Should We Expect Higher Growth from Lower Inflation?

By Christopher Ragan

When the Bank of Canada embarked on its drive for "price stability" in the early 1990s, it was well known both inside and outside the bank that obtaining the long-term benefits of low inflation would require suffering short-term costs in the form of temporarily lower output and higher unemployment. As it happened, inflation in Canada fell sharply, from about 6 per cent in 1990 to below 2 per cent in 1992, and a significant recession occurred. For the next six years, inflation fluctuated mildly between 1 per cent and 2 per cent, though it was more often below 1.5 per cent By the summer of 2000, low and stable inflation had surely been achieved in Canada.

Now both critics and supporters of the bank's disinflation policy have begun to wonder when the long-term benefits will appear. Especially notable has been the different macroeconomic performances of Canada and the U.S. While the U.S. had slightly higher inflation than Canada in 1992-98, its unemployment rate was significantly lower and the rate of productivity growth slightly higher. This has led many to question whether Canada's inferior macroeconomic performance is related to the Bank of Canada's strong policy stance against inflation.

Given the amount of effort devoted to researching inflation's causes and effects, it is perhaps surprising there is little consensus about the benefits of low inflation. Though economists and the public agree that low inflation is desirable, there is much less agreement about *why* this should be so. Non-economists typically focus on how inflation affects their real purchasing power. As shown by a recent survey by Shiller (1997), it is common for them to conclude that increases in the overall price level generate a reduction in real purchasing power and thus a reduction in overall living standards. They often do not seem to realize that real incomes may be unaffected when changes in nominal incomes accompany changes in prices.

Economists focus on other aspects of inflation. Some emphasize the benefits of low inflation that are, at least in principle, detectable in conventional macroeconomic data, such as a higher growth rate of productivity or real per capita gross domestic product. Others stress factors that are less visible and measurable, but nonetheless genuine, such as greater efficiency of the price system, which results in a welfare-improving reallocation of resources.

Over the past few years, Bank of Canada Governor Gordon Thiessen

and other senior bank officials have stated the case for attaining and maintaining low inflation. In his speeches, many of which are reprinted in the *Bank of Canada Review*, Mr. Thiessen clearly recognizes that some benefits of low inflation — such as greater efficiency of the price system — are probably impossible to discern in the readily available data. He has also argued, however, an important benefit of low inflation is that it leads to a greater rate of economic growth and, through this channel, to an improvement in living standards. Consider the following example from the first year of his stewardship at the Bank of Canada, when Canada's inflation rate had been close to 2 per cent for two years:

> Why has price stability been chosen as the objective of monetary policy? The economy is more efficient, and this helps to support growth in output, high employment and rising living standards. (*Bank of Canada Review*, Summer 1994, p. 59)

Is it reasonable to expect low inflation to lead to higher output growth? This paper is aimed at answering this important question by reviewing and assessing the theoretical and empirical literature on the link between in-

flation and real economic growth. The objective is to determine whether it is reasonable, based on the theoretical arguments and empirical evidence, to expect lower inflation to lead to higher rates of real economic growth. My conclusion is that the current body of research in this area does not provide the basis for such an expectation. It is worth noting here my emphasis on theoretical and empirical research, for both are central to the design of economic policy.

I do *not* address three important issues here:

- The link between inflation and growth when inflation is very high. There is compelling evidence that inflation at this rate — such as 100 per cent a year or more — is extremely damaging to economies, not least in terms of reducing economic growth. But for most industrialized countries in recent years, the relevant policy issue is the link between inflation and growth when inflation is more moderate, say 10 per cent or less.

- The short-run or transitional effects on output associated with disinflation; the focus is only on the long-run link between inflation and growth.

- The possibility, discussed recently by Akerlof, Dickens and Perry (1996), Fortin (1996) and Hogan (1998), that low rates of inflation may permanently reduce the *level* of output (and raise unemployment) because of the inability of nominal wages to fall in the face of negative shocks.

These three omissions are intentional, but are not because I believe the omitted topics are unimportant; rather, these issues are avoided so this paper can have a sharper focus on the single issue of the long-run relationship between inflation and economic growth in moderate-inflation economies. In this sense, the paper addresses only the "long-term gain" part of the overall cost-benefit analysis that presumably accompanies any central bank's decision to reduce inflation.

Inflation and Growth in Theory

Permanent effects of inflation on the growth rate of real output require a model in which growth is endogenous; the standard neoclassical growth model with an exogenous growth rate cannot sensibly be used to address this issue.[1]

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, typically depending on the level of investment in physical or human capital. 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 here is on how this literature generates a link between inflation and the growth rate of real output.

In order to theoretically model the relationship between inflation and economic growth, 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.

A. Mechanisms for Endogenous Growth

There have been several approaches at 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 the law of diminishing returns does not eventually lead to a steady state in which 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 the marginal product of capital remains high so investment continues indefinitely, thus generating steady-state growth in per capita output.

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. Any exogenous event that changes the returns to either physical or human capital accumulation

will potentially affect the steady-state growth rate.

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

In an endogenous-growth model containing a CIA constraint or a TC function, the basic linkage between inflation and economic growth is as follows. Individuals hold money only in order to buy consumption goods and ultimately derive utility only from the consumption. Moreover, they hold money from period t to period t + 1 in order to purchase goods dated t + 1. They therefore hold money across time, and so inflation increases the cost of holding

such money. But since money must be held in order to buy consumption goods, an increase in inflation is tantamount to a tax on consumption. Finally, since all income is ultimately consumed over the person's lifetime, higher inflation lowers the after-tax real return from investments in 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 monetary linkage. The empirical significance of this linkage is questionable, however, especially in modern countries with moderate inflation. There are two reasons. One involves the changing nature of financial transactions and what this implies about the costs associated with holding money. The other involves the necessary elasticities of behavioural variables (such as work effort or human-capital accumulation) with respect to changes in income and/or relative prices.

- Costs of Holding Money. 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, these costs are unlikely to be significant.[2] If inflation were high *and* people held currency over significant intervals of time, there might then be a 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 relative to very high inflation. Moreover, the cost of withdrawing and transferring money is now so low that people can make their desired transactions while holding only small amounts of money for short periods of time. It is unlikely people hold enough money for long enough periods of time to make the tax from moderate inflation even noticeable, let alone significant.[3]

- Elasticities. The inflation-generated cost of holding money in endogenous-growth models acts as a tax. People respond to this higher tax by reducing work effort, reducing the accumulation of physical capital, or reducing the acquisition of human capital. For this to be an empirically meaningful mechanism for decreasing the economy's growth rate, the tax increase and the response to it must both be significant. I have argued the inflation tax itself is likely to be very small. The inflation-growth link then relies on the presence of substantial elasticities for work effort or capital accumulation. There is little reason, however, to think these elasticities are large, especially the elasticity of work effort. The empirical labour literature certainly suggests low wage elasticities for labour supply —see, for example, the exhaustive surveys by Killingsworth and Heckman (1986) and Pencavel (1986). Though casual evidence confirms university enrolments are

indeed sensitive to employment prospects, it is doubtful the acquisition of human capital would respond significantly if at all to the small costs moderate inflation presents as a tax on cash balances.

One final point about investment and the inflation tax 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 make most 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 an unlikely mechanism through which inflation might reduce investment and economic growth.

Inflation and Growth in the Data

The empirical literature on inflation and economic growth has taken two paths. The first 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 spurred by the rebirth of growth theory in the past decade, a second approach has evolved, examining data from a large cross-section of countries. Kormendi and Meguire (1985) is an early example; Fischer (1993) and Barro (1996a, 1996b) are more recent ones. I review both approaches in turn.

A. Time-Series Studies of Inflation and Growth

Jarrett and Selody (1982) examine the link between inflation and the growth of (labour) productivity in Canada using quarterly data for 1963-79. Their study places less emphasis on the underlying structural relationship between these two variables and instead focuses on the time-series correlations in a simple 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 one-percentage point permanent reduction in inflation 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."[4]

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 a one-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 pattern of Canadian inflation over the past few years, from a reasonably steady 5 per cent-6 per cent in 1990 to a reasonably steady 2 per cent (or less) in 2000. Is there a believable mechanism at work that could convert this four-point disinflation into a *permanent* increase in the annual growth rate of productivity of a full 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 main reasons to be sceptical:

- Robustness of the Results. Cameron, Hum and Simpson (1996) argue that the Jarrett and Selody results are not robust. Using data from the past four decades for Britain, the United States, Germany and Canada, they argue the inflation-growth relationship observed by Jarrett and Selody (which they replicate for each country) 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 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) approach of Jarrett and Selody (1982) is based on the detection of a cointegrating relationship — a stable long-run relationship — between inflation and productivity growth. As is often the case with time-series studies, however, no economic structure is included in the analysis. For example, there are no controls for variables that are usually viewed as influencing long-run growth, such as accumulation 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 difficult. Does an observed long-run relationship between inflation and growth indicate causality? Or is growth actually driven by 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 influencing 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) make this point in their response to the finding by Rudebusch and Wilcox (1994) of a significantly negative relationship between inflation and productivity growth in the U.S. Sbordone and Kuttner argue it would be natural to expect a negative relationship between inflation and productivity growth over the business cycle if firms hoard labour in response to short-run reductions in demand and if monetary policy affects output faster than inflation — both of which are familiar and relatively uncontroversial ideas among macroeconomists. The story is straightforward. Suppose the monetary authority detects pressures in the economy that will soon push up inflation. In response, monetary policy is tightened and the growth rate of output 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.

These three points suggest that the single-country time-series approach to uncovering the long-run link between inflation and growth faces two 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 policymakers' understanding of the *effects* 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 is to separate the long-run inflation-growth relationship from the much noisier short-run relationship. The relevant policy issue to 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 fundamental 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 using quarterly or annual data and, instead, 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 is that the use of 5- or 10-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.

B. Multi-Country Studies of Inflation and Growth

The underlying logic of examining data from many countries is that inflation is a sufficiently universal phenomenon, that if there is a significant causal link from inflation to growth, it should be detectable 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 suitably account 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 been a subtle change in this multi-country cross-section approach over the past decade. Beginning with Kormendi and Meguire (1985), the method 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 this approach in their empirical extensions of the Solow growth model. Though this pure cross-section approach is 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, more 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 well-known example. In what follows, I focus on Barro's work but it should be kept in mind that his results are broadly consistent with those of other researchers.

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:

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

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 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 long-term time-series variation existing within individual countries. This goes about as far as is practically possible toward addressing the concerns raised by Bruno and Easterly (1996, 1998). The X variables include the level of gross domestic product at the beginning of the decade (to examine the "convergence" hypothesis), investment and public expenditure as shares of output, several variables reflecting the extent of human capital in the population, 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 the inflation rate increases the growth rate of real per capita output. He finds a negative and statistically significant relationship between a country's average annual inflation rate and its average annual growth rate of real per capita GDP. Specifically, the estimated value of γ is about -0.025. His interpretation is that a policy-induced reduction in

the annual inflation rate of 10 percentage points would raise the annual growth rate of real per capita GDP by 0.25 percentage points.[6]

There are four concerns raised by this analysis. The first concern relates to the validity of Barro's interpretation of a *causal* link from inflation to growth. The second relates to the different types of countries in the sample. The third concern relates to whether his evidence pertains to the effect of inflation on the level or the growth rate of per capita GDP. The fourth is a more general point regarding the overall fragility of the empirical results in this type of international cross-section study.

- Endogeneity of Inflation. An important problem with estimating a regression like Equation (1) is that inflation is clearly an endogenous variable, being 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. Such 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: an index of a country's central-bank independence; lagged inflation; and a set of dummy variables indicating the colonial status of the country. He finds the central result (the estimated value of γ) is 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 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 difficult to find. Suffice it to say his 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 there is a need for a multi-equation approach and thus a more structural analysis.

- High-Inflation and Low-Inflation Countries. Even if one were convinced 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 and the U.S., which are both moderate-inflation countries. But the sample also contains countries like Israel, Brazil and Turkey —countries which, over many years in the sample, were much less sta-

ble 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, first, whether the inflation-growth link he uncovers is dominated by the inflation-growth link in high-inflation countries and, second, whether the experience of the high-inflation countries is at all relevant to the policy issue in moderate-inflation countries. As I argued in the introduction, it is easy to believe that countries with high inflation rates experience lower growth rates because of the dramatic demonetisation that extreme inflation typically causes. Does Barro offer any evidence in support of an inflation-growth rela-

tionship among a sub-sample of moderate-inflation countries?

As it turns out, the inflation-growth link he finds is indeed the result of the high-inflation countries. He 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 a 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 a 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 a year; while Judson and Orphanides put it 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 five-year periods whereas Judson and Orphanides use annual data.

- Growth Rate or Level of GDP? Even if one took Barro's empirical results at face value, it is not clear whether they are most relevant for determining the effect of inflation on the growth rate of per capita GDP or on the level of per capita GDP. At first glance, the estimation of Equation (1) clearly appears to be examining the relationship between inflation and

the growth rate of real per capita GDP. But recall that one of the right-hand-side variables is the (log of the) level of real per capita GDP at the beginning of the 10-year sample period. If we let y_t denote the log of real per capita GDP in year t, then the left-hand-side variable in Equation (1) is $y_t - y_{t-10}$ whereas one of the right-hand-side variables is y_{t-10}. In this case, it is easy to rearrange Equation (1) to show that γ — the coefficient on inflation — does not show the effect of a change in inflation on the growth rate of GDP but instead shows the long-run multiplier effect of a change in inflation on the *level* of GDP.[7]

One interpretation of Barro's empirical results, therefore, is that the growth effect of inflation is only transitory. The genuine effect of a reduction in inflation is to increase the level of per capita GDP, but this shows up empirically as an increase in the growth rate during the transition period to the higher level of real GDP. It follows that the cost-benefit case in favour of any given disinflation becomes weaker because there are not permanent growth effects. There may, indeed, be permanent effects on the level of GDP, the importance of which should not be downplayed, but such permanent level effects on GDP typically pale in comparison to the importance of even small permanent effects on the growth rate of GDP.

- General Fragility of the Empirical Results. I have mentioned three possible problems with Barro's empirical results, and what we should infer from those results about the probable relationship

between inflation and long-run economic growth. But plaguing this body of empirical work — by Barro and others — 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 lacks robustness.

Levine and Renelt (1992) make this argument forcefully. Using data from a large collection of countries, they show that of the many growth determinants suggested in the literature, almost none are robust to small changes in the conditioning set of variables. For example, if they are interested in examining the robustness of the inflation-growth relationship, they estimate many different regression equations, each with a different set of right-hand-side variables.[8] They then observe how the estimated coefficient on inflation changes across these different regressions. If the sign of the estimated coefficient changes, they deem the relationship to be non-robust, or fragile. Levine and Renelt find that for many economic variables, even economically "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 existing in such cross-section studies is that countries with higher investment rates tend to have higher growth rates. The effects of all other

alleged determinants of growth are found to be non-robust — the effect of inflation appears to be one of the more fragile.

There has been some criticism of their study. The main problem is that some of the regressions that are estimated may be worse than others in the sense that they provide a poorer overall fit of the variable to be explained. But Levine and Renelt treat all the equations as equally important when determining whether the variable in question is robustly related to growth. Sala-i-Martin (1997) provides an alternative version of the same basic exercise. He weights a regression more heavily if it provides a better fit of the data, and thus addresses to some extent this criticism. However, he still finds that inflation and economic growth are not strongly related in the data — that is, there is not a robust statistical relationship.

The foregoing discussion suggests there is no compelling empirical evidence of a link between inflation and growth. What evidence does exist is quite fragile. 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. They conclude that, at best, the existing empirical results "can be seen as uncovering the conditional correlation between infla-

tion and growth, with no meaningful interpretation and little or no implications for monetary policy or welfare."

In summary, the empirical evidence about the inflation-growth relationship is tenuous. There is certainly no compelling empirical evidence on which to base the expectation that lower inflation will lead to higher growth. Of course, a committed believer could argue that the growth effects of inflation have simply 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 is some 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.

Inflation, Taxation and Investment

Feldstein (1982) was probably the first to emphasize the importance of the tax system when thinking about the effects of inflation. Of particular importance is the way a firm treats its depreciation and inventory expenses. For tax purposes these expenses are computed on a historical-cost basis, rather than on replacement cost, although it is the latter that more truly captures the 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. This overstatement results in an increase in the effective corporate tax rate above the level that would exist in the absence of inflation, with the consequence investment be-

comes less profitable. The obvious implication is that in countries without indexed corporate income-tax systems, a reduction in inflation can be expected to lead to a rise in the level of investment.

This argument has been recognized by the Bank of Canada. The interaction of inflation and incomplete indexation forms the basis for an excellent paper by Black, Macklem and Poloz (1994), which examines the general welfare cost of inflation rather than the more limited issue of the inflation-growth relationship. It is clear in their model that lower inflation, through the mechanism just outlined, increases the flow of investment. But in their model, and more generally, it is not necessarily true that greater investment will lead to higher growth, even though it may lead to greater productivity and a higher level of real output. A permanent increase in the rate of investment will increase the capital stock and thus lead to a higher level of output, but whether it produces a higher growth rate of output depends importantly on the nature of the growth process.[9] For example, in some endogenous-growth models, where the rate of productivity growth depends on the rate of investment (especially in research and development activities), an increase in investment will lead to an increase in the long-run growth rate (see Barro and Sala-i-Martin, 1995, for a detailed discussion). In contrast, in a standard neoclassical growth model, a reduction in the tax on investment (which is effectively what happens when inflation falls and taxes are not indexed) increases the steady-state capital stock and the level of steady-state

output, but leaves the steady-state growth rate unaffected.

This last possibility provides an additional reason for thinking that the inflation-growth relationship discussed in the previous section — as small and fragile as it is — may overestimate the true relationship. If lower inflation does lead to an increase in the steady-state level of output, but the effect is gradual, then some of the empirically observed inflation-growth relationship may merely be capturing inflation's gradual effect on the level of output. If this is true, reduced inflation has even less to offer in terms of permanently higher growth rates.

As compelling as the general inflation-tax-investment argument is, it is surprising that there is no clear empirical evidence that lower inflation is associated with higher investment. In Barro's (1996a, 1996b) multi-country cross-section studies, for example, he finds a statistically significant negative relationship between inflation and investment (as a share of GDP) but, as with his inflation-growth results, he also finds the relationship is driven by the countries with high inflation rates. For moderate-inflation countries, even those with inflation as high as 25 per cent a year, there is no clear relationship between inflation and investment. To be fair, however, the focus of Barro's study was not on the implications of unindexed taxes. Indeed, the issue of inflation's effect on investment through the tax system appears to have attracted no empirical research. This would be a potentially fruitful area for future exploration.

There are two possible explanations for why there appears to be no clear empirical relationship between inflation and investment. The first is that, in most countries, the corporate tax system treats nominal interest payments as a deductible expense, rather than the real interest payments that are a truer measure of the economic cost. Through this channel, high inflation therefore leads to an overstatement of costs and an understatement of profits. This effect will offset to some extent the reverse effect working through depreciation and inventory expenses. The second possibility relates to including residential housing in measures of private investment. As inflation drives up nominal mortgage interest rates, the user cost of housing is tilted toward the present, and this will tend to reduce investment in residential housing. But in countries where mortage interest is tax deductible, the value of these deductions is also brought forward in time. The net result is uncertain, but it will surely complicate the relatively simple prediction that lower inflation leads to greater investment.

Conclusion

The theoretical literature provides no compelling reason for expecting lower inflation to lead to higher growth through inflation's effect on the cost of holding money. In a modern moderate-inflation economy in which people hold small amounts of cash for short periods, the "inflation tax" on cash balances is probably so small as to be dwarfed by the noise of everyday life. When combined with the inelastic responses of work effort or investment, this potential link between inflation and growth loses its plausibility.

The empirical literature is also unpromising for those wishing to argue the growth benefits of low inflation. There is no compelling evidence, coming from the time-series or cross-section approaches, that disinflation from moderate levels can be expected to lead to a permanently higher growth rate of output. Though some individual studies do suggest a negative relationship between inflation and growth, the evidence is not robust. It is almost impossible to view the time-series evidence as robust, since the searched-for long-term relationship is confounded by the presence of short-run fluctuations. Moreover, the absence of structure in these time-series studies precludes an interpretation based on causality, which is clearly at the heart of the relevant policy issue. The cross-section evidence is more promising, but even here the results are fragile. In particular, the observed negative relationship between inflation and growth is driven by the experience of the high-inflation countries. If the sample is limited even to countries with annual inflation rates less than 25 per cent — an upper bound much higher than most would consider "moderate" — there is no evidence of any relationship between inflation and growth.

At the beginning of this paper, I asked, "Is it reasonable to expect low inflation to lead to higher output growth?" My answer is that there is only one basis for such an expectation, but even here there is plenty of room for scepticism. There is good reason, in countries with an imperfectly indexed corporate income-tax system (such as Canada), to expect a

reduction in inflation to lead to an increase in the rate of investment. But whether this increase in investment results in higher output growth or just a one-time increase in the level of output is debatable, and depends crucially on the nature of the growth process — a process about which there is little agreement within the economics profession (see, for example, Lipsey (1996) for an extensive review of the various forces of technological change and long-run growth). Unfortunately, the theoretical link between inflation and investment does not seem to be visible in the data. Thus the foundation on which to base the expectation for higher growth following reduced inflation appears to be quite unstable. Having said this, there are two important caveats deserving of mention.

The first is to note that the empirical studies providing no compelling evidence of a link between inflation and growth also provide no compelling evidence of the *absence* of such a relationship. In terms of Barro's estimated Equation (1), the estimate of γ is insignificantly different from zero (at "conventional" levels of statistical significance), precluding the rejection of the null hypothesis that γ is equal to zero. But the imprecision of the estimate (the large standard error) also implies the estimate of γ is insignificantly different from 0.01 or -0.01. Quite different would be the finding that γ is precisely estimated to be so close to zero that we could easily reject the alternative hypotheses of γ being 0.01 or -0.01.

In other words, the imprecision of the estimated relationship between inflation and growth permits the argument that there may well be a "true" negative relationship between inflation and growth, but the current data and empirical techniques cannot pin down this relationship precisely. Indeed, this is the argument used by some economists who argue low inflation in Canada is still a sufficiently new phenomenon that the beneficial effects on growth have not yet had time to show themselves. Though this may be correct, it is equally logical to argue the opposite case—that there is actually a *positive* relationship between inflation and growth and the disinflation-induced reduction in growth has simply not yet revealed itself.

The second caveat relates to the conclusion one may be tempted to draw from this paper regarding the wisdom of the Canadian disinflation in the early 1990s. One might argue, since there appears to be no solid basis for expecting an increase in Canada's growth rate, that the disinflation of the early 1990s was unwarranted. After all, there were certainly some short-run costs imposed in the form of unemployment, bankruptcies, and so on. This conclusion, however, fails to recognize that higher economic growth is not the only benefit of reduced inflation. I have argued elsewhere — see Ragan (1998) and the references therein — that many of the benefits of low inflation are likely to be undetectable in the sorts of data economists typically have at their disposal. Low inflation leads to an improvement in the efficiency of the price system, as signals sent by changes in relative prices are more likely to be received as such rather than being misinterpreted as changes in the overall price level. Low and stable inflation may directly increase people's well-being as less time needs to be spent distinguishing real changes from nominal changes. Finally, low inflation may directly raise people's welfare for the simple reason that it reduces the extent to which they view themselves as being on an unpleasant economic treadmill, constantly running just in order to stay still.

These benefits of low inflation are genuine; and all cannot be observed in familiar types of data (and perhaps in any data). Though economists have stressed these "unobservable" benefits of low inflation for many years, the profession has spent much less time deriving methods to assess their empirical importance. Given the weak evidence regarding the relationship between inflation and growth, and thus the weakness of the argument that disinflation will stimulate growth, central bankers wishing to implement and defend a policy of disinflation should emphasize these unobservable benefits. To build the case for disinflation solely on the benefits of higher growth is to build it on an unstable foundation. Though it is surely more challenging to do so, central bankers would be on firmer ground to focus more of their effort on explaining and estimating these unobservable benefits of low inflation.

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Notes

1. The neoclassical growth model, however, does allow the possibility that inflation affects the economy's level of steady-state output. Many of the problems that plague the inflation-growth literature, however, 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.

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

3. This point is demonstrated in Cooley and Hansen (1989), albeit in a slightly different setting. They show in a conventional macroeconomic model with a CIA constraint that when individuals hold money for 3 months, the welfare cost of a 10-percent inflation is four times greater than when individuals hold money for only one month. Though the emphasis on this paper is on the growth effects of inflation rather than on the pure "welfare" effects, Cooley and Hansen's paper gives an indication of how important the length of money holding is to the results.

4. 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.

5. Kormendi and Meguire (1985) actually examine the relationship between output growth and the *change* in infla-

tion. 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.

6. Note that Barro's suggested effect of inflation on growth is an order of magnitude smaller than the effect suggested by Jarrett and Selody (1982), using admittedly very different samples and methods. As argued in the text, however, even Barro's more modest estimate probably overstates the magnitude of the inflation-growth link for moderate-inflation countries.

7. Let γ be the coefficient on inflation and δ the coefficient on lagged real GDP. Since both are estimated to be negative (the latter indicating convergence in GDP), the long-run effect on Δy from a one-percentage-point change in inflation is given by $-\gamma/\delta$. I thank a referee for pointing this out to me.

8. They also allow some variables to be present in all equations — variables for which there is a very broad consensus that they belong in the estimated equation.

9. One possibility is that the greater investment has a temporary effect on the growth rate of GDP as the economy adjusts to its higher permanent level of GDP. For the purposes of this paper, however, I refer to this as a level effect of inflation, not a growth effect.

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