues. The challenge using this approach is to address some of Sims' (1996) concerns about structure. Use of more than one equation and thinking more carefully about instrumentation may have large payoffs in terms of generating convincing empirical results.

7.3   Challenge 2: Take the unobservable benefits seriously

A quite different challenge for central banks is to take more seriously the importance of the unobservable benefits of low inflation. The problem with these unobservable benefits, of course, is that they are unobservable, and thus their quantitative importance is difficult to assess. This challenge has two dimensions.

The first dimension is the development of more complete theoretical descriptions of the unobservable benefits. One possibility is to build a dynamic general-equilibrium model with money and with more than one good. To this could be added a link between inflation (money growth) and relative-price volatility. The nature of this link will obviously be important. Such a model could then be simulated to examine how inflation-induced variations in relative prices directly reduce welfare. Perhaps this has already been done, but I am not aware of it.[13]

More challenging still is to get a sense of the quantitative importance of the cost to individuals arising from the fact that inflation makes day-to-day life more difficult. Simply building a model that includes inflation as an argument in individuals' utility functions obviously does not help. On the empirical side, a survey could be used to ask people how much they would be willing to pay to avoid a given inflation rate, but such survey results would hardly be compelling.

The second dimension is communication: If central banks are to take seriously the unobservable benefits of low inflation, considerable attention must be paid to explaining these benefits to the public. This also is no small task; the job of clearly explaining that inflation distorts decisions and reduces allocative efficiency (in addition to making ordinary life more complicated) is surely more difficult than explaining the concept of comparative advantage to first-year undergraduates.

As difficult as these benefits are to explain to the general public, such an explanation is possible, and it is important that central banks make the effort to provide one. To gloss over the unobservable and intangible efficiency and welfare arguments is to implicitly emphasize only those benefits that are observable and tangible. But this approach is remarkably vulnerable to the

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13.   One recent paper that comes close is Cooley and Hansen (1996). They build a dynamic general-equilibrium model with Lucas-style "island" markets in which agents are confused between changes in relative prices and the price level. But they do not examine how inflation affects welfare; their goal is to determine if such a model can generate fluctuations in aggregate variables to match those in the actual economy.

criticism that compelling evidence of such benefits is absent, thus seriously undermining the case for disinflation. To build a serious—and believable—case for disinflation, central banks must strengthen their emphasis on the unobservable benefits of low inflation.

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