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# SOME EVIDENCE ON HYSTERESIS AND THE COSTS OF DISINFLATION IN CANADA

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## ABSTRACT

This paper addresses the following questions: How large are the output costs of disinflation in Canada? Are these costs temporary, as predicted by natural-rate models, or are they permanent, as predicted by hysteresis models? Are the costs of disinflation higher at lower rates of inflation? Are they higher when the economy is at or below full employment? The answers to these questions are sought within the context of an expectations-augmented Phillips curve -- a framework which permits direct calculation of the output-inflation trade-off. Our estimation results imply that the output loss of reducing inflation by 1 percentage point (the so-called sacrifice ratio) is around 2 per cent, which is lower than many other estimates. Moreover, we find no evidence of hysteresis in Canada, which means that this loss is temporary and not permanent. Finally, we could find no evidence that the slope of the Phillips curve is non-linear -- the costs of disinflation do not appear to vary with either the level of inflation or the degree of excess supply.

## RÉSUMÉ

La présente étude traite les questions suivantes. Quel est le coût de la désinflation au Canada, évalué en fonction de la perte de production qu'elle entraîne? La perte de production est-elle temporaire, comme il ressort des modèles de taux naturel, ou est-elle permanente, comme le laissent croire les modèles d'hystérèse? Le coût est-il plus élevé lorsque le taux d'inflation est bas ou lorsque l'économie se situe au niveau du plein emploi ou juste au-dessous de ce niveau? Ces questions sont analysées à l'aide d'une courbe de Phillips avec attentes inflationnistes, qui permet le calcul direct de l'arbitrage production-inflation. D'après les résultats des estimations, le pourcentage de la production auquel il faut renoncer pour abaisser le taux d'inflation de 1 point de pourcentage (c.-à-d. le ratio de sacrifice) est d'environ 2 %, chiffre inférieur à bien d'autres estimations. De plus, les auteurs n'observent aucun phénomène d'hystérèse au Canada, ce qui signifie que la perte de production est temporaire. Enfin, selon l'étude, rien n'indique que la courbe de Phillips est non linéaire, puisque les coûts de la désinflation ne varient ni avec le niveau de l'inflation, ni avec l'importance de l'offre excédentaire.

# 1. INTRODUCTION

This paper estimates the costs of disinflation, in terms of the output or employment loss necessary to achieve a reduction in inflation. There has been some controversy recently over the size of these costs in Canada. For example, in a recent paper, Fortin (1990) claims that the costs of reducing inflation from the current rate of about 5 per cent have been underestimated, and are in fact much higher than the benefits. This is in stark contrast to the cost-benefit analysis of Howitt (1990), who estimates that the benefits of reducing inflation by 1 percentage point, from whatever level, are 27 times greater than the costs.

The difference between these cost-benefit analyses arises from differences in the estimates of the costs of disinflation.[1] Howitt uses the experience of the 1981-82 disinflation to compute an estimate of the sacrifice ratio -- i.e., the proportion of a year's output that must be foregone to reduce inflation permanently by 1 percentage point -- and arrives at a figure of 4.7 per cent of GDP. Fortin seems willing to accept this estimate but argues that there is evidence of full hysteresis in Canada. According to this hypothesis, only the change in the unemployment rate, and not its absolute level, influences the inflation rate. This means that there would be a long-run trade-off between output and inflation, rather than the short-run trade-off predicted by the standard expectations-augmented Phillips curve.[2] As Fortin points out, if full hysteresis holds, then instead of Howitt's temporary output loss of 4.7 per cent of GDP, we would get a permanent output loss, resulting in a sacrifice ratio of 313 per cent of GDP -- a huge difference.[3] This is sufficient to transform the results of the cost-benefit analysis from a net gain to a net loss.

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1. In fact, Fortin (1990) uses Howitt's estimate of the benefits of a one percentage point drop in inflation -- 1.875 per cent of GDP.

2. See Friedman (1968) for the classic statement of this model, also known as the natural-rate hypothesis.

3. The calculation done by Fortin (1990) is as follows: if the output loss of a disinflation is permanent, then employing the same discount rate used by Howitt (1990), 0.015, yields a discounted present value of the output loss of 4.7/0.015 = 313. Under full hysteresis, the sacrifice ratio is undefined, and makes sense only as a discounted present value of the output loss.

Fortin goes further and claims that, in addition to exhibiting full hysteresis, the Phillips curve is non-linear in the sense that the costs of disinflation depend inversely on the rate of inflation. In particular, he argues that disinflation would be more costly at lower rates of inflation, somewhere below 5 per cent. This argument is based on the view that inflation rates near zero require nominal wage cuts, and that since such cuts are likely to be resisted relatively stiffly, the output costs of further reducing inflation will rise as inflation falls.[4]

Our approach to calculating the costs of disinflation is to estimate versions of the standard expectations-augmented Phillips curve. Despite competition from other approaches, the expectations-augmented Phillips curve continues to be widely used in models of inflation dynamics. Indeed, a recent paper by Stockton and Glassman (1987) compares the forecast performance of the Phillips curve model with those of Barro-type rational expectations models and monetarist models, and the Phillips curve model is found to dominate the other models. Moreover, this framework is a natural one to use for the task at hand, since the concept of the sacrifice ratio then has clear meaning. In fact, most of the discussion of sacrifice ratios and costs of disinflation has been presented within the explicit or implicit context of the Phillips curve (this is true of both Howitt and Fortin, for example). In using this framework explicitly, we seek to answer the following questions: How large are the costs of disinflation in Canada? Are these costs temporary, as predicted by natural-rate models, or are they permanent as predicted by hysteresis models? Is the Phillips curve non-linear? Are the costs of disinflation higher at lower rates of inflation? Are they higher when the economy is at or below full employment?

4. This argument would seem to ignore productivity growth, which has been around 1.7 per cent per annum in Canada during the 1980s (see Cozier 1989b). Productivity growth of this magnitude would permit nominal wage increases (rather than no growth or cuts) even at producer price inflation rates near zero.

## 2. THE BASIC EMPIRICAL APPROACH

The expectations-augmented Phillips curve, expressed in terms of price inflation, may be written as:

$$\Pi_t = \Pi_t^e + \delta (Y_t - Y_t^*) + \varepsilon_t, \qquad \delta > 0, \tag{1}$$

where $\Pi_t$ is the rate of inflation, $\Pi_t^e$ is the expected rate of inflation, $Y_t - Y_t^*$ is the output gap[5], defined as the deviation of output, $Y_t$, from its equilibrium or potential level, $Y_t^*$, and $\varepsilon_t$ represents shocks to inflation such as oil or commodity price shocks. While equation (1) can be seen as based on the natural-rate hypothesis of Friedman (1968), similar equations can also be derived in models within the more recent New Keynesian paradigm.[6] It is common to assume some form of adaptive expectations to model $\Pi_t^e$. The most common assumption is that expected inflation is simply a (weighted) average of past inflation rates. This gives rise to the "accelerationist" version of the Phillips curve:

$$\Pi_t = \sum_{i=1}^{k} \alpha_i \Pi_{t-i} + \delta (Y_t - Y_t^*) + \varepsilon_t, \tag{2}$$

where the accelerationist restriction is:

$$\sum_{i=1}^{k} \alpha_i = 1. \tag{3}$$

5. Note that the definition of the output gap used here corresponds to excess demand, the reverse of the more usual definition, which is excess supply.

6. Cozier (1989a) provides an example of a Phillips curve derived from a model in which intertemporally optimizing firms face quadratic costs of changing prices. In that model, the parameter $\delta$, the slope of the Phillips curve, is explicitly a function of the degree of price stickiness.

The accelerationist restriction, (3), has been criticized by Sargent (1971), who argues that, under the assumption of (weak-form) rational expectations, the sum of the coefficients on past inflation depends on the inflation generation process and does not necessarily have to equal unity.[7] That is, a rejection of restriction (3) does not necessarily reject the natural-rate hypothesis. We feel, however, that the use of adaptive expectations here, and elsewhere in the Phillips curve literature, can be justified by recent evidence from experimental asset markets (e.g., Smith, Suchanek and Williams 1988), that the expectations of actual real world agents are highly adaptive in practice. Perhaps the costs of processing information are so high, and knowledge of the true model and shocks is so uncertain, that agents use simple rules of thumb, such as supposing that inflation will be in the future what it has been on average in the recent past. This idea is pursued by Robert Lucas (1986), who argues that adaptive rules dominate the short-run dynamics of the economy and that full rationality is a property only of the steady state.[8] It would be disturbing, though, if the assumption of backward-looking or adaptive expectations conflicted with the emergence of a rational equilibrium in the long run. However, Lucas provides an example of a model with multiple equilibria, in which a simple adaptive rule, analogous to that in equation (2), actually converges to the (correct) Pareto-optimal rational equilibrium in the long run.

There is another way to view equation (2), which is probably appropriate for our purpose of computing the historical cost of disinflation. A rearrangement of (2) gives:

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7. Over the sample covered in this paper, the null hypothesis that the rate of inflation contains a unit root cannot be rejected. This lends support to our use of the accelerationist model, at least for our sample, in which there is considerable drift (both upward and downward) in the inflation rate.

8. It is possible that agents' expectations are rational only in the Nash sense, according to which expectational errors are white noise, rather than in the stronger Muth sense, according to which expectations are equal to the predictions of the true economic model. In any case, even this weaker form of rational expectations is rejected by the aforementioned experimental evidence.

$$Y_t - Y_t^* = \frac{1}{\delta}\left(\Pi_t - \sum_{i=1}^{k} \alpha_i \Pi_{t-i}\right) - \frac{1}{\delta}\varepsilon_t. \tag{4}$$

Knowledge of the coefficients in this equation allows us to answer the question: Over history, when inflation changed from its average value, what was the effect on output? In other words, it is a direct way of computing the sacrifice ratio over history. This is the sense in which the accelerationist model is a natural way of estimating the costs of disinflation.

We checked for the appropriateness of the accelerationist restriction and could not reject at the 5 per cent level.[9] Given this result, it is convenient to rewrite equation (2), along with restriction (3), as follows:

$$\Delta\Pi_t = \sum_{i=1}^{k-1} \beta_i \Delta\Pi_{t-i} + \delta(Y_t - Y_t^*) + \varepsilon_t, \tag{5}$$

where the $\beta$s and $\alpha$s are related as:

$$\beta_i = -\sum_{j=i+1}^{k} \alpha_j. \tag{6}$$

Equation (5) is our empirical formulation of the model. Free estimation of this equation will provide estimates of the $\alpha$s (which are unscrambled from

9. It turns out that testing for the summation restriction in equation (2), along with the assumption that the output gap is exogenous with respect to inflation, is equivalent to doing a modified Dickey-Fuller test of the form:

$$\Delta\Pi_t = -(1-\rho)\Pi_{t-1} + \sum_{i=1}^{m} \upsilon_i \Delta\Pi_{t-i} + \delta(Y_{t-1} - Y_{t-1}^*) + \varepsilon_t,$$

where $\rho = \sum_{i=1}^{k} \alpha_i$.

Testing the null of $\rho = 1$ from this equation is equivalent to testing the summation restriction, equation (3).

the $\beta$s) and $\delta$. This form for the Phillips curve is quite common and is used, for example, by Hallman, Porter and Small (1989). Once equation (5) is estimated, and assuming that it is a stable difference equation of order k-1 in $\Delta\Pi$, the sacrifice ratio, $\Phi$, can be arrived at through simulation.[10] However, an analytical solution for $\Phi$ is available. First, note that the permanent effect on inflation of a temporary one-period shock to the output gap is:

$$\lim_{z \to \infty} \frac{\partial \Pi_{t+z}}{\partial (Y_t - Y_t^*)} = \frac{\delta}{1 - \sum_{i=1}^{k-1} \beta_i} \geq 0 . \tag{7}$$

The sacrifice ratio, which is the output gap required to change inflation permanently by one percentage point, is simply the inverse of this:

$$\Phi = \frac{1 - \sum_{i=1}^{k-1} \beta_i}{\delta} = \frac{1 - \sum_{i=1}^{k-1} \left( \sum_{j=i+1}^{k} \alpha_j \right)}{\delta} . \tag{8}$$

The sacrifice ratio depends on both the coefficient on the gap and the distribution of the lagged inflation coefficients.[11] Note that if the model is

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10. If equation (5) is non-convergent, then a temporary output gap will cause accelerating inflation, rather than just an increase in inflation, and the sacrifice ratio would be undefined.

11. This last point is important because it is often convenient to treat models like equation (2) as if they were equivalent to the simpler model:

$$\Pi_t = \Pi_{t-1} + \delta (Y_t - Y_t^*) + \varepsilon_t ,$$

in which case the sacrifice ratio is simply the inverse of the coefficient on the gap, $1/\delta$. However, such ignoring of the lag distribution is incorrect in general, and the errors are potentially very large. There is no substitute for simulation or correct incorporation of the lag distribution in formula (8).

estimated on quarterly data with inflation measured at annual rates, as ours is, then $4^*\delta$ must be substituted for $\delta$ in formula (8) if we wish to calculate the percentage of a year's (rather than a quarter's) output lost in reducing inflation by one percentage point. Note also that if there are several lags on the output gap in the estimated regression, with individual coefficients $\delta_i$, then $\delta$ must be replaced by $\sum \delta_i$. This last point means that, in models in which both the level and the change in the gap matter, the sacrifice ratio depends only on the coefficients on the level of the gap and the lagged inflation rates, and not at all on the coefficient(s) on the change in the gap.

Various versions of equation (5) are estimated to test the hypotheses studied. Both the output gap and the unemployment gap (gap between the unemployment rate and its natural rate) are used. We use quarterly Canadian data over the period 1964Q3 to 1988Q4. Inflation is measured by the annualized percentage change in the GDP deflator. The output gap is measured by the percentage deviation of real GDP from the measure of potential GDP in the Bank of Canada's RDXF model. Figure 1 shows inflation and the output gap. The measure of potential output is obtained by evaluating a Cobb-Douglas production function with the capital stock at its actual level, employment at its equilibrium level (as determined by the natural rate of unemployment, trend hours and the trend labour force), and total factor productivity (technology) at its trend level, where this trend is calculated using the Prescott-Hodrick technique.[12] The unemployment rate is that for the entire labour force. The unemployment gap is measured by the deviation of the unemployment rate from the estimate of the natural-rate series in the Bank of Canada's RDXF model (see Rose 1988 for a recent estimate of the natural rate). Several other variables in addition to these are included in the regressions. To control for supply shocks, current and several lagged values of the rate of change in a real commodity price index and the rate of change of a real oil price index were included. In addition, a dummy was included to control for the effects of the Anti-Inflation Board over the period 1975Q4 to 1978Q3.

12. Laxton and Tetlow (1991) provide an alternative multivariate filter for computing potential output. Since it uses information on current inflation, it can provide timely updates of potential output.

## 3. IS THERE HYSTERESIS IN CANADA?

The hysteresis approach posits that the natural rate of unemployment automatically follows in the path of the actual unemployment rate. The implication of this for the Phillips curve is that inflation depends on the change in unemployment, and not at all on the level of unemployment. In the following discussion, our presentation of the hysteresis argument basically follows that of Gordon (1989).

Our equation (2) can be written in terms of the unemployment gap as:

$$\Pi_t = \sum_{i=1}^{k} \alpha_i \Pi_{t-i} - \delta' (U_t - U_t^*) + \varepsilon_t , \qquad \delta' > 0 , \qquad (9)$$

where $U_t - U_t^*$ is the unemployment gap -- the deviation of the unemployment rate, $U_t$, from its natural rate, $U_t^*$. Hysteresis arises when the natural rate of unemployment depends on the past value of actual unemployment, as well as structural variables, represented by $S_t$:

$$U_t = \gamma U_{t-1} + (1-\gamma) S_t , \qquad 0 \leq \gamma \leq 1. \qquad (10)$$

The parameter $\gamma$ is the degree of hysteresis, with $\gamma = 1$ representing full hysteresis. Substituting equation (10) into our natural-rate model, (9), yields:

$$\Pi_t = \sum_{i=1}^{k} \alpha_i \Pi_{t-i} - \delta' \gamma \Delta U_t - \delta' (1-\gamma) U_t + \delta' (1-\gamma) S_t + \varepsilon_t \qquad (11)$$

which says that in general, under less than full hysteresis, both the level and the change in the gap matter. Since, as previously noted, in models in which both the level and the change in the gap matter, the change in gap term has no implications for the output-inflation trade-off, hysteresis only provides an interesting alternative to the natural-rate hypothesis under conditions of full hysteresis, when $\gamma = 1$. This is, in fact, the assertion of Fortin (1990) for Canada, and this is the case examined by Gordon (1989). Under full hysteresis, the Phillips curve is simply:

$$\Pi_t = \sum_{i=1}^{k} \alpha_i \Pi_{t-i} - \delta' \Delta U_t + \varepsilon_t \,. \tag{12}$$

Changes in inflation depend only on the change in the gap, and not at all on the level of the gap. This model is distinguished sharply from the natural-rate formulation in (9). If true, full hysteresis has serious implications for monetary policy, in that a reduction in inflation can only be achieved at the expense of a permanent increase in the unemployment rate (and loss of output). Like Gordon, we shall use the fact that unemployment gaps, with appropriate substitutions, can be written in terms of output gaps and vice versa. In terms of output gaps, hysteresis would imply that only the change in the output gap matters, and not its level. Thus,

$$\Pi_t = \sum_{i=1}^{k} \alpha_i \Pi_{t-i} + \delta \Delta (Y_t - Y_t^*) + \varepsilon_t \,. \tag{13}$$

Equation (13) is derived by assuming that output is produced by a constant returns to scale production function with exogenous technical progress and labour force. This gives an Okun's Law type relationship between the unemployment gap and the output gap.[13]

13. It should be noted, however, that going from unemployment gaps to output gaps will result in an extra term in equation (13). This term is a linear function of trend output growth, and is reasonably treated as a constant term. In any case, our estimated equations take account of this since they all have constant terms.

Testing for evidence of full hysteresis will involve inclusion of both the level and the change in the gap in our empirical Phillips curve formulation, as follows:

$$\Delta\Pi_t = \sum_{i=1}^{k-1} \beta_i \Delta\Pi_{t-i} + \delta_1 (Y_t - Y_t^*) + \delta_2 \Delta (Y_t - Y_t^*) + \varepsilon_t \,. \qquad (14)$$

Hysteresis requires that the coefficient on the change in the gap be significant, while that on the level is zero. The accelerationist model requires that the coefficient on the level of the gap be significant. It should be noted, though, that both the level of the gap and the change in the gap can be significant in a natural-rate model. As shown in Duguay (1984)[14], both the level of the gap and change in the gap are important in the Phillips curve when allowance is made for a role for the equilibrium inflation rate, modelled as the excess of nominal spending growth over potential output growth. Thus hysteresis is supported only when the change in gap alone is important.

Estimation results for versions of equation (14) are presented in Table 1.[15] Results are presented for models with the level of the output gap and the change in the output gap, and for models with the level of the unemployment gap and the change in the unemployment rate. While the AIB dummy, the real oil price and the real commodity price contribute significantly to changes in inflation, their coefficients are not reported because they are not important to the question at hand. Also, note that on the basis of the Q statistic, the residuals appear to be free of serial correlation. Model 2 in Table 1 shows that, even when the change of the unemployment rate is included as an explanatory variable, it is not

14. See also Duguay (1979).

15. In these subsequent results, the unemployment rate variables are contemporaneous while output gap variables are lagged once. This is due to our finding that contemporaneous output gaps are not significant while contemporaneous unemployment gaps are. This probably reflects the fact that output Granger-causes the unemployment rate and not vice versa (i.e., employment is a coincident or lagging indicator of output).

significant, while the level of the unemployment rate remains significant, with about the same coefficient as in Model 1 (which excluded the change in the unemployment rate). Results for the output gap, in Model 4, provide evidence that both the level of the gap and the change in the gap are important. The evidence then is that full hysteresis is not supported by the Canadian data, though partial hysteresis might be.[16] The inflation rate responds to the level of the gap, and perhaps also the change in the gap, but not only to the change. It should be noted that McCallum (1988) also rejects hysteresis for Canada. Gordon (1989), using a similar methodology, rejects full hysteresis in five OECD countries. The rejection of full hysteresis implies that the costs of disinflation are temporary, consistent with the natural-rate hypothesis.[17]

16. This should not be really surprising. Although claims of hysteresis in Canada and elsewhere were often provoked by the persistent rise in unemployment associated with the recession of the early 1980s, the sharp decline in unemployment rates in the later part of the decade casts doubt on the validity of this hypothesis.

17. A recent paper by Fortin (1991) finds evidence of full hysteresis in Canada over the 1973 to 1990 period. The sample used is shorter than ours (1964 to 1988), and he uses annual rather than quarterly data. Moreover, over a longer sample period, the evidence for hysteresis disappears.

## 4. IS THE PHILLIPS CURVE NON-LINEAR?

It is sometimes argued that the slope of the Phillips curve is not fixed. For example, Fortin (1990) argues that, because the probability of nominal wage cuts is higher at lower rates of inflation, and because nominal wages are rigid downward, the disinflationary costs would be greater when the rate of inflation is low (somewhere below 5 per cent) than when it is high. Another, perhaps more common type of non-linearity, occurs where, because of capacity constraints, the Phillips curve is steeper above full employment than below. In this case, the temporary output costs of reducing inflation starting in a situation of excess demand would be smaller than the temporary output costs of reducing inflation when starting under conditions of excess supply.

We check for these two types of non-linearity in Table 2. Models 5 through 8 test for non-linearity of the output gap coefficient for different threshold inflation rates. Each of these models has two variables for the output gap: the first represents output gaps when the inflation rate is at or above a threshold level; the second represents output gaps when the inflation rate is below that threshold level. The threshold inflation rates are 4, 5, 6 and 7. In all cases, the F-test for the null hypothesis that the coefficient on the gap is the same for inflation rates above or below the threshold level is strongly supported. The F-statistics are never close to significance, even at the 1 per cent level. Thus the costs of disinflation do not appear to vary with the rate of inflation, at least over the sample and range of threshold inflation rates considered.

Model 9 in Table 2 tests the hypothesis that the coefficient on the output gap differs depending on the state of excess supply. As the F statistic indicates, the null hypothesis of no difference is strongly supported. The costs of disinflation do not seem to vary with the degree of excess supply.

## 5. HOW LARGE ARE THE COSTS OF DISINFLATION?

The statistical evidence from the previous sections rejects the view that there is hysteresis in Canada, indicating that the costs of disinflation are temporary. The costs of disinflation do not vary with the existing rate of inflation, or with the state of excess demand/supply. In computing the costs of disinflation then, Models 3 and 4 in Table 1, which are more or less standard forms of the expectations-augmented Phillips curve, are appropriate. The difference between them is that Model 3 has only the level of the gap while Model 4 has both the level of the gap and the change in the gap. Being estimated in terms of the output gap, these two equations provide alternative direct estimates of the sacrifice ratio.

Table 3 focusses on these two models, providing the lagged distribution of the changes in inflation (the $\beta$s), as well as the unscrambled lagged inflation coefficients (the $\alpha$s). When Models 3 and 4 are simulated, it is found that a 1 per cent positive output gap for one year produces an increase in inflation of 0.56 percentage points and 0.49 percentage points respectively. The sacrifice ratios given in Table 3 are simply the inverse of these: 1.8 for Model 3 and 2.1 for Model 4. These ratios are confirmed by direct calculation using formula (8). The t-statistics for the sacrifice ratios indicate that both estimates are significant at the 5 per cent level. On the basis of these results, a good estimate of the sacrifice ratio would be around 2 per cent of GDP.[18]

A sacrifice ratio of 2 is much lower than the 4.7 estimated by Howitt (1990). There are several differences between our approach and his, which explain the divergence. Howitt's sacrifice ratio is calculated by examining just the 1981-82 recession, whereas ours is based on an estimated Phillips curve over the 1964-1988 period. Thus we are able to control for other influences on inflation such as oil and commodity price shocks. Another difference is that we relate inflation directly to output gaps, while Howitt works indirectly through unemployment rates and wage inflation. When we compute the

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18. Using our sacrifice ratio of 2, Howitt's (1990) estimate of the benefits of a 1 per cent drop in inflation (1.875 per cent of GDP), and Howitt's discount rate (0.015), the annual benefit of a 1 percentage point drop in inflation is 62 times as large as the cost (125/2 = 62). These net benefits are significantly higher than Howitt's, which are 27 times greater than the costs.

sacrifice ratio over just the disinflation period of the early 1980s, using a direct comparison of output gaps and the change in inflation, we get a sacrifice ratio of 2, very close to our Phillips curve estimates. While one would expect similar results from the two approaches (direct and indirect), a lot depends on Howitt's assumption of an Okun's Law coefficient of 2 and a natural rate of unemployment of 7.5 per cent. Our own estimates of the Okun's Law coefficient and the natural rate through the 1981-82 recession were 1.3 and 8.2 per cent respectively, and these differences go a long way towards explaining the divergence between the estimates of the sacrifice ratio.[19]

Our method of estimating the costs of disinflation obviously depends critically on the measurement of equilibrium or potential output. As mentioned previously, the measure of potential output used so far comes from the Bank of Canada's RDXF model and is based on a Cobb-Douglas production function. It is interesting to compare the output gaps obtained by using this measure with those obtained by other measures of equilibrium output. In the literature, it is quite common to estimate equilibrium output as some sort of trend (e.g., Gordon 1989). Figure 2 shows the output gaps based on the following alternative measures of equilibrium output: the RDXF measure, a Prescott-Hodrick trend, a linear trend, and a quadratic trend. With the exception of the linear trend, the output gaps are quite similar, giving roughly the same picture of expansion and recession. The linear trend is probably the least appropriate because it does not allow for changes in the trend growth rate of output over the period -- in particular, the growth slowdown starting in the 1970s. The Prescott-Hodrick trend procedure, which is a type of two-sided moving average, will tend to capture changes in trend growth. The quadratic trend can pick up perhaps one major change in trend, but not several or even two, unless by chance.

The RDXF potential output series will capture changes in trend growth in two ways: (a) since the production function is evaluated using the actual capital stock, any changes in its trend will be automatically captured; and

19. This possible reconciliation of the estimates was pointed out to us by Pierre Duguay. See Ford and Rose (1989) for estimates of Okun's Law and the natural rate of unemployment by a joint estimation approach.

(b) trend total factor productivity is computed by the Prescott-Hodrick moving-average technique. Unlike the other measures, the linear trend assumes constant growth. Thus the fact that growth did in fact slow over the period means that actual output is always way below equilibrium in the 1960s and 1980s, and always way above equilibrium in the 1970s -- a somewhat implausible characterization.

Table 4 compares the sacrifice ratios obtained by estimating our Phillips curve using the four alternative measures of the output gap. As before, the models are estimated in both level and level plus change form. The estimates using the RDXF-based output gap are the same as those in Table 3. As the results show, the estimated sacrifice ratios vary from a low of 1.1 for the Prescott gap in level specification, to a high of 6.3 for the linear-trend gap in level/change formulation, with an average of 2.2. The sacrifice ratios from the linear trend model are outliers and, in any case, are not significantly different from zero. Moreover, it is important to note that the range of estimated sacrifice ratios is much narrower for the three more plausible specifications. When we consider only the RDXF, Prescott and quadratic formulations for the gap, the range of sacrifice ratios is between 1.1 and 2.6.

If we take the accelerationist model of the Phillips curve seriously, then a test of the appropriateness of a particular measure of the output gap is whether it has predictive content for changes in inflation. That is, if the model is correct, then output disequilibria should map into price disequilibria, the latter being reflected in the rate of change of prices. Each equation reported in Table 4 has identical sample size and lag length. The only variation is in the measure of the gap term(s). Variations in the $Rbar^2$ statistic can therefore be used as a measure of the incremental explanatory power of the various gap measures.[20] In both specifications, the RDXF gap measure maximizes the $Rbar^2$. The gap based on the linear trend has the poorest fit.

20. Note that, with the exception of the linear trend gap measure, all the gap measures are significant at the 5 per cent level, with the RDXF measure having the largest t-statistic.

On balance, therefore, while the estimate of the sacrifice ratio is sensitive to the measurement of equilibrium output, the weight of the evidence presented in this paper would favour a fairly low number, around 2. This low sacrifice ratio would mean that the costs of disinflation are probably lower than previously thought. However, it is important to note in view of our finding that the Phillips curve is symmetric, that this also means that the benefits of higher inflation are small. Thus, raising inflation by 1 percentage point has, historically, resulted in an average temporary output gain of only 2 per cent of GDP. The sacrifice ratio cuts both ways. It is also worthy of note that, when there is a shock of 1 per cent excess demand (the output gap), inflation begins to increase as early as one quarter later (by about 0.3 percentage points at annual rates), reaching its maximum effect (about 0.5 percentage points) after one year. Thus, our results imply that the benefits in terms of higher output of an inflationary policy are small and temporary, and that the consequences in terms of higher inflation are felt quickly.[21] These results can be cast in terms of the old debate over the transmission mechanism. If the lags from monetary policy to inflation are *long and variable,* our results suggest that it is the lag from monetary policy to excess demand that is long, compared to the relatively short lag from excess demand to inflation.

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21. While the benefits of higher inflation are temporary, the costs are likely to be permanent as in Howitt (1990).

## 6. CONCLUSION

This paper addresses the following questions: How large are the output costs of disinflation in Canada? Are these costs temporary as predicted by natural-rate models, or are they permanent as predicted by hysteresis models? Are the costs of disinflation higher at lower rates of inflation? Are they higher when the economy is at or below full employment? We seek the answers to these questions within the context of an expectations-augmented Phillips curve, a framework which permits direct calculation of the output-inflation trade-off. Our estimation results imply that the short-run output loss of reducing inflation by 1 per cent (the so-called sacrifice ratio) is around 2 per cent, which is lower than some other estimates. Moreover, we find no evidence of hysteresis in Canada, which means that this loss is temporary and not permanent. Finally, we could find no evidence that the slope of the Phillips curve is non-linear -- the costs of disinflation do not appear to vary with either the level of inflation or the degree of excess supply.

## Table 1
## Tests of Hysteresis

**1964Q3 to 1988Q4**

| Model | Variable | Coefficient | t | DW | Q(27) | $Rbar^2$ |
|---|---|---|---|---|---|---|
| (1) | $UGAP_t$ | -0.344 | -2.43* | 2.1 | 21.8 | 0.30 |
| (2) | $UGAP_t$ | -0.331 | -2.36* | 2.1 | 19.0 | 0.31 |
| | $\Delta RU_t$ | -1.126 | -1.71 | | | |
| (3) | $YGAP_{t-1}$ | 0.326 | 3.10* | 2.0 | 20.7 | 0.33 |
| (4) | $YGAP_{t-1}$ | 0.273 | 2.58* | 2.2 | 25.1 | 0.35 |
| | $\Delta YGAP_t$ | 0.570 | 2.16* | | | |

NOTE: The coefficient estimates above come from the following equation:

$$\Delta\Pi_t = a + \sum_{i=1}^{4} \beta_i \Delta\Pi_{t-i} + \delta_1 YGAP_{t-1} + \delta_2 \Delta YGAP_{t-1} + b\Delta AIB + \sum_{i=0}^{4} c_i \Delta PCOM_{t-i} + \sum_{i=0}^{1} d_i \Delta POIL_{t-i} + \varepsilon$$

where $\Pi$ = the rate of inflation, measured by the quarterly percentage change in the GDP deflator at annual rates, UGAP = the labour market gap (deviation of actual unemployment from its natural rate), YGAP = the output gap (percentage deviation of output from potential output), RU = the unemployment rate, AIB = a dummy for the period in which the Anti-Inflation Board was in operation, PCOM = the quarterly percentage change in a real Canadian commodity price index, at annual rates, POIL = the quarterly percentage change in a real crude oil price index, at annual rates.

$Rbar^2$ is the adjusted R-squared statistic. DW is the Durbin-Watson statistic. Q(27) is the Box-Ljung Q-statistic with 27 degrees of freedom. An asterisk denotes significance at the 5% level.

## Table 2
# Tests of Non-Linearity in the Phillips Curve
**1964Q3 to 1988Q4**

| Model | Condition | Number | Coefficient on $YGAP_{t-1}$ | t | DW | Q(27) | $Rbar^2$ | F |
|---|---|---|---|---|---|---|---|---|
| (5) | $\Pi \geq 4$ | 66 | 0.261 | 2.04* | 2.0 | 22.0 | 0.32 | 0.77 |
| | $\Pi < 4$ | 38 | 0.442 | 2.61* | | | | |
| (6) | $\Pi \geq 5$ | 55 | 0.324 | 2.26* | 2.0 | 20.7 | 0.32 | 0.00 |
| | $\Pi < 5$ | 49 | 0.328 | 2.23* | | | | |
| (7) | $\Pi \geq 6$ | 43 | 0.353 | 2.35* | 2.0 | 20.8 | 0.32 | 0.07 |
| | $\Pi < 6$ | 61 | 0.304 | 2.23* | | | | |
| (8) | $\Pi \geq 7$ | 38 | 0.333 | 2.08* | 2.0 | 20.8 | 0.32 | 0.00 |
| | $\Pi < 7$ | 66 | 0.322 | 2.51* | | | | |
| (9) | $YGAP \geq 0$ | 33 | 0.317 | 1.45 | 2.0 | 20.7 | 0.32 | 0.00 |
| | $YGAP < 0$ | 71 | 0.332 | 1.94 | | | | |

NOTE: The coefficient estimates above come from the following equation:

$$\Delta\Pi_t = a + \sum_{i=1}^{4} \beta_i \Delta\Pi_{t-i} + \delta YGAP_{t-1} + b\Delta AIB + \sum_{i=0}^{4} c_i \Delta PCOM_{t-i} + \sum_{i=0}^{1} d_i \Delta POIL_{t-i} + \varepsilon_t$$

where $\Pi$ = the rate of inflation, measured by the quarterly percentage change in the GDP deflator at annual rates, YGAP = the output gap (percentage deviation of output from potential output), AIB = a dummy for the period in which the Anti-Inflation Board was in operation, PCOM = the quarterly percentage change in a real Canadian commodity price index, at annual rates, POIL = the quarterly percentage change in a real crude oil price index, at annual rates.

$Rbar^2$ is the adjusted R-squared statistic. DW is the Durbin-Watson statistic. Q(27) is the Box-Ljung Q-statistic with 27 degrees of freedom. An asterisk denotes significance at the 5% level. Condition is the filter used to check for non-linear effects from YGAP. Number is the number of observations for which each condition is satisfied. F is the F-statistic for null hypothesis that there is no difference between the YGAP coefficients under both conditions.

Table 3

## Calculating the Sacrifice Ratio

1964Q3 to 1988Q4

DEPENDENT VARIABLE = $\Delta\Pi_t$

| Independent Variable | Model (3) | Model (4) |
|---|---|---|
| $\Delta\Pi_{t-1}$ | -0.647 | -0.588 |
| | (-6.56)* | (-5.85)* |
| $\Delta\Pi_{t-2}$ | -0.362 | -0.330 |
| | (-3.18)* | (-2.93)* |
| $\Delta\Pi_{t-3}$ | -0.182 | -0.185 |
| | (-1.58) | (-1.63) |
| $\Delta\Pi_{t-4}$ | -0.125 | -0.138 |
| | (-1.26) | (-1.42) |
| $YGAP_{t-1}$ | 0.326 | 0.273 |
| | (3.10)* | (2.58)* |
| $\Delta YGAP_{t-1}$ | | 0.570 |
| | | (2.16)* |
| **Implied Coefficients on Lagged Inflation Rates....** | | |
| $\alpha_1$ | 0.353 | 0.412 |
| $\alpha_2$ | 0.285 | 0.258 |
| $\alpha_3$ | 0.180 | 0.145 |
| $\alpha_4$ | 0.057 | 0.047 |
| $\alpha_5$ | 0.125 | 0.138 |
| **Implied Sacrifice Ratio.....** | | |
| Sacrifice Ratio | 1.8 | 2.1 |
| T-Statistic | 3.4* | 2.8* |

Note: Models (3) and (4) are the same as in Table 1. See Table 1 for the diagnostics on these models. An asterisk indicates significance at the 5 per cent level.

Table 4
## Alternative Estimates of the Sacrifice Ratio

| 1964Q3 to 1988Q4 | RDXF's Potential | Prescott Trend | Linear Trend | Quadratic Trend |
|---|---|---|---|---|
| Equations with the level of the output gap..... | | | | |
| Sacrifice Ratio | 1.8 | 1.1 | 5.2 | 2.1 |
| T-Statistic | 3.4* | 3.2* | 1.6 | 2.6* |
| $Rbar^2$ | 0.33 | 0.32 | 0.27 | 0.30 |
| Equations with both the level and the change in the output gap.... | | | | |
| Sacrifice Ratio | 2.1 | 1.2 | 6.3 | 2.6 |
| T-Statistic | 2.8* | 2.5* | 1.4 | 2.0* |
| $Rbar^2$ | 0.35 | 0.33 | 0.31 | 0.32 |

Note: $Rbar^2$ is the adjusted R-squared statistic. An asterisk indicates significance at the 5 per cent level.

# DATA APPENDIX

## Definitions

$\Pi$ is the quarterly percentage change in the GDP price deflator, at annual rates. The GDP price deflator is computed by dividing nominal gross domestic product (CANSIM, D20011) by gross domestic product at 1981 prices (CANSIM, D20031).

RU is the quarterly average of the national unemployment rate (CANSIM, D767611). UGAP is the labour market gap defined as the difference between RU, the reported unemployment rate, and the natural unemployment rate, estimated by the Bank of Canada. YGAP is the output gap defined as the percentage difference between realized gross domestic product (CANSIM, D20031) and potential GDP from the Bank of Canada's RDXF model (which uses a Cobb-Douglas production function framework).

AIB is a dummy variable for the period in which the Anti-Inflation Board was fully operational. It is equal to 1 for the period 1976Q1 to 1978Q2 and 0 elsewhere. PCOM is the annualized quarterly percentage change in a real Canadian commodity price index. The real Canadian commodity price index is computed at the Bank of Canada and encompasses U.S. producer prices for the following commodities produced in Canada: metals, chemicals, lumber and pulp and paper and the Canadian export price of wheat expressed in US dollars. POIL is the annualized quarterly percentage change in a rea l crude oil price index. The real oil price index is the average refinery acquisition cost of crude petroleum in Canada (computed by the Bank of Canada) divided by the GDP price deflator.

## The Data

| Date | Π | UGAP | RU | YGAP |
|---|---|---|---|---|
| 63: 2 | 1.97944 | -0.647353 | 5.12810 | -1.25745 |
| 63: 3 | 3.48066 | -0.897410 | 4.88942 | -1.24498 |
| 63: 4 | 2.81085 | -1.15290 | 4.64364 | 1.21009 |
| 64: 1 | -0.176677E-01 | -1.32425 | 4.41637 | 2.07468 |
| 64: 2 | 5.27354 | -1.35659 | 4.39520 | 1.40354 |
| 64: 3 | 3.41179 | -1.47099 | 4.29085 | 1.65887 |
| 64: 4 | 2.37469 | -1.71988 | 4.05105 | 1.10865 |
| 65: 1 | 1.82593 | -1.97699 | 3.71891 | 3.03836 |
| 65: 2 | 5.69616 | -1.84524 | 3.86051 | 2.83763 |
| 65: 3 | 3.68722 | -2.14228 | 3.57298 | 2.97024 |
| 65: 4 | 3.27032 | -2.56070 | 3.16264 | 4.25380 |
| 66: 1 | 6.33384 | -2.23432 | 3.38251 | 5.02480 |
| 66: 2 | 5.61569 | -2.52005 | 3.10509 | 4.88832 |
| 66: 3 | 4.87275 | -2.18666 | 3.44721 | 3.62354 |
| 66: 4 | 2.55722 | -2.24141 | 3.40076 | 3.31881 |
| 67: 1 | 6.17872 | -1.82224 | 3.71157 | 1.56877 |
| 67: 2 | 3.98557 | -1.80339 | 3.73880 | 2.04667 |
| 67: 3 | 1.27423 | -1.86256 | 3.68674 | 1.20630 |
| 67: 4 | 5.38577 | -1.39519 | 4.16009 | 0.372090 |
| 68: 1 | 5.48352 | -0.991855 | 4.43081 | 0.000000 |
| 68: 2 | 1.81744 | -0.902825 | 4.52665 | 1.34026 |
| 68: 3 | 2.61101 | -1.15613 | 4.51853 | 2.07344 |
| 68: 4 | 3.24485 | -1.72256 | 4.43583 | 3.17165 |
| 69: 1 | 7.07930 | -1.93798 | 4.29814 | 2.79579 |
| 69: 2 | 6.04950 | -1.85241 | 4.38807 | 2.27623 |
| 69: 3 | 2.47559 | -1.87753 | 4.36873 | 2.38783 |
| 69: 4 | 3.93327 | -1.63557 | 4.61676 | 3.03336 |
| 70: 1 | 7.98652 | -1.25213 | 4.83454 | 1.43675 |
| 70: 2 | 3.67742 | -0.345248 | 5.74694 | -0.458149 |
| 70: 3 | 2.28866 | 0.549163E-01 | 6.15191 | -0.151820 |
| 70: 4 | 4.11685 | 0.105144E-01 | 6.11235 | -1.75467 |
| 71: 1 | 2.38366 | -0.200661 | 6.24415 | -2.24566 |
| 71: 2 | 3.77937 | -0.171307 | 6.27677 | -0.800046 |
| 71: 3 | 2.05974 | -2.09887 | 6.09414 | 1.72147 |
| 71: 4 | 5.76130 | -2.04893 | 6.14408 | 1.27551 |
| 72: 1 | 8.47890 | -2.20376 | 5.98925 | -0.405696 |
| 72: 2 | 4.11728 | -2.11298 | 6.08004 | 0.980375 |
| 72: 3 | 5.54761 | -1.80178 | 6.39123 | 0.983216E-01 |
| 72: 4 | 7.25294 | -1.72016 | 6.47285 | 1.62972 |
| 73: 1 | 6.38015 | -2.34389 | 5.84912 | 3.58485 |
| 73: 2 | 13.2483 | -2.80859 | 5.38442 | 3.28478 |

| Date | Π | UGAP | RU | YGAP |
|---|---|---|---|---|
| 73: 3 | 12.8267 | -2.78342 | 5.40959 | 2.40290 |
| 73: 4 | 13.5790 | -2.67032 | 5.52269 | 3.79816 |
| 74: 1 | 16.8604 | -2.93391 | 5.25910 | 3.40135 |
| 74: 2 | 16.6003 | -3.02090 | 5.17211 | 2.76389 |
| 74: 3 | 12.6491 | -2.93711 | 5.25591 | 2.19063 |
| 74: 4 | 8.89762 | -2.54222 | 5.65080 | 1.65235 |
| 75: 1 | 7.40701 | -1.48151 | 6.71150 | 0.442778 |
| 75: 2 | 9.12467 | -1.36271 | 6.83030 | 0.130575 |
| 75: 3 | 11.7535 | -1.18658 | 7.00643 | 0.386549 |
| 75: 4 | 10.0247 | -1.04781 | 7.14521 | 0.170510 |
| 76: 1 | 7.56003 | -1.32093 | 6.87208 | 1.25622 |
| 76: 2 | 11.1882 | -1.21467 | 6.97835 | 2.31386 |
| 76: 3 | 2.19013 | -0.985511 | 7.20750 | 1.75186 |
| 76: 4 | 9.29503 | -0.748964 | 7.44405 | 0.633874 |
| 77: 1 | 4.83234 | -0.294550 | 7.89846 | 1.10071 |
| 77: 2 | 7.58087 | -0.293155 | 7.89986 | 0.416357 |
| 77: 3 | 5.66700 | 0.358158E-01 | 8.22883 | -0.166669E-01 |
| 77: 4 | 3.71190 | 0.172424 | 8.36544 | 0.825502 |
| 78: 1 | 5.13779 | 0.197639 | 8.39065 | 0.868388 |
| 78: 2 | 6.29150 | 0.237024 | 8.43004 | 1.52312 |
| 78: 3 | 8.92702 | 0.250164 | 8.44318 | 1.44500 |
| 78: 4 | 9.12942 | -0.104177 | 8.08884 | 1.95069 |
| 79: 1 | 8.03366 | -0.345055 | 7.84796 | 2.38222 |
| 79: 2 | 15.8084 | -0.646406 | 7.54661 | 2.40583 |
| 79: 3 | 9.09213 | -1.10123 | 7.09178 | 2.96027 |
| 79: 4 | 11.2086 | -0.994602 | 7.19841 | 2.94611 |
| 80: 1 | 8.90908 | -0.686061 | 7.50695 | 2.58473 |
| 80: 2 | 10.8260 | -0.470246 | 7.72277 | 1.70842 |
| 80: 3 | 12.2295 | -0.774495 | 7.41852 | 0.433728 |
| 80: 4 | 9.91747 | -0.998419 | 7.19459 | 1.51306 |
| 81: 1 | 12.4017 | -0.951166 | 7.24185 | 2.66910 |
| 81: 2 | 9.65972 | -1.06939 | 7.12363 | 2.93053 |
| 81: 3 | 10.6877 | -0.714809 | 7.47820 | 1.00213 |
| 81: 4 | 8.53688 | 0.157981 | 8.35099 | -0.702369 |
| 82: 1 | 9.33343 | 0.644628 | 8.83764 | -2.80044 |
| 82: 2 | 7.80167 | 2.20605 | 10.3991 | -4.86789 |
| 82: 3 | 7.31233 | 3.81748 | 12.0105 | -6.27010 |
| 82: 4 | 7.40027 | 4.45620 | 12.6492 | -7.59978 |
| 83: 1 | 2.39308 | 4.35792 | 12.5509 | -6.73440 |
| 83: 2 | 3.94842 | 4.02331 | 12.2163 | -5.35084 |
| 83: 3 | 4.75941 | 3.30440 | 11.4974 | -4.58944 |
| 83: 4 | 4.74929 | 2.88546 | 11.0785 | -4.61671 |
| 84: 1 | 3.69657 | 3.08483 | 11.2779 | -3.81770 |

| Date | Π | UGAP | RU | YGAP |
|---|---|---|---|---|
| 84: 2 | 0.988983 | 3.21281 | 11.4058 | -2.31057 |
| 84: 3 | 1.33054 | 2.99256 | 11.1856 | -1.86606 |
| 84: 4 | 2.20382 | 2.88589 | 11.0789 | -1.46830 |
| 85: 1 | 1.87802 | 2.81784 | 11.0109 | -0.897494 |
| 85: 2 | 5.60987 | 2.37930 | 10.5723 | -1.23802 |
| 85: 3 | 2.90651 | 1.96851 | 10.1615 | -0.802819 |
| 85: 4 | 1.03252 | 1.89917 | 10.0922 | 0.632085 |
| 86: 1 | 1.99531 | 1.43528 | 9.62829 | -0.976909E-01 |
| 86: 2 | 1.47334 | 1.35821 | 9.55122 | -0.402790 |
| 86: 3 | 3.49645 | 1.35435 | 9.54736 | -1.09223 |
| 86: 4 | 4.76939 | 1.19950 | 9.39251 | -1.85590 |
| 87: 1 | 5.69956 | 1.30964 | 9.50265 | -1.09850 |
| 87: 2 | 4.19217 | 0.845405 | 9.03842 | -0.452994 |
| 87: 3 | 3.69477 | 0.471285 | 8.66430 | 0.337195 |
| 87: 4 | 4.39758 | -0.413629E-01 | 8.15165 | 0.876260 |
| 88: 1 | 4.10220 | -0.367298 | 7.82571 | 1.00095 |
| 88: 2 | 2.73180 | -0.542353 | 7.65066 | 1.53526 |
| 88: 3 | 5.65839 | -0.350956 | 7.84206 | 1.53792 |
| 88: 4 | 4.77056 | -0.454620 | 7.73839 | 1.46618 |

| Date | AIB | PCOM | POIL |
|---|---|---|---|
| 63: 2 | 0.000000 | -0.385487 | 4.11493 |
| 63: 3 | 0.000000 | 2.80384 | -0.457427 |
| 63: 4 | 0.000000 | -0.264843 | 0.169259 |
| 64: 1 | 0.000000 | 0.495540 | 2.98096 |
| 64: 2 | 0.000000 | -0.539007 | -2.21571 |
| 64: 3 | 0.000000 | -0.125084 | -3.29922 |
| 64: 4 | 0.000000 | 1.98066 | -2.31961 |
| 65: 1 | 0.000000 | -0.553407 | -1.79319 |
| 65: 2 | 0.000000 | 0.650537 | -5.38918 |
| 65: 3 | 0.000000 | 0.476762 | -3.55610 |
| 65: 4 | 0.000000 | 1.11661 | -3.16676 |
| 66: 1 | 0.000000 | 0.302138 | -5.95656 |
| 66: 2 | 0.000000 | 1.11651 | -3.94241 |
| 66: 3 | 0.000000 | -0.735273 | -4.64634 |
| 66: 4 | 0.000000 | -3.78787 | -2.49346 |
| 67: 1 | 0.000000 | -1.52069 | -5.81917 |
| 67: 2 | 0.000000 | -2.39772 | -3.83281 |
| 67: 3 | 0.000000 | -0.840275 | -1.25820 |
| 67: 4 | 0.000000 | 0.619928 | -5.11052 |
| 68: 1 | 0.000000 | 1.80471 | -5.19846 |

| Date | AIB | PCOM | POIL |
|---|---|---|---|
| 68: 2 | 0.000000 | -1.77543 | -1.78500 |
| 68: 3 | 0.000000 | -0.958953 | -2.54457 |
| 68: 4 | 0.000000 | 4.43697 | -3.14286 |
| 69: 1 | 0.000000 | 6.89179 | -6.61126 |
| 69: 2 | 0.000000 | -2.75281 | -11.0155 |
| 69: 3 | 0.000000 | -3.24728 | -7.99057 |
| 69: 4 | 0.000000 | 1.73749 | 2.04520 |
| 70: 1 | 0.000000 | -0.214996 | -11.3854 |
| 70: 2 | 0.000000 | -0.249100 | 6.81145 |
| 70: 3 | 0.000000 | -0.306550 | 3.51177 |
| 70: 4 | 0.000000 | -3.76196 | 1.61239 |
| 71: 1 | 0.000000 | 38.8545 | 24.6808 |
| 71: 2 | 0.000000 | 2.69115 | 8.28592 |
| 71: 3 | 0.000000 | 5.63809 | -2.01817 |
| 71: 4 | 0.000000 | 0.900032E-01 | -5.44745 |
| 72: 1 | 0.000000 | 0.429335 | -7.81617 |
| 72: 2 | 0.000000 | 2.83697 | -3.95446 |
| 72: 3 | 0.000000 | 4.02681 | -5.25603 |
| 72: 4 | 0.000000 | 7.27223 | -6.76246 |
| 73: 1 | 0.000000 | 9.21822 | -5.99750 |
| 73: 2 | 0.000000 | 13.2631 | 112.838 |
| 73: 3 | 0.000000 | 7.29763 | 3.07419 |
| 73: 4 | 0.000000 | 25.1320 | 22.6571 |
| 74: 1 | 0.000000 | 17.6332 | -14.5382 |
| 74: 2 | 0.000000 | 7.86477 | 492.564 |
| 74: 3 | 0.000000 | 0.432558 | -9.72941 |
| 74: 4 | 0.000000 | -8.47932 | -6.98314 |
| 75: 1 | 0.000000 | -10.6878 | -7.19412 |
| 75: 2 | 0.000000 | -5.42303 | -7.22815 |
| 75: 3 | 0.000000 | -8.17069 | 93.6460 |
| 75: 4 | 0.000000 | -1.08324 | -8.92443 |
| 76: 1 | 1.00000 | 2.57795 | -7.87592 |
| 76: 2 | 1.00000 | 2.00252 | -9.82761 |
| 76: 3 | 1.00000 | 1.22787 | 55.8374 |
| 76: 4 | 1.00000 | -9.01287 | -8.02491 |
| 77: 1 | 1.00000 | -6.86267 | 24.4069 |
| 77: 2 | 1.00000 | -4.42258 | -6.43709 |
| 77: 3 | 1.00000 | -5.34759 | 36.4930 |
| 77: 4 | 1.00000 | -4.74445 | -3.56296 |
| 78: 1 | 1.00000 | 3.99691 | 32.6749 |
| 78: 2 | 1.00000 | 2.74820 | -5.42297 |
| 78: 3 | 0.000000 | 0.675258 | 29.4195 |
| 78: 4 | 0.000000 | 4.64653 | -7.80179 |
| 79: 1 | 0.000000 | 3.08184 | -0.446950 |

| Date | AIB | PCOM | POIL |
|---|---|---|---|
| 79: 2 | 0.000000 | 3.86290 | -12.9115 |
| 79: 3 | 0.000000 | 1.41890 | 24.9941 |
| 79: 4 | 0.000000 | -0.474460E-01 | -1.84510 |
| 80: 1 | 0.000000 | -6.73878 | 21.5614 |
| 80: 2 | 0.000000 | -12.6012 | -6.19738 |
| 80: 3 | 0.000000 | 4.68935 | 43.6406 |
| 80: 4 | 0.000000 | 2.95773 | 23.3439 |
| 81: 1 | 0.000000 | -7.06272 | 75.0874 |
| 81: 2 | 0.000000 | -5.10998 | 26.7068 |
| 81: 3 | 0.000000 | -3.01537 | 38.4689 |
| 81: 4 | 0.000000 | -7.01451 | 18.4155 |
| 82: 1 | 0.000000 | -2.98225 | 6.94939 |
| 82: 2 | 0.000000 | -2.57367 | -7.04070 |
| 82: 3 | 0.000000 | -8.12383 | 22.3663 |
| 82: 4 | 0.000000 | -4.35498 | -6.89037 |
| 83: 1 | 0.000000 | 5.86692 | 15.6386 |
| 83: 2 | 0.000000 | 4.07002 | -3.79845 |
| 83: 3 | 0.000000 | 3.35333 | -4.54318 |
| 83: 4 | 0.000000 | 2.90383 | -4.53396 |
| 84: 1 | 0.000000 | -0.182097 | -1.91115 |
| 84: 2 | 0.000000 | -0.518893 | -0.580103 |
| 84: 3 | 0.000000 | -1.67415 | -1.14198 |
| 84: 4 | 0.000000 | -0.264731 | 15.2999 |
| 85: 1 | 0.000000 | -3.46117 | 11.9697 |
| 85: 2 | 0.000000 | -3.90740 | -11.0384 |
| 85: 3 | 0.000000 | -2.57629 | -14.2503 |
| 85: 4 | 0.000000 | -1.39692 | 8.87279 |
| 86: 1 | 0.000000 | -1.53650 | -61.0839 |
| 86: 2 | 0.000000 | 5.07919 | -85.5481 |
| 86: 3 | 0.000000 | 0.281938 | -18.1762 |
| 86: 4 | 0.000000 | -2.53725 | 50.2128 |
| 87: 1 | 0.000000 | -3.64354 | 58.7182 |
| 87: 2 | 0.000000 | 4.22018 | 15.8543 |
| 87: 3 | 0.000000 | 2.16766 | 28.0940 |
| 87: 4 | 0.000000 | 11.8734 | -25.0726 |
| 88: 1 | 0.000000 | 11.5387 | -46.5137 |
| 88: 2 | 0.000000 | 8.78198 | -20.6593 |
| 88: 3 | 0.000000 | 12.8266 | -34.8857 |
| 88: 4 | 0.000000 | 3.20773 | -35.2551 |

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Figure 1

Inflation and the Output Gap

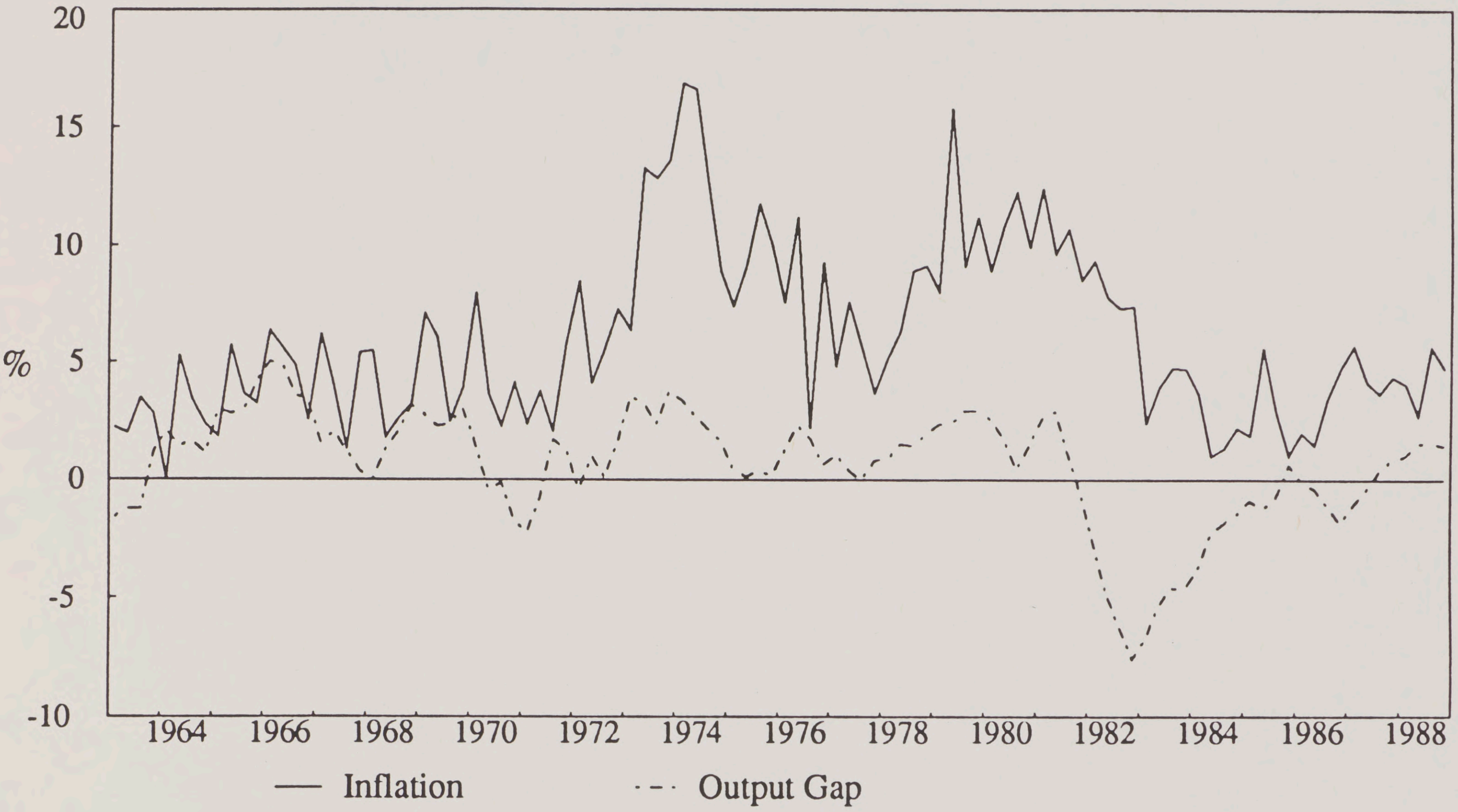


Figure 2

Alternative Measures of the Output Gap