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The Benefits of Low Inflation: Taking Stock

"A nickel ain't worth a dime any more" [Yogi Berra]

Brian O'Reilly

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ABSTRACT

This paper surveys the empirical literature on the benefits of low inflation, emphasizing contributions since 1990. It follows the framework of a section in the Bank's 1990 *Annual Report*, "The benefits of price stability." This framework looks at the costs of inflation, or the benefits of price stability, in the context of four themes: inflation creates uncertainty about the future; there are costs of having to cope with inflation; inflation affects equity and fairness; and 'living with inflation' is no answer.

In this survey, the section on each theme begins with a brief summary of the points raised in the article in the 1990 *Annual Report.* The empirical literature, including surveys, is then reviewed extensively enough to establish a context. This is followed by a discussion of those benefits of low inflation that have been well quantified in the relevant literature and those that have not; how the literature on this issue has advanced since 1990; and what areas might benefit most from more research in the future.

Overall, the empirical evidence on the nature of the relationship among inflation, inflation uncertainty, relative price variability, and output has made substantial progress since 1990. Although a consensus view cannot be said to exist on the basis of this survey, there are indications (especially in the work that allows for the interaction of inflation, money balances, and the tax system) that the gross benefits of low inflation are larger than thought at the beginning of the 1990s.

The papers surveyed here imply that the choice of an optimal inflation rate for monetary policy depends on (i) how well papers showing sizeable benefits stand up in future research; and (ii) the results of ongoing research on the magnitude and persistence of various costs.

RÉSUMÉ

L'auteur examine les recherches empiriques consacrées aux avantages d'un bas niveau d'inflation, en particulier les études menées depuis 1990, en faisant appel à la grille d'analyse retenue dans la section qui traitait de ces avantages dans le Rapport annuel du gouverneur de la Banque du Canada pour l'année 1990. Dans ce document, les coûts de l'inflation, partant, les avantages de la stabilité des prix, étaient regroupés sous quatre thèmes : l'inflation crée de l'incertitude au sujet de l'avenir; se protéger contre elle comporte des coûts; elle est source d'iniquité; composer avec elle ne règle rien.

Les parties du rapport technique consacrées à chacun de ces thèmes s'ouvrent sur une brève synthèse des points soulevés dans le Rapport annuel pour 1990. L'auteur examine les travaux empiriques, y compris ceux qui font un survol de la littérature, afin de bien situer le débat. Puis il examine lesquels parmi les avantages d'une faible inflation ont été correctement quantifiés jusqu'ici et passe en revue les progrès accomplis à ce chapitre depuis 1990 et les domaines sur lesquels on aurait intérêt à axer les recherches à l'avenir.

Dans l'ensemble, l'étude empirique de la nature des relations entre l'inflation, l'incertitude entourant celle-ci, la variabilité des prix relatifs et la production a beaucoup progressé depuis 1990. Bien qu'on ne puisse pas parler de consensus sur la foi des résultats obtenus jusqu'à maintenant, il existe des indications, surtout dans les travaux qui tiennent compte de l'interaction entre l'inflation, les encaisses monétaires et le régime fiscal, que les avantages bruts d'une faible inflation sont plus importants que ce que l'on croyait au début des années 90.

Avant de pouvoir tirer une conclusion concernant le choix du taux d'inflation optimal, il faudra attendre de voir si les études qui prêtent des avantages considérables à la stabilité des prix seront corroborées par les recherches ultérieures; les résultats des travaux en cours sur la taille et la persistance des coûts de l'inflation seront également déterminants.

1 INTRODUCTION, SUMMARY, AND CONCLUSIONS

The quotation in the title captures the essence of several problems with inflation and why people dislike it (Shiller 1997a). Inflation erodes the value of money in its roles as a unit of account and as a monetary standard. This is in contrast to most other activities where, once a standard is chosen, every effort is made to ensure that it is maintained (Konieczny 1994). Inflation creates confusion because, while one can recognize that a "nickel ain't worth a dime," it may be much more difficult to determine what it is worth and what it will be worth. The former problem deals with the role of money as a means of exchange while the latter affects money's role as a store of value. Even when people are told what a nickel is worth, there is evidence that they will confuse nominal and real values when questioned, unless the questions are framed in a particular way (Shafir, Diamond, and Tversky 1997). This should not be surprising since nominal values are used in tax and accounting frameworks and all other market activities, including those affecting savings and investment decisions. There is also some reluctance on the part of the public to use indexation (Shiller 1997b).

This paper reviews the empirical literature on the benefits of low inflation, particularly those contributions since 1990.[1] The paper follows the framework of the section, "The benefits of price stability," in the Bank of Canada's 1990 *Annual Report*. The discussion there looks at the costs of inflation, or the benefits of price stability, under four headings: inflation creates uncertainty about the future; there are costs of having to cope with inflation; inflation affects equity and fairness; and 'living with inflation' is no answer.

Each of the four themes is addressed in this paper, each section beginning with a brief summary of the points raised in the 1990 *Annual Report.* An overview of the theory or approach pertaining to that particular issue follows. The empirical literature in each area is reviewed selectively but extensively enough to establish a context. (Other references are given in the bibliography.) Then some of the relevant work on Canada—enough to give a sense of the debate or consensus—is considered. Each section ends with a discussion of those benefits of low inflation that have been well quantified in the literature and those that have not; of how the literature on this issue has advanced since 1990; and of those areas that might benefit most from more research.

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1. The qualitative case for low inflation is well summarized in Selody (1990).

Overall, the empirical evidence on the relationships among inflation, inflation uncertainty, relative price variability, and output has made substantial progress since 1990. While a consensus does not yet exist, there are indications that the gross benefits of low inflation could be greater than was thought at the beginning of the 1990s. This is especially evident in the work that allows for the interaction of inflation and the tax system. The evidence, even if viewed with some skepticism, would suggest that focussing monetary policy on a higher inflation rate would be counterproductive, now that the cost of achieving inflation in the 2 per cent range has been paid. The only reason to change this conclusion would be if the weight of the evidence suggested there were net benefits to operating the economy at a higher rate of inflation.

As for the evidence on what net benefits would suggest about the optimal inflation rate, Akerlof, Dickens, and Perry (1996) and Fortin (1996) express the view that inflation should be higher than its current level because of the existence of nominal rigidities. However, they have not proven their case. When combined with historical estimates of the costs of disinflation, the evidence from recent partial-equilibrium and general-equilibrium work (which incorporates the interaction of inflation with the tax system) suggests that inflation should be lower than its current level in steady state. However, it cannot be considered to be unequivocal proof.[2] It is uncertain what further work will provide clear enough results so that there is agreement on the optimal rate of inflation on the basis of its net benefits. At some point, the balance of the evidence may have to be looked at in a manner similar to that used by Black, Coletti, and Monnier (1998). This paper essentially weighs the evidence in the framework of a model of the Canadian economy. It shows the net benefits of low inflation in Canada to be positive when account is taken of the interaction of inflation, money balances, and the tax system—under various assumptions about the sources and magnitudes of the costs of disinflation and using various estimates of the benefits from the literature.

There has been more progress on the relationships between inflation and relative price variability or between inflation and inflation uncertainty than on establishing the link between these "noise" variables and output. For the first relationship, the menu-cost model appears to be empirically robust in the United States and Canada. This implies that this relationship is bidirectional and that, in a world of zero inflation, the distribution of price changes should become more

2. Both sets of "evidence" can be questioned and have been. On Akerlof, Dickens, and Perry, see Gordon (1996), Mankiw (1996), Groshen and Schweitzer (1997), and Hogan (1997). On Fortin, see Freedman and Macklem (1997) and Crawford and Harrison (1998). On calibrated general-equilibrium models, see Ragan (1997).

symmetric. For the second relationship (between inflation and inflation uncertainty), the empirical evidence suggests that it is positive, although some work finds inflation uncertainty increases mainly when inflation regimes change. In contrast, the empirical evidence is neither extensive nor strong on the relationship between either relative price variability or inflation uncertainty and output growth. A better understanding of the interrelationships among inflation, inflation variability, inflation uncertainty, and growth may help both in interpreting the existing empirical results and in designing experiments to measure the strengths of the various links.

As for the cost of coping with inflation, the benefit arising from the reduced need for individuals to replenish cash balances as frequently at low rates of inflation (lower shoe-leather costs of inflation) is estimated in the literature to be quite small, no matter what technique is used. However, as Howitt (1997) points out, this benefit of low inflation could still be economically significant if allowance is made for the public-good aspect of holding money (Laidler 1977) and for the spillover effect of inflation on all liquid assets, not just those in M1 (Fried and Howitt 1983). Further research should focus on how best to conceptualize these aspects for analysis in a more complete framework, perhaps within the context of a general-equilibrium model.

Another result of economic agents trying to protect themselves against inflation is the use of a greater number of productive resources in the financial sector than would be required with low or no inflation and given the fundamentals of the economy. The limited work on this question suggests that inflation increases the size of the financial sector in high-inflation countries but is equivocal for low- or even moderate-inflation countries. Further research here might involve first studying how the size of the financial sector is related to fundamental factors and then examining whether the actual size is what might be expected.

As for the effect of inflation on the physical costs of changing prices (the menu costs of inflation), direct estimates for some industry sectors suggest that the costs can be economically significant. From a broader perspective, though, the direct saving from menu costs is not considered as important as that achieved through improving the overall efficiency of the price system—when prices more clearly reflect the underlying demand and supply conditions. How exactly to capture this effect empirically needs more thought.

Significant progress has been made in one area in capturing some of the interactions of inflation with elements of the economic system. This is the area of

both partial- and general-equilibrium analyses of the interaction of inflation with the tax system. The estimates of the gross benefits of low inflation, no matter which approach is used, have evolved over time towards economically larger effects. In terms of partial-equilibrium analysis, Feldstein's (1996) work on the United States, which concludes that the optimal "true" inflation rate should be zero, has received support from independent work by Cohen, Hassett, and Hubbard (1997) on the effects of inflation on the user cost of capital in the United States. Feldstein's work has been replicated for Great Britain and Germany with similar conclusions being drawn. Further exploration of the robustness of the implication for optimal inflation (after allowing for measurement error) would entail applying his approach to Canada and other countries. With respect to work on general-equilibrium modelling, much progress has been made in the 1990s, especially in addressing fiscal questions, including the interaction of inflation and the tax system. The results of these models (e.g., Black, Macklem, and Poloz 1994; Bullard and Russell 1997) suggest that low inflation provides sizeable benefits. It would seem worthwhile to continue exploring the interaction of inflation and the tax system with these types of models, especially the sensitivity of the results to changes in key parameters of the underlying model, such as the elasticity of labour supply and the interest-elasticity of savings.

Time-series or cross-sectional analyses of the effect of lower inflation on the level of productivity or output, or on the growth in productivity or output, are fraught with many difficulties. The main common problems are the relatively few years of evidence on low inflation, the difficulty of controlling for various other factors (including the stage of the business cycle), and the lack of a clear understanding of the mechanism underlying the relationship. Cross-country work has to deal also with the various stages of development and the varying economic and institutional structures of the countries included in the analysis. The evidence is very clear that there are observable costs to high inflation but is much less clear about the benefits of moving from moderate to low inflation. Almost none of the studies, however, obtain a statistically significant positive coefficient on inflation. The most promising avenue for future research would be to develop a better conceptual understanding of exactly how inflation, inflation uncertainty, and inflation variability are related to the growth or level of output and welfare.

There is relatively little evidence on the question of the effect of inflation on equity and fairness. As a result, little can be concluded about this relationship. The literature in the 1990s raised the question of what the appropriate welfare measure should be. It noted in particular that use of income distribution could be very misleading because a number of factors could be at play. Absolute-income

measures or consumption-poverty measures, as opposed to income-poverty measures, were suggested as possible alternatives to use in time-series–type analysis. Survey results for Brazil, Germany, and the United States indicated that the general public sees inflation as leading to unfair situations that result in a lower standard of living. One avenue for future research into this question is to calibrate a heterogeneous-agent general-equilibrium model to some of the distributional as well as macroeconomic characteristics of the Canadian economy. Experiments could then be undertaken to better understand how inflation might affect the welfare of various groups.

The debate on whether indexation or price stability is the best way to address the inflation–tax-system interaction requires a clearer understanding of why full indexation was not introduced in the past in most industrial countries. From a conceptual viewpoint, indexation lowers the marginal cost of inflation. Hence, its adoption could undermine the credibility of the government's commitment to a low-inflation regime. Since governments in many industrial countries fought inflation conspicuously with variants of income policies, concern for their reputations may have been one of the reasons that indexation was not introduced. Technical and administrative costs of introducing such a major change to the tax system may have been another. Certainly at points in the post-WWII period, various bodies in the economy spent many resources to look at adjusting for the effects of inflation. However, market activities and their associated records continue to be mainly in nominal terms. This obviously implies that the costs of undertaking an initiative to adjust for inflation more than outweigh any perceived benefit. Another implication is that the best way to address this cost is to have as low an inflation rate as is consistent with the structure of the economy. Further research on this question might want to list, in as detailed a manner as possible, what might be the explicit and implicit costs of attaining full indexation.

2 INFLATION CREATES UNCERTAINTY ABOUT THE FUTURE

The part of the article in the 1990 *Annual Report* dealing with inflation creating uncertainty noted that decisions to buy or sell and to borrow or invest are based on both current and future prices, and inflation creates confusion about the information that these prices convey. As a result, there can be overinvestment in some products relative to the underlying demand for them and underinvestment in others with the resultant need for adjustment.

This section of the paper surveys the empirical evidence of a link between inflation and relative price variability, and between inflation and inflation uncertainty. It ends by addressing the evidence of a link between either relative price variability or inflation uncertainty and real output growth. Golob (1993) describes reasonably well the views on these various relationships up to the early 1990s. This survey is therefore drawn upon to summarize the status of the empirical work on each of these issues until then. The need, as noted in Golob's survey, to distinguish between relative price variability and inflation uncertainty remains, since an association between inflation and relative price variability does not necessarily imply a link with greater inflation uncertainty.

Relative price variability (or price dispersion) has to do with prices of goods and services changing relative to one another without there needing to be any change in the aggregate price level. This is generally measured as the dispersion of individual inflation rates with respect to aggregate inflation. A recurring theme in models that consider price dispersion is that it leads to the misallocation of economic resources (Friedman 1977). Inflation uncertainty describes the extent to which future inflation is unknown. Since uncertainty cannot be measured directly, the definition of inflation uncertainty can vary widely. Two broad approaches are (1) to base the definition on the dispersion of survey forecasts (surveys of forecasters, businesses, or consumers); and (2) to calculate uncertainty from an economic or statistical model.

2.1 Overview of theoretical foundations

With respect to the theoretical foundations of the relationship between inflation and relative price variability, Golob's taxonomy of three classes of models is as good as any other for identifying the main strands. The class of limited-information models implies that lower inflation would reduce relative price variability and improve economic efficiency (the "equilibrium misperceptions model" of Lucas (1973); the "sticky prices" contract model of Taylor (1981); or some fixed "menu cost" of price adjustments as in Sheshinski and Weiss (1977) or in Ball and Mankiw (1994a; 1994b; 1995)). The second class, models that are agnostic about the level of aggregate inflation, attributes the movement in inflation and relative price variability to a common shock (Fischer 1981). Finally, there are sticky-price models that imply economic efficiency may be reduced if aggregate inflation is too low (the "asymmetric price response" model of Marquez and Vining (1984) or the "nominal wage rigidity" model of Akerlof, Dickens, and Perry (1996)).

The usual assumption up to the 1990s was that the asymmetric stickiness assumed in some limited-information models was exogenous (Tobin 1972). However, recent work (Ball and Mankiw 1994b) treats this asymmetry as an endogenous response to inflation that would disappear if inflation were eliminated. Ball and Mankiw (1995) suggest that the skewness of the distribution of relative price shocks may also be an important short-run determinant of inflation, based on the menu-cost model of price adjustment. The testable prediction is that the skewness of the distribution of all relative price changes should outperform the relative prices of certain commodities in explaining inflation. Moreover, in the presence of trend inflation, the variance of relative price shocks will also be positively related to inflation in the short run. However, the influence on inflation would be the reverse of the more familiar idea that inflation creates variability in relative prices (Friedman 1977; Fischer 1981).

Concerning the theoretical foundations for a positive relationship between inflation and inflation uncertainty, Ball (1992) presents a model in which a rise in inflation raises uncertainty about future monetary policy and hence about future inflation. Instead of the effect of regime uncertainty, Holland (1993b) posits that agents are unsure about the price-level effects of a given change in the quantity of money because the length of contracts and the degree of indexation change over time. On the other hand, Devereux (1989) outlines a model where there is a positive correlation between inflation and inflation uncertainty that arises from real shocks. The initial uncertainty is about real shocks and an increase in this uncertainty results in higher uncertainty about inflation and lower wage indexation. The latter in turn leads policymakers to stimulate the economy because of their preference for higher output and the greater impact of monetary policy in a world with a lower degree of indexation.

Regarding the implications of increased uncertainty about inflation for real activity, Ragan (1994) asks what the impact on the economy would be if agents had unchanged expectations of inflation but were less certain about inflation. When the analysis is focussed on aggregate demand and the real interest rate, he concludes that there would be very small real effects of reduced inflation uncertainty. However, Ragan raises the possibility of larger real effects if there were lower costs of financial intermediation with reduced inflation uncertainty.

In the next two subsections of the paper, the empirical work on the relationships between inflation and relative price variability and inflation and inflation uncertainty is reviewed. Following those is a discussion about this work in the context of new developments in the 1990s and about the implications for future

research and for a low-inflation target. Finally, the evidence on the link of either relative price variability or inflation uncertainty with real activity is reviewed briefly.

2.2 Empirical literature: inflation and relative price variability

Interest in the relationship between inflation and relative price variability increased with high inflation in the 1970s, but it waned somewhat with low inflation in the 1990s. This subsection first presents Golob's (1993) conclusions on the relationship between inflation and relative price variability and then goes on to discuss the major empirical development in this area in the 1990s, the evidence on the menu-cost model.

Golob (1993) reports that different measures of relative price dispersion were used in the studies he surveyed. However, both weighted and unweighted variances of inflation in the components of the relevant-price measure, relative to aggregate inflation in it, were common. With respect to data, either consumer or producer prices were used at levels of aggregation that varied from one study to the next. The empirical work ranged from graphical or tabular analysis through formal tests of statistical significance, as opposed to structural models, so that no conclusive distinction could be made among various theories. As for results, Golob indicated the studies were not unanimous but his view was that there was substantial empirical evidence of a positive relationship between inflation and the variability of relative prices. The top part of Table 1 in Appendix 1, excerpted from Golob's paper, presents his evidence on the relationship between inflation and relative price variability.

As for evidence on the menu-cost model, Ball and Mankiw (1995) find strong support in U.S. data for the proposition that inflation is positively related to the skewness of the distribution of relative price changes. This is true both for simple correlations between inflation and skewness that control for the inertia in inflation, and in the context of estimated Phillips curves. Moreover, Ball and Mankiw find that, when they add their measure of skewness to an otherwise conventional Phillips curve that includes the relative prices of oil and food, the coefficients on these relative prices are close to zero and statistically insignificant. The coefficient on the skewness variable continues to be positive and statistically significant. In addition, they also find some evidence in their Phillips curves of an independent effect of the variance of relative prices on inflation. These empirical results are based on annual data, inflation is defined in terms of the producer price

index, and the distribution of relative price changes is computed for each year based on four-digit producer price index components.

Using Canadian data, Amano and Macklem (1997) find considerable empirical support for the predictions of Ball and Mankiw's (1994b; 1995) menu-cost model of price adjustment. In particular, Amano and Macklem find that the asymmetry in the distribution of disaggregated relative producer-price changes has considerable explanatory power for inflation. This exists both in the context of partial correlations and in price Phillips curves that control for other important influences on inflation. This is true whether they measure inflation using the GDP deflator, the CPI, or the CPI excluding food and energy. It is true for different measures of the degree of economic slack, and it holds when key relative prices are included separately in the Phillips curve. Indeed, by the standards of the Phillips curve literature, the importance of the asymmetry in the distribution of relative price shocks is one of the most robust features of aggregate price adjustment in Canada. This appears to reflect the fact that the skewness of this distribution contributes importantly to explaining inflation dynamics, particularly in key periods when inflation has changed rapidly.

In addition, Amano and Macklem's Phillips curve evidence suggests that the variance of the distribution of relative price changes also affects inflation. Since there is trend inflation in much of the sample, this finding is consistent with the prediction of menu-cost models that the variance of cost shocks will affect inflation in the presence of trend inflation. This Phillips curve evidence, together with the results from Granger-causality tests, suggests the presence of bidirectional causality between inflation and relative price variability.

2.3 Empirical literature: inflation and inflation uncertainty

Analysis of inflation uncertainty requires a model or strategy for estimating inflationary expectations. Early papers used the variability of inflation (usually the standard deviation over some time interval) as a proxy for uncertainty. This was inadequate as an uncertainty measure, and more sophisticated techniques developed that involved the use of either surveys or more formal statistical/economic models. The latter approach can take the form of forecasting models (in which the variance of the prediction errors is the measure of inflation uncertainty) or conditional heteroskedastic models (in which the conditional heteroskedasticity becomes the estimate of uncertainty). For some indication of the approaches used in the literature

surveyed by Golob (1993), see Appendix 1, Tables 2 and 3, the top sections of which are taken from his paper.

In characterizing the literature, Golob (1993, 22) generalizes that "empirical studies find that both survey and mathematical estimates of uncertainty are positively related to the level of inflation," but that "papers based on surveys have been more consistent in finding a statistically significant relationship than those based on mathematical models." On the robustness of survey evidence, Zarnowitz and Lambros (1987) demonstrate that results from the Livingston survey, which measures the consensus among respondents, are highly correlated with the results from the post-1968 ASA-NBER Survey of Professional Forecasters. Since the latter provides a direct measure of the uncertainty associated with individual inflation forecasts, and since it is individual uncertainty that should be used, the Zarnowitz and Lambros evidence supports the usefulness of the Livingston data in empirical research. According to Golob, both surveys show a strong positive correlation between uncertainty and the level of inflation.

Golob (1993) notes that different researchers give various reasons for the less-consistent results of the mathematical models. A positive relationship between inflation and uncertainty is more common when models with time-varying parameters are used to estimate uncertainty (Holland 1992); when the mean and serial correlation in inflation are allowed to vary over time (Evans 1991); when a Markov switching model for inflation is used (Evans and Wachtel 1993); and when long-term uncertainty is used.

Golob (1993) comments that there was little empirical work able to distinguish among the theories about the inflation–inflation uncertainty relationship. However, he says that the available evidence favoured the Ball (1992) theory that, at high inflation, the public does not know the tastes of future policymakers and hence has greater uncertainty. Holland (1995), using the Livingston survey as a measure of uncertainty, shows that higher inflation precedes increases in uncertainty but not the reverse. Brunner and Hess (1993) support this conclusion using a state-dependent conditional heteroskedasticity model.

Golob (1994b) uses four linear quarterly econometric models of the inflation process in the United States to demonstrate that inflation uncertainty (as measured by the innovations in econometric models) has been declining in both core CPI and the GDP deflator but not for the CPI or PPI. This is because energy prices have more weight in these latter indices and the volatility of energy prices has increased in recent decades. He confirms the "widely recognized" positive

relationship between inflation and uncertainty. Holland (1995) investigates, using Granger causality, whether an increase in inflation precedes an increase in inflation uncertainty. He concludes that it does for the postwar United States and, hence, that higher inflation uncertainty can be considered part of the welfare costs of inflation.

Batchelor and Dua (1996) compare a direct, ex ante measure of inflation uncertainty in the United States with a number of proxies used in empirical studies (forecasted standard deviations from ARIMA, ARCH, and structural models of inflation). The direct measure is the root mean-square subjective variance of the probability distributions for future inflation, constructed by respondents to the ASA-NBER surveys of U.S. economic forecasters. Batchelor and Dua find that the proxies are not significantly correlated with the direct measure or with one another and do not give the same results in regressions with the typical set of independent variables (past and expected inflation, past forecast errors, and a lagged dependent term). Batchelor and Dua conclude that use of such proxies leads to incorrect inferences about the correlation between inflation and inflation uncertainty and between inflation uncertainty and the real interest rate. As caveats, they mention measurement error and the possibility that their measure may be drawn from a group that is not representative of the relevant population.

With respect to countries other than the United States, Joyce (1995) estimates U.K. quarterly inflation uncertainty over 1950–94, conditional on a univariate specification of mean inflation using a variety of ARCH-related volatility models. Results reject the symmetry restriction imposed in standard ARCH and GARCH models, suggesting that inflation uncertainty is much more sensitive to "bad news." Preferred estimates of the conditional variance of inflation are found to be positively associated with the level of inflation. Sauer and Bohara (1995) find, for the 1966–90 sample period, that uncertainty about (steady-state) inflation is lower, less variable, and less persistent in Germany. German inflation uncertainty declines along with actual inflation whereas (long-term) U.S. uncertainty remains at high levels.

Ricketts and Rose (1995) apply Markov switching models to CPI inflation in the G-7 countries. They find that there is systematic evidence of a relationship between higher levels of inflation and higher volatility of inflation. Ricketts (1995) indicates that the Markov switching model provides for two types of uncertainty: (1) given the regime, uncertainty about the shocks to inflation within one of the states; and (2) the possibility of uncertainty about the state. With respect to the latter, Ricketts' work with the Canadian CPI shows two periods of extended uncertainty about the state: in the late 1960s when inflation began an upward trend,

and at the end of the 1980s. Ricketts (1996) makes similar points but suggests that it is difficult to say much about uncertainty at the end of the 1980s and in the early 1990s, given the introduction of the GST.

Crawford and Kasumovich (1996) report on tests of the hypothesis that inflation uncertainty increases at higher levels of inflation. The tests applied generalized autoregressive conditional heteroskedasticity (GARCH) techniques to two models of the inflation process in Canada: a simple autoregressive model and a reduced-form Phillips curve model. Crawford and Kasumovich find the link between inflation and its uncertainty to be somewhat model dependent with a significant positive relationship between inflation and inflation uncertainty in the autoregressive case but not in the reduced-form model. They suggest that the true relationship may lie somewhere between the two sets of results, given the extreme assumptions in each case. By excluding all explanatory variables other than past inflation, the simple autoregressive approach ignores some information that agents would have used to forecast inflation. Hence, this approach will tend to overstate the actual uncertainty faced by agents. Conversely, the reduced-form model may understate the uncertainty that existed, since the model implicitly assumes that agents had more information on the structure of the economy than was actually available at each point in time.

Hess and Morris (1996) discuss the costs of inflation uncertainty, real-growth variability, and relative price volatility and examine their empirical relationship with inflation. Hess and Morris conclude that inflation uncertainty, real-growth variability, and relative price volatility all tend to rise as long-run inflation rises from low to moderate levels. They believe that their results suggest that there are long-run benefits to keeping inflation from rising from even low levels.

Caporale and McKiernan (1997) apply a GARCH model to post-WWII monthly inflation data for the United States. They find a significant positive relationship between the level of inflation and its conditional variance (uncertainty). They claim that their results are robust to an alternative (ARMA) model of inflation and do not depend on the high-inflation 1970s.

Howitt (1997), looking at a number of indicators for Canada, notes that the level and volatility of the inflation rate have come down since 1990, making the process of taking decisions less uncertain over a longer horizon. As evidence, he cites the fall in the level and dispersion of inflation expectations, and in nominal interest rates; the lengthening of the average term of household mortgages; less

concentration at the short end of the market in business borrowing; a pickup in investment relative to output, and in investment in machinery and equipment relative to total investment; and a decline in strike activity.

2.4 Discussion of the work on the link between inflation and relative price variability, and inflation and inflation uncertainty

Golob (1993) suggests that the differing Granger-causality results for the relationship between inflation and relative price dispersion can be reconciled by accepting that causality runs from inflation to price dispersion except during periods dominated by major supply shocks. He specifically cites the oil shock of the 1970s. Recent work on menu-cost models by Amano and Macklem (1997) provides a different perspective. In their work, they control for changes in the relative price of oil, non-energy commodities, and the real exchange rate and still find their asymmetry variable to be significant. Their results suggest that the bidirectional causality is more complicated than that posited by Golob.

Bryan and Cecchetti (1996) argue that Ball and Mankiw's (1995) empirical evidence on the positive relationship between the skewness of the distribution of relative price changes and inflation is a statistical artifact since the mean and the skewness of the distribution of producer prices will be positively correlated by construction. Amano and Macklem (1997) use as their dependent variable in their Phillips curve work an inflation term not directly derived from the same series as their asymmetry variable. As a further test, they include as an independent variable in the Phillips curve regression an inflation variable derived from the same series as their asymmetry variable. They find that the asymmetry variable remains statistically significant. This suggests that the empirical evidence supporting the menu-cost model is more than a statistical artifact.

The main development over the 1990s in the empirical work on the link between inflation and relative price variability is the support given to the implications of the menu-cost model. To some extent, this development goes at least part way to address Golob's concern about being able to distinguish between theories on the relationship between inflation and relative price variability. However, it may not go far enough if there is not a clear understanding of why the costs exist in the first place. Kashyap (1995) argues that such an understanding is necessary for assessing how various types of changes might affect the extent to which prices are sticky. (Kashyap gives the example of increased automation of pricing decisions.)

As for the implications for the choice of how to define price stability, the logic of the menu-cost model suggests that there should be increasing symmetry in price changes in a world of low inflation (see Ball and Mankiw (1994b)). This would occur because agents could no longer rely on inflation to make the downward adjustments in real prices as in the past. Another aspect is that businesses have an incentive not only to work at keeping costs under control on an ongoing basis but also to change prices promptly in the face of situations where they cannot. It is unclear what will be the net effect of these changes on the frequency of price changes (and hence the slope of aggregate supply). It may not be such a bad thing from a conceptual perspective if the aggregate Phillips curve becomes flatter in a low-inflation world (see Ball, Mankiw, and Romer (1988)). The flattening of the Phillips curve implies that inflation control may be easier, since the adjustment to excess demand shocks is slower. This gives the monetary authority more time to assess the situation and to react. Whether this is true empirically is yet to be determined.

On the basis of his survey in the early 1990s, Golob (1993) concludes that there is substantial evidence that inflation is positively related to inflation uncertainty with the causality from inflation to inflation uncertainty. On balance, the recent work can be interpreted as supporting this conclusion. However, some of this work has raised the possibility that the relationship might be between changes in the inflation regime and inflation uncertainty. Positive relationships between inflation and inflation uncertainty, and between changes in inflation regimes and inflation uncertainty, have the same implication: less inflation uncertainty in a stable, low-inflation environment. Future research, covering more low-inflation years and based on alternative models of inflation that explicitly incorporate policy-regime uncertainty, might clarify whether inflation uncertainty increases with the level of inflation or with the change in inflation regimes, or with both.

2.5 The link to real activity

With regard to a negative relationship between real activity and relative price dispersion or inflation uncertainty, Golob interprets the evidence as stronger for inflation uncertainty than for relative price dispersion. He acknowledges several caveats around the empirical evidence such as the fragility of cross-country results (Levine and Renelt 1992) and the implications for the time-series evidence of the oil shocks, food shocks, and end of price controls in the 1970s. He notes the ambiguity in the theoretical work on the relationship between investment and inflation uncertainty, and between labour supply and inflation uncertainty. He

posits that some costs would not be detected (increased search costs, suboptimal choice of consumption goods) in linear regressions of output growth on price dispersion. Overall, he finds the empirical evidence of the impact of relative price dispersion and/or inflation uncertainty on the real economy to be inconclusive.

The literature reviewed here, especially the cross-country studies, is ambiguous about the impact of relative price variability and/or inflation uncertainty on economic activity. Cozier and Selody (1992) are very tentative about whether inflation volatility has a negative long-run effect on income per capita. Barro (1995) finds that inflation variability is not statistically significant when tested jointly with inflation. Judson and Orphanides (1996) use intra-year inflation data to construct an annual measure of inflation volatility. They find it is negatively correlated with growth in per capita GDP even after they control for the effect of the level of inflation. Using data on the United States and measuring inflation uncertainty by a state-dependent conditional-variance model, Lee and Ni (1995) find that inflation uncertainty has a highly significant negative correlation with real activity.

It seems fairly clear that regressions of per capita GDP on inflation and relative price variability and/or inflation uncertainty, even controlling for other relevant variables, are not going to resolve this issue. Indeed, it is possible to conceive of inflation uncertainty having a positive effect on growth even while inflation has a negative long-run effect, as shown by Dotsey and Sarte (1997). They build a simple monetary model to analyse the effects of inflation and inflation variability (inflation uncertainty) on growth. In their model, inflation variability tends to increase growth through a precautionary savings motive. This result and the high correlation between inflation and inflation variability lead to an attenuation of the negative long-run relationship between inflation and real growth. They conclude that this provides a partial rationale for the lack of robustness in cross-country regressions of growth and inflation. An obvious conclusion is that a better understanding of the structural underpinnings of the relationships among inflation, relative price variability, inflation uncertainty, and output would help both in designing empirical tests and in interpreting their results.

3 THE COSTS OF HAVING TO COPE WITH INFLATION

As for the costs of having to cope with inflation, the article in the 1990 *Annual Report* noted that entrenched inflation leads businesses and individuals to spend time and money to deal with its effects. This observation encompassed more than the need for more frequent revision and reissue of price lists and catalogues

(menu costs). Several other examples of costs arising from an inflationary environment were shorter contracts (and thus more frequent negotiations) so that parties are not locked into a situation where they can be hurt by unexpected inflation; greater difficulty for buyers in obtaining guaranteed prices of products for future delivery; an increased focus by investors on hedges against inflation rather than on productive investments; diversion of productive resources to the financial sector to provide shelter from the effects of inflation; higher interest rates due both to an inflation and an inflation risk premium; more front-loading of the payment burden of nominal contracts such as mortgage loans; a lower effective after-tax return on savings; and distortions in behaviour arising from the interaction of inflation with a corporate tax structure designed for a world with stable prices.

There are some costs due more to expected (or anticipated) inflation and others due more to unexpected (or unanticipated) inflation. Conceptually, these costs of inflation can be subdivided. The costs of anticipated inflation arise from such things as the need to economize on real money balances (shoe leather); the need to revise price lists (menu costs); the less-than-full indexation of the tax system (accounting distortions); and the less-than-full indexation of debt contracts (contractual distortions).[3] Contributing to the costs of unanticipated (uncertain) inflation are increased uncertainty from unplanned redistributions of income and wealth; overinvestment in real assets to hedge against inflation; less long-term investment because uncertainty about inflation discourages long-term contracts; higher risk premiums on financial instruments; uncertainty about future monetary policy; and misallocation of resources in markets and across time, because of greater uncertainty about changes in current and future relative prices.[4]

3.1 Gross versus net benefits of low inflation[5]

When examining the empirical literature on the benefits of low inflation, one has to distinguish between gross and net benefits. If there is not already a low-inflation regime, then there are usually costs associated with the disinflation

3. The shoe-leather benefit of eliminating inflation is the value society places on the extra money balances that would be held if inflation were at its optimal rate.

4. Another distinction sometimes made in the literature is that between an accumulation and efficiency channel. When inflation affects determinants of growth such as human capital or investment in research and development, it is acting through the accumulation channel. When inflation worsens long-run macroeconomic performance of market economies by reducing total factor productivity, it is acting through the efficiency channel.

5. I thank Tiff Macklem for allowing me to draw on his notes on the Bank of Canada conference papers reviewed in this section.

required to get there. In the bulk of the literature, these costs are usually assumed to be transitory while the benefits of low inflation are assumed to be permanent. There is, however, a literature that suggests the cost of disinflating, in terms of lost output and higher unemployment, gets larger and more persistent the lower the level of inflation from which the disinflation begins.[6] Another cost of lower inflation arises from the fact that inflation, as a tax, generates revenues for the government. These revenues are lost at lower inflation rates unless replaced by another tax; and the viable options are usually distortionary in their own right, although some less so than others. These revenue changes result not only from reduced seigniorage revenues but also from the large inflation-induced distortions in an unindexed or partially indexed tax system (taxation of nominal interest income, reduced value of historical cost accounting, and capital cost allowance for firms).[7] In those studies that derive estimates of the net benefits of low inflation, widely accepted estimates for various elasticities and the sacrifice ratio (the percentage decline in output associated with a 1 percentage point decline in inflation) are used and the sensitivity of the results to alternative estimates explored.

Recently, Tobin's (1972) lubricant hypothesis (that a certain rate of positive inflation is required to facilitate real wage adjustments in the economy) has been resurrected. (See Fortin (1996) and Akerlof, Dickens, and Perry (1996).) These papers argue that firms cannot reduce nominal wages except in extreme circumstances. This results in less downward flexibility in wages at low rates of inflation and a higher average rate of unemployment. Consequently, there is a long-run negative relationship between inflation and unemployment so that low inflation can be achieved only at the expense of permanently higher unemployment and lower output. This work implies that the costs of disinflation could potentially be much higher from low-inflation rates than the usual estimates drawn from recent disinflation experience (a flatter slope to the Phillips curve). The implications of the model for the U.S. economy are unproven and would seem to be contradicted by the current U.S. experience of low inflation and a low unemployment rate. For an overview and critique of the Akerlof, Dickens, and Perry model, see Gordon (1996), Mankiw (1996), and Hogan (1997).

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6. See Ball, Mankiw, and Romer (1988), and Yates and Chapple (1996).

7. Howitt (1997) dismisses the seigniorage revenues from inflation as being of any empirical importance in an advanced industrial country like Canada. Aiyagari (1997) makes the same point for the U.S. economy but then goes on to argue that, since foreigners and people active in the underground economy use or hold relatively large amounts of U.S. currency, lower inflation would implicitly transfer resources to them.

In his presidential address to the Canadian Economics Association, Fortin argues that the weak levels of economic activity in Canada in the 1990s, the "Great Canadian Slump" of his title, result from Canadian monetary policy targeting zero inflation.[8] After reviewing various structural factors and dismissing them as sources of the slump, Fortin concludes that the interaction of the financial authorities emphasizing too aggressive an inflation target with an institutional rigidity in the labour market (resistance to nominal wage cuts) imposed permanently higher unemployment on the Canadian economy. Freedman and Macklem (1997) review Fortin's arguments and conclude that it is not all a demand-side story as argued by Fortin. Freedman and Macklem outline the pressures on private sector producers to restructure; note the need to focus on the government debt, as opposed to just the deficit; and provide their interpretation of interest rate movements during the late 1980s and the 1990s. They indicate the importance of unexpected developments in the economy and of market-driven movements arising from political, fiscal, and foreign economic developments.

With respect to evidence on downward wage rigidity in Canada, Crawford and Harrison (1998) look at a variety of data sources. Beginning with union wage settlements, they find more wage freezes at lower rates of inflation than at higher. However, the extent of this effect is much smaller in the private sector than the public sector. The wage data are for the base wage rates for union wage settlements for bargaining units of greater than 500 employees. Crawford and Harrison put a reasonable upper bound on the excess number of wage freezes in the union wage data in the 1990s at between 10 to 15 per cent in the private sector. This estimate is based on a comparison of fitted hazard functions at 6 per cent and at 2 per cent inflation. When they use alternative data sources to gauge the flexibility of nominal wages in the non-union sector, including the potential to adjust total compensation without changing the base wage rate, they find evidence that union wage settlements understate the overall flexibility in compensation costs in the private sector. Each of the data sources provides only partial information, but together they suggest that (i) wage freezes are less frequent in the non-unionized sector and wage rollbacks more frequent, and (ii) variable compensation (bonuses) makes a significant contribution to flexibility in the overall compensation structure of firms of all sizes.

8. As Freedman and Macklem (1997) point out in their comment on Fortin's address, the Bank and the government during the period under consideration were targeting low rates of inflation, not zero inflation.

On the question of whether the slope of the Phillips curve changes at lower rates of inflation, Dupasquier and Ricketts (1998) consider several different types of non-linearity or asymmetry that may arise in the short-run Phillips curve, and examine the evidence for each using data for Canada and the United States. They find that the non-linearity with the most support in the data is the capacity-constraint–type of convexity. This non-linearity implies that inflation will rise more in response to excess demand than it will fall in response to an equivalent amount of excess supply. But, it suggests that there are no additional costs to disinflation starting from low-inflation rates relative to starting from high-inflation rates. However, they also find that, particularly in the case of Canada, the data have some difficulty in distinguishing between alternative types of non-linearity. For some specifications, there is evidence that the short-run Phillips curve gets flatter at low rates of inflation, holding the formulation of expectations constant. The results of subsequent research by Dupasquier and Ricketts (1997) lend more support to the view that there may be more than one non-linearity at play. Specifically, they find evidence of both an asymmetry in the Phillips curve arising from capacity constraints and a reduction in the slope of the Phillips curve as inflation declines. While a flatter short-run Phillips curve will tend to increase the costs of further disinflation, it will also tend to increase the benefits; since, once the lower rate of inflation has been achieved, inflation will tend to be more stable because it will be less sensitive to the output gap.[9]

Another perspective on the relative merits of the lubricant hypothesis is provided in Groshen and Schweitzer (1997). They use a 40-year panel of wage changes made by large mid-western U.S. employers to investigate whether inflation-induced distortionary price and wage fluctuations (sand) can be distinguished from fluctuations associated with inflation facilitating adjustments to shocks when wages are rigid (grease) in a labour market. Their strategy is to consider inflation-induced deviations among employers' mean wage changes as unintended intra-market distortions (sand); while inflation-induced, interoccupational wage changes are taken to reflect intended alignments with intermarket forces (grease). They find support for the identification strategy and that occupational wages in large firms gained flexibility in the last four years (1993–1996). Their results support other findings that grease and sand effects exist but suggest that they offset each other in a welfare sense and in unemployment

9. Tessier's survey of the literature leads him to conclude that a disinflation towards price stability tends to increase the sacrifice ratio but that there is no empirical evidence that indicates nominal wage rigidity emerges in a period of low inflation. These two conclusions together lead him to suggest that something other than nominal wage rigidity is required as an explanation for the first conclusion although he notes that there are major identification problems to be overcome.

effects. At levels up to 5 per cent, the net impact of inflation is beneficial but statistically indistinguishable from zero; above 5 per cent, it turns detrimental. The net benefits of inflation, when positive, never exceed a tenth of gross benefits. Groshen and Schweitzer (1997, 29) state that their results "buttress the conclusion that low-inflation regimes may not raise unemployment or impair the smooth functioning of labor markets." They conclude that the net labour-market benefits of inflation are an order of magnitude smaller than the gross estimates of the grease effect "because of inflation's simultaneous sand effects. . . . Thus, the labor market provides little guidance on which inflation goal to choose in a low-inflation regime."[10]

An extension of the lubricant hypothesis to financial markets is Summers' (1991) argument that some inflation is needed to allow real interest rates to go negative for stabilization reasons. Since the real interest rate is just the nominal interest rate less the expected inflation rate over the relevant holding period, and nominal interest rates do not usually fall below zero, the implication is that there has to be some inflation (Summers suggested 2 to 3 per cent) if a negative real interest rate is desired. The empirical results to date suggest that the Summers effect does not lead to a quantitatively important cost to low inflation. This conclusion is reinforced by the fact that monetary stimulus may come more through asset prices and the exchange rate at low interest rates and that it may come through fiscal policy.

Black, Coletti, and Monnier (1998) consider the implications of the nominal interest rate having a floor at zero (the Summers effect) using stochastic simulations with the Bank of Canada's Quarterly Projection Model (QPM). For reasonable parameter choices (in particular an equilibrium real interest rate of 3 per cent), they find that a lower bound of zero on the nominal interest rate has only minor implications for an inflation target range with a midpoint as low as zero. However, if the inflation target is more than 1 per cent below the nominal interest rate floor, then the implications of the Summers effect become economically significant in their simulations.

With many industrial countries having paid the price to reach inflation of around 2 per cent, the midpoint of the inflation-control target range in Canada, the most pressing policy question should be whether there still remain net benefits from going to even lower inflation. A line of research related to recent inflation

10. Mishkin and Posen (1997, 12) state, "in labor markets, Groshen and Schweitzer (1996) calculate that the loss of output due to inflation of 10 percent (compared with a level of 2 percent) is 2 percent of GDP."

experience addresses the question whether several years of low inflation have increased the credibility of the monetary authority such that the costs of further disinflation would be less than indicated by historical experience.

Johnson (1998) uses survey measures of expected inflation from 1984 to 1995 to provide some evidence on the credibility of monetary policy in 18 countries, including Canada. A first result of interest is the apparent endogeneity of the decision to adopt inflation targets. For the full 1984–1995 sample, the inflation-targeting countries occupy six of the seven highest slots in terms of the variance of the inflation forecast errors. The clear suggestion is that countries with poor inflation-control records turned to targets. Among the inflation-targeting countries, Canada and New Zealand have the most credible targets. Johnson also finds that the package of policies associated with inflation targets did substantially reduce the variance of forecast errors in the inflation-targeting countries as a whole, suggesting that targets have had some success. However, the reductions in inflation in the 1990s in the non-inflation–targeting countries are associated with a decline in the forecast error variance in those countries. As a result, while credibility has increased (by Johnson's measure) with the move towards low inflation, it is difficult to draw firm inferences about the extra contribution of inflation targets. Further evidence on this question is provided in Perrier (1997) where Johnson's methods are applied to data on inflation forecasts from the Conference Board's *Survey of Forecasters*. Perrier's results suggest that monetary policy has achieved an appreciable degree of credibility and that the establishment of the inflation-control targets has likely contributed to making inflation more predictable.

St-Amant (1997) reports that the empirical literature to date suggests that maintaining inflation over time at a rate consistent with the announced targets may change the inflation process but that no announcement effect on inflation expectations has been found. There is also no evidence that announcing targets has reduced the cost of disinflation. However, St-Amant sees the evidence as suggesting that announcing inflation targets has reduced uncertainty in the financial markets, especially for those countries that have adopted targets after having had discretionary monetary policy.

3.2 The empirical evidence on the link between inflation and output

The burgeoning empirical literature on the relation between inflation and output growth, and between inflation and the level of output, is focussed on discovering first the robust stylized facts and then the structural explanation, if any, that underpins them. A number of studies attempt to get a direct measure of some of the costs associated with inflation, in particular menu costs. However, most studies rely on one or more of the following: back-of-the-envelope calculations, single-country analyses, cross-country analyses, and general-equilibrium modelling to generate empirical estimates.

Back-of-the-envelope calculations for individual countries draw on previous empirical work on money demand equations or other demand equations (for savings and housing investment). The calculations estimate the deadweight loss area (the area of unsatisfied demand) under (i) the money demand curve (shoe-leather costs) or (ii) the demand curves for various sectors of the economy arising from inflation and tax interactions. The single-country and cross-country analyses use either time-series data and techniques for a particular country or group of countries, or data averaged over time for each one of several countries in a cross-country panel. General-equilibrium models obtain their key parameters from the literature and are usually calibrated to the economic characteristics of a particular country. The general-equilibrium models are simulated to verify the reasonableness of the calibration and to obtain results for comparisons of steady-state output or welfare measures under different inflation rate assumptions. Several papers calculate the net benefit from lower inflation by netting the present value of the gain from lower inflation against the present value of the cost of achieving it. Empirical estimates from a large number of studies organized by empirical approach are given in the tables in Appendix 2, which are excerpted from Black, Coletti, and Monnier (1998).

The above approaches have been used in the empirical literature in assessing the benefits of low inflation: reducing shoe-leather costs; reducing that part of the financial sector due solely to the need for people to protect themselves against inflation; lower menu costs; lowering the cost arising from the interaction of inflation with an unindexed or partially indexed tax system; increasing the level of productivity and/or output; and increasing the growth in productivity and/or output. Selected papers that give a sense of the status of the empirical literature since 1990 are discussed below.

To provide a common basis of comparison, the equivalent variation estimates of Black, Coletti, and Monnier (1998) are used where available, often in addition to the results as reported in the original study. Equivalent variation (hereafter EV) is the proportional increase in consumption that the household would require in each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state. Note that the equivalent variation numbers are expressed as the per cent change in consumption for a 1 percentage point change in inflation.

3.2.1 Empirical estimates of the shoe-leather costs of inflation

Shoe-leather costs traditionally arise from considering real money balances as a consumption good and inflation as a tax on real balances (Bailey 1956; Friedman 1969). The welfare cost is then measured by the appropriate area under the money demand curve with the cost of inflation depending on how much the demand for money varies with the nominal interest rate. The cost will be positively related both to the rate of inflation, reflected in the nominal interest rate, and to the sensitivity of money demand to the interest foregone as a result of holding cash.

Back-of-the-envelope (partial-equilibrium) and general-equilibrium approaches have been used to obtain estimates of the shoe-leather costs of inflation. Estimates from both approaches are very sensitive to the specification of the money demand function and to the chosen definition of money (monetary base or M1). The back-of-the-envelope estimates assume that real income, real wealth, and the real rate of interest are unaffected by inflation. These estimates of the cost of inflation range from a low of 0.016 per cent (EV), as calculated by Howitt (1990) using Boothe and Poloz's (1988) estimated Canadian narrow monetary aggregate (M1) demand function, to a high of 0.12 per cent (EV) as estimated by Eckstein and Leiderman (1992) for Israel (see Table 2 in Appendix 2).

General-equilibrium models take into account distortions due to economic agents responding to inflation by substituting into leisure or devoting productive time to economizing on cash balances. Major issues in interpreting their results hinge on the key elasticities embodied in the model (e.g., the elasticities of saving and labour supply), on their calibration to the characteristics of the economy that they are supposed to represent, and on whether they assume exogenous or endogenous growth. The estimates of the welfare costs of inflation from general-

equilibrium models range from a low of 0.003 per cent (EV) in Gomme (1993) to a high of 0.5 per cent (EV) in Marquis and Reffett (1994).[11]

- **Some studies using back-of-the-envelope calculations**

Howitt (1990) examines the effect of inflation on the Canadian economy and addresses the question of what the long-term inflation rate should be in Canada. He uses a money demand equation from Boothe and Poloz (1988) to estimate the shoe-leather costs of inflation and arrives at an estimate of one-tenth of 1 per cent of 1988 GNP for a decline in inflation from 9 per cent to zero. (This equals 0.016 per cent in equivalent variation terms for each percentage point reduction in inflation; see Table 2 in Appendix 2.) He then notes that this is likely underestimated since money is a public good and the effects of inflation are "likely to be spread by a chain of substitution going beyond M1 to the holding of all liquid assets." Thus, "the shoe-leather cost of inflation may be important even in a world where, as appears to be happening, M1 is a shrinking component of the overall financial system" (Howitt 1990, 75).

Carlstrom and Gavin (1991), in a similar exercise for the U.S. economy, use a partial-equilibrium analysis to show that the loss associated with a money-induced recession is of the same order of magnitude as the gain attributable to reduced shoe-leather costs if the inflation rate were reduced from 4 per cent to zero. They assume that the transition costs of disinflating from 4 per cent to zero would be the same as in the early 1980s when inflation was reduced from 8 to 4 per cent. Carlstrom and Gavin measure the transition costs as the accumulated deviation of consumption from its trend level over the period from the beginning of disinflation in 1979 until consumption returned to its trend level in 1985. To calculate the gain from the elimination of shoe-leather costs, they use the monetary base and data as of 1991 for the key terms (the income velocity of the monetary base, the real interest rate, and the semi-elasticity of money demand). They estimate that the reduction in deadweight loss would be about 0.06 per cent of GNP per year (0.023 per cent in EV terms). They note that, if the long-run income elasticity of money demand is about 1.0, the benefit would grow approximately one-for-one with the economy. Thus, the present value of the gain would be some 8 per cent of current GNP. For both the disinflation costs and the shoe-leather benefits, Carlstrom and Gavin undertake sensitivity analyses. They also indicate explicitly that they assume the resources needed to replace the lost revenues of lower inflation are negligible.

11. As reported in Gillman (1995).

Overall, they conclude that the costs of disinflating and the shoe-leather costs are of the same order of magnitude even though the shoe-leather costs of inflation are small compared to other costs such as the interaction of inflation with the nominal tax system. (They mention bracket creep and the taxation of nominal interest income.)

- **Some studies using a general-equilibrium approach**

The partial-equilibrium approach, using the area under the money demand function, holds real output constant and allows the velocity of money to respond to inflation. In comparison, the general-equilibrium models of Cooley and Hansen (1989; 1991) hold the velocity of money constant and have output respond to inflation. Their model incorporates money using a cash-in-advance (CIA) constraint. Output responds because inflation acts as a tax on consumption and lowers the return to working. In equivalent variation terms, Cooley and Hansen's results for the tax on money balances range from 0.01 to 0.04 per cent (EV) depending, respectively, on whether they are using base money or an M1 definition of money. When they take into account the inflation–tax interaction in addition to the tax on money balances, their equivalent variation results rise to 0.10 per cent.

The Cooley and Hansen CIA model is extended in Gomme (1991) by endogenizing growth along the lines of King and Rebolo (1990). This extended model is driven by the accumulation of human capital. Gomme finds that eliminating 10 per cent inflation leads to less than 0.01 percentage point gain in the growth rate of output (0.003 per cent in EV terms). In Gomme's model, efficient allocations satisfy the condition that the marginal value of the last unit of today's consumption equal the marginal cost of the last unit of work. A rise in the inflation rate leads to the marginal value of today's last unit of consumption falling so that people have to work less. This leads to a decline in the marginal propensity to consume and lower capital accumulation. Gomme's model does not incorporate the savings from the lower transactions costs associated with lower inflation.

Compared with both the above researchers, Black, Macklem, and Poloz (1994) obtain significantly larger results for the effect of the tax on money balances: 0.3 per cent (EV, exogenous growth) to just under 0.5 per cent (EV, endogenous growth). Their simple general-equilibrium growth model incorporates a standard interest–elastic money demand function for the M1 monetary aggregate. This demand function is motivated through a fairly general transactions-costs technology, of which cash-in-advance is a special case. Black, Macklem, and Poloz see their model as capturing the general-equilibrium effects of both the traditional

welfare costs of Bailey and the inflation-induced, labour-leisure distortion of Cooley and Hansen (1989); hence the higher welfare estimate.

Dotsey and Ireland (1996) present a general-equilibrium monetary model in which inflation distorts a variety of marginal decisions by acting as a tax on money balances. Together, the distortions yield substantial welfare cost estimates. A sustained 4 per cent inflation, such as that experienced in the United States since 1983, costs the economy the equivalent of 0.41 per cent of output per year (0.13 per cent in EV terms) when currency is identified as the relevant definition of money. It costs over 1 per cent of output per year (0.25 per cent in EV terms) when M1 is defined as money.

3.2.2 The effect of inflation on the size of the financial sector

Rather than addressing the shoe-leather costs of going to the bank more often, English (1996) focusses on the increased production of financial services by financial firms. In his model, households must make purchases either with cash or with costly transaction services provided by firms in the financial services sector (e.g., credit or debit cards or other methods of paying without cash). With higher inflation, households substitute purchased financial services for money balances so that the financial services sector gets larger. Testing the model with cross-sectional data (up to 73 countries), English finds that the size of a nation's financial sector (measured either as the financial sector's share of GDP or employment) is strongly affected by its inflation rate. For example, he reports that a 10 per cent inflation rate in the United States would increase the share of GDP produced in the financial sector by about 1 1/2 percentage points. English points out that the results are driven by the experience of a few high-inflation countries. He then goes on to note that institutional inertia or non-linearities could limit the expansion of the financial sector in the face of moderate inflation, hence lowering their costs below his results. However, he indicates that other factors that would raise his cost estimates (e.g., shoe-leather costs, non-financial sector production of financial services, and inflation-related distortions affecting consumption, investment, and labour decisions) have not been taken into account in his work.

3.2.3 Direct estimates related to menu costs

Menu costs, like shoe-leather costs, require economic agents to change their behaviour in the face of inflation. Essentially, inflation should lead price-setters to

change their prices more frequently, resulting in more uncertainty about prices on the part of consumers, whether businesses or households. While some studies provide direct estimates of the cost of changing prices, usually for a group of companies in an industry sector, other studies look at the history of price changes to provide suggestive evidence. For example, studies have characterized the profile of pricing behaviour by surveying companies on their price-setting practices (Hall, Walsh, and Yates 1997), by analysing the historical evolution of the prices of a selected group of commodities (Kashyap 1995), or by measuring the cost of changing prices using estimates of the costs of such activities in a store or group of stores (Levy, Bergen, Dutta, and Venable 1997).

The results of a Bank of England survey in autumn 1995 to investigate the price-setting behaviour of 654 U.K. companies (heavily weighted to manufacturing firms) are presented in Hall, Walsh, and Yates (1997). There was considerable evidence of price rigidity with the median company reviewing its prices monthly but changing them only twice a year. While saying that market conditions are of primary importance in price determination, Hall, Walsh, and Yates note that many companies set their prices on the basis of cost plus a markup. Survey respondents said that the physical menu costs of changing prices were a less important source of price rigidity than the need to preserve customer relationships or market share.[12] Hall et al. interpret the results as saying that time-dependent pricing rules (prices reviewed at discrete time intervals) are more widespread than state-dependent pricing rules (no routine pricing review but prices changing when a sufficiently large change in market conditions occurs).[13] Indeed, they conclude that the results indicate that the short-run response of companies to a change in demand is to adjust output rather than price. For the results of the earlier survey on U.S. companies that Hall, Marsh, and Yates drew on when designing their survey, see Blinder (1991).

Looking at data on price changes for a selected set of goods, Kashyap (1995) analyses the size, frequency, and synchronization of price changes for 12 retail goods over 35 years. He reports three basic findings: (1) nominal prices are fixed for a year on average but the time between changes is very irregular; (2) prices

12. As Hall, Walsh, and Yates note in their footnote (23), the theoretical literature on menu costs indicates that small menu costs can have large effects on economic welfare. They cite Mankiw (QJE 100, 1985) and Akerlof and Yellen (AER 75, 1985). The costs to the company are those of changing output as demand changes but there is also a cost to the company's customers who cannot fully satisfy their demand for the good because the price is rigid.

13. For an application of a state-dependent model to Canadian data, see Dahlby (1992). Dahlby cites and uses the Sheshinski-Weiss (1977) model of costly price adjustment to investigate the pricing behaviour of 69 firms in the Alberta automobile insurance market over the period 1974–82. Ball, Mankiw, and Romer (1988) present a time-dependent model of menu costs.

change more often during periods of high overall inflation; and (3) when prices change, the size of the change is widely dispersed. With respect to the last point, Kashyap points out that the price change for the same item is often both “large” and “small”; that the size of the changes does not depend on overall inflation; and that small price changes are quite common. He observes that models that generate price rigidity by assuming a constant cost of changing prices in an otherwise stationary environment cannot explain his data. His interpretation is that modellers cannot use menu-cost models without having a clear understanding of what is creating menu costs.

Another approach in estimating menu costs is to use store-level data, as do Levy, Bergen, Dutta, and Venable (1997) for five multi-store chains, to document the exact process of changing prices and to measure menu costs directly. They show that changing prices is a complex process, requiring dozens of steps and a non-trivial amount of resources. The menu costs average $105,887 per year per store, comprising 0.70 per cent of revenues, 35.2 per cent of net margins, and $0.52 per price change. They suggest that these menu costs may form a barrier to price changes. They give the specific example of the supermarket chain in their sample that faces higher menu costs due to item-pricing laws that require a separate price tag on each item. As a result, it changes prices two-and-one-half times less frequently than the other four chains. Moreover, they note that within this chain the prices of products exempt from the law are changed over three times more frequently than the price of products subject to the law. The implication would seem to be that legislative or regulatory changes or some way of automating around them could significantly change menu costs.

3.2.4 Interaction of inflation, the tax system, and money balances

Inflation reduces the real after-tax return to savers because taxes are paid on the component required to maintain the real value of the asset. As a result, the allocation of consumption over time is distorted from what it would otherwise be, leading to a welfare loss. In back-of-the-envelope studies, the welfare costs are obtained by evaluating the appropriate area under the individual’s relevant compensated demand curve. In general-equilibrium models, an effort is made to incorporate the salient features of the tax system and the way they affect the behaviour of economic agents. The major issues with interpreting the results are as noted above. Moreover, welfare results are usually derived from a comparison of steady-state results at different inflation rates and so do not address the question of transition costs.

Both types of studies indicate higher welfare costs from the interaction of inflation, the tax system, and money balances than do those studies that focus solely on the tax on money balances. For back-of-the-envelope calculations, the lowest estimate is 0.14 per cent (EV) while the highest is 0.71 per cent (EV) (Table 1, Appendix 2). The results of general-equilibrium studies range from 0.10 per cent (EV) to 1.84 per cent (EV) with the lowest number coming from the most dated study and the highest number from the most recent study (Table 6, Appendix 2).

- **Some studies using back-of-the-envelope calculations**

In looking at the United States, Feldstein (1996) examines the distortion that occurs in the process of household capital accumulation because of the interactions of inflation, the tax system, and money balances. Feldstein assumes fully anticipated inflation, treating it as an additional tax on consumption and housing purchase decisions, as a direct tax on money, and as lowering the debt service costs of the government. He adds together his estimates of the net welfare gains of lower inflation (net of the impact on government revenues), arising from the reduction in distortions in decisions on consumption (savings) and housing purchases; of the reduced shoe-leather costs associated with money demand; and of the effect on debt servicing costs. His preferred estimate of the net annual deadweight loss of a 2 per cent inflation is 1 per cent of real output (equals 0.7 per cent in EV terms). He provides six estimates under different assumptions about key variables, almost all of which show a welfare gain from lower inflation. Feldstein notes that this annual gain continues forever and grows at the same rate as GDP (about 2 1/2 per cent a year). This implies, using his preferred estimate, a present value gain of close to 40 per cent of the initial level of GDP using his discount rate of 5.1 per cent. Since he estimates the cost of shifting from 2 per cent inflation to price stability as about 5 per cent of GDP, he concludes that optimal inflation should likely be zero after excluding the measurement bias (assumed to be 2 per cent per year for consumer price index inflation). Feldstein uses conservative estimates of the discount rate (the 5.1 per cent real net-of-tax rate of return on the Standard and Poor's portfolio of equities from 1970 to 1994) and of the sacrifice ratio (the upper end of the range in Ball (1995)).

Further support for Feldstein's arguments—that there are potentially significant economic benefits of reducing even the current modest levels of inflation in the U.S. economy—is given in Cohen, Hassett, and Hubbard (1997). This paper quantifies the impact of a permanent change in inflation on the user cost of capital for different types of assets. It also examines the implication for the

choice of capital durability and intra-temporal distortions in the allocation of capital. Cohen, Hassett, and Hubbard conclude that (1) inflation even at current levels increases the user cost of capital significantly; (2) the marginal gain in investment in response to a percentage-point reduction in inflation is larger for lower levels of inflation; (3) steady-state consumption would benefit significantly from lower inflation; and (4) inflation has only a small impact on the intra-temporal distortion of the allocation of capital within the U.S. domestic business sector. They suggest that the transferability of their results to the case of a small open economy depends on the marginal source of finance. When it is new equity issuance, the results are comparable to those in a closed economy. However, when it is debt, the ability to deduct interest payments is important enough to reverse the results.

In replicating Feldstein's analysis for the United Kingdom, Bakhshi, Haldane, and Hatch (1997) report that lowering inflation by 2 percentage points leads to benefits equivalent to 0.2 per cent of GDP per year (0.14 per cent in EV terms) when central estimates of the key parameters are used. With an estimated discount rate of 5.3 per cent and a growth rate for output of 2 per cent, this implies a net present value equivalent to some 6.5 per cent of GDP. They then calculate the level of welfare benefit that would be needed to counterbalance the costs of disinflation, given values for the discount rate and the growth rate of the economy. They conclude that, even with high estimates of the output costs of disinflation (4 to 6 per cent of a year's output lost for a 2 percentage point reduction in inflation), the welfare benefits of reducing inflation exceed the output costs of doing so.

Tödter and Ziebarth (1997) apply Feldstein's analysis to Germany and find that lowering inflation by 2 percentage points results in benefits of 2 per cent of GDP (1.4 per cent in EV terms). Tödter and Ziebarth report that the deadweight loss of 2 per cent inflation is so great because of the high savings rate, heavily taxed capital income, and unindexed tax system in Germany. Using average data for the period 1991–95 for the discount rate and sacrifice ratio, they conclude that it would be optimal to aim at a zero inflation rate or stability of the measured price level.

- **Some studies using a general-equilibrium approach**

The work by Black, Macklem, and Poloz (1994) mentioned above also looks at the interaction of inflation, the tax system, and money balances under different assumptions. To do this, the authors go to some lengths to incorporate the salient features of various aspects of the Canadian tax system. They look at, in turn, the implications of introducing alternative configurations of fiscal or tax policy; of endogenizing growth; and of opening the model economy. They discuss the

implications, for their welfare results and for the choice of tax instruments, of using various types of distortionary taxes to hold government expenditures constant instead of offsetting them by letting transfers decline. Reducing inflation decreases welfare if a corporate tax is used but increases welfare with either an income or consumption tax, more so with the latter. Their results, in EV terms, range from 0.96 per cent (exogenous growth) to 1.68 per cent (endogenous growth) when they allow for the interaction of inflation, taxation, and money balances. Overall, they conclude that the economic costs of ongoing inflation due to tax distortions appear to be quite large; the results seem to be robust across models and parameter settings.

Bullard and Russell (1997) study the welfare cost of inflation in a general-equilibrium life-cycle model with exogenous growth, costly financial intermediation, and taxes on nominal quantities. They find a stationary equilibrium that matches a wide variety of facts about the postwar U.S. economy. The model indicates that the welfare consequences of inflation are an order of magnitude larger than existing estimates in the literature, even at very low inflation rates. In EV terms, their estimate of the welfare cost is 1.84 per cent for every percentage point in inflation reduction. The authors state that the most important reason for this finding is that higher inflation reduces real returns to all assets in a quantitatively important way. Higher inflation therefore forces agents to alter their life-cycle consumption, work, and savings plans. This creates a large distortion because real interest rates are the central allocation mechanism in the neoclassical growth framework they use. The bulk of the welfare cost of inflation can be attributed to the fact that inflation increases the effective tax rate on capital income.

3.2.5 Estimates of the effect of inflation on the level of output

The models used to test for the effect of inflation on the level of output are often variants of the traditional neoclassical growth model. In this model, an array of government policies and private sector choices (e.g., school attainment, life expectancy, government consumption to GDP, investment ratio, etc.) determine whether output per capita will be higher or lower in the long run. The model also has the feature that its per capita growth rate is increasing in the gap between its long-term prospective output per capita and its current output per capita. Human capital can play a role both in determining the prospective level of output per capita and the rate of convergence to it from the current actual level. Inflation and inflation uncertainty effects have been included as explanatory variables in the growth regression, sometimes motivated as having effects on the level of efficiency or technology. Given that convergence occurs over an extended period, the empirical

results of these models can often appear as if inflation is affecting the growth of output per capita because of an extended adjustment period. However, the final result relates to a change in the level of output per capita. Empirical estimates are obtained by cross-country regressions, usually using some time-averaged data.

Included in the studies that find relatively large effects of inflation on the level of output is the one by Cozier and Selody (1992). Using an internationally comparable data base for 62 countries, Cozier and Selody estimate the effects of the level and volatility of inflation on long-run macroeconomic performance for the period 1960–85. A significant negative effect of inflation on the level of income per capita is found. It appears robust when nested within a modified version of the neoclassical growth model with human capital. The paper suggests that a 1 percentage point reduction in inflation raises the growth of income by some 0.1 percentage points on a transition path to a new level of income. The new level is about 3 per cent higher after 30 years (just under 2 per cent, EV) and close to 7 per cent in the long run. Unlike Cozier and Selody, Fortin (1993) finds no significant effects of either the average level or the volatility of inflation on cumulative growth. He regresses the cumulative growth from 1960–85 for 22 OECD countries using the same sort of variables as did Cozier and Selody, except for an average population size variable that he motivates as a scale variable.

Barro (1995) uses data for over 100 countries from 1960 to 1990 to assess the effect of inflation on economic performance. He employs a framework similar to that sketched in the introductory paragraph to this section. Inflation is tested, first independently and then jointly with inflation variability (the standard deviation of inflation). Holding a number of country characteristics constant, the regression results indicate that an increase in average inflation of 10 percentage points per year reduces the growth rate of real per capita GDP by 0.2 to 0.3 percentage points per year (0.40 per cent EV) and lowers the ratio of investment to GDP by 0.4 to 0.6 percentage points. Inflation variability is not statistically significant when tested jointly with inflation, and the coefficient on inflation changes little from what it was when independently included in the equation. Barro tests for linearity by estimating the system with separate coefficients for inflation in three ranges: up to 15 per cent; between 15 and 40 percent; and over 40 per cent. The levels of inflation have a statistically significant effect on growth in real GDP per capita for the categories above 15 per cent but are not statistically significant from one another. This leads Barro to conclude that the data conform to a linear relationship.[14] He tests for

14. Other researchers have interpreted these type of results to mean that the inflation/output relation is non-linear.

causality using plausible instruments for inflation and concludes that the relations reflect causal influences from inflation to growth and investment. Barro points out that even small estimated effects can cumulate to large numbers. He gives the example that a shift in monetary policy that raises the long-term average inflation rate by 10 percentage points per year is estimated to lower the level of real GDP by 4 to 7 per cent after 30 years.

Andrés and Hernando (1997) consider the evidence at the OECD level within the framework of the convergence equations. They ask whether the correlation between inflation and growth over a transition period is due to the inclusion of high-inflation countries; whether country-specific effects influence the results; and whether there is reverse causation (from GDP to inflation). Their findings are that even the low (less than 6 per cent) or moderate (between 6 and 12 per cent) inflation rates experienced in the OECD countries have a temporary negative impact on the growth rates of per capita income, generating a permanent reduction in the level of per capita income; both the level of investment and the efficiency of use of productive factors are reduced; permanently lower inflation of 1 percentage point leads to a 0.5 to 2 per cent increase in the steady-state level of per capita income, depending on the specification and levels of inflation; the correlation between inflation and future income is never found to be positive, no matter what subsample is used, even one that excludes high-inflation countries; inflation Granger-causes income; and the lagged correlation between these two variables remains significant even after controlling for country-specific variables.

3.2.6 Estimates of the effect of inflation on output growth

The simplest approach in investigating the relation between inflation and growth is to regress output or productivity growth on current and lagged inflation, using various time-series techniques. Other techniques involve exploring the relationship between inflation and growth by dividing countries into high-inflation and low-inflation countries or by looking at this relationship around inflation crises.

As for the evidence that uses single-country time-series analysis, about half the papers reported in Table 3 in Appendix 2 failed to find evidence to support a long-term link between inflation and income or productivity growth, while some suggest that the benefits are quite large. As for those papers that used other approaches applied to cross-country data, a similar ambiguity in results is evident (see Table 4 in Appendix 2).

- **Single-country evidence from time-series analysis**

Looking at a number of countries, Grimes (1991) investigates whether there are any systematic empirical impacts of the inflation rate or the change in the inflation rate on the growth in GDP over time. Grimes controls for other variables when estimating (with OLS and SUR) the relationship for each one of 21 industrial countries, as classified by the International Monetary Fund, over the period 1961–87. He generally finds a negative coefficient on the level of wholesale price inflation and a positive coefficient on the change in wholesale price inflation. This implies a negative long-run relationship between inflation and output growth. The coefficients on inflation in his SUR estimation are negative and statistically significant at the 5 per cent level for both Canada and the United States and positive on the change in inflation. When he restricts the coefficient on inflation to be the same in each country's regression, he finds that an annual inflation rate of 9 per cent is estimated to decrease the annual growth rate by about 1 per cent (3.4 per cent in EV terms). He concludes that costs of even a low-inflation rate are large given that it is the growth rate, not just the level, of output that is affected by inflation.

As for evidence on the relationship between inflation and labour productivity growth for Canada, Fortin (1993) argues that a negative relationship may simply reflect the Bank of Canada's policy reaction together with the negative cyclical relationship between inflation and productivity. Using a simplified version of the Jarrett and Selody (1982) model, he finds that the coefficient obtained using data for the 1964–1991 period is less than that reported in the original Jarrett and Selody work. He goes on to show that it becomes statistically insignificant when he controls for the state of the cycle with capacity utilization terms. MacLean and Setterfield (1993) also question the robustness of the Jarrett and Selody result. In commenting on their work, Selody (1993) indicates that the empirical evidence on the relationship between inflation and productivity is more extensive than their references indicate. He also indicates that MacLean and Setterfield's sample is too short for them to justify their conclusion that inflation and productivity growth are independent in the long run.

For the relationship between inflation and productivity growth in the United States, Sbordone and Kuttner (1994) corroborate the negative correlation between inflation and productivity growth (at cyclical and long-run horizons). They interpret the relationship using Granger causality and find that inflation Granger-causes productivity when only these two variables are included in the analysis. Turning to the long-run relationship, Sbordone and Kuttner use a bivariate time-series model to estimate the ultimate effect on productivity of a permanent shock to inflation.

Here they conclude that the size and sign of the estimated effect depend heavily on the identifying assumptions used to distinguish inflation shocks from productivity shocks. They then go on to sketch a model that has labour productivity falling while inflation remains high, generating a negative correlation that does not reflect any causal link from inflation to productivity.

Cameron, Hum, and Simpson (1996) report on tests of the relationship between inflation and productivity growth using long quarterly and annual data sets for Canada, the United States, the United Kingdom, and West Germany. Their results from cointegration and other time-series tests show no evidence for any connection between inflation and the level of productivity but do find a strong connection between inflation and productivity growth. However, they view the latter relationship as "so internally inconsistent as to be incredible" (Cameron, Hum, and Simpson 1996, 153), attributing it to statistical bias that arises from attempting to cointegrate stationary and non-stationary series.

- **Cross-country evidence**

With respect to cross-country evidence on inflation and growth, the specific objective in Bruno and Easterly (1996) is to document this relationship for the period before, during, and after inflation crises (inflation greater than 40 per cent per year for two or more years). They look for a simple, robust pattern in the 32 inflation crises in 26 countries identified by their criteria. They find that growth went down sharply during the inflation crisis and then increased above the pre-crisis rate after the crisis was over (a bust-boom scenario). Using the same regression format as Levine and Renelt (1992), they looked at the residuals for the before-, during-, and after-inflation crisis subperiods. Bruno and Easterly find that the during- and after-crisis residuals average out to the before-crisis residual, which was not significantly negative in the countries considered. They draw the following conclusions: that a simple cross-section of inflation on growth (per capita growth and per capita growth relative to the world average) is sensitive to both the sample period and to the exclusion of high-inflation countries; that an inflation rate of 40 per cent or more for two or more years results in low growth; and that, where there exists evidence of sufficient quality and length for the post-crisis time series, growth is sufficiently rapid to make up for the fall in output during the crisis.

Extending more traditional techniques used in cross-country analysis, Judson and Orphanides (1996) re-examine the relationship between inflation, inflation volatility, and growth using cross-country panel data for the past 30 years. With regard to the level of inflation, Judson and Orphanides find that exploitation

of the time dimension of the data reveals a strong negative correlation between inflation and income growth for all but very low-inflation countries. This is in contrast to results from cross-sectional time-average regression comparisons. To examine the role of inflation uncertainty on growth, they use intra-year inflation data to construct an annual measure of inflation volatility. Incorporating this measure in their analysis, they find that inflation volatility is also robustly and negatively correlated with growth, even after controlling for the effect of the level of inflation.

3.3 Assessment of the empirical evidence by other researchers

Assessment of the literature by other researchers is sketched in this section. The first subsection outlines some of the methodological concerns pertaining, in particular, to the single-country and cross-country analyses, focussing on the latter. The second subsection provides a brief summary of other surveys of this literature.

3.3.1 Methodological critiques

Various studies have raised questions from a number of perspectives about the robustness of the empirical evidence on the inflation and output relationship. With respect to the single-country and cross-country analyses, early questions were whether the estimated equations controlled for all of the relevant factors (Levine and Renelt 1992); or, for the cross-country analyses, whether the results were sensitive to the sample of countries and time period (Clark 1993). Other studies questioned whether the earlier studies used the correct notion of trend (Bullard and Keating 1995; and Ericsson, Irons, and Tryon 1993). A more recent study investigates the kind of relationship that one would expect from the data in the context of using artificial data from a known model (Ambler and Cardia 1998).

The robustness of coefficient estimates in cross-country regressions to alterations in the conditioning information set was first tested by Levine and Renelt (1992), using Leamer's (1983) extreme bounds analysis. After Levine and Renelt included measures of physical and human capital accumulation rates in these cross-country regressions, the inflation rate was not significantly related to per capita output growth. Using the same approach but a different information set, specifically that advocated by Barro (1991), Levine and Zervos (1993) conclude that indicators of financial development are strongly associated with long-run growth and that it is difficult, if not impossible, to identify believable links between a wide assortment of indicators of individual policies and long-run growth. Haslag (1997) challenges

the conclusion of Levine and Renelt (1992) that resulted from including capital accumulation measures. He argues that, since the theoretical literature shows that inflation effects operate through movements in capital accumulation (both physical and human), the inclusion of capital accumulation in these regressions will weaken the role of inflation.

Clark (1993) identifies slight modifications in the sample of countries and in the time period as creating several difficulties with inferring inflation's costs from cross-country growth regressions. Clark suggests that estimates derived from periods encompassing the 1970s are driven at least in part by endogeneity, noting that estimates for 1950–70 indicate a very weak relationship between inflation and growth. When he allows for alternative specifications, for example, a model that assumes that inflation drives steady-state growth rather than just income levels, his conclusions are the same. On the whole, he sees no use in cross-country growth regressions and suggests that investment analysis along the lines of Huizinga (1992) might be more profitable.

Aggregation questions are explored in Ericsson, Irons, and Tryon (1993) who conclude that cross-country regressions obtaining a negative correlation between inflation and output growth are fragile because of improper aggregation over time and over countries in the regressions. Ericsson, Irons, and Tryon show that averaging data over time can introduce a contemporaneous correlation (positive, zero, or negative) between two time-averaged series even if the original series are not contemporaneously correlated. Using annual data, they demonstrate that output growth and inflation Granger-cause each other in the G-7 countries, so that regressions with time-averaged data may confound the dynamics of the underlying process. Their analysis with Johansen's procedure of annual data finds cointegration between inflation and the level of output in all G-7 countries except Canada. Given that the feedback of the error correction occurs in either the inflation or output equations or both, they conclude that cross-country results are essentially spurious.

Taking a somewhat different approach, Bullard and Keating (1995) use structural vector autoregressions (SVARs) to investigate the response of the level of real output to permanent inflation shocks for each country in a large sample of countries in the postwar period. For all of the countries in two of their country groupings, they were able to reject the hypothesis of a unit root in output growth even though these countries did experience permanent inflation shocks according to their tests. The implication that permanent inflation shocks do not have significant permanent effects on output growth rates is said to be "in contrast to

some recent claims [DeGregorio 1993; Fischer 1991] that output growth rates are negatively related to inflation" (Bullard and Keating 1995, 493).

Extending the analytical approach to this question further, Chari, Jones, and Manuelli (1995; 1996) ask whether standard endogenous growth models with transactions demand for money, when calibrated to properties of U.S. data, are consistent with the quantitative relationship between inflation and growth that is documented in the empirical growth literature. They interpret this literature as indicating that a 10 per cent increase in the rate of inflation implies a 0.2 to 0.7 per cent decrease in the growth rate of output and that none of the models considered comes close to accounting for numbers of that magnitude. They use four types of endogenous growth models: a one-sector Ak model; a two-sector model with the relative price of capital endogenized; a Lucas model; and a Romer model. In each model, they try three different models of money demand (cash-in-advance in consumption; shopping time; and cash-in-advance for everything). The transmission mechanism between inflation and growth in these models is the inflation-generated tax on consumption arising from the need to hold currency because it is either required by the model or it will reduce transactions costs. Chari, Jones, and Manuelli then show that higher inflation in the context of including higher reserve requirements will generate in their calibrated models an empirical relationship of the magnitude in the empirical literature. Stockman (1996) suggests that they have mixed level and growth results in arriving at their estimate of the magnitude of the size of the relationship between inflation and the growth rate of output. This would thus put the size of the relationship on the high side and bias their exercise against concluding that the models find similar results. With respect to their conclusions on the role of required reserves, Stockman argues that they fail to allow for endogenous responses and hence overstate the role of an increase in the required reserve ratio.

Ambler and Cardia (1998), utilizing a conceptual approach similar to that of Chari, Jones, and Manuelli, employ an endogenous growth model to analyse the implications for cross-section and time-series regressions that attempt to uncover the empirical link between inflation and growth. Ambler and Cardia emphasize the need to distinguish the correlation (conditional or unconditional) between these series from the relevant trade-off facing policymakers. They interpret their work to mean that the results of the empirical literature uncover only the conditional correlation between inflation and growth but have no meaningful structural interpretation and contain few, if any, insights for monetary policy or welfare. Van Norden (1998) notes that the Ambler and Cardia paper cannot be cited as "proof" that the growth effects of a low-inflation policy cannot be large. He argues that, for

reasonable parameters, the effects of the interactions of inflation with an imperfectly indexed tax system are much larger than those produced by the "consumption tax" mechanism that they use. He considers their most valuable message to be that one should not confuse the correlation (conditional or unconditional) between inflation and growth with the relevant trade-off facing policymakers.

3.3.2 Other surveys on the relationship between inflation and output

Despite these observations on the relative merits of the techniques used and their ability to determine causation, some surveys of the empirical evidence on the relationship between inflation and the growth or level of output conclude that the evidence demonstrates there are significant benefits to living in a world with no inflation. Other surveys suggest that, while there may be significant conceptual benefits, the empirical evidence is at best ambiguous.

Briault (1995) surveys the academic literature on the costs of inflation. He begins by noting that there are many theoretical reasons why inflation and uncertainty about future inflation may reduce economic welfare. He finds on balance that most of the time-series studies that he reviews find a negative relationship between inflation and growth. The findings are similar for the cross-country studies. He notes that a few studies found no significant relationship between inflation and growth and indicates the weaknesses of each type of approach. He examines the costs of disinflation, highlighting rigid prices and wages, debt contracts, and labour contracts. He supports the idea that the benefits of low inflation will be permanent while the costs of disinflating will be temporary, quoting various surveys. Briault does, however, acknowledge that some studies find persistent costs of disinflation.

Haslag (1997), after surveying the empirical literature on the correlation between inflation and per capita output growth, suggests that the evidence shows a significant negative correlation. He acknowledges that the conclusions may not be robust when researchers control for a set of common variables or when they change the trend rate of output growth. However, he emphasizes that formal statistical analyses fail to find a significant positive correlation between inflation and per capita output growth. He thus concludes that, even with all the caveats, the evidence suggests a non-positive relationship between inflation and output growth (see Appendix 3 for a table excerpted from his paper). In addition, Haslag reports that Fischer (1991) calculates the average inflation rates for two smaller groups of

countries (one that is growing one standard deviation faster than average; the other growing one standard deviation slower) to find that the faster-growing group of countries has much lower inflation on average than does the slower-growing group of countries. Haslag interprets the results of Sarel (1996) and Judson and Orphanides (1996) as indicating that the relationship between negative inflation and output growth is robust when inflation is moderate or high (inflation greater than 8 to 10 per cent).

Lamy (1997) surveys the literature on the empirical relationship between inflation and real output growth, examining the results of a variety of studies: bivariate; multivariate; cross-sectional; and time-series. He indicates that some studies focus on linking inflation directly to real GDP, while other studies look at the relationship between inflation and productivity. He finds that the studies do suggest that reducing inflation will tend to raise annual real GDP growth but that the range of the estimates is quite large. Moreover, most of the studies reviewed found that the relationship between inflation and growth was non-linear. Thus, as inflation falls to relatively low rates, the positive impact of lower inflation on output tends to diminish.

Ragan (1997) reviews existing empirical literature on the benefits of low inflation to identify a set of benefits in which monetary authorities can have genuine confidence. With respect to back-of-the-envelope–type calculations, he accepts that there are small but positive benefits from a reduced tax on holdings of real money balances. However, he does not think that they can justify a disinflation by themselves. Ragan then turns to the effects of the interaction of inflation and a partially indexed tax system. He notes that, while Feldstein's (1996) estimate of the deadweight loss is large, the effect on net welfare is sensitive both to parameter assumptions and to the way in which reduced government revenues from lower inflation are offset by other distortionary taxes. He does not find the time-series evidence on the inflation-growth relationship to be very compelling for reasons similar to those given above. He notes that the international cross-section approach finds a link but only for those countries with high and very high rates of inflation. In the literature on the relationship between inflation and the level of output, he finds that (i) time-series studies suffer from confounding business-cycle relationships; (ii) cross-section studies suffer from unconvincing identifying assumptions; and (iii) both types of studies lack robustness. Ragan turns next to model approaches. He argues that, in endogenous growth models, the elasticities would have to be unrealistically large if they incorporated the following characteristics of a modern, moderate-inflation country: moderate inflation; short holding

periods for money; and low elasticities of work effort. A similar criticism is expressed for cash-in-advance real-business-cycle models.

Mishkin and Posen (1997) give an overview of the reasons why most central bankers and academic monetary economists prefer price stability as the long-term goal of monetary policy. Mishkin and Posen do say that the economic costs of inflation are larger in economies with high rates of inflation (more than 30 per cent a year). They believe, however, that recent work shows that there are substantial costs even at low rates of inflation. They agree that shoe-leather costs are small unless inflation rises to more than 100 per cent per year; that the financial sector share in the GDP rises a percentage point for every 10 percentage points of inflation up to 100 per cent (they cite English (1996)); that future decisions are affected by increased uncertainty about relative prices and the future price level caused by inflation (they cite Groshen and Schweitzer's work); and that the whole pricing mechanism becomes distorted. They also note that risk premiums, the frequency of price changes, the relative attractiveness of real versus nominal assets and short-term versus long-term contracting are all affected by inflation. As for the interaction of inflation with an unindexed or partially indexed tax system, they point out how it increases the cost of capital, lowering investment and leading to a misallocation of capital that, in turn, distorts labour supply decisions. They refer to cost estimates from Fischer (1994), 2 to 3 per cent of GDP at 10 per cent inflation, and to estimates from Feldstein (1996), 1 per cent of GDP at 4 per cent inflation allowing for a 2 per cent measurement error. They note that the costs of inflation reduce the base from which the economy can grow. They see in the time-series literature the consensus on the relation between inflation and growth that "on average, a 1 percent rise in inflation can cost an economy 0.1 to 0.5 percentage points in its rate of growth" (Mishkin and Posen 1997, 13). Mishkin and Posen acknowledge that the result varies with the level of inflation, the effects being much greater at higher levels. They then indicate that the study by Judson and Orphanides (1996) presents evidence that inflation variability has a significant negative effect on growth even at low levels of inflation.

Black, Coletti, and Monnier (1998) have as their objective the determination of a plausible range of net welfare outcomes associated with a permanent reduction in inflation. The welfare costs of disinflation are obtained by simulating the Bank of Canada's Quarterly Projection Model (QPM) under various scenarios. These range from the temporary costs of disinflation in the base-case version of QPM through several modifications (labour-market hysteresis, induced permanent increases in government debt, and interest rate floors) that imply permanent costs of disinflating to a low-inflation rate. Since the steady-state version of QPM is

superneutral with respect to inflation, they survey the empirical literature (see Tables in Appendix 2) to obtain estimates of the benefits of low inflation, transforming the reported effects into welfare measures that can be compared with costs estimated using QPM.

They report that the costs associated with lowering inflation clearly exceed the estimated benefits if the benefits are fully captured by the partial-equilibrium estimates of the inflation tax on money balances (Table 2 in Appendix 2). However, the evidence becomes mixed if general-equilibrium estimates of this effect are used (Table 5 in Appendix 2). When they allow for the interaction of inflation and the tax system (Tables 1 and 6 in Appendix 2), the balance clearly tilts in favour of reducing inflation. This result is also robust to the choice of a different discount rate and a delay in the arrival of the benefits of lower inflation. The effect of an interest rate floor does not have a significant qualitative impact on their results. Black, Coletti, and Monnier do not draw a definitive conclusion on the net benefits or costs of low inflation. Their results, however, clearly suggest that the welfare costs of disinflation are outweighed by the benefits for most estimates of benefits taken from the literature, especially in those models that account for the interaction of inflation and the tax system.

Parkin (1997) presents three reasons for the different interpretations of the empirical evidence on net benefits of low inflation. First, he notes that many of the items identified as a cost of inflation, such as production of banking services, investment services, other financial services and accounting services, are actually captured in the data as a benefit, i.e., an increase in measured real GDP. To the extent that real GDP could be corrected for the part of these services that are due to high and variable inflation, a better series for analysing the benefits of low inflation would be available. Second, Parkin agrees with Konieczny's (1997) observation that the costs of inflation are not continuous. Thus, extrapolating to zero from positive inflation rates is likely to understate the benefits of having zero inflation. Finally, he observes that economic agents have not been able, since the nineteenth century, to have confidence that the "current and confidently expected inflation rate is zero."[15] Therefore, inferences based on situations where this does not hold are likely to understate the true benefits of low inflation.

15. Crow (1997) originated this phrase.

3.4 Discussion of the empirical evidence

Substantial effort has been made since 1990 to better understand the relationship between inflation or inflation volatility and the growth or level of real output or welfare. In most cases, the estimates of the benefits of low inflation assume a fully anticipated inflation and thus ignore the benefits of removing the potentially large costs of unanticipated inflation. At a minimum, there are definitely costs of high inflation, which implies there are benefits of low to moderate inflation. But it appears possible to go further than this. Even in those areas where benefits of low inflation have usually been estimated to be small (e.g., the shoe-leather and menu-cost areas), the approaches used to derive estimates often cannot capture potentially magnifying effects. In those areas where the most progress has been made in accounting for the interactions of inflation with other distortions in the economy (inflation and the tax system, for example) by using general-equilibrium models, the results in the literature are evolving towards higher rather than lower estimates of the gross benefits of moving towards low inflation.

Of course, gross benefits are not net benefits. Replacing the revenues lost by moving to lower inflation and the need to offset the costs of disinflation have to be taken into account. On the former, studies in which the fiscal authority uses the less distortionary of available tax instruments show sizable net benefits. For the latter, the literature is in agreement that the costs of disinflation are transitory. Since this conclusion was reached after extensive debate, the onus for proving these costs are *not* transitory appears to be on those who would suggest they are permanent. At present, their case appears unproven and their evidence is subject to other interpretations than the ones that they give.

The benefit arising from the reduced need of individuals to replenish cash balances as frequently at low rates of inflation (lower shoe-leather costs of inflation) is estimated in the literature to be quite small, no matter what technique is used. It should be recalled that inflation acts like a tax on real money balances. Thus the incentive is to keep these balances as small as possible in order to limit the "tax" burden. Since there are currently many ways to pay for transactions other than with cash, a small estimated benefit of low inflation from lower shoe-leather costs is likely not surprising. However, as Howitt (1997) points out, this benefit to low inflation could be still economically significant if allowance is made for the public-good aspect of holding money (Laidler 1977) and for the spillover effect of inflation on all liquid assets, not just those in M1 (Fried and Howitt 1983). Further research could focus on extending the initial steps taken in Bullard and Russell (1997) where the welfare cost of inflation is studied in a general-equilibrium

life-cycle model with growth, costly financial intermediation, and taxes on nominal quantities.

Other results arising from economic agents trying to protect themselves against inflation are a divergence of productive resources to the financial sector and a larger financial sector than would otherwise be required, given the fundamentals of the economy and no inflation. When the literature discusses the contribution of inflation to the size of the financial sector, it focusses on the divergence of resources from productive to precautionary or even speculative activities. A given level of real activity in the economy—other things held constant—requires a financial sector of a certain size to facilitate exchanges, including those related to savings and investment. The limited work on this question suggests that inflation does increase the size of the financial sector, especially for high-inflation countries. In low- or even moderate-inflation countries, the size of the financial sector might not expand as much due to institutional inertia or non-linearities. Further research here might attempt to determine how the size of the financial sector is related to fundamental factors and then examine whether the actual size is what might be expected.

Direct estimates for some industry sectors suggest that the physical costs of changing prices as a result of inflation (menu costs) can be economically significant. From a broader perspective, however, the direct saving from menu costs is not considered as important as that achieved by improving the overall efficiency of the price system—when prices more clearly reflect the underlying demand and supply conditions. As the earlier section on the relation between inflation and uncertainty indicated, the empirical evidence suggests that people are more uncertain about inflation, and therefore prices, when inflation is higher than when it is lower. Moreover, the evidence is equivocal at best about the impact of relative price variability and/or inflation uncertainty on output. Some thought is needed on exactly *how* to capture this latter effect empirically.

One area where significant progress has been made in capturing some of the interactions of inflation with elements of the economic system is in partial- and general-equilibrium analyses of the interaction of inflation and the tax system. The estimates over time of the gross benefits of low inflation, no matter which approach is used, have evolved towards economically larger effects. The partial-equilibrium approach of Feldstein (1996) has been replicated for other countries with the relative results turning out as might be expected (see Bakhshi, Haldane, and Hatch (1997) for the United Kingdom; Tödter and Ziebarth (1997) for Germany). Support is also provided for Feldstein's conclusions for the United States by the work of Cohen, Hassett, and Hubbard (1997). It would therefore seem that Feldstein's

approach and results have to be taken seriously. Further exploration of the robustness of the implication of an objective of zero inflation (after allowing for measurement error) would entail applying his approach to Canada and other countries.

With respect to general-equilibrium modelling, much progress has been made in the 1990s in addressing fiscal questions, including the interaction of inflation and the tax system. Again, the results of these models suggest that low inflation provides sizeable benefits relative to a higher inflation rate. It would seem worthwhile to continue exploring with these models the question of the interaction of inflation and the tax system, especially the sensitivity of the results to various changes in the underlying model, including their calibrations.

Time-series and cross-sectional analyses on the effect of lower inflation on the level of productivity or output, or on the growth in productivity or output, are fraught with many difficulties. The main common problems are the relatively few years of evidence on low inflation, the difficulty of controlling for various other factors (including the stage of the cycle), and the lack of a clear understanding of the mechanisms underlying the relationship. Cross-country work has to deal also with the different stages of development and the different economic and institutional structures of the countries included in the analysis. The evidence is very clear that there are observable costs to high inflation but it is much less clear about the benefits of low inflation. However, none of the studies reviewed here obtains a statistically significant positive coefficient on inflation with the exception of Sarel (1996); see Table 5. The most promising avenue for future research seems to be acquiring a better conceptual understanding of exactly how inflation, inflation uncertainty, and relative price variability are related to the growth or level of output and welfare. Such an understanding will not only help in the specification of the relationships to be estimated but also in the interpretation of the coefficients. In the meantime, further research will likely entail a continuing reassessment of the results with the same specifications, or slight variations on them, as more data that has been collected during a low-inflation period become available.

4 EQUITY AND FAIRNESS

Under the heading of equity and fairness, the 1990 *Annual Report* article argued that the least sophisticated members of economic society are the ones who lose out when inflation takes hold. Inflation is a zero-sum game in that “winners” gain only at the expense of “losers.” This leads to a sense of unfairness. Owing to

the absence of complete indexation, the costs of inflation do not fall equally across the population. Unanticipated inflation thus redistributes income and wealth: those on fixed incomes and with little wealth in the form of real and foreign assets are made worse off; and wealth is transferred from lenders to borrowers because of negative real interest rates ex post. As inflation reduces the value of government debt and the real cost of servicing the debt, current holders of government debt lose and future taxpayers gain; thus there is an arbitrary redistribution of wealth between generations.

People view inflation as unfair. This is clear in the responses by non-economists to a survey questionnaire exploring what people in the United States, Germany, and Brazil think of inflation and the problems it causes (Shiller 1997a). The results from 677 responses allowed comparisons among the responses of people in each of the three countries, between young and old, and between economists and non-economists. Non-economist responses suggest that people believe that inflation lowers their standard of living because wages or pension incomes do not keep up. They see the cause of inflation as stemming from individuals or groups in the economy acting badly by implementing unwarranted price increases that erode the real wages and incomes of others. Other problems associated with inflation were said to be the following: that it was misleading, even deceptive; that it created a selfish social atmosphere that was harmful to national morale; that high inflation could result in chaos and anarchy; and that inflation and the associated decline in the currency could damage national prestige. Economists break down the costs of inflation into inconveniences (shoe-leather and menu costs), the effects on nominal institutions, habits, or contracts, and the effects of uncertainty about inflation or about government efforts to suppress inflation. The general public, however, apparently focusses on the direct effects of inflation on their standard of living as sketched above and on the opportunities for deception created by inflation. Shiller notes that the general public's concerns are not completely unrelated to those raised by economists, stating that some of them must arise from their experience with nominal contracts. He sees consistency, though, in the view by both groups that inflation is to be avoided.

The question of the adverse effects of inflation on the distribution of income is addressed in Blinder and Esaki (1978). They use ordinary least-squares regression analysis on the quintile distribution of income among U.S. families over the period 1947 to 1974 to inquire into the effects of unemployment and inflation. They conclude that the most unequivocal message is that the incidence of unemployment is regressive with each percentage point rise taking about 0.26 to 0.30 per cent of the national income away from the lowest 40 per cent of the income

distribution and giving it to the richest 20 per cent. They find the effects of inflation on the income distribution to be much less important.

In a study on Canada, Buse (1982) attempts to determine how the size distribution of income is affected by cyclical fluctuations in macroeconomic activity. Drawing on individual tax returns for the period 1947 to 1978, he finds that neither the inflation rate nor the unemployment rate has a significant effect on the Gini index or the quintile shares. However, the aggregate participation rate is said to have an equalizing effect. He also estimates models for the top and bottom deciles, again finding the effect of inflation to be weak or non-existent. He concludes that the absence of any impact of inflation is an interesting result but that more work is required to determine the robustness of the conclusion.

Bulir and Gulde (1995) examine the effects of inflation and associated financial instability on income distribution. They use an extended version of the Kuznets "secular equalization" model for the cross-country sample; the Schultz (1969) model for overall income distribution for the time-series analysis; and the Blinder and Esaki model for the relative income shares of the population. For overall income inequality, Bulir and Gulde find that the level of inflation, inflation variability, and the variability of the nominal exchange rate have a negative impact. They report that the model used to generate these results shows that inflation increases inequality in Canada. For disaggregated measures of the income distribution, they find that inflation tends to be a regressive tax in lower-income countries with a relatively unsophisticated financial sector; but that the estimated models fail to reject the hypothesis that inflation might have the effect of a progressive tax in some countries. They characterize the results for Canada from this part of their work as being mixed. Bulir and Gulde conclude that inflation matters for income distribution, but they are puzzled by the striking differences across countries and wonder about the implications for a general theory.

Powers (1995) notes that the studies by Blank and Blinder (1996) and Blank (1993) find a significant positive relation between inflation and poverty rates, while Cutler and Katz (1991) and Mocan (1995) find a small negative relationship. She then goes on to argue that the measures of poverty used in these studies are poorly specified and that a consumption poverty measure is likely to be more appropriate. Using this poverty measure and an approach similar to that of the earlier studies, she finds that both inflation and unemployment significantly increase the consumption poverty measure with the coefficient on the inflation rate nearly half that of the unemployment rate. She concludes that, even if an inflation-

unemployment trade-off is a maintained assumption, possible distributional consequences of short-run stabilization policies cannot be ignored.

Sarel (1997) examines the relationship between the macroeconomic environment and trends in income distribution. He regresses the rate of change of the Gini coefficient against a set of macroeconomic and demographic variables, a control variable to allow for the different sample periods across countries, and a variable to control for possible convergence in income inequality across countries. He finds that an improvement in the income distribution was associated with the following: a higher growth rate; a higher income level; a higher investment rate (relative to private and public consumption); a real depreciation (especially in low-income countries); and an improvement in the terms of trade. He interprets the failure to find a significant effect from inflation as positive in the sense that "adjustment policies (such as reducing public consumption and stabilizing inflation) does [sic] not necessarily have a negative impact on income distribution, as feared by many" (Sarel 1997, 19).

4.1 Discussion

One major difficulty with the regression work reported above is that it does not allow for the endogeneity of inflation and unemployment. Hence, the estimates may not be all that reliable. As for the Blinder and Esaki approach, Powers (1995) notes that the quintile share of income may not be informative about changes in welfare. If income is taxed away from the top quintile and destroyed, it does not leave the bottom quintile better off even though their share of income will have increased. Similarly, interpretation of the influences of inflation and unemployment on quintile shares is difficult since either one or both could harm low-income groups absolutely while their effects on quintile shares suggest otherwise. With respect to the consumption poverty approach, Powers notes that measures of consumption poverty are controversial and therefore her results may be unique to the specific measure used.

On the relative merits of the income distribution for indicating the welfare implications of inflation, Altig (1992) argues that the absolute level of income for individuals is probably a better indicator of their welfare. In addition, he notes that income distribution evidence focusses on cyclical fluctuations in economic activity. As a result, the evidence fails to take account of the lack of a trade-off between inflation and unemployment in the long run. To demonstrate his point, Altig constructs a simple general-equilibrium model with the long-run costs of inflation

arising from distortions created by a tax system based on nominal income. The model, while highly stylized, has an imperfectly indexed tax system; "rich" and "poor" people, with the former owning capital; "rich" people earning a bigger share of the economic pie than their proportion in the population; inflation raising the tax burden of the "rich" more than it does of the "poor"; and inflation having little effect on income distribution. The "poor" are hurt because the inflation-induced tax on capital ultimately reduces the capital stock, output, and productivity. This reduces the "poor's" overall standard of living, which was already low.

There is relatively little direct empirical evidence on equity and fairness, if such evidence is interpreted as having to involve income distributions or poverty measures. The main advances in this literature in the 1990s relate to focussing the discussion on what is the best measure of welfare. The work that addressed this question suggests that lower inflation is better than higher inflation but it is too much of a stretch to infer what the optimal inflation target should be, given the paucity of evidence. As for future research, it does not seem too promising to continue with regressions of income distributions or even poverty measures on macroeconomic variables: even if good measures of sufficient length on income distribution and poverty could be obtained, the results may be sensitive to what is included and what is not. A more promising avenue may be to follow Altig's lead and construct general-equilibrium models with agents that represent as much as possible the distribution of human capital and other features in the economy and then to try various scenarios to determine the sensitivity of results.

5 LIVING WITH INFLATION IS NO ANSWER

The article in the 1990 *Annual Report* made two main points: (1) there are high costs to adjusting to living with inflation (indexing incomes, changes in the personal and corporate tax systems, legal arrangements, accounting standards, etc.); and (2) a policy of tolerance of inflation systematically undermines the capacity of a country to produce good economic performance.

As noted above, more recent work with both partial- and general-equilibrium models that account for tax distortions typically find that the benefits of reducing inflation outweigh the costs. It might be argued, and often is, that the best solution is to index the tax system (Ragan 1997). Such a suggestion ignores the question of why institutional arrangements in countries like Canada were not changed in response to the inflation experience of the 1970s. Private contracts and accounting systems are almost always in nominal terms. Recent work by Shafir,

Diamond, and Tversky (1997) suggests that people focus on nominal values because they are understandable, because most other units of measurement do not regularly change, and because in many cases they provide a reasonable estimate of real worth.

A few authors (Ragan (1997) arguing the case most strongly) suggest that the costs of introducing complete indexation would be less than those of disinflation to remove the distortions arising from the interaction of inflation with a partially indexed tax system. However, various other authors (Marty and Thornton (1995) and Feldstein (1996) address this question specifically in some detail) do not see indexation as a solution, for several reasons. They point out that no industrial country has fully (or even substantially) indexed its tax system despite a long history of proposals to do so. There are broad conceptual reasons, associated with the credibility of policy along with technical and administrative reasons, why full indexation has not been introduced.

From a broad conceptual basis, indexation can be taken as a signal that the financial authorities (fiscal and monetary policy authorities) are giving up the battle against inflation since it reduces the marginal costs of inflation. Lower marginal costs usually lead to increases in the activities to which they apply, *ceteris paribus*. Marty and Thornton (1995) note that foregoing indexation may actually help in developing a credible reputation for pursuing anti-inflation policies. The co-ordination problem in the private sector is another aspect that would have to be addressed before any move to indexation. With a large number of diverse firms with different information and shocks, how do they distinguish between real and nominal factors?

As for technical “legal” problems, Feldstein (1996) points out that, while it is relatively straightforward to come up with indexing rules for “plain vanilla” bonds and stocks, it is not so easy when more complicated instruments are involved. He gives the example of a convertible bond that, under certain circumstances, can be converted to a stock and therefore will have the price protection built into stocks. The same bond, under other circumstances, will remain a bond with an annual interest flow. It would not be possible to have a general rule that they should be taxed like equity when a significant proportion of them may be trading like bonds because their conversion price is above the actual price of the stock. He also considers the cases of commercial mortgages and of derivative securities tailored to the tax laws. However, the basic point is the same: the distinction between debt and equity is fuzzy.

Administrative problems would be created in an indexed world. Economic agents with active diversified portfolios, including chequing and savings accounts, would have to keep detailed records of how long they held particular types of instruments in any given tax year if they wanted to take full advantage of the indexation provisions. Feldstein sketches distortions arising from the various ways that taxes are indexed. For example, if capital gains were indexed by the price level at the time of sale to that at the time the asset was purchased, there would be an incentive for individuals with widely diversified portfolios to adjust the timing of the sale of stocks with real losses to offset gains in other parts of the portfolio. In response, losses might be allowed only when the nominal value of the asset has fallen, but then there would be an incentive to produce new conglomerate securities to preserve as much of the tax advantage as possible. One distortion would be substituted for another.

5.1 Discussion

The main question to be answered by those proposing indexation as a solution to the costs arising from the interaction of inflation with the tax system is the one posed by Paul Jenkins (Jenkins 1998, 478) in his remarks at a Bank of Canada conference held in May 1997. “Why did institutional arrangements not adapt to take account of anticipated inflation after two decades during which inflation averaged 7 per cent per year?” He then went on to interpret the continued existence of nominal private contracts and a nominal accounting system as meaning that the costs of adjusting to the risks created by inflation are substantial. He concluded that “the best and cheapest form of indexation is one in which the central bank is entrusted with maintaining price stability” (Jenkins 1998, 479).

As Jenkins suggests, indexing the tax system is really just the tip of the iceberg. The nominal basis of the tax system reflects the nominal basis of generally accepted accounting principles on which virtually all private and public sector accounting is based. There has been considerable study of how accounting systems might be indexed, but the best minds in the accounting profession could not come up with a system that would be widely accepted. As stressed by Konieczny (1994), money is the unit of account on which financial and real investment decisions are made. Indexing the tax system (if it can be done) simply fixes one element of the broader system that is based on the concept of a stable unit of value.

To the extent that low inflation is seen as a backdrop to the efficient functioning of the economy, it would make sense to address the interaction

distortion by having low inflation. As Feldstein and others have noted, not only are changes to the tax system often hard to make because of the diverse interests involved, but they often create other distortions as economic agents adjust their behaviour to the new information. The cost of introducing full indexation is not solely a matter of government tax specialists changing the rules of the game. It has to include the costs of economic agents in the economy learning the new rules as well as the costs of any distortions created by the new rules and the response of economic agents to them. Further research on this question might want to list, in as detailed a manner as possible, what the explicit and implicit costs of attaining full indexation might be.

Appendix 1

Empirical evidence on the relationship between inflation and relative price variability and between inflation and inflation uncertainty

Table 1 Empirical research finding a positive inflation-price variability (or in the case of the menu-cost model, the inflation-price skewness) relationship

	Country	Author(s)	Data
EXCERPTED FROM GOLOB 1993	Argentina	Blejer (1983) Tommasi (1992b)	monthly: 1977-81 weekly: 1990
	Germany	Graham (1930) Hercowitz (1981) Fischer (1982)	monthly: 1920-23 monthly: 1920-23 [sic] quarterly: 1969-80
	Israel	Cukierman and Leiderman (1984) Danziger (1987) Van Hoomissen (1988) Lach and Tsiddon (1992)	monthly: 1966-80 monthly: 1968-83 monthly: 1971-84 monthly: 1978-83
	Mexico	Blejer and Leiderman (1982)	annual: 1951-76
	Netherlands	Parks (1978)	annual: 1921-63
	U.K.	Domberger (1987) Mizon (1991)	quarterly: 1974-84 quarterly: 1965-87
	U.S.	Mills (1927) Vining and Elwertowski (1976) Parks (1978) Ashley (1981) Fischer (1982) Stockton (1988) Ram (1988) Buck (1990) Ball & Mankiw (1992b)	annual: 1892-1926 annual: 1948-74 annual: 1930-75 monthly: 1953-75 quarterly: 1948-80 quarterly: 1949-80 quarterly: 1973-86 annual: 1881-1913 annual: 1949-89
	Cross-country	Glejser (1965)	annual: 1953-59
MENU COST			
	U.S.	Ball and Mankiw (1995)	annual: 1949-89 (PPI)
	13 OECD countries	Loungani and Swagel (1995)	annual: 1960–90 (PPI)
	Canada	Amano and Macklem (1997)	annual and quarterly: 1962-94 (IPPI)

Table 2 Empirical research indicating a positive inflation–inflation-uncertainty relationship

	Author(s)	Model for Uncertainty	Country	Time Interval
EXCERPTED FROM GOLOB 1993	Okun (1971)	std. dev. of inflation	cross-country	annual: 1951-68
	Logue and Willett (1976)	std. dev. of inflation	cross-country	annual: 1951-70
	Jaffee and Kleiman (1977)	a) std. dev. of inflation b) SRC	cross-country U.S.	annual: 1950-71 quarterly: 1955-71
	Foster (1978)	average absolute change	cross-country	annual: 1954-75
	Cukierman and Wachtel (1979; 1982)	a) Livingston b) SRC	U.S. U.S.	semiannual: 1948-75 quarterly: 1966-76
	Fischer (1981b)	a) variability b) Livingston c) SRC	U.S. U.S. U.S.	5 yr.: 1806-1979 semiannual: 1950-80 quarterly: 1954-78
	Frohman, Laney, and Willett (1981)	a) forecast error b) Livingston	U.S. U.S.	annual: 1954-79 annual: 1954-76
	Taylor (1981)	a) std. dev. of inflation b) Livingston	seven OECD seven OECD	annual: 1960-79 annual: 1956-79
	Pagan, Hall, and Trivedi (1983)	Morgan Poll	Australia	quarterly: 1973-81
	Holland (1984)	Livingston	U.S.	semiannual: 1954-83
	Froyen and Waud (1987)	forecast error	four countries	quarterly: 1965-83
	Zarnowitz and Lambros (1987)	a) ASA-NBER b) Livingston	U.S. U.S.	annual: 1969-81 annual: 1969-81
	Ball and Cecchetti (1990)	a) forecast error b) forecast error	U.S. 40 countries	quarterly: 1960-89 quarterly: 1960-89
	Evans (1991)	time-varying ARCH	U.S.	monthly: 1960-88
	Evans and Wachtel (1992)	Markov switching	U.S.	quarterly: 1955-91
	Holland (1992b)	Livingston	U.S.	semiannual: 1954-90
	Brunner and Hess (1993)	state-dependent cond. heteroskedasticity	U.S.	quarterly: 1947-92
	Kim (1993)	Markov switching	U.S.	quarterly: 1958-90

Table 2 Empirical research indicating a positive inflation–inflation-uncertainty relationship

	Author(s)	Model for Uncertainty	Country	Time Interval
OTHER	Golob (1994b)	forecast errors	U.S.	quarterly: 1954-94 (PGDP) quarterly: 1958-94 (core CPI) quarterly: 1958-94 (CPI, PPI)
	Crawford and Kasumovich (1996)	GARCH	Canada	quarterly: 1916-94 1963-94
	Judson and Orphanides (1996)	var. of quarterly rate of infl.	119 countries non-oil intermed, OECD	annual: 1959-92 annual: 1959-92 annual: 1959-92 annual: 1959-92

Table 3 Empirical evidence that fails to show an inflation–inflation-uncertainty relationship

	Author(s)	Model for Uncertainty	Country	Time Interval
GOLOB 93	Engle (1983)	ARCH	U.S.	quarterly: 1947-79
	Katsimbris (1985)	std. dev. of inflation	cross-country	2 yr.: 1955-83
	Bollerslev (1986)	GARCH	U.S.	quarterly: 1948-83
	Cosimano and Jansen (1988)	ARCH	U.S.	quarterly: 1956-79
OTHER	Batchelor and Dua (1996)	RMSE of inflation forecasts of the ASA-NBER forecasters	U.S.	annual: 1969-89

Appendix 2

Empirical evidence on the costs of inflation as summarized in Black, Coletti, and Monnier (1998)

Table 1 Interaction of inflation and taxation: partial-equilibrium estimates of the benefits of disinflation

Study	Country	Experiment	Estimate	Adjusted	EV
				per cent	
Feldstein (1996)	U.S.	2% to 0%	1.0 (Y)	0.71	0.71
Fischer (1981)	U.S.	10% to 0%	2.0 (Y)	0.29	0.29
		Subsequent to Black et al.			
Bakhshi, Haldane and Hatch (1997)	U.K.	2% to 0%	0.2 (Y)	0.14	0.14
Tödter and Ziebarth (1997)	Germany	2% to 0%	2.0 (Y)	1.42	1.42

Note: Y or C in the fourth column indicates whether the measure in the paper is based on output or consumption. Column five labelled "Adjusted" scales the reported estimate to a 1-percentage-point reduction in inflation. For those papers that report the cost in terms of output, the consumption equivalent is obtained by dividing the estimate by the ratio of consumption to income (0.7). Finally, the last column reports the equivalent variation (EV). EV is the proportional increase in consumption the household would require each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state.

Table 2 Tax on money balances: partial-equilibrium estimates of the benefits of disinflation

Study	Country	Reduction in inflation	Reported	Adjusted	EV
				per cent	
Howitt (1990)[a]	Canada (M1)	9% to 0%	0.1 (Y)	0.02	0.02
Carlstrom and Gavin (1993)	U.S. (base)	4% to 0%	0.06 (Y)	0.02	0.02
McCallum (1990)	U.S. (M1)	10% to 0%	0.28 (Y)	0.04	0.04
Fischer (1981)	U.S. (base)	10% to 0%	0.30 (Y)	0.04	0.04
Lucas (1981)	U.S. (M1)	10% to 0%	0.45 (Y)	0.06	0.06
Eckstein and Leiderman (1992)	Israel (M1)	10% to 0%	0.85 (Y)	0.12	0.12

a. Using Boothe and Poloz's estimated M1 demand function.

Note: Y or C in the fourth column indicates whether the measure in the paper is based on output or consumption. Column five labelled "Adjusted" scales the reported estimate to a 1-percentage-point reduction in inflation. For those papers that report the cost in terms of output, the consumption equivalent is obtained by dividing the estimate by the ratio of consumption to income (0.7). Finally, the last column reports the equivalent variation (EV). EV is the proportional increase in consumption the household would require each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state.

Table 3 Single-country time-series estimates of the benefits of disinflation

Study	Country	Estimate[a]	EV
		per cent	
Cameron, Hum, and Simpson (1996)	Canada, U.S., U.K., Germany	0	0
Fortin (1993)	Canada	0	0
Kryiakopoulos (1990)	Australia	0	0
Sbordone and Kuttner (1994)	United States	0	0
Stanners (1993)	Industrialized countries	0	0
Bullard and Keating (1995)	58 postwar economies	0	0
Englander and Gurney (1994)	OECD	0.06	2.00
Grimes (1991)	OECD	0.10	3.40
Smyth (1994)	U.S.	0.20	7.00
Jarrett and Selody (1982)	Canada	0.30	10.60
Rudebusch and Wilcox (1994)	U.S.	0.35	12.50

a. Growth rate effect.

Notes: Income or productivity gain (per cent of GDP) for a 1-percentage-point reduction in the rate of inflation. Column three is the percentage change in income or productivity for a 1-percentage-point reduction in the rate of inflation. Finally, the last column reports the equivalent variation (EV). EV is the proportional increase in consumption the household would require each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state.

Table 4 Cross-country time-series estimates of the benefits of disinflation

Study	Estimate	EV
	per cent	
Bruno and Easterly (1996)	0.00[a] if $\pi < 40\%$	0.00
Judson and Orphanides (1996)	0.00[a] if $\pi < 10\%$	0.00
Alexander (1990)	0.20	0.20
Barro (1995)[b]	0.02[b]	0.40
Fischer (1993a)	0.04[a]	1.40
Cozier and Selod(1992)[b]	0.10[b]	1.98
Grier and Tullock (1989)	0.16[a]	5.50

a. Growth rate effect.

b. Temporary growth rate effect lasting 30 years (see Fortin 1997).

Notes: Income or productivity gain (per cent of GDP) for a 1-percentage-point reduction in the rate of inflation. Column two is the percentage change in income or productivity for a 1-percentage-point reduction in the rate of inflation. Finally, the last column reports the equivalent variation (EV). EV is the proportional increase in consumption the household would require each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state.

Table 5 Tax on money balances: general-equilibrium estimates of the benefits of disinflation

Study	Country	Experiment	Estimate	Adjusted	EV
				per cent	
Gomme (1993)[a]	U.S.	8.5% to optimum	0.03 (Y)	0.003	0.003
Cooley and Hansen (1989)	U.S. (base)	10% to 0%	0.08 (Y)	0.01	0.01
Jones and Manuelli (1989)	U.S. (NA)	10% to 0%	0.08 (Y)	0.01	0.01
Dotsey and Ireland (1996)	U.S. (base)	10% to 0%	0.20 (Y)	0.03	0.03
Cooley and Hansen (1989)	U.S. (M1)	10% to 0%	0.30 (Y)	0.04	0.04
Cooley and Hansen (1991)	U.S. (M1)	10% to 0%	0.27 (Y)	0.04	0.04
Dotsey and Ireland (1996)	U.S. (M1)	10% to 0%	0.92 (Y)	0.13	0.13
Dotsey and Ireland (1996)[a]	U.S. (base)	10% to 0%	0.92 (Y)	0.14	0.14
Gillman (1993)	U.S.	10% to −2.9%	2.19 (Y)	0.24	0.24
Dotsey and Ireland (1996)[a]	U.S. (M1)	10% to 0%	1.73 (Y)	0.25	0.25
Black, Macklem, and Poloz (1994)	Canada	10% to 0%	3.04 (C)	0.30	0.30
Black, Macklem, and Poloz (1994)[a]	Canada	10% to 0%	4.82 (C)	0.48	0.48
Marquis and Reffett (1994)[b]	U.S.	10% to optimum	7.15 (Y)	0.50	0.50

a. Endogenous growth model.

b. As reported in Gillman (1995).

Notes: Y or C in the fourth column indicates whether the measure in the paper is based on output or consumption. Column five labelled “Adjusted” scales the reported estimate to a 1-percentage-point reduction in inflation. For those papers that report the cost in terms of output, the consumption equivalent is obtained by dividing the estimate by the ratio of consumption to income (0.7). Finally, the last column reports the equivalent variation (EV). EV is the proportional increase in consumption the household would require each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state.

A notable omission from this table is Lucas (1994). Lucas’s use of a log-log money demand function rather than the usual semi-log specification implies that the benefits from reducing inflation increase as the inflation rate declines. Lucas estimates that the benefit from a reduction in the inflation rate from 10 to 0 per cent generates an increase in GDP of about 1 per cent. The benefits from reducing inflation from 0 to −3 per cent are disproportionately large. Pursuit of a negative inflation target is not considered to be relevant to the current policy discussion.

Table 6 Interaction of inflation, taxation, and money balances: general-equilibrium estimates of the benefits of disinflation

Study	Country	Experiment	Estimate	Adjusted	EV
				per cent	
Cooley and Hansen (1991)	U.S.	10% to 0%	0.68 (Y)	0.10	0.10
Chang (1992)	U.S.	4.7% to 0%	2.53	0.54	0.54
James (1994)	Canada	4% to 3%	0.6 (C)	0.60	0.60
Black, Macklem, and Poloz (1994)	Canada	10% to 0%	9.58 (C)	0.96	0.96
Black, Macklem, and Poloz (1994)[a]	Canada	10% to 0%	16.77(C)	1.68	1.68
Subsequent to Black et al.					
Bullard and Russell (1997)	U.S.	5% to 4%	1.29 (Y)	1.84	1.84

a. Endogenous growth model.

Notes: Y or C in the fourth column indicates whether the measure in the paper is based on output or consumption. Column five labelled “Adjusted” scales the reported estimate to a 1-percentage-point reduction in inflation. For those papers that report the cost in terms of output, the consumption equivalent is obtained by dividing the estimate by the ratio of consumption to income (0.7). Finally, the last column reports the equivalent variation (EV). EV is the proportional increase in consumption the household would require each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state.

Appendix 3

Empirical evidence on the costs of inflation as summarized in Haslag (1997)

Table 1 Empirical evidence on the inflation-growth relationship (Haslag 1997)

Author(s)	Samples	Methodology	Synopsis of Results
Kormendi and Meguire	46 countries, 1948-77, varying periods	cross-country regression using sample means	negative and significant relationship between output growth and inflation exists
Fischer (1991)	73 countries	comparison of sample means from fast- and slow-growing countries	inflation in fast-growth group is lower than in slow-growth group
DeGregorio (1993)	12 Latin American countries, 1950-85	cross-country regression using six-year averages, non-overlapping	negative and significant relationship between output growth and inflation exists
Gomme (1993)	82 countries, 1949-89, varying periods	cross-country simple correlations using annual data	output growth and inflation are negatively correlated
Bullard and Keating (1995)	58 countries	regressions for each country	inflation has no significant long-run effect on the level of output
Ericsson, Irons, and Tryon (1993)	G-7 countries	regressions for each country	inflation rate has no significant long-run effect on output growth

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