On the Costs and Benefits of Price Stability

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Introduction

While there is broad-based agreement that the double-digit inflation of the 1970s is undesirable, there is much less agreement that very low inflation—price stability—is the appropriate goal for monetary policy. The literature on the welfare benefits of low inflation reflects this diversity of opinion, as individual researchers often come to different conclusions. These differences hinge on many factors, including the particular benefit of lower inflation that is being considered, whether the costs of reducing inflation are transitory or permanent, and the methodology used to quantify these effects.

The purpose of this paper is to reconsider the costs and benefits of price stability. In general terms, the approach we follow is along the lines of Howitt (1997), Feldstein (1996), and Thornton (1996), which compare the present value of the benefits of low inflation with the present value of the costs of achieving (and maintaining) low inflation. To avoid focussing on a single estimate of the costs or benefits of lower inflation, we consider a wide range of estimates and a variety of hypotheses regarding the workings of the economy.

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One problem with the literature on this subject is that individual studies frequently yield answers that are difficult to compare. We address this issue by establishing a common welfare measure with which we attempt to standardize the results from the literature, and then build up a distribution of the costs and benefits of lower inflation.

This paper also provides interesting results, new to the literature, on the costs of achieving and maintaining price stability. In addition to the "conventional" assessment of the costs associated with reducing inflation, we examine some popular arguments advanced against the pursuit of price stability, such as labour-market hysteresis, the deterioration of the fiscal position from a tightening in monetary policy, and the existence of a nominal interest rate floor. To assess these potential costs quantitatively in the Canadian context, we use the Bank of Canada's macroeconomic simulation model QPM (Quarterly Projection Model). In particular, we extend the base QPM model to incorporate features such as labour-market hysteresis, an induced fiscal effect of monetary policy actions, and a floor on nominal interest rates, and we use these extended versions of the model to assess the macroeconomic implications of these features.

We begin the paper by describing our welfare measure. We then turn to QPM to examine the costs of achieving low inflation, and some potential costs of maintaining it. Next we review the literature studies on the benefits expected to arise from a reduction in inflation. These studies are categorized according to the methodology that they use, such as general versus partial equilibrium analysis, and the particular benefit that they consider, such as the reduction in the inflation tax on money balances or the reduced distortion arising from the interaction between inflation and the tax system. Finally, we compare the estimates of the costs and benefits of price stability and perform a limited sensitivity analysis.

1 A Welfare Measure

Before one can evaluate the various costs and benefits associated with price stability, one must settle on a metric from which welfare can be measured. One must also specify how the results from the literature will be mapped into this welfare measure, including when the benefits of low inflation start to accrue. The last point is particularly important because benefits that are delayed for some time are not worth as much as those that accrue immediately.

1.1 Welfare defined

In this paper we use the present value of log consumption as the basis for a welfare function. We choose this primarily for simplicity, and because log consumption is a popular choice of utility function, but also because, as described in the next section, it is easy to convert and interpret other authors' measures. The welfare function takes the form

$$W = \sum \frac{1}{(1+\lambda)^t} \log(c_t), \tag{1}$$

where c is real aggregate consumption and λ is the social planner's discount rate. In this welfare function it is assumed that all variables are measured quarterly at quarterly rates.

For closed economies, the choice of a social discount rate is often based on the discount rate for a representative consumer. First-order conditions typically equate this discount rate to the real interest rate less the growth rate.[1] As Feldstein (1996) notes, one can make a case for a very low discount rate by choosing, for example, the (average) real return on government bonds as the real interest rate—Howitt (1990) uses a discount rate of 1.5 per cent (implicitly) based on this method. An alternative, more conservative measure is to base the real interest rate on the return to equity. This approach suggests a discount rate of 2.6 per cent for the United States (Feldstein 1996). Thornton (1996) considers a range of discount rates between 3.05 and 4.5 per cent for the United States.

The problem with this analysis is that, because it is for a closed economy, it does not necessarily apply to Canada since there is generally no reason why the consumers' discount rate should be equal to the interest rate less the growth rate. Scarth (1994), following an interpretation of Calvo and Obstfeld (1988), argues that one choice of social discount rate is simply the individual's discount rate. In the social planner's problem, this would lead to an "egalitarian" solution, where all individuals have the same level of consumption at any moment (Calvo and Obstfeld 1988). Scarth consequently uses a value of 3 per cent, which is close to the individual's discount rate of 3.1 per cent used in QPM. In accordance with the above studies, we adopted a rate of 3 per cent as the base-case discount rate for this study. We also present some sensitivity analysis.

1.2 Using the welfare measure

Specifying the welfare measure is only half the battle, if that. Next one must calculate how to map into it the results from the literature. Indeed,

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1. Feldstein (1996) notes that a permanent increase in output of x per cent has the present value of $x/(d - g)$ per cent of current output, where d is the discount rate, which Feldstein sets to the real interest rate, and g is the real growth rate. In terms of the social welfare function described above, Feldstein has essentially identified the individual's discount rate as $r - g$.

this is one of the principal contributions of this paper. It is easiest to group the papers according to how they report their results. First, we scale the results to be consistent with a 1 percentage point change in inflation. Then we calculate the change in welfare using one of the methods below. Finally, we derive a measure of equivalent variation.

1.2.1 Inflation affects the level of consumption

If consumption increases by x following a 1 percentage point disinflation, then the new level of welfare, W', is given by:[2]

$$\begin{aligned} W' &= \sum \frac{1}{(1+\lambda)^t} \log[c_t(1+x)] \\ &= W + \sum \frac{1}{(1+\lambda)^t} \log(1+x) \\ &= W + \frac{1+\lambda}{\lambda} \log(1+x). \end{aligned} \tag{2}$$

Sometimes it is also necessary to scale the result by the fraction of consumption to income. This is the case, for example, when the authors report something along the lines of "consumption increases by 8 billion 1990 dollars, or 2 per cent of GDP." Here we report 2 divided by 0.7 (where 0.7 is the share of consumption to GDP) as the percentage by which consumption increases.

In equation (2), it is implicitly assumed that the benefits accrue immediately. This need not be the case, and in the final section of this paper we present some sensitivity analysis on this point. The formula above, and its counterpart below, are easily adjusted to take this into account.

1.2.2 Inflation affects the growth rate of consumption

Some papers, those in Tables 8 and 9 in particular, report the effect on the growth rate of output or total factor productivity. It is assumed that the growth rate of consumption increases by the same amount. In this case, if x is the increase in the growth rate of consumption, welfare is given by:[3]

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2. λ is measured at quarterly rates.

3. Once again, λ is measured at quarterly rates, as is x. Generally speaking the quantities reported in the literature are at annual rates. If y is an annual rate, then the corresponding quarterly rate is $(1+y)^{0.25} - 1$.

$$
\begin{aligned}
W' &= \sum_{i=0}^{\infty} \frac{\log[c_{t+i}(1+x)^i]}{(1+\lambda)^i} \\
&= \sum_{i=0}^{\infty} \frac{\log(c_{t+i}) + i\log(1+x)}{(1+\lambda)^i} \\
&= W + \log(1+x)\sum_{i=0}^{\infty}\frac{i}{(1+\lambda)^i} \\
&= W + \frac{1+\lambda}{\lambda^2}\log(1+x). \qquad (3)
\end{aligned}
$$

1.2.3 A measure of equivalent variation

To facilitate comparison between the levels of welfare, we derive a measure of equivalent variation, EV, defined as the proportional increase in consumption the households would require each period in the initial high-inflation steady state to be as well off as in the low-inflation steady state.[4] More exactly, EV is defined as:

$$
\begin{aligned}
W' &= \sum \frac{1}{(1+\lambda)^t}\log[c_t(1+EV)] \\
&= W + \sum \frac{1}{(1+\lambda)^t}\log(1+EV) \\
&= W + \frac{1+\lambda}{\lambda}\log(1+EV), \qquad (4)
\end{aligned}
$$

where W' is defined from one of the previous two sections. Note that with the base-case assumption that the benefits accrue immediately, the corresponding measures of EV are:

$$EV = x, \qquad (5)$$

when x denotes a level change, and

$$EV = (1+x)^{1/\lambda} - 1 \approx \frac{x}{\lambda}, \qquad (6)$$

when x denotes change in the growth rate.

4. The authors thank Steven James for suggesting the use of an EV measure.

2 Assessing the Costs of Achieving and Maintaining Price Stability

2.1 A brief overview of QPM

To quantify the costs associated with reducing and maintaining inflation at a low level, we use the Bank of Canada's Quarterly Projection Model. QPM has been documented in a series of Bank of Canada technical reports beginning in November 1994.[5] This section briefly reviews some of the model's key features.

QPM is designed to serve two purposes. It is used by Bank staff, first, in preparing economic projections, and second, for research on policy analysis. To fulfil its mandate, QPM attempts to bridge the gap between forecasting models and more structural models designed solely for policy analysis.

The model is calibrated to match a wide variety of stylized facts of the Canadian economy. For example, estimated vector autoregression models have been used to establish short-run impulse patterns and cyclical properties that are consistent with the data. In addition, a host of empirical studies done within and outside the Bank have been used to assist in selecting some key model parameters and properties.

QPM is a system of two models. Steady-state QPM (SSQPM) is a model of the long-run equilibrium. It is based on the Blanchard-Weil model of household behaviour. SSQPM describes the determinants of the long-term choices made by profit-maximizing firms and overlapping generations of consumers, given the policies of the fiscal and monetary authorities, all in the context of an open economy with important ties to the rest of the world. The economic behaviour of these agents, given their long-run budget constraints, as well as the market-clearing conditions of an open economy determine the long-run equilibrium or steady state to which the dynamic model converges. Black, Laxton, Rose, and Tetlow (1994) provide a detailed description of SSQPM.

The dynamic model, QPM, traces out the path of the economy from its initial conditions to the steady state as determined by SSQPM. The dynamic model has several key features. First, agents are forward-looking. Expectations are modelled as a mixture of both forward-looking, model-consistent expectations and a backward-looking, adaptive component. Expectations play an important role in the model. In addition, adjustment of

5. See Black, Laxton, Rose, and Tetlow (1994); Armstrong, Black, Laxton, and Rose (1995); and Coletti, Hunt, Rose, and Tetlow (1996). See also Poloz, Rose, and Tetlow (1994) for a less technical review of the QPM system and its use at the Bank of Canada.

both prices and quantities is assumed to be costly so there is an intrinsic element to the model's dynamics.

A key feature of QPM is that it is dynamically stable and converges on the equilibrium from SSQPM. There are three key stocks in the QPM system: government bonds, private sector physical capital, and net foreign assets. The steady-state levels of these stocks are consistent with the economic theory in SSQPM, and the necessary flows are supported by relative price movements. If a shock affects a stock, then the flows have to be generated to return the model to its steady state.

QPM also incorporates endogenous monetary and fiscal policy reaction functions. The objective of monetary policy is to control inflation. It is implemented through a forward-looking reaction function in which the monetary authority adjusts its policy instrument to bring inflation into line with the inflation target. The instrument of monetary policy is the short-term interest rate, which affects domestic spending through the yield curve. Equation (7) shows the monetary authority's reaction function:

$$R_t^S - R_t^L = \delta(R_{t-1}^S - R_{t-1}^L) + \theta\left[\sum_{i=6}^{7}(\pi_{t+i}^e - \pi_{t+i}^T)\right], \tag{7}$$

where R^S is the short-term nominal interest rate (specifically, the 90-day commercial paper rate), R^L is a long-term nominal rate (the 10-year-and-over Government of Canada bond rate), π^e is the rate of inflation expected by the monetary authority, and π^T is the target rate of inflation. Because of lags between changes in monetary policy and changes in prices, the monetary authority in QPM looks ahead to determine the appropriate value for its instrument. Some weight is also given to the lagged dependent variable.

Since the central bank cannot control inflation directly, shocks that hit the economy will have an effect on inflation, regardless of how high the weight on the inflation gap is set in equation (7). The reason is that monetary policy influences the outcome with a lag. Hence, the monetary authority cannot keep inflation precisely at the target level. Deviations will occur, and may persist for some time, owing to the intrinsic and expectational dynamics of the system.

The fiscal authority is also modelled endogenously in QPM. The public sector in QPM reflects a consolidation of the activities of federal, provincial, and local governments. This government sector purchases goods and services, makes transfers to the private sector, and raises revenue through direct taxation of income as well as indirect taxation of domestic transactions. It also issues debt denominated in domestic currency.

Fiscal policy in the extended version of QPM used for this paper is characterized by a set of three target ratios: the level of debt relative to output, the level of spending relative to output, and the level of transfers to persons relative to output. In accordance with the stylized facts for the Canadian economy, the short-run level of spending is assumed to be slightly procyclical while the level of transfers to persons is countercyclical. The rate of personal direct taxation and the government budget deficit adjust to validate these choices.

Equation (8) shows a stylized version of the model's fiscal policy reaction function:

$$\Gamma_t = \eta\Gamma_{t-1} + (1-\eta)(\Gamma^{ss} + \xi((D/Y) - (D/Y)^{ss})). \tag{8}$$

The rate of personal direct tax, Γ, is adjusted to realize the target ratios. The steady-state model provides Γ^{ss}, the tax rate necessary to maintain a constant steady-state debt-to-income ratio. The actual tax rate will eventually converge to Γ^{ss}. If the actual debt ratio, D/Y, is above its steady-state value, then the tax rate will rise to increase revenues and bring the ratio down. The rule is calibrated with a large weight on the lagged tax rate since tax rates typically are not adjusted rapidly in response to economic conditions. In QPM, the parameter η is chosen so that the government can achieve a 10 percentage point reduction in its target in five to six years (starting from a steady state).

2.2 The base-case cost of disinflation

A popular approach to assessing the costs of lowering inflation is to estimate a Phillips curve and to calculate the associated sacrifice ratios.[6] The Bank of Canada has studied the sacrifice ratio intensively. Recently, much of this work has centred on the estimation of "accelerationist" Phillips curves (Cozier and Wilkinson 1991, Dupasquier and Girouard 1992). The standard expectations-augmented Phillips curve can be expressed as follows:

$$\Pi_t = \Pi_t^e + \delta(Y_t - Y_t^*) + \varepsilon_t, \qquad \delta > 0 \tag{9}$$

where Π is the rate of inflation, Π^e is the expected inflation rate, Y is output, Y^* is potential output, and ε represents shocks to inflation, such as a commodity price shock. Assuming adaptive expectations and the accelerationist restriction, equation (9) can be written as:

6. The sacrifice ratio is defined as the output forgone to achieve a permanent reduction in inflation of 1 percentage point.

$$\Pi_t = \sum_{i=1}^{k} \alpha_i \Pi_{t-i} + \delta(Y_t - Y_t^*) + \varepsilon_t, \tag{10}$$

where the accelerationist restriction is:

$$\sum_{i=1}^{k} \alpha_i = 1. \tag{11}$$

The Phillips curve can be inverted to calculate the sacrifice ratio Φ:[7]

$$\Phi = \frac{1 - \sum_{i=1}^{k-1} \left(\sum_{j=i+1}^{k} \alpha_j \right)}{\delta}. \tag{12}$$

Cozier and Wilkinson (1991) compute a sacrifice ratio of about 2 per cent of gross domestic product (GDP), using inflation measured by the GDP deflator, while Dupasquier and Girouard (1992) arrive at a lower figure, working with a measure based on the consumer price index (CPI).

Many other estimates of the Canadian sacrifice ratio are available, and they tend to cover a broad range. Howitt (1990) looks at the 1981-82 disinflation episode and concludes that the sacrifice ratio is about 4.7 per cent of GDP. Ball (1994) estimates the Canadian sacrifice ratio at 2.4 per cent over the 1981-85 period. Debelle (1996) calculates the Canadian sacrifice ratio at 2.0 per cent over the same period and estimates the sacrifice ratio at 3.5 per cent over the 1990-93 disinflation. Cecchetti (1994), using the Blanchard-Quah (1989) restriction to decompose aggregate supply and demand shocks, calculates two alternative measures of the Canadian sacrifice ratio. Under the assumption that output is trend stationary, he calculates the average sacrifice ratio to be 1.6 per cent over the 1957-92 period. Under the assumption that output is I(1) he estimates the sacrifice ratio at 5.7 per cent.[8]

Although useful, the calculation of sacrifice ratios from Phillips curves has severe limitations. As Buiter and Miller (1985) point out, inflation is clearly an endogenous process, and single equation representations of

7. Models in which it is possible to compute a unique sacrifice ratio represent expected inflation by lagged inflation with the sum of lags restricted to unity. This is often called the "integral gap" model. It is questionable on both theoretical and empirical grounds; see Laxton, Rose, and Tetlow (1993). Given their reduced-form nature, it is not surprising that Phillips curves tend to be unstable over time and exhibit unstable sacrifice ratios; see Ball (1994), Hostland (1995), and Lipsett and James (1995).

8. Inflation is assumed to be I(1) in both specifications.

inflation are void of policy analysis. The costs of disinflation depend on a wide variety of factors including the prevailing economic conditions, the state of inflationary expectations, the credibility of the monetary authority, and the reaction of other domestic policy agents (for example, fiscal policymakers).

This point is illustrated in the Canadian context by Laxton, Rose, and Tetlow (1993). They estimate a Phillips curve for Canada that permits excess demand and supply to have different effects on inflation. Their results suggest an important asymmetry in price adjustment, whereby excess demand creates more inflationary pressure than excess supply of the same magnitude creates disinflationary pressure.[9] Next, Laxton, Rose, and Tetlow embed their Phillips curve in a small macro model and conduct simulation experiments. Two interesting results emerge. First, the cyclical cost of reducing inflation (measured as the cumulative loss of output during the transition) is considerably larger than the corresponding gain from raising inflation. Second, the magnitude of this cost is quite sensitive to the weight placed on the forward-looking component of expectations. Since this parameter is not precisely measured, this imprecision must be taken seriously.

For the calibration of QPM, the staff elected to assume only a modest degree of forward-looking behaviour, about 20 per cent, which results in a sacrifice ratio of about 3 and a "benefit ratio" of about 1.[10] There is considerable uncertainty regarding this aspect of the model's calibration. These properties are demonstrated in simulations reported in the next section.

2.2.1 A 1 percentage point disinflation shock

As a base-case estimate of the costs of disinflation, we consider the effects in QPM of a reduction in the target rate of inflation of 1 percentage point. The analysis here is limited to business cycle effects, as this version of QPM does not incorporate the benefits of lower inflation. Aside from a small seigniorage effect, there are no long-run effects of inflation on the real economy. The results for this base-case scenario are shown in Figure 1.

To bring about a reduction in the rate of inflation, the monetary authority raises short-term interest rates by about 100 basis points on average in the first year. Long-term rates increase just slightly in the first

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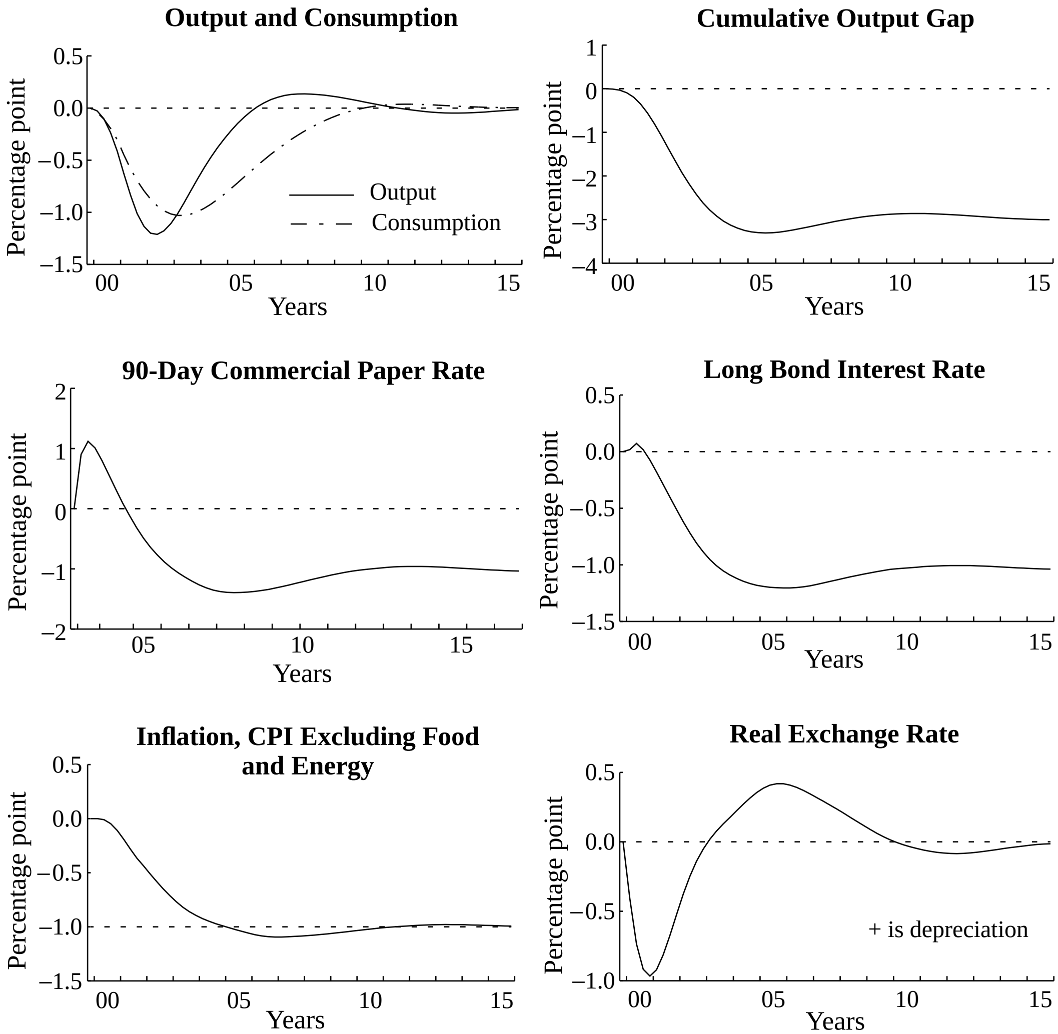
9. Other studies have found support for the non-linear Phillips curve. For the OECD see Turner (1995), and for the United States see Clark, Laxton, and Rose (1996).

10. These results also depend on the degree of forward-looking behaviour in wage determination. In accordance with empirical evidence, QPM is configured with greater weight on forward elements in price determination than in wage determination.

Figure 1

A 1 Percentage Point Disinflation Shock (Shock Minus Control)



year and then fall relative to the control, reflecting agents' expectations of lower inflation. The rise in short-term interest rates results in a modest appreciation of the dollar and this acts to depress domestic and foreign demand. The maximum effect on aggregate demand is felt in the third year, at which point a (negative) output gap of over 1 per cent has built up. Inflation reaches its new target level after five years. By that time, short-term interest rates have actually undershot their long-run level in order to curtail the building disinflationary momentum.

In the end, the total output forgone to reduce inflation permanently by 1 percentage point is a loss of 3 per cent of one year's output. The transition to lower inflation also implies a welfare deterioration of 0.14 per cent of consumption by the EV measure.

2.3 Labour-market hysteresis and the costs of disinflation

An important aspect of the base-case estimate of the costs of disinflation is that the estimate assumes that monetary policy affects the unemployment rate only temporarily. This conventional view has, however, sometimes been challenged. In particular, Blanchard and Summers (1986) suggested that reducing inflation may raise the unemployment rate permanently (see Fortin 1991 for an application to Canada). In this section we assess the welfare cost of disinflation with labour-market hysteresis incorporated into QPM. The size of the effect is calibrated to be consistent with the evidence provided in a number of studies.

Labour-market hysteresis posits that the natural rate of unemployment automatically follows the path of the unemployment rate. The theoretical arguments used to explain this include (1) human capital models, where skills tend to deteriorate more the longer people are unemployed, thereby further reducing the probability that they can find employment; and (2) insider-outsider models, where insiders prevent the wage from falling after a negative shock to employment (Poloz 1994).

As Laidler (1990) and Fortin (1990) argue, the presence of labour-market hysteresis implies that the costs associated with a disinflationary policy cannot be viewed as temporary. If labour-market hysteresis is present, the costs of a disinflationary policy are permanent and could exceed the permanent benefits of the lower inflation rate.

Most previous studies have concluded that Canadian labour markets do not exhibit hysteresis (see Cozier and Wilkinson 1991, Fortin 1989, McCallum 1988, and Nott 1996). Fortin (1991) argues that hysteretic effects were important over the 1973-90 period. However, subsequent research by Poloz and Wilkinson (1992), Jones (1995), and Nott (1996) has shown this result to be quite fragile.

Recognizing that it is difficult to identify hysteretic effects in the data, we consider the possibility that hysteresis does play an important role in Canadian labour markets. We do this by modifying QPM to incorporate a path-dependent non-accelerating inflation rate of unemployment. We then calibrate the model to a recent microeconomic study done by Wilkinson (1997).

Using the 1988-90 Labour Market Activity Survey, Wilkinson estimates hazard models and finds some evidence of duration dependence, supporting the "loss of skills" hypothesis of hysteresis.[11] On the basis of these findings as well as those of Jones (1995), Wilkinson converts the microeconomic evidence into estimates of hysteresis at the macroeconomic level. These estimates use the hysteretic and non-hysteretic survival functions to calculate the average duration of unemployment. Given that the unemployment rate is the incidence of unemployment multiplied by the duration of unemployment, the effect of hysteresis on unemployment duration can be transformed into an estimate of the unemployment rate. The hysteretic effect is measured as the permanent change in the unemployment rate arising from a 1 percentage point increase in the unemployment rate. The range of estimates from Wilkinson (1997) and Jones (1995) is from 0.03 to 0.07 percentage points. For the purpose of this paper a midpoint estimate of 0.05 percentage points is used (Hysteresis 1).

We examine a second calibration based on work done by Jaeger and Parkinson (1994). They estimate an "unobserved components" model for unemployment and find that a 1 percentage point increase in unemployment rate leads to a permanent increase of 0.2 percentage points in trend unemployment (Hysteresis 2).

Figure 2 shows the results of a 1 percentage point disinflation with hysteresis compared with the base-case results. The main differences between the base-case disinflation shock and the hysteretic labour-market calibrations are the larger increase to the unemployment rate in the short run, as well as the tendency for the unemployment rate to remain "stuck" at a higher equilibrium value. To generate the same amount of disinflationary pressure, the unemployment rate needs to rise more in the short run, since the natural rate of unemployment is also increasing. As seen in Figure 2, a permanent increase in the unemployment rate has a permanent negative effect on consumption.

The transition to lower inflation in the Hysteresis 1 calibration implies a welfare deterioration of 0.19 per cent of consumption by the EV

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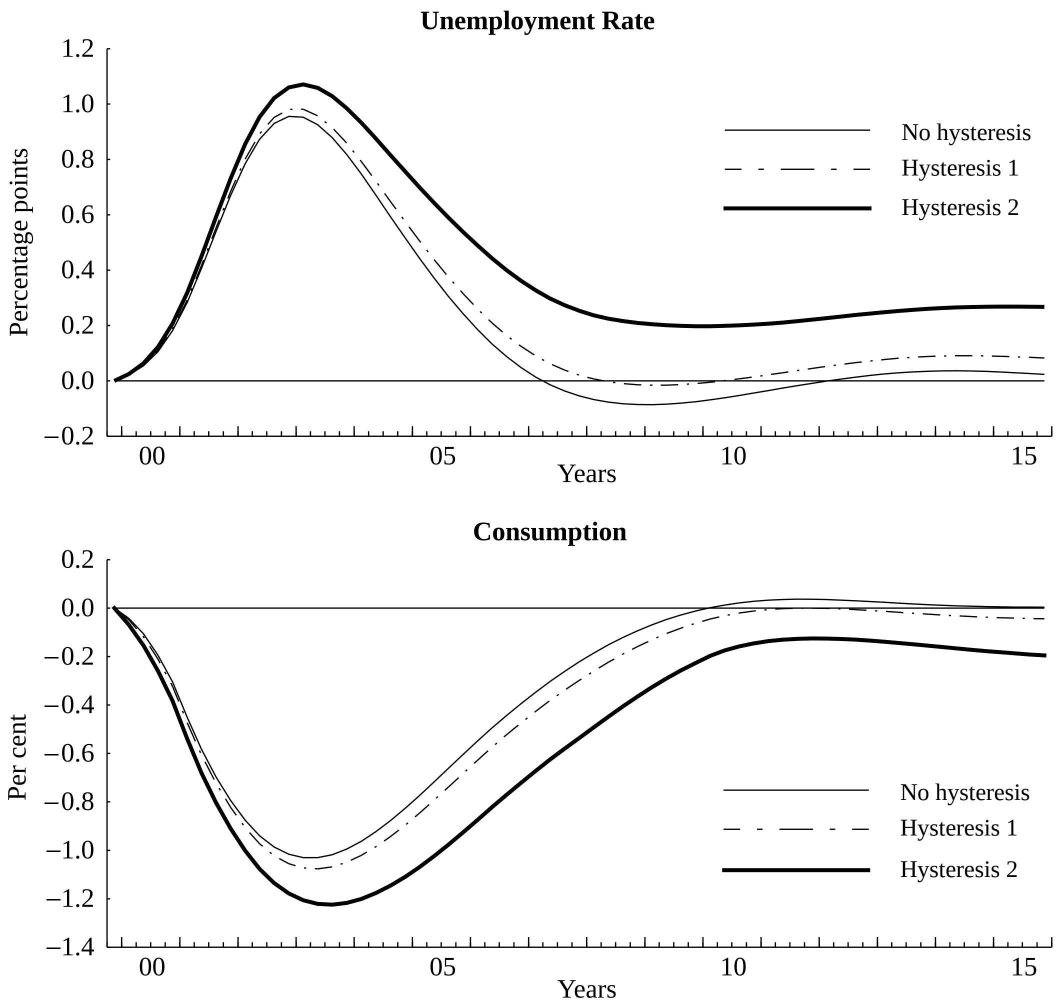
11. These estimates are interpreted by Wilkinson (1997) as an upper bound on the macroeconomic implications of the estimated duration dependence at the microeconomic level. This reflects the fact that Wilkinson sets the non-hysteretic probability of exiting from unemployment for any length of unemployment spell to be the same as that in the first week of unemployment. A more conservative approach would be to suppose that the non-hysteretic probability of exiting from unemployment is some weighted mean of the exit probabilities defined by the downward-sloping hysteretic curve. In this case, the positive and negative probability deviations from the weighted mean would at least partly offset one another, implying less hysteresis at the aggregate level.

Figure 2

Labour Market Hysteresis and Disinflation (Shock Minus Control)



measure. By contrast, the more generous Hysteresis 2 calibration implies a welfare deterioration of 0.33 per cent of consumption by the EV measure.

2.4 An alternative fiscal response to a disinflation

One of the effects of a disinflation shock is a temporary deterioration of the government budget deficit. Higher interest rates and transfers as well as lower revenues associated with the process of reducing inflation spill over to the fiscal position. In the base-case model, the fiscal authority increases the direct tax rate to offset this effect and maintain the original long-run debt-to-GDP ratio. In this section, we reconsider the effects of a disinflation while allowing the long-run debt-to-GDP ratio to increase permanently, thereby reducing the short-term pain of the disinflation at the cost of a permanently higher debt burden.

2.4.1 The fiscal authority and government debt in QPM

We begin by briefly reviewing the role of the fiscal authority in QPM and how it may interact with monetary policy. There are three main points. First, permanent increases in the debt ratio reduce steady-state potential output and consumption. Second, higher levels of government debt raise the risk premium demanded by lenders. Finally, the dynamic path for the deficit is affected by interest rates, cyclically sensitive transfers, cyclically sensitive tax revenues, and the level of government spending.

In QPM, a permanently higher debt ratio reduces consumption because consumers behave in a non-Ricardian manner, so that they perceive the increase in debt as a rise in wealth, increasing consumption expenditure in the short run, at the expense of long-term consumption (Black, Laxton, Rose, and Tetlow 1994). In addition, higher government debt increases the interest rate at which the government can borrow, with the effect of further reducing long-run consumption (Macklem, Rose, and Tetlow 1995).

In this extended version of QPM there are two types of effects of government debt on risk premiums. A permanent component ties the risk premium to the level of the debt-to-GDP ratio, while a direction effect is a transitory change in the risk premium designed to capture the direction of movement of the actual debt-to-GDP ratio. These effects are calibrated according to Alesina et al. (1992) for 12 OECD countries for the 1979-89 period. These modest effects are as follows: (1) a 1 percentage point increase in the long-run government debt-to-GDP ratio results in an increase of 1.7 basis points in the risk premium; and (2) the direction effect is set so that the risk premium increases by 6.6 basis points per percentage point change in the actual debt-to-GDP ratio.[12]

The deficit is affected by the government's spending behaviour as well as by the revenues it receives. The most important components of spending in this version of QPM are goods and services and transfers. The government receives revenue from firms (through capital taxation), from workers (through income taxation), and via indirect taxation (mainly consumption taxes).

On the revenue side, QPM has been calibrated to be broadly consistent with the estimates of the elasticity of tax revenues for a change in

12. The risk premium is also applied to net foreign liabilities because their existence is largely driven by the need to finance foreign debt.

economic activity as provided by the Department of Finance (Boucher 1995). On the expenditure side, government spending on goods and services is assumed to be fixed at its steady-state level in the short run and allowed to adjust to a constant fraction of output (18.5 per cent) over the longer term. Transfers to persons are set to 12.5 per cent of GDP in the steady state. In the dynamic model, the elasticity of transfers is set to 0.5, so that for every 1 per cent reduction in demand (measured by the output gap), there is a 0.5 per cent increase in transfers.[13]

2.4.2 Disinflation and government debt

In the base-case disinflation shock, interest rates go up and demand goes down. Both these conditions lead the level of government debt to increase. In the base case, the fiscal authority increases taxes in order to return the ratio of government debt to GDP to its target level. Here we repeat the base-case disinflation shock, this time allowing the government to raise its target level of government debt as a proportion of GDP instead of increasing taxes.

In a crude attempt to mimic the budget planning process, we allow the fiscal authority to reassess its long-run debt targets at the end of each year for three consecutive years, after which it must act to stabilize the debt-to-GDP ratio. Effectively, we allow the long-run debt-to-GDP target to move one-for-one with the actual debt-to-GDP ratio over the first three years of the simulation. Figure 3 illustrates the effect of the shock compared with the base case.

To understand the nature of this shock, consider first the impact on the government debt-to-GDP ratio of a 1 percentage point reduction in inflation. As shown in Figure 3, the run-up in the government debt-to-GDP ratio for a 1 percentage point reduction in the inflation rate is about 1.7 percentage points. To put this rule of thumb in perspective, this implies that a 4 percentage point reduction in inflation would raise the debt-to-GDP ratio by 7 percentage points. That is about one-fifth of the observed increase in the debt-to-GDP ratio between 1989 and 1996, over which period inflation fell slightly less than 4 percentage points.[14]

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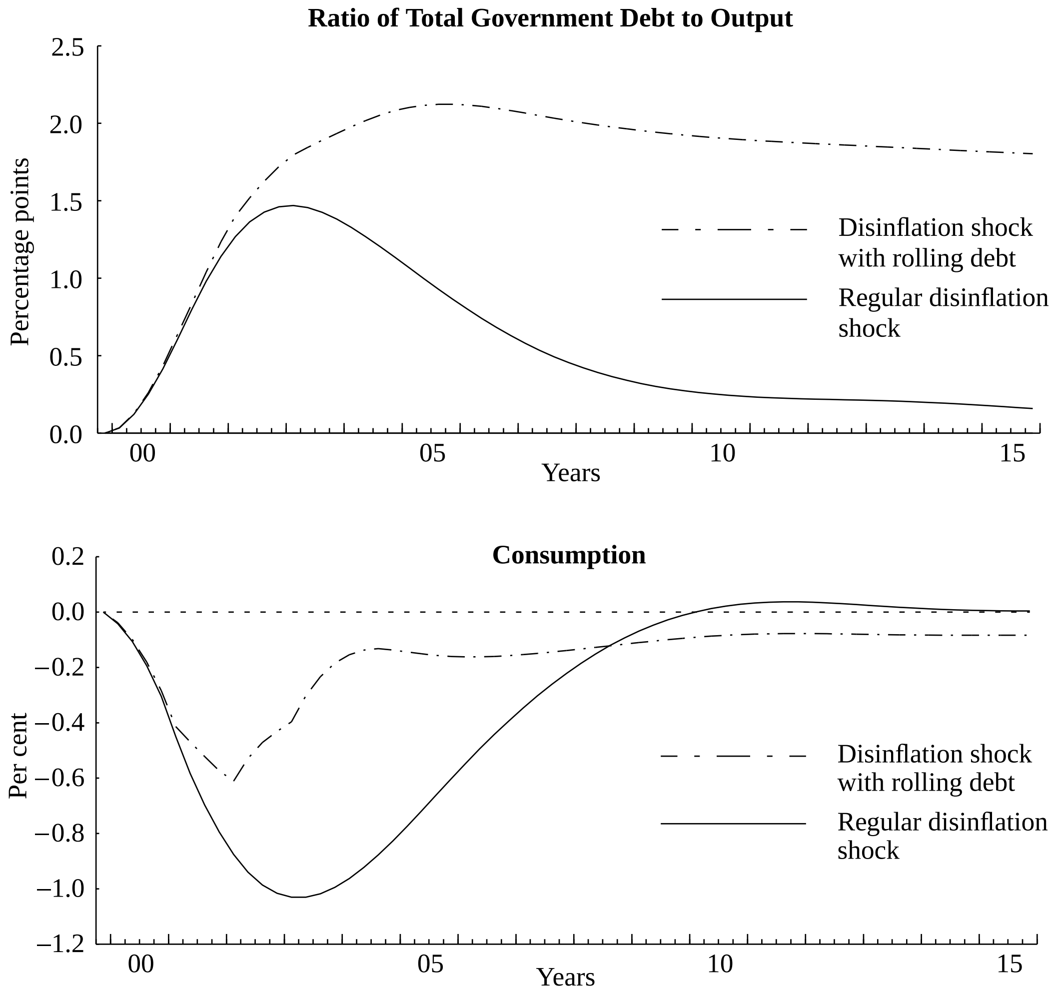
13. The calibration is based on the fact that about 25 to 30 per cent of transfers to persons are cyclical in nature. The elasticities of the cyclical components of transfers to persons (employment insurance and welfare) for a change in economic activity come from Boucher (1995).

14. This simulation is conducted around a steady-state control case. It is not a counterfactual experiment and there has been no attempt to mimic the economic conditions that prevailed over the 1989 to 1996 period.

Figure 3

The Fiscal Authority and Disinflation (Shock Minus Control)



An important feature of this result is the fact that nominal long-term interest rates decline rapidly as agents lower their inflation expectations because of the disinflationary actions of the monetary authority. The decline in nominal long-term interest rates mitigates the rise in interest payments on the debt coming from the rise in short-term interest rates. To assess the impact of the assumption regarding the degree of "forward-lookingness" in inflation expectations on long-term interest rates, the experiment is repeated with the additional assumption that all government debt is short-term in nature. This simulation is meant to provide an upper bound on the possible impact of higher interest payments on the debt resulting from a disinflationary policy. If we assume that all debt is short-term in nature, the rise in the debt-to-GDP ratio is 2.3 percentage points for a 1 percentage point reduction in the inflation target. Applying this rule of thumb over the 1989 to 1996 period results in the conclusion that monetary policy added 9.2 percentage points to the debt-to-GDP ratio, or about one-third of its total increase.

The increase in government debt in the short run makes consumers feel wealthier, and consumption does not fall nearly as much as in the base disinflation experiment. This comes, however, at the expense of a steady-state decline in consumption, consistent with a higher personal tax rate required to finance the higher debt. Interestingly, the expansionary policy followed by the fiscal authority improves welfare relative to the base disinflation case. This seems odd because both the disinflation shock and the government debt shock are welfare deteriorating in their own right. We can, however, gain some insight into this result by focussing on the behaviour of the monetary authority: the impact of the shock to consumption forces the monetary authority to take a slower approach to reducing inflation than in the base-case disinflation shock, and this leads to an increase in welfare.The transition to lower inflation under the alternative fiscal response implies a welfare deterioration of 0.121 per cent of consumption by the EV measure, slightly less than the base-case disinflation cost.[15]

2.5 Interest rate floors

One problem facing a monetary authority targeting low inflation is the possible existence of a floor to nominal interest rates. If such a floor exists, the monetary authority could find itself in a position where it is unable to reduce interest rates sufficiently to ensure the timely return of inflation to its target level. For example, suppose the economy is subject to a (large) negative demand shock. The standard response of the monetary authority in this case is to lower interest rates to stimulate the economy and return inflation to its target. If the ability of the monetary authority to reduce interest rates is hampered by an interest rate floor, it has lost a powerful lever for monetary policy.

Several questions arise. The first is simply, does a floor to nominal interest rates exist, and if so, what is its level? A second is, assuming that a floor exists, what is its effect on the economy?

In all likelihood, a nominal interest rate floor exists at zero (Summers 1991). If this were not the case, consumers could actually earn more real interest by simply keeping their money under their mattresses![16] Fuhrer and

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15. Note however that this result is highly sensitive to the choice of discount rate. Figure 5 (discussed later in the text) shows that for a discount of 2 per cent, the costs associated with the base disinflation shock are less than the costs associated with the alternative fiscal response.

16. This argument ignores the cost of (safe) storage.

Madigan (1994) assess the significance of such a floor and find that, for large unanticipated shocks, such a floor could pose a significant problem for the monetary authority.

Some authors have argued that, although a floor on market interest rates exists at zero, the floor on bank lending rates is above zero (Cozier and Lavoie 1994). Lending rates must exceed deposit rates by a spread that is large enough to compensate banks for the costs of administering loans and deposits, and for the risk of loan losses. As bank deposit rates approach zero, lending rates cannot fall appreciably without reducing the spread that the banks earn on loans. Although lower market rates will put increasing pressure on bank lending rates from lenders outside the banking system, banks would be expected to resist further reductions in lending rates. If, as argued by these authors, lending rates have more impact on consumer and business demand than do market rates, this friction could dampen the effect of monetary policy. As a rough approximation, we model this resistance by banks as a floor on nominal interest rates in the model at 0.5, 1.0, 1.5, and 2.0 per cent.

2.5.1 The effect of an interest rate floor

In this section, QPM is used to gauge the costs of an interest rate floor, assuming that it exists. To do this, we perform stochastic simulations of QPM to build up a distribution of output and consumption, and interest, inflation, and exchange rates under different target inflation rates and assumptions about the level of the interest rate floor. (These results, discussed later, are shown in Table 2.)

For this experiment, QPM is subjected to random demand shocks, which directly affect both consumption and investment.[17] The variance of these shocks is calibrated so that the standard deviation of output relative to its trend, as measured using the extended multivariate filter, is close to its historical average. Obviously, this approach omits a number of other key shocks that are likely to hit the economy, not the least being shocks to total factor productivity, the exchange rate, and the price level itself. (We plan future research incorporating these shocks as part of the stochastic simulation of QPM.)

Each period, the economy is subjected to a new demand shock. Agents then base their decisions for this period under the assumption that there are no future demand shocks. This determines all the flow variables in the economy, as well as interest rates and relative prices. These, in turn,

17. This is similar to the “standard” demand shock used in QPM. See Coletti et al. (1996).

Table 1

The Base-Case Calibration of QPM

Variable	Historical standard deviation[a]	Model standard deviation
Output relative to its short-run equilibrium level	1.6[b]	2.1
Output relative to its short-run equilibrium level	2.1[c]	
Year-over-year growth in output	2.8	2.5
Quarterly growth in output	4.3	3.9
CPIXFE inflation deviation from its target[d]	3.0	0.8
Nominal interest rate on 90-day corporate paper	3.5	2.0
Slope of the yield curve	1.2	1.1
Real G-6 exchange rate	6.7	1.8

a. Calculated using data from 1961Q1 to 1992Q4. See Black, Macklem, and Rose (1998).
b. The trend is calculated using a Hodrick-Prescott (HP) filter with a smoothness parameter of 1600.
c. The trend is calculated using an extended multivariate, HP filter. See Butler (1996) for details.
d. CPIXFE is the consumer price index excluding food and energy.

determine the stocks and the state of the economy next period. In the next time period, a new demand shock is revealed and the process is repeated.

In this way, long time series for consumption and other variables are built up as the result of the interaction between the demand shocks, the economy, and the interest rate floor. From these time series, the average level of consumption, relative to its equilibrium level, is obtained.[18]

Table 1 describes the base-case calibration and compares the moments resulting from the stochastic simulations with those seen in history. Note that the variability of demand is quite similar to that seen historically.

For the purposes of assessing the importance of an interest rate floor, the variance of nominal interest rates is key. As Table 1 shows, the variance of the nominal interest rate from the model is considerably lower than that observed historically. The Fisher relationship is useful to explain this. Ignoring potentially important cross-correlations, the Fisher relationship implies that the variance of nominal interest rates is determined from the variance of the inflation rate and the variance of real interest rates. Because the policy in QPM explicitly targets the inflation rate, it is not surprising that

18. As a technical detail, 20 time series each 16 years long are obtained. This involves a total of 1,280 simulations. To avoid starting-point problems, the first two years of each of the time series are removed, so the statistics in the table are based on 280 observations.

the variance of the inflation rate is lower than observed historically, and it is this that is behind the low variance of nominal interest rates. [19]

The presence of an interest rate floor means that, for some shocks, the monetary authority cannot reduce interest rates by as much as it would if the interest rate floor did not exist. Thus, for these shocks the monetary authority will not stimulate aggregate demand as much as it would otherwise. Consequently, the average level of aggregate demand falls in the presence of an interest rate floor.

Several aspects of the model and its calibration will affect the size of this reduction. In terms of the calibration, the average level of nominal interest rates is important. Two main determinants of this level are the target rate of inflation and the real interest rate. In Tables 2 and 3 several different target rates of inflation are considered. The real interest rate, however, is left unchanged. In this version of QPM, a real interest rate of 4 per cent is used (this is discussed further below).

Table 2 reports the impact of the nominal interest rate floor, in terms of aggregate consumption, for different inflation rates, as well as the percentage of time the interest rate floor binds (that is, is effective). The change in average consumption is reported relative to the level of consumption when there is a 2 per cent target rate of inflation and a 0 per cent interest rate floor.[20] As expected, the higher the target rate of inflation and the lower the interest rate floor, the smaller the reduction in consumption. Indeed, when the interest rate floor is at 0 per cent and the target rate of inflation is 2 per cent, the floor has a negligible effect. Conversely, if the interest rate floor is at 2 per cent and the target inflation rate is 1 per cent, the average level of consumption is reduced by 0.016 per cent. Because this reduction is permanent, the welfare implications of this change are important.

Further study of Table 2 reveals that it is the difference between the target rate of inflation and the level of the interest rate floor that is important. For example, the economic implications of a target rate of 0 per cent and an interest rate floor at 0 per cent are the same as those of a target rate of inflation of 2 per cent and a floor at 2 per cent. This is not surprising, given that QPM is neutral with respect to the level of the inflation rate.

Table 3 summarizes the effect of interest rate floors in terms of the differences between the target rate of inflation and the level of the interest rate floor. We see that the effect of the interest rate floor is quite non-linear.

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19. Black, Macklem, and Rose (this volume) discuss the interaction and trade-offs between monetary policy, the variance of interest rates, and the variance of inflation.

20. This level of inflation corresponds, for all intents and purposes, to the base-case model, since the floor hardly binds.

Table 2

The Effect of Reducing Inflation from 2 Per Cent

	Target rate of inflation, per cent		
	0	**1**	**2**
		per cent	
Interest rate floor at 0 per cent			
Change in average consumption	−0.005	−0.002	0.00
Percentage of time the interest rate floor binds	1.39	0.69	0.14
Interest rate floor at 0.5 per cent			
Change in average consumption	−0.008	−0.003	−0.001
Percentage of time the interest rate floor binds	2.78	0.90	0.41
Interest rate floor at 1.0 per cent			
Change in average consumption	−0.017	−0.005	−0.002
Percentage of time the interest rate floor binds	6.31	1.39	0.69
Interest rate floor at 1.5 per cent			
Change in average consumption	−0.045[a]	−0.007	−0.003
Percentage of time the interest rate floor binds	9.64[a]	2.78	0.90
Interest rate floor at 2.0 per cent			
Change in average consumption	na[b]	−0.016	−0.005
Percentage of time the interest rate floor binds	na[b]	6.18	1.39

a. Three replications failed when obtaining this estimate, suggesting that these estimates are positively biased. The replications that failed did so in the presence of significantly deflationary shocks.

b. Most of these simulations did not converge so the results are not reported. Seven of the replications did in fact converge and average consumption actually increased relative to the control.

na means not available.

Roughly speaking, if the target rate of inflation is more than 1 percentage point below the interest rate floor, the policymaker should be wary.

Table 3 is constructed, however, for a particular real interest rate. Other things being equal, a lower real interest rate means that the floor will bind more often, so that the reduction in average consumption will be larger. In terms of Table 3, if the real interest rate is 1 percentage point lower, the bottom two rows should be shifted to the right. The version of QPM used in this paper has a real interest rate of 4 per cent in the steady state. This may be on the high side (if one considers the level of real interest rates in the 1980s and 1990s to be abnormally high). Another reasonable alternative is 3 per cent, just under the historical average (starting in 1965Q1). This corresponds to a shift of the second and third rows in Table 3 two cells to the

Table 3

The Effect of the Interest Rate Floor

	Target rate of inflation minus the interest rate floor, per cent								
	−2.0	**−1.5**	**−1.0**	**−0.5**	**0**	**0.5**	**1.0**	**1.5**	**2.0**
Change in average consumption	na[a]	−0.045[b]	−0.017	−0.008	−0.005	−0.003	−0.002	−0.001	0.00
Percentage of time the interest rate floor binds	na	9.64	6.31	2.78	1.39	0.90	0.69	0.41	0.14

a. Most of these simulations did not converge so the results are not reported. Seven of the replications did in fact converge and average consumption actually increased relative to the control.

b. Three replications failed when obtaining this estimate, suggesting that these estimates are positively biased. The replications that failed did so in the presence of significantly deflationary shocks.

na means not available.

right. Now the policymaker should be wary when targeting a rate of inflation equal to or below any interest rate floor.

For the next section, we use some arbitrary assumptions to come up with a single number representing the welfare costs of reducing inflation by 1 percentage point. To do this, we assume that the inflation rate is being reduced from 2 per cent, the current target, to 1 per cent. In addition, we assume that the interest rate floor bites at the relatively high level of 1 per cent and that the real interest rate is 3.5 per cent. Together, these assumptions imply a welfare reduction of 0.01 per cent of consumption by the EV measure.

For several reasons, we think that our implementation of the Summers (1991) effect in QPM may overstate the effects of an interest rate floor. First, consumption in QPM is directly affected by the term structure of interest rates. If short-term interest rates are expected to be zero for some time, long-term interest rates also decline, reducing the stimulative impact of zero short-term interest rates on aggregate demand. Nor does one observe the (non-linear) wealth effect resulting from the increased present value of financial assets when interest rates are low. Changing these features of the model would require significant adjustment to the model structure, however, so we leave this for future work.

3 The Benefits of Low Inflation

As mentioned earlier in the paper, this version of QPM has been configured to embody superneutralities—inflation has no real effects in steady state. Non-neutralities could have been built into the model, but many of the effects of inflation are not well represented in a macroeconomic framework such as QPM. Our approach therefore is to review the existing literature on the benefits of price stability. The literature in this area is extensive and the papers incorporate a wide variety of methodologies and a significant range of estimates. To assess the potential benefits fairly, we build up a distribution of estimates and use them to gauge the likelihood that they will be sufficient to cover the cost of reducing inflation.[21]

Broadly speaking, the costs of inflation may be categorized as coming from one of two sources according to whether inflation is fully anticipated or unanticipated (Selody 1990). The costs of fully anticipated inflation arise when people (or institutions) who understand and anticipate inflation adapt (or not) in such a way that they would be better off under low inflation. For example, fully anticipated inflation acts as a tax on money balances, and leads individuals to reduce their cash balances. A second example is the tax system in Canada. Because the tax system is not fully indexed, the presence of inflation can lead to increases in tax rates and associated inefficiencies. Consider, for instance, the treatment of depreciation allowances. Since depreciation allowances for tax purposes are calculated on a historical cost basis, they underestimate the replacement cost of machinery in times of rising prices. A third example involves the "menu" costs argument. If it is costly for firms to change prices, then they tolerate limited deviations of the desired price from the actual. Inflation then becomes costly because it creates inefficient relative price variability without any offsetting benefit (Briault 1995, Ball and Mankiw 1994).

Costs due to unanticipated inflation arise because of the uncertainty surrounding inflation. This has two aspects, the effect of high inflation on the predictability of the aggregate price level, and the effect of high inflation on the variability of relative prices (Edey 1994). By making it more difficult to separate relative price changes from changes in the aggregate price level, inflation reduces the ability of the price system to allocate resources effectively (Selody 1990).

The next few sections consider the benefits of low inflation, estimated first using economic models (Subsections 3.1 to 3.3) and then using econometric techniques (Subsection 3.4).

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21. The papers surveyed are not limited to those that deal exclusively with the Canadian economy. We acknowledge that the estimated benefits of lower inflation as obtained from studies of foreign countries are not strictly comparable to the costs of achieving and maintaining low inflation in Canada. Including these other estimates, however, allows us to consider a broader range of important papers.

3.1 Model-based estimates of the welfare costs of inflation

The model-based literature on the estimates of the cost of inflation has mainly focussed on two sources of cost: the tax on money balances and the interaction of inflation and the tax system. There seems to be general agreement that menu costs are likely to be small when inflation is low (Edey 1994).

There is little formal calculation of the costs of inflation uncertainty. Studies have calculated the effects of inflation uncertainty on prices and quantities, but have not gone as far as working out the welfare effects. The results merely illustrate the costs of inflation. Also, it is very difficult to derive the cost of inflation uncertainty, especially given the lack of direct evidence supporting the proposition that inflation raises uncertainty. In fact, although in cross-country comparisons, the effect of high inflation on aggregate price uncertainty appears to be well established, at the individual country level, correlations between inflation and its variability are less obvious.[22]

The empirical literature has generally estimated the welfare costs of inflation using one of two methods: the earlier papers have used a partial-equilibrium approach, and more recent papers have applied a general-equilibrium methodology.

3.2 Partial-equilibrium estimates

3.2.1 Tax on money balances

The traditional approach, developed by Bailey (1956) and Friedman (1969), treats real money balances as a consumption good and inflation as a tax on real balances. This approach measures the welfare cost by computing the appropriate area under the money demand curve. In this simple model, the cost of inflation depends 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, which will be reflected in the nominal interest rate, and to the sensitivity of the demand for money to the interest forgone as a result of holding cash.

The partial-equilibrium estimates of the cost of inflation from the taxation of money balances are very low (see Table 4). Estimates of the welfare costs measured on an EV basis range between a low of 0.02 per cent, 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 as estimated by Eckstein and Leiderman (1992) for Israel. These estimates are very sensitive to the specification of

22. For an empirical study of the relationship between inflation and inflation uncertainty using Canadian data, see Crawford and Kasumovich (1996).

Table 4

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

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

the money demand function and to the chosen definition of money (monetary base or M1). In addition, this approach is incomplete since real income, real wealth, and the real rate of interest are assumed to be unaffected by inflation.

3.2.2 Inflation and the tax system

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. This reduction creates a welfare loss by distorting the allocation of consumption between the early years in life and the later years. To analyse the deadweight loss that results from this distortion, studies usually consider a simple two-period model of individual consumption. In the first period, individuals save part of their income for their retirement consumption in the second period and consume the rest. In this framework, saving can be thought of as the expenditure to purchase retirement consumption. As inflation increases, the price of retirement consumption increases because it affects the return on saving. The welfare costs are obtained by evaluating the appropriate area under the individual's compensated demand curve for retirement consumption.

In Table 5, two studies that measure this cost are reported. The estimated welfare costs from the interaction of inflation and taxation appear to be much higher than the ones from the tax on money balances (shown in Table 4).

Table 5

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

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.

3.3 General-equilibrium estimates

Partial-equilibrium analysis, while a useful tool, can be misleading (Gillman 1995). Taking into account agents’ behaviour in a general-equilibrium setting may either increase or reduce the costs of inflation. For example, inflation causes agents to substitute inefficiently out of the market activity and into leisure, resulting in a larger drop in output, having potentially smaller implications for welfare if utility depends on both consumption and leisure. A second example is that inflation causes agents to devote productive time to activities that enable them to economize on their cash balances (see Gillman 1993 and Dotsey and Ireland 1993). General-equilibrium models used in recent studies take these other distortions into account.

Tables 6 and 7 present the various general-equilibrium estimates from the literature. These estimates of the welfare costs are usually much higher and display more variance than the partial-equilibrium ones.

3.4 Econometric estimates

A related body of literature, developed more or less independently of the literature on the costs of inflation, is concerned with the impact of inflation on output. Some models allow for a negative association between inflation and output, because inflation is associated with greater price variability and greater uncertainty, thereby reducing both the effectiveness of the price mechanism, and investment. Under the new growth theory, this association could lead to a growth rate effect.

Table 6

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 1993	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	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

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.

a. Endogenous growth model.

b. As reported in Gillman 1995.

A first look at the empirical evidence shows a predominantly negative long-term relationship between inflation and output. But these results are subject to the problem of robustness. There is also an ambiguity as to whether inflation affects the level of output or its growth rate. The main problem, however, is that both inflation and output growth are endogenous, and trying to find a relationship between the two is difficult.

3.4.1 Single-country approaches

Beginning with single-country time-series analysis, the simplest approach is to regress output or productivity growth on current and lagged

Table 7

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

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. Endogenous growth model.

inflation. Simple equations regressing growth on inflation cannot, however, be expected to generate unbiased results. For one thing, in almost all countries there is a positive relationship, at least over the short run, between growth and inflation, with the direction of causation running from higher growth to higher inflation. In addition, single-country time-series observations that exhibit a negative correlation may be picking up the results of the monetary authority's reactions. As pointed out in Sbordone and Kuttner (1994), a negative relationship between inflation and productivity growth at cyclical frequencies is expected in a world where firms hoard labour in response to short-run reductions in demand, and where monetary policy affects output faster than inflation.

A further problem is that the negative correlation between inflation and output or productivity growth is observed in the years immediately following the oil price shocks of 1972-73 and 1979, when inflation was relatively high and output and productivity growth relatively low. If those years are excluded, the results become less significant (Briault 1995). The results are also based on a limited range of explanatory variables (partly because of the limited number of observations).

Table 8 reports the results for the single-country estimations. As is clearly evident from the table, the estimated relationship between inflation and income or productivity growth covers a wide range. About half the papers reviewed failed to find evidence in support of a long-term link

Table 8

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
Novin 1991	Canada	0.20	7.00
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

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.

a. Growth rate effect.

between inflation and income or productivity, while those papers that did find evidence of the link suggest that the benefits are quite large.

3.4.2 Cross-country approaches

The studies in the second set of approaches use data based on growth rates and their possible determinants for several countries. Averaging the data for each country in the sample over a number of years avoids many of the problems of short-run trade-offs and policy reactions that arise when using higher frequency data, but at the expense of considerable loss of information. In addition, statistical tests on the direction of causation cannot be applied to cross-sectional data.

As with the single-country approaches, the results of cross-country regressions are based on a limited range of explanatory variables and specifications that are sensitive to the addition of other variables. Levine and Renelt (1992) argue that the results from cross-country regressions designed to search for empirical linkages between long-run growth and a variety of economic variables (including inflation) are sensitive to small changes in the conditioning information set. In addition, the coefficients are sensitive to the presence of countries with high inflation. Some studies, such as Judson and Orphanides (1996) and Bruno and Easterly (1996), remove these countries

Table 9

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 1993	0.04[a]	1.40
Cozier and Selody 1992[b]	0.10[b]	1.98
Grier and Tullock 1989	0.16[a]	5.50

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.

a. Growth rate effect.

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

from the sample with the result that the negative correlation between inflation and growth is no longer statistically significant.

Table 9 reports the results for the cross-country estimations.

4 The Costs and Benefits Compared

In this section the costs associated with a disinflationary policy are compared with the benefits of having lower inflation. We focus on two particular benefits from lower inflation: those stemming from the reduction in the inflation tax on money balances and those from the reduced distortion arising from the interaction between the tax system and inflation. The econometric estimates of the benefits from lower inflation are not included in the figures because the range of these estimates is so large. In addition, we do not include the expected benefits coming from some other sources such as inflation uncertainty. In particular, we do not include what many view to be the most important benefit of low inflation—enhanced allocative efficiency stemming from the improved ability of the price system to allocate resources. Two specific examples are the implications for saving and investment of reduced uncertainty, and the improvement in intertemporal decisions resulting from a stable unit of account.[23] In this

23. For an overview of the sources of the benefits from lower inflation see Selody (1990), Howitt (1997), and Konieczny (1994).

important respect the benefits from lower inflation are restricted in scope and clearly are understated.

The benefits from the two sources considered and estimated costs have been converted to the EV measure of welfare and are presented in Figure 4. The "box and whisker" plot used here is to be interpreted in the following manner. Each type of estimate of the benefits from lower inflation is represented by a box and whisker. The benefit groupings are labelled by table number as they are presented in Section 3. The line in the middle of the box represents the median of the data. The box extends from the 25th percentile, $x_{[25]}$, to the 75th percentile, $x_{[75]}$, the so-called interquartile range (IQ) or mid-spread. The lines emerging from the box are called the whiskers, and they extend to the upper and lower adjacent values.[24] Observed points more extreme than the adjacent values, if any, are referred to as outside values and are individually plotted with a circle. The costs of achieving and maintaining low inflation under various scenarios are shown by a series of horizontal lines.

Several important issues must be addressed before making any comparison of the costs and benefits. First is the choice of discount rate. The base discount rate is 3.0 per cent. To give some sense of the importance of this assumption, Figure 5 shows the costs and benefits assuming a discount rate of 2.0 per cent. The second important issue to be considered is the timing of the arrival of the benefits. Since most estimates of the benefits of lower inflation are steady state in nature, it is not clear how to incorporate them in a dynamic sense. The calculations made in Figure 4 assume that the benefits begin immediately. Figure 6 explores the possibility that the benefits to lower inflation do not arrive for about 10 years. The third important factor to consider is the sample of papers that represent the benefits of lower inflation. The key issues here are the breadth and the appropriateness of the choice of papers included in the survey.

Focussing on the results from Figure 4, we can see 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 4).[25] If we consider instead the general-equilibrium estimates of the effect of the inflation tax on money balances (Table 6), the evidence becomes mixed. Allowing for the interaction of inflation and the tax system (Tables 5 and 7) clearly tilts the balance in favour of reducing inflation. This result is also robust to the

24. The upper adjacent value is defined as the largest data point less than or equal to $x_{[75]}$ + 1.5*IQ. The lower adjacent value is defined as the smallest data point greater than or equal to $x_{[25]}$ – 1.5*IQ. Recall that IQ = $x_{[25]} - x_{[75]}$.

25. Summers (1991) reaches the same conclusion.

Figure 4

The Case for Price Stability: Discount Rate = 3 Per Cent, Benefits Arrive Immediately

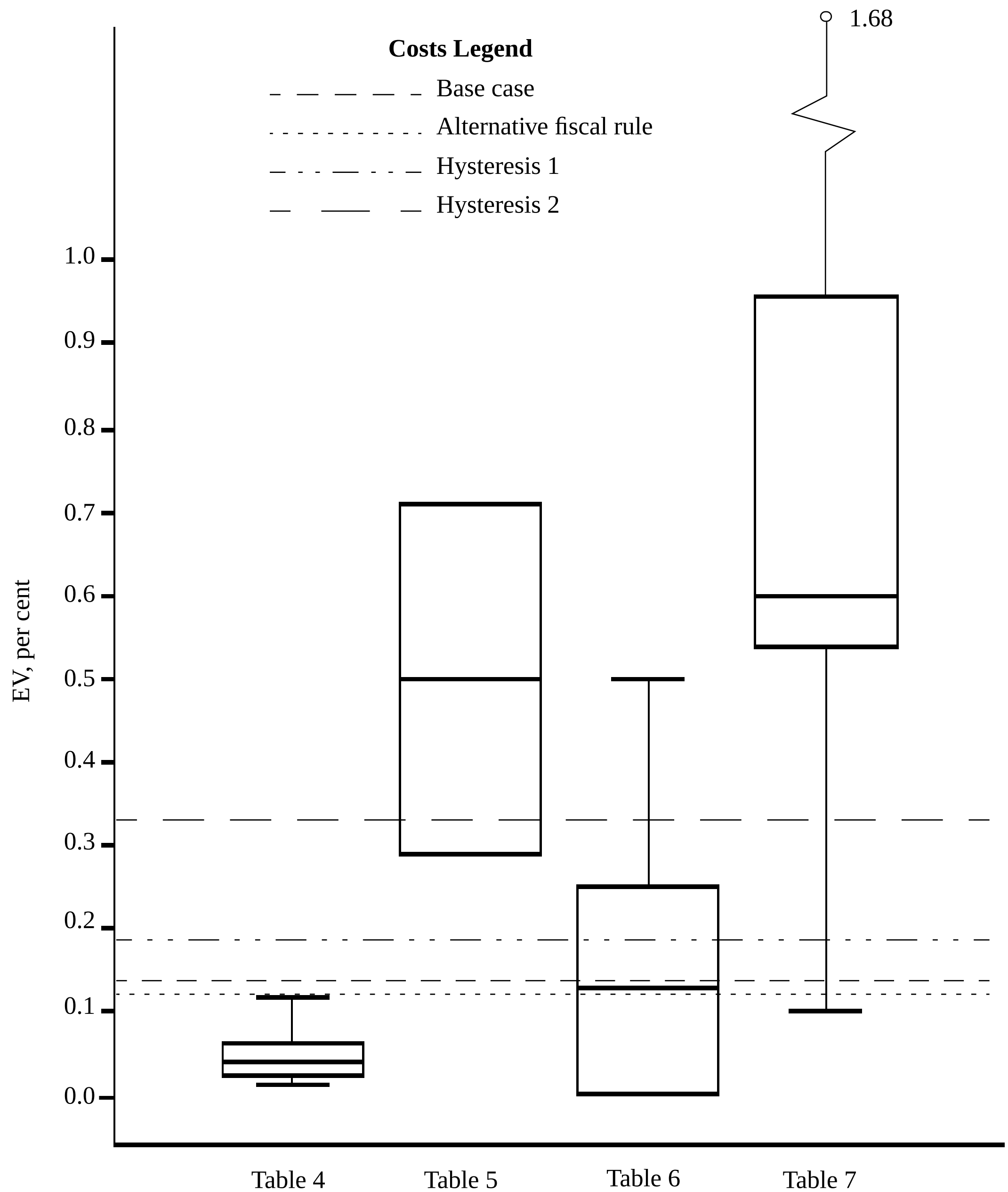

Table 4: Tax on money balances (partial equilibrium).
Table 5: Inflation and taxation (partial equilibrium).
Table 6: Tax on money balances (general equilibrium).
Table 7: Inflation and taxation (general equilibrium).

Figure 5

The Case for Price Stability: Discount Rate = 2 Per Cent, Benefits Arrive Immediately

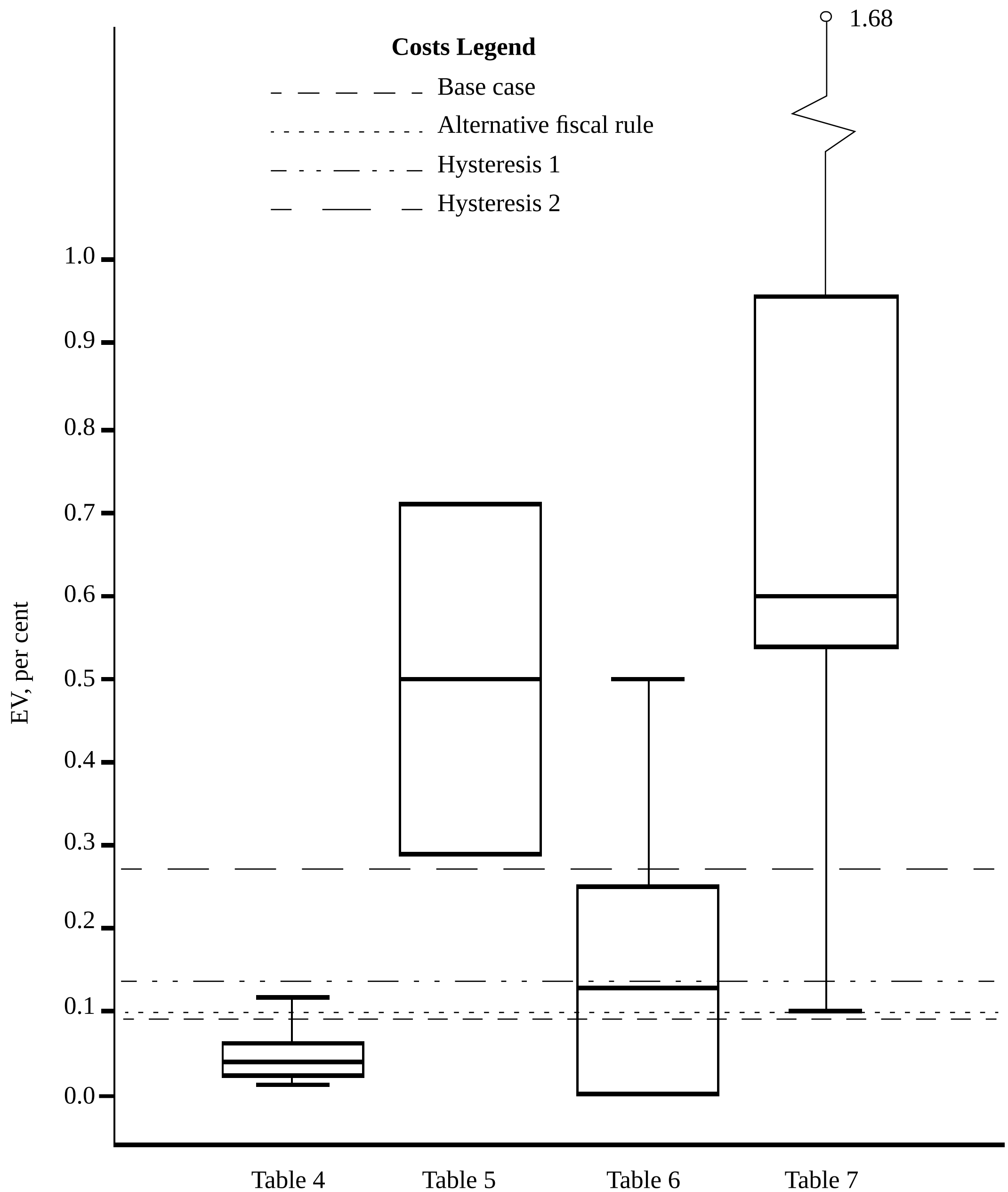

Table 4: Tax on money balances (partial equilibrium).
Table 5: Inflation and taxation (partial equilibrium).
Table 6: Tax on money balances (general equilibrium).
Table 7: Inflation and taxation (general equilibrium).

Figure 6

The Case for Price Stability: Discount Rate = 3 Per Cent, Benefits Arrive After a 10-Year Delay

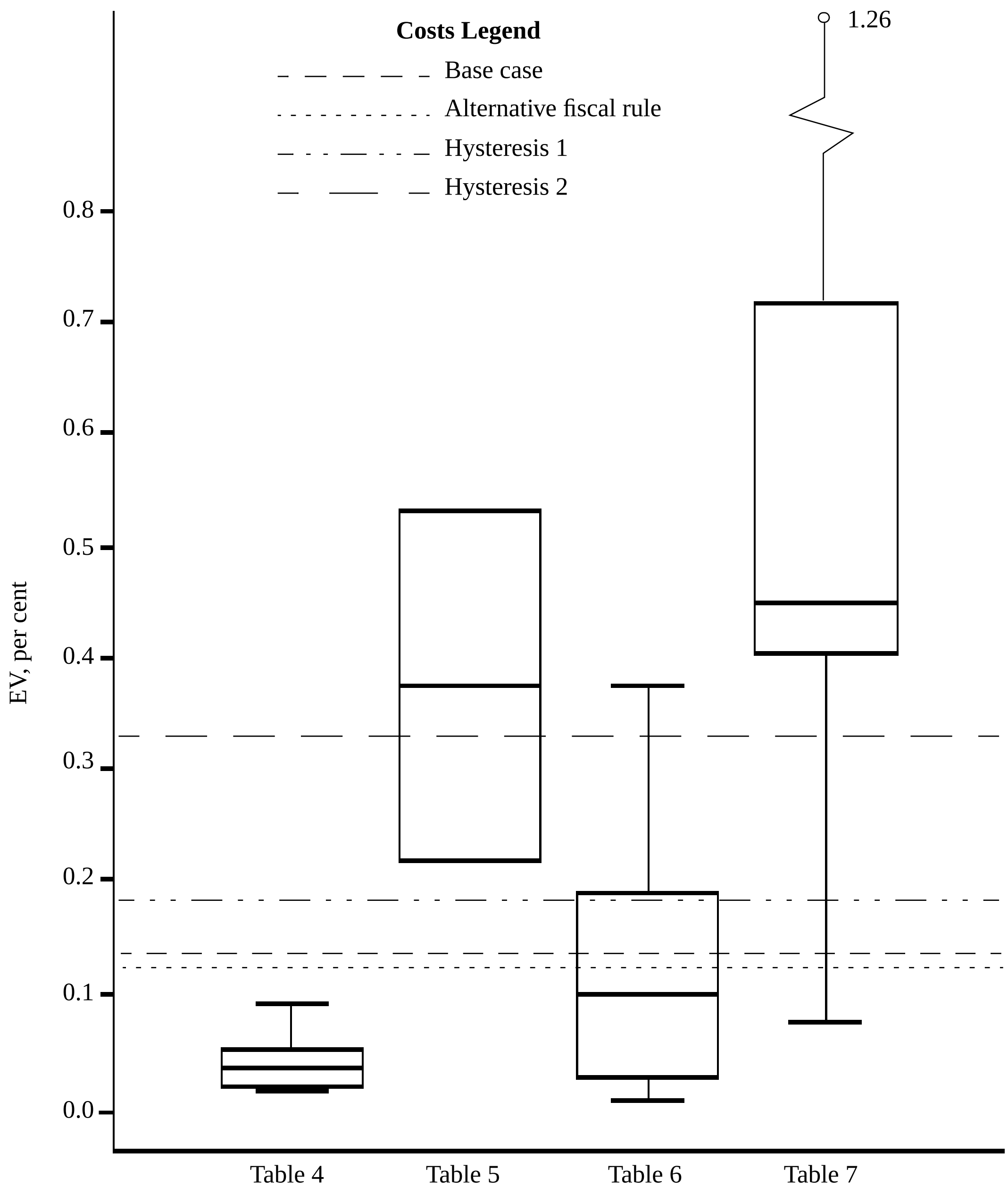

Table 4: Tax on money balances (partial equilibrium).
Table 5: Inflation and taxation (partial equilibrium).
Table 6: Tax on money balances (general equilibrium).
Table 7: Inflation and taxation (general equilibrium).

choice of a 2 per cent discount rate (Figure 5)[26] and a 10-year delay in the arrival of the benefits of lower inflation (Figure 6). Although it can be argued that a less expensive alternative to inflation reduction is to eliminate capital taxation and fully index the tax system, there is little evidence, across the major industrialized countries, that this notion is practical or politically feasible (Fischer 1996).

The effect of an interest rate floor has not been included on the graph since it is a long-run cost. It is easy, however, to determine its implication—it will shift upwards all the lines representing the costs of lowering inflation by an additional 0.01 per cent. This does not have a significant qualitative impact on the graph.

In conclusion, we would suggest that Figure 4 is a useful tool for gauging whether the costs of lowering inflation outweigh the permanent benefits that follow. Reasonable people could differ in the weights they place on the available evidence and we leave it to the reader to judge the case.

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26. Note that the EV measure for level shifts is not affected by the discount rate when there is no delay. Although the discount rate affects welfare, the EV measure is also affected and the two effects cancel each other out.

References

Alesina, A., A. Prati, and G. Tabellini. 1992. “Default Risk on Government Debt in OECD Countries.” *Economic Policy: A European Forum* (October): 427-51.

Alexander, W. R. J. 1990. “Growth: Some Combined Cross-Sectional and Time Series Evidence from OECD Countries.” *Applied Economics* 22 (September): 1197-204.

Armstrong, J., R. Black, D. Laxton, and D. E. Rose. 1995. *The Bank of Canada’s New Quarterly Projection Model.* Part 2. *A Robust Method for Simulating Forward-Looking Models*. Technical Report No. 73. Ottawa: Bank of Canada.

Bailey, M. J. 1956. “The Welfare Cost of Inflationary Finance.” *Journal of Political Economy* 64 (April): 93-110.

Ball, L. 1994. “What Determines the Sacrifice Ratio?” In *Monetary Policy*, edited by N. G. Mankiw, 155-82. Chicago: University of Chicago Press.

Ball, L., and N. G. Mankiw. 1994. “Asymmetric Price Adjustment and Economic Fluctuations.” *Economic Journal* 104 (March): 247-61.

Barro, R. J. 1995. “Inflation and Economic Growth.” NBER Working Paper No. 5326. National Bureau of Economic Research, Cambridge, Mass.

Black, R., T. Macklem, and S. Poloz. 1994. “Non-Superneutralities and Some Benefits of Disinflation: A Quantitative General-Equilibrium Analysis.” In *Economic Behaviour and Policy Choice Under Price Stability*, 477-516. Proceedings of a conference held at the Bank of Canada, October 1993. Ottawa: Bank of Canada.

Black, R., D. Laxton, D. Rose, and R. Tetlow. 1994. *The Bank of Canada’s New Quarterly Projection Model.* Part 1. *The Steady-State Model: SSQPM*. Technical Report No. 72. Ottawa: Bank of Canada.

Black, R., T. Macklem, and D. Rose. 1998. “Policy Rules for Price Stability.” Bank of Canada. This volume.

Blanchard, O. J., and D. Quah. 1989. “The Dynamic Effects of Aggregate Demand and Supply Disturbances.” *American Economic Review* 79 (September): 655-73.

Blanchard, O. J., and L. H. Summers. 1986. “Hysteresis and the European Unemployment Problem.” In *NBER Macroeconomics Annual 1986*, edited by S. Fischer, 15-78. Cambridge, Mass.: MIT Press.

Boothe, P. M., and S. S. Poloz. 1988. “Unstable Money Demand and the Monetary Model of the Exchange Rate.” *Canadian Journal of Economics* 21 (November): 785-98.

Boucher, E. 1995. “Cyclically Adjusted Budget Balances: A Summary of the Methodology Used by the Department of Finance.” Internal paper. Fiscal Policy Division, Department of Finance, Ottawa.

Briault, C. 1995. “The Costs of Inflation.” *Bank of England Quarterly Bulletin* 35 (February): 33-45.

Bruno, M., and W. Easterly. 1996. “Inflation and Growth: In Search of a Stable Relationship.” *Federal Reserve Bank of St. Louis Review* 78 (May–June): 139-46.

Bullard, J., and J. W. Keating. 1995. “The Long-Run Relationship Between Inflation and Output in Postwar Economies.” *Journal of Monetary Economics* 36 (December): 477-96.

Buiter, W. H., and M. H. Miller. 1985. “Costs and Benefits of an Anti-Inflationary Policy: Questions and Issues.” In *Inflation and Unemployment: Theory, Experience and Policy-Making*, edited by V. E. Argy and J. W. Neville, 11-38. Boston: Allen & Unwin.

Butler, L. 1996. *The Bank of Canada’s New Quarterly Projection Model (QPM).* Part 4. *A Semi-Structural Method to Estimate Potential Output: Combining Economic Theory with a Time-Series Filter.* Technical Report No. 77. Ottawa: Bank of Canada.

Calvo, G. A., and M. Obstfeld. 1988. “Optimal Time-Consistent Fiscal Policy with Finite Lifetimes: Analysis and Extensions.” In *Economic Effects of the Government Budget*, edited by E. Helpman, A. Razin, and E. Sadka, 163-98. Cambridge, Mass.: MIT Press.

Cameron, N., D. Hum, and W. Simpson. 1996. “Stylized Facts and Stylized Illusions: Inflation and Productivity Revisited.” *Canadian Journal of Economics* 29 (February): 152-62.

Carlstrom, C. T., and W. T. Gavin. 1993. “Zero Inflation: Transition Costs and Shoe Leather Benefits.” *Contemporary Policy Issues* 11 (January): 9-17.

Chang, L.-J. 1992. “The Welfare Costs and Impact of Inflation Tax on Depreciation Allowances and the Cyclical Movements of Aggregates.” Unpublished. Graduate School of Management, Rutgers University.

Cecchetti, S. G. 1994. “Comment” on “What Determines the Sacrifice Ratio?” by L. Ball. In *Monetary Policy*, edited by N. G. Mankiw, 188-93. Chicago: University of Chicago Press.

Clark, P., D. Laxton, and D. Rose. 1996. “Asymmetry in the U.S. Output-Inflation Nexus.” *International Monetary Fund Staff Papers* 43 (March): 216-51.

Coletti, D., B. Hunt, D. E. Rose, and R. Tetlow. 1996. *The Bank of Canada’s New Quarterly Projection Model.* Part 3. *The Dynamic Model: QPM*. Technical Report No. 75. Ottawa: Bank of Canada.

Cooley, T. F., and G. D. Hansen. 1989. “The Inflation Tax in a Real Business Cycle Model.” *American Economic Review* 79 (September): 733-48.

———. 1991. “The Welfare Costs of Moderate Inflations.” *Journal of Money, Credit, and Banking* 23 (August): 483-503.

Cozier, B. V., and C. Lavoie. 1994. “Is There a Floor to Nominal Interest Rates? Evidence and Implications for the Conduct of Monetary Policy.” Department of Finance paper presented at the 1994 meeting of the Canadian Economics Association, University of Calgary.

Cozier, B. V., and J. G. Selody. 1992. “Inflation and Macroeconomic Performance: Some Cross-Country Evidence.” Working Paper No. 92-6. Bank of Canada, Ottawa.

Cozier, B. V., and G. Wilkinson. 1991. *Some Evidence on Hysteresis and the Costs of Disinflation in Canada.* Technical Report No. 55. Ottawa: Bank of Canada.

Crawford, A., and M. Kasumovich. 1996. “Does Inflation Uncertainty Vary with the Level of Inflation?” Working Paper No. 96-9. Bank of Canada, Ottawa.

Debelle, G. 1996. “The Ends of Three Small Inflations: Australia, New Zealand, and Canada.” *Canadian Public Policy* 22 (March): 56-78.

Dotsey, M., and P. N. Ireland. 1993. “On the Costs of Inflation in General Equilibrium.” Federal Reserve Bank of Richmond.

———. 1996. “The Welfare Cost of Inflation in General Equilibrium.” *Journal of Monetary Economics* 37 (February): 29-47.

Dupasquier, C., and N. Girouard. 1992. “Un modèle de l’inflation au Canada.” Internal paper. Bank of Canada, Ottawa.

Eckstein, Z., and L. Leiderman. 1992. “Seigniorage and the Welfare Cost of Inflation: Evidence from an Intertemporal Model of Money and Consumption.” *Journal of Monetary Economics* 29 (June): 389-410.

Edey, M. 1994. “Costs and Benefits of Moving from Low Inflation to Price Stability.” *OECD Economic Studies* 23 (Winter): 109-30.

Englander, A. S., and A. Gurney. 1994. “Medium-Term Determinants of OECD Productivity.” *OECD Economic Studies* 22 (Spring): 49-109.

Feldstein, M. 1996. “The Costs and Benefits of Going from Low Inflation to Price Stability.” NBER Working Paper No. 5469. National Bureau of Economic Research, Cambridge, Mass.

Fischer, S. 1981. “Towards an Understanding of the Costs of Inflation: II. *Carnegie-Rochester Conference Series on Public Policy* 15 (Autumn): 5-41.

———. 1993. “The Role of Macroeconomic Factors in Growth.” *Journal of Monetary Economics* 32 (December): 485-512.

———. 1996. “Why Are Central Banks Pursuing Long-Run Price Stability.” In *Symposium on Achieving Price Stability: Selected Papers*, 1-27. Proceedings of a conference held by the Federal Reserve Bank of Kansas City, August 1996. Kansas City: the Bank.

Fortin, P. 1989. “How ‘Natural’ is Canada’s High Unemployment Rate?” *European Economic Review* 33 (January): 89-110.

———. 1990. “Can Canadian Anti-Inflationary Policy Be Made More Cost Effective?” Centre de recherche sur les politiques économiques. Unpublished. Université du Québec à Montréal.

———. 1991. “The Phillips Curve, Macroeconomic Policy, and the Welfare of Canadians.” *Canadian Journal of Economics* 24 (November): 774-803.

Fortin, P. 1993. "The Unbearable Lightness of Zero-Inflation Optimism." *Canadian Business Economics* 1 (Spring): 3-18.

———. 1997. "Comment" on "Low Inflation and the Canadian Economy" by P. Howitt. In *Where We Go from Here*, edited by D. Laidler, 76-88. Policy Study No. 29. Toronto: C. D. Howe Institute.

Friedman, M. 1969. "The Optimum Quantity of Money." In *The Optimum Quantity of Money and Other Essays*, 1-50. Chicago: Aldine Publishing.

Fuhrer, J. C., and B. Madigan. 1994. "Monetary Policy When Interest Rates Are Bounded at Zero." Working Paper No. 94-1. Federal Reserve Bank of Boston.

Gillman, M. 1993. "The Welfare Cost of Inflation in a Cash-in-Advance Economy with Costly Credit." *Journal of Monetary Economics* 31 (February): 97-115.

———. 1995. "Comparing Partial and General Equilibrium Estimates of the Welfare Cost of Inflation." *Contemporary Economic Policy* 13 (October): 60-71.

Gomme, P. 1993. "Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Model." *Journal of Monetary Economics* 32 (August): 51-77.

Grier, K. B., and G. Tullock. 1989. "An Empirical Analysis of Cross-National Economic Growth 1951-80." *Journal of Monetary Economics* 24 (September): 259-76.

Grimes, A. 1991. "The Effects of Inflation on Growth: Some International Evidence." *Weltwirtschaftliches Archiv* 127 (4): 631-44.

Hostland, D. 1995. "Changes in the Inflation Process in Canada: Evidence and Implications." Working Paper No. 95-5. Bank of Canada, Ottawa.

Howitt, P. 1990. "Zero Inflation as a Long-Term Target for Monetary Policy." In *Zero Inflation: The Goal of Price Stability*, edited by R. G. Lipsey, 67-108. Policy Study No. 8. Toronto: C. D. Howe Institute.

———. 1997. "Low Inflation and the Canadian Economy." In *Where We Go from Here*, edited by D. Laidler, 27-67. Policy Study No. 29. Toronto: C. D. Howe Institute.

Jaeger, A., and M. Parkinson. 1994. "Some Evidence on Hysteresis in Unemployment Rates." *European Economic Review* 38 (February): 329-42.

James, S. 1994. "The Interaction of Inflation with a Canadian-Type Capital Tax System: A Dynamic General Equilibrium Analysis Incorporating Endogenous Leverage and Heterogeneous Households." Working Paper No. 94-01. Department of Finance, Ottawa.

Jarrett, J. P., and J. G. Selody. 1982. "The Productivity-Inflation Nexus in Canada, 1963-1979." *Review of Economics and Statistics* 64 (August): 361-67.

Jones, S. R. G. 1995. *The Persistence of Unemployment: Hysteresis in Canadian Labour Markets.* Montreal: McGill-Queen's University Press.

Jones, L. E., and R. E. Manuelli. 1993. "Growth and the Effect of Inflation." NBER Working Paper No. 4523. National Bureau of Economic Research, Cambridge, Mass.

Judson, R., and A. Orphanides. 1996. "Inflation, Volatility and Growth." Finance and Economics Discussion Series No. 96-19. U.S. Board of Governors of the Federal Reserve System, Washington, D.C.

Konieczny, J. D. 1994. "The Optimal Rate of Inflation: Competing Theories and Their Relevance to Canada." In *Economic Behaviour and Policy Choice Under Price Stability.* Proceedings of a conference held at the Bank of Canada, October 1993, 1-40. Ottawa: Bank of Canada.

Kryiakopoulos, J. 1990. "Does Moderate Inflation Affect Growth?" Research Department, Reserve Bank of Australia.

Laidler, D. 1990. "The Zero-Inflation Target: An Overview of the Economic Issues." In *Zero Inflation: The Goal of Price Stability,* edited by R. G. Lipsey, 131-51. Policy Study No. 8. Toronto: C. D. Howe Institute.

Laxton, D., D. Rose, and R. Tetlow. 1993. "Is the Canadian Phillips Curve Non-Linear?" Working Paper 93-7. Bank of Canada, Ottawa.

Levine, R., and D. Renelt. 1992. "A Sensitivity Analysis of Cross-Country Growth Regressions." *American Economic Review* 82 (September): 942-63.

Lipsett, B., and S. James. 1995. “Interpreting Sacrifice Ratios Across Countries and Over Time.” Working Paper No. 95-06. Fiscal Policy and Economic Analysis Branch, Department of Finance, Ottawa.

Lucas, R. E., Jr. 1981. “Discussion” of “Towards an Understanding of the Costs of Inflation: II” by S. Fischer. *Carnegie-Rochester Conference Series on Public Policy* 15 (Autumn): 43-52.

———. 1994. “On the Welfare Cost of Inflation.” Unpublished. Department of Economics, University of Chicago.

Macklem, R. T., D. E. Rose, and R. Tetlow. 1995. “Government Debt and Deficits in Canada: A Macro Simulation Analysis.” Working Paper No. 95-4. Bank of Canada, Ottawa.

Marquis, M. H., and K. L. Reffett. 1994. “New Technology Spillovers into the Payment System.” *Economic Journal* 104 (September): 1123-38.

McCallum, B. T. 1990. “Inflation: Theory and Evidence.” Chapter 18 in *Handbook of Monetary Economics*, vol. 2, edited by B. M. Friedman and F. H. Hahn. Amsterdam: Elsevier, North-Holland.

McCallum, J. 1988. “Les taux de chômage canadien et américain dans les années 1980 : Un test de trois hypothèses.” *L’Actualité Économique* 64 (December): 494-508.

Novin, F. 1991. “The Productivity-Inflation Nexus Revisited: Canada, 1969-1988.” Working Paper No. 91-1. Bank of Canada, Ottawa.

Nott, L. 1996. “Hysteresis in the Canadian Labour Market: Evidence from the 1990s.” Research Report No. 9605. Unpublished. Department of Economics, University of Western Ontario, London, Ontario.

Poloz, S. S. 1994. “The Causes of Unemployment in Canada: A Review of the Evidence.” Working Paper No. 94-11. Bank of Canada, Ottawa.

Poloz, S. S., D. Rose, and R. Tetlow. 1994. “The Bank of Canada’s New Quarterly Projection Model (QPM): An Introduction.” *Bank of Canada Review* (Autumn): 23-38.

Poloz, S. S., and G. Wilkinson. 1992. “Is Hysteresis a Characteristic of the Canadian Labour Market? A Tale of Two Studies.” Working Paper No. 92-3. Bank of Canada, Ottawa.

Rudebusch, G. D., and D. W. Wilcox. 1994. “Productivity and Inflation: Evidence and Interpretations.” Unpublished, May. Federal Reserve Board, Washington, D.C.

Sbordone, A., and K. Kuttner. 1994. “Does Inflation Reduce Productivity?” *Federal Reserve Bank of Chicago Economic Perspectives* 18 (November–December): 2-14.

Scarth, W. 1994. “Zero Inflation Versus Price Stability.” In *Economic Behaviour and Policy Choice Under Price Stability*, 89-119. Proceedings of a conference held at the Bank of Canada, October 1993. Ottawa: Bank of Canada.

Selody, J. G. 1990. *The Goal of Price Stability: A Review of the Issues*. Technical Report No. 54. Ottawa: Bank of Canada.

Smyth, D. J. 1994. “Inflation and Growth.” *Journal of Macroeconomics* 16 (Spring): 261-70.

Stanners, W. 1993. “Is Low Inflation an Important Condition for High Growth?” *Cambridge Journal of Economics* 17 (March): 79-107.

Summers, L. 1991. “How Should Long-Term Monetary Policy Be Determined?” *Journal of Money, Credit, and Banking* 23 (August): 625-31.

Thornton, D. L. 1996. “The Costs and Benefits of Price Stability: An Assessment of Howitt’s Rule.” *Federal Reserve Bank of St. Louis Review* 78 (March–April): 23-35.

Turner, D. 1995. “Speed Limit and Asymmetric Inflation Effects from the Output Gap in the Major Seven Economies.” *OECD Economic Studies* 24 (1995/I): 57-88.

Wilkinson, G. 1997. “A Micro Approach to the Issue of Hysteresis in Unemployment: Evidence from the 1988-1990 Labour Market Activity Survey.” Working Paper No. 97-12. Bank of Canada, Ottawa.