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Inflation and Unemployment in the U.S. and Canada: A Common Framework *

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Abstract:
This paper summarizes the results of our efforts to broaden the theory of the Phillips curve and to explain the joint evolution of inflation and unemployment in the United States and Canada since 1930.

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INTRODUCTION

A central tenet of modern macroeconomics, which transcends schools of thought, is the existence of a negative trade-off between inflation and unemployment – the Phillips curve. This curve is also seen by practical policymakers as a key component of the "transmission mechanism" of monetary policy. Nevertheless, there remains some uneasiness in the contemporary economic literature about its theoretical foundations as well as its structural stability over time and across countries.

In the low-inflation environment of the 1960s, the Phillips curve was treated as if it provided a menu for policymakers to choose from in the long run. You could trade off more inflation for less unemployment permanently. All this changed in the higher-inflation decades of the 1970s and 1980s. While short-run trade-offs remained, they were shifting over time to such an extent that it appeared little or no inflation-unemployment trade-off was left for policymakers to exploit in the long run. The long-run Phillips curve, in other words, had to be drawn as a vertical line in inflation-unemployment space. This reflected the classical dichotomy that long-run unemployment was purely the result of real economic forces, while monetary policy could only influence the level of steady-state inflation. However, as inflation returned to low levels in the 1990s, a new puzzle emerged: a wide range of unemployment rates, from 4 percent in the United States to 11 percent in Canada, were seen to coexist with a narrow range of inflation rates, from 1 to 3 percent. Low unemployment rates appeared to generate surprisingly little increases in inflation in the United States, and high unemployment rates to provoke surprisingly little decreases in inflation in Canada. This development sent researchers, including ourselves, back to their drawing tables.

Our work on the Phillips curve has been carried out since 1995 at the Brookings Institution and the Canadian Institute of Advanced Research. From the outset, we shared Solow's (1976) view that it was "mistaken to conclude from the breakdown of an established regularity [such as the pre-1970 negatively sloped long-run Phillips curve] that it had been nonsense all along." Instead, our strategy was to look for a broader theory that could explain the negatively sloped long-run trade-off of the 1950s and 1960s, the vertical long-run Phillips curve of the 1970s and 1980s, and the U.S. and Canadian inflation puzzles of the 1990s all within a common framework. In doing so, rather than *assuming*, as classical thinking leading to the vertical long-run Phillips curve does, that all nominal wages and prices are set purely in terms of expectations about *relative* values, we decided to *test* this hypothesis with data.

Our work builds on two ideas that we and others had considered in the past, but whose relevance had not been fully established and whose implications for the Phillips curve had never been adequately developed. The first is the possibility that workers are loath to accept nominal wage cuts except when they understand employers are in severe financial stress. The second is the possibility that at low levels of inflation many wage and price setters ignore future expected inflation because the effects of that inflation are too small to be worth reckoning and compete with other concerns and perceptions. These two phenomena would allow *nominal* values to play some role in wage- and price-setting.

They would also likely have a greater impact in low-inflation periods such as the 1950s, 1960s and 1990s than in high-inflation periods such as the 1970s and 1980s. This made good intuitive sense to us and, moreover, there was the potential to explain several decades of economic history within the kind of unifying framework we were looking for. We soon discovered from various sources of evidence that these phenomena also corresponded to true real-world behaviour – including, to our own surprise, wage and price behaviour during the Great Depression of the 1930s.

This paper summarizes the results of our efforts to broaden the theory of the Phillips curve and to explain the joint evolution of inflation and unemployment in the United States and Canada since 1930. The next three sections set the stage by reviewing the evolution of ideas about the inflation-unemployment trade-off from the negatively sloped long-run Phillips curve of the 1950s and 1960s to the vertical long-run Phillips curve of the 1970s and 1980s, and then to the U.S. and Canadian inflation puzzles of the 1990s. The following two sections show how the two hypotheses of downward nominal wage rigidity and near-rational ignorance of low inflation were developed, review their macroeconomic implications and report how their empirical validity was tested with various datasets. Before concluding, we consider two main objections that have been leveled thus far at our general approach as a tool of economic policy, and we summarize the policy implications.

THE 1950S AND 1960S: NEGATIVELY SLOPED LONG-RUN PHILLIPS CURVES

In the late 1950s and early 1960s, British, Canadian and American economists discovered with data going back to the 19th century that there was a negative statistical relation between inflation and unemployment in the United Kingdom, the United States and Canada (Phillips 1958; Lipsey 1960; Samuelson and Solow 1960; Eckstein and Wilson 1962; Perry 1964; Kaliski 1964). Lower unemployment could be achieved by accepting higher inflation, and inflation could be reduced by accepting higher unemployment. This inflation-unemployment trade-off was given the name of its pioneer, A.W. Phillips.

Very early, Phillips, Lipsey and their followers viewed the aggregate change in wages as an increasing function of past inflation and a decreasing function of the unemployment rate. In simplified terms, their formulation was:

$$(1) \qquad \dot{w}/w = a\pi_{-1} + b/u + x ,$$

where $\dot{w}/w$ = percentage annual change in the nominal wage, π_{-1} = last year's inflation, u = unemployment rate and x = other determinants of the wage change. Past increases in the cost of living (or expected inflation based on recent inflation performance) were seen as a key element of wage bargaining. Empirical estimates of the inflation sensitivity parameter, a, clustered around one-half, indicating that past (or expected) inflation was incorporated only *partially* into current wage changes. Further, statistical tests supported a *convex* relation between inflation and unemployment. A nonlinear form using the inverse of the unemployment rate became standard.[1] The "other determinants" x reflected structural influences that were captured by a regression constant and by supply-side variables such as trend productivity growth, tax changes, wage-price guideposts, etc. (e.g., Bodkin, Bond, Reuber and Robinson 1966; Perry 1966).

Wage equations such as (1) were usually combined with an aggregate price equation. A stripped-down version assumed the aggregate price level was set as a markup over trend unit labour costs. This markup relation could be obtained from two alternative routes. First, the share of labour in aggregate value added, say (wL)/(pY), was observed to be reasonably constant on trend. This suggested one could write p = k(wL/Y), i.e., the aggregate price level, p, could be expressed as a constant markup, k, over trend unit labour costs, wL/Y (where w = nominal wage, L = labour input and Y = real value added). Second, one could rely on the classical proportionality relationship between price and marginal cost, and then assume the aggregate production function was Cobb-Douglas. This implied the share of labour was constant on trend and generated the same markup relation, p = k(wL/Y). In rate-of-change terms, the latter expression became $\pi = \dot{w}/w - q$, where π = current-year inflation and q is the trend rate of change in labour productivity Y/L.[2] Incorporating this markup relation into (1) and defining z = x – q led to the typical *short-run Phillips curve* of the 1950s and 1960s:

$$\pi = a\pi_{-1} + b/u + z^* + \varepsilon\,, \qquad (2)$$

where $\varepsilon = z - z^*$ is the short-run deviation of z from its long-run value z^*.

The term $a\pi_{-1}$ in equation (2) introduces a dynamic feedback from changes in past inflation π_{-1} onto current inflation π. This feedback implies that the long-run effect of any permanent change in unemployment on inflation will be larger than the immediate impact, depending on the size of the coefficient of past-year inflation, a. If, say, a permanent reduction in unemployment raises current inflation directly by h points this year, then next year's inflation will be higher not only because the direct effect of lower unemployment will remain, but also because there will be a higher cost of living factor to pass through from this year – expected inflation will be higher. The total effect on inflation next year will be h + ah points. In two years from now, the story will be repeated and the total increase in inflation will be $h + a(h + ah) = h + ah + a^2h$. And so on. Since there is only partial pass-through of cost of living increases from one year to the next ($a < 1$), the total effect on inflation will increase each year by a smaller and smaller amount. In the end, the cumulative effect on inflation will converge to the value $h(1 + a + a^2 + a^3 + \ldots) = h/(1-a)$. This long-run multiplier effect is still a finite quantity, but one that can be significantly larger than the impact multiplier h. For example, if a = 0.5, h/(1-a) is worth twice the value of h.

Naturally, in this framework, forward-looking policy authorities must take the dynamic feedback into account when they seek to influence the unemployment rate through aggregate demand management. In comparing situations with various levels of permanent unemployment, it is the long-run, not only the short-run, inflationary consequences that are relevant to them. The set of feasible combinations of steady inflation and unemployment rates is obtained by setting $\pi = \pi_{-1}$ and $\varepsilon = 0$ in equation (2), yielding:

$$(3) \qquad \pi = [b/(1-a)]/u + z^{*}/(1-a) \, .$$

This equation establishes a negatively sloped and convex long-run relation between permanent inflation and unemployment, called the *long-run Phillips curve*. The latter partitions the unemployment-inflation plane in two portions. The northeast portion is a region of declining inflation; the southwest portion, a region of rising inflation.

Figure 1 gives an illustration of the long-run Phillips curve for the range of low inflation rates (3 percent or less) observed over the period 1955-1967. This specific example approximates the numerical results from the 1966 study by Bodkin, Bond, Reuber and Robinson and the 1972 review paper by Eckstein and Brinner. Parameter values $a = 0.5$, $b = 12$ and $z^{*} = -1.5$ are assumed, giving $\pi = 24/u - 3$. The trade-off has the property that full price stability can be achieved only by keeping unemployment at 8 percent, while unemployment can be maintained at 4 percent only by allowing inflation to rise to 3 percent.[3] In the 1960s, long-run Phillips curves such as this one were thought to provide the available menu of steady-state inflation and unemployment rates for macropolicy to choose from (e.g., Reuber 1964; Perry 1966; Rees 1970).

Whether this relation could be extrapolated to ever lower unemployment rates, beyond those experienced in the periods from which the relations were estimated, was a different matter that would soon be confronted by events. The policymakers of the 1960s, and the economists who were advising them were clearly wary of pushing the relation too far. The concepts of full employment and the corresponding potential output path were part of their analytic framework. And by 1966, President Johnson's Council of Economic Advisers was urging fiscal restraint to avoid overheating the U.S. economy.

THE 1970S AND 1980S: VERTICAL LONG-RUN PHILLIPS CURVES

The long-run Phillips curve (3) was overtaken by new events, ideas and empirical results in the late 1960s and early 1970s. We single out four developments. First, the rate of inflation increased from the 2-to-3 percent range before 1968 into the 5-to-6 percent range by 1970, and eventually into the 8-to-10 percent range by 1976. This created a challenging new macroeconomic environment for theoretical analysis and empirical testing of the inflation process. Second, not a coincidence, radical new ideas about the inflation-unemployment trade-off were put forward by economists working in the classical tradition. They began to question the fact that expected inflation appeared with a coefficient of less than one in equations explaining wage change and price inflation such as (1) and (2) above (Phelps 1967; Friedman 1968; Lucas 1972). Third, the convexity of the inflation-unemployment trade-off disappeared from empirical studies. The nonlinear form b/u was progressively replaced by the linear form $-cu$. Fourth, a richer set of supply-side influences (captured by z) were introduced into empirical Phillips curves. The new variables included demographic structure (Perry 1970), real commodity price changes

(Gordon 1975), and policy variables such as unemployment insurance generosity (Grubel, Maki and Sax 1975).

A fundamental tenet of classical economic thinking is that nominal wages and prices do not play any meaningful, lasting role in economic decisions. They matter only when compared to other nominal wages and prices. Consequently, only *relative* wages and prices matter for nominal wage and price decisions, if not in the short run, where temporary wage and price misperceptions are possible, then certainly in the long run where the only steady rate of inflation is the accurately expected one. This classical axiom means wage setters are concerned not with nominal wages, but with *expected real wages*. Firms care about the ratio of wages to their expected sales prices – a key determinant of profitability – and employees care about the ratio of wages to the expected cost of living – a measure of their purchasing power. The straight implication of classical theorizing is that the proper object of aggregate wage analysis is not nominal wage change (as envisaged by Phillips and Lipsey), but expected real wage change, namely the variable $\dot{w}/w - \pi^e$, where π^e = expected inflation. The classical wage change equation of 1970s and 1980s vintage looked like the following:

$$\dot{w}/w = \pi^e - cu + x \,. \tag{4}$$

The major amendment to equation (1) was that the coefficient of expected inflation had to be set equal to one in this wage growth equation. A frequent additional change was that nonlinearity disappeared from most empirical wage growth equations. The convex form b/u was usually replaced by the linear form -cu. Combining equation (4) with the price markup assumption $\pi = \dot{w}/w - q$, defining $z = x - q = z^* + \varepsilon$ as before, and writing $u^* = z^*/c$ produced the "expectations-augmented" short-run Phillips curve:

$$\pi = \pi^e - c(u - u^*) + \varepsilon \,. \tag{5}$$

Repeated estimation of this equation was done with U.S. and Canadian data for the 1970s and 1980s. When π^e was proxied by a linear combination of one or more lagged-inflation variables, the hypothesis that the sum of the coefficients on those lagged-inflation variables was equal to one could not be rejected. Estimates of the linear slope parameter c were around one-half (e.g., Gordon 1982, 1990; Fortin 1989).

A key characteristic of equation (5) when $\pi^e = \pi_{-1}$ is its *accelerationist* nature. If we define the annual change in inflation $\Delta\pi = \pi - \pi_{-1}$, then the equation can be written as:

$$\Delta\pi = -c(u - u^*) + \varepsilon \,. \tag{6}$$

It is the *change* in inflation – the acceleration in prices – that is a decreasing function of the *level* of unemployment. In the absence of supply-side disturbances ($\varepsilon = 0$), inflation will increase, remain unchanged, or decrease depending on whether the actual unemployment rate u is less than, equal to, or greater than some threshold unemployment rate u^*, called the *natural rate of unemployment* in the theoretical literature (after Friedman 1968) and dubbed the *non-accelerating-inflation rate of unemployment*

(*NAIRU*) in the empirical literature (after Modigliani and Papademos 1975). Being defined as z^*/c, the NAIRU is the outcome of long-run real economic forces captured by the variable z^*. If unemployment was held persistently above or below the NAIRU, there would be unending price deceleration or acceleration.

In the world described by equation (6), there is a *unique sustainable rate of unemployment* – the NAIRU itself. From equation (5), it is also clear that this is the permanent rate of unemployment for which expectations of inflation are fulfilled, since $\pi^e = \pi$ and $\varepsilon = 0$ implies $u = u^*$. No other unemployment rate is consistent with an unchanging level of inflation, whatever that level turns out to be. This means there is *no* trade-off between inflation and unemployment in the long run. The long-run Phillips curve is then represented as a vertical straight line in the unemployment-inflation plane, as in Figure 2. Estimates of the NAIRU have differed across periods and countries. In the late 1980s, it was thought to fall in the 5.5-to-6.5 percent range in the United States (e.g., Gordon 1990) and close to 8 percent in Canada (e.g., Rose 1988).

The policy implications of the vertical long-run Phillips curve are just as dichotomic as its classical underpinnings. Along that vertical line, monetary policy can choose the permanent rate of inflation, but it has no influence on the permanent rate of unemployment. The central bank can reduce inflation by first keeping monetary conditions tight and unemployment above the NAIRU. Then, once inflation has declined as desired, it will ease monetary conditions and return unemployment to the NAIRU level to keep inflation steady at its lower value. This startling policy implication was popularized by Friedman (1968).[4]

Given the large accumulation of evidence in favor of equation (5) between the late 1960s and the late 1980s, the view of the world underlying the vertical long-run Phillips curve has had a major impact on monetary policy thinking and strategy. Most central bankers now believe that the benefits from price stability or very low inflation are large and permanent and that the related unemployment costs are small and temporary. Targeting very low rates of inflation has become the near-exclusive preoccupation of many central banks, on the ground that output and employment will more or less take care of themselves whatever the targeted level of inflation.

THE CANADIAN AND U.S. INFLATION PUZZLES OF THE 1990S

However, events in the 1990s have raised new questions about the long-run Phillips curve in the United States and Canada. The firmly-held view, based on the vertical long-run Phillips curve, that price stability or very low inflation had to be the overriding objective of monetary policy led the U.S. Federal Reserve and the Bank of Canada to reestablish the kind of low-inflation environment that prevailed in the 1950s and 1960s. Since the end of 1991 in Canada, and of 1993 in the United States, the annual inflation rate for the consumer price index excluding food and energy, called *core* inflation, has remained within fairly narrow ranges in the two countries: between 1.2 and 2.3 percent in Canada, and between 2.1 and 3.0 percent in the United States.

The surprising development is that these low and stable inflation rates have coexisted with a wide range of annual unemployment rates – from 6.1 to 4.1 percent in the United States, and from 11.4 to 6.8 percent in Canada. More specifically, between 1994 and 2000 the U.S. unemployment rate accumulated 7.2 point-years *less* than if it had been held at the NAIRU level of 6 percent, which was widely quoted at the beginning of the 1990s. But instead of rising by 3.6 points (half times 7.2 points, if c = 0.5), U.S. core inflation declined by 0.5 point between 1994 and 2000. Even if the estimated NAIRU level had been as low as 5.5 percent, the change in core inflation over the period would have been significantly overestimated. The evolution in Canadian unemployment has been just the opposite. Between 1992 and 2000, the Canadian unemployment rate accumulated 11.8 point-years *more* than if it had been held at a conservatively estimated NAIRU level at the end of the 1980s – say 8 percent. But instead of declining by 5.9 points (half times 11.8 points, again if c = 0.5), Canadian core inflation for 2000 was actually only 0.1 point below its 1992 level. In other words, the U.S. and Canadian experiences in the 1990s have both raised a serious challenge for the constant-NAIRU model of the 1970s and 1980s, for opposite reasons. We have had a case of “missing inflation” in the United States, and a case of “missing deflation” in Canada.

There are three ways to solve these twin puzzles within the Phillips curve paradigm based on equation (5). First, significant temporary disturbances from the supply side (non-zero values of ε) could have hit the economy. Second, structural developments could have changed the value of the NAIRU (u^* could have moved up or down). Third, the advent of persistent low inflation could have changed the way expectations of future inflation are formed (π^e would be formed differently). Economists working in the classical tradition characterized by equation (5) have emphasized all three possibilities.

In the case of the United States, recent studies have suggested that beneficial supply-side shocks and a decline in the NAIRU can account for at least part of the missing-inflation puzzle. Gordon (1998) has calculated that by 1998 the most important identified supply-side shock, namely the absolute drop in the real price of U.S. imports, had been exerting a cumulative downward pressure of 1.3 points on U.S. inflation since 1994. Further, based on evidence from estimated Phillips curves with time-varying intercepts (z^*), Staiger, Stock and Watson (1997) and Gordon (1998) have found that the U.S. NAIRU fell by about one point from the mid-1980s to 1998.

In the case of Canada, it cannot be realistically argued that inflationary supply-side shocks or an increase in the NAIRU have been responsible for the higher-than-predicted inflation rate. First, price increases from imports, food, energy and indirect tax changes have been roughly in line with core inflation cumulatively since 1992. The supply side has not been a special source of additional inflation. Second, evidence from the Canadian Beveridge curve indicates that structural unemployment and the NAIRU have been falling, not rising, during the 1990s (Fortin 1999). A falling NAIRU, far from solving the Canadian puzzle, only increases the amount of missing deflation to be explained.

This has led Bank of Canada economists to emphasize the third possibility – that the formation of inflation expectations has changed in the 1990s (e.g., Fillion and Léonard 1997; Kichian 2001). These studies typically force the NAIRU (or, equivalently, potential output) to follow a predetermined time path, and then interpret any estimated time variation in the intercept and the coefficients of lagged inflation as reflecting changes in the way the public forms its expectations of future inflation, possibly as a result of the Bank of Canada's official inflation-targeting policy. However, this attempt at interpretation leads to estimated time series for expected inflation that overpredict actual inflation and overestimate direct survey measures of expected inflation by a substantial and systematic margin. This is how the excessive inflation experienced by Canada during the 1990s is "explained" by this line of research.

In our view, evidence based solely on the vertical long-run Phillips curve framework is inadequate for explaining why there was "too little" inflation in the United States and "too much" inflation in Canada during the 1990s. The point that beneficial supply-side shocks acted as temporary inhibitors of inflation in the United States is clearly useful and well-taken. However, the results obtained by Staiger, Stock and Watson (1997) and Gordon (1998) for the United States and by Bank of Canada economists for Canada are generated by allowing the NAIRU or inflationary expectations to move over time in such a way that, true or false, the classical view can always fit the facts, and by then inventing ex post reasons – *dei ex machina* – for any detected time variation in the estimated parameters. While it is certainly possible that structural changes in the U.S. and Canadian economies have lowered the sustainable rate of unemployment (e.g., Stiglitz 1997; Fortin 1999; Cohen, Dickens and Posen 2001), simply positing a shift in the NAIRU anytime the rate of inflation does not behave the way the classical model predicts is neither good science nor a good guide for policy if it is possible instead to develop a theory that can explain these failures.

Working in a less restrictive environment, Brainard and Perry (2000) have allowed all the key parameters of the U.S. Phillips curve to vary over the period 1960-1998. These include not only the intercept z^* (which incorporates systematic determinants of the natural rate as well as a constant), but also the coefficients of lagged inflation, a, and of the inverse unemployment rate, b, in equation (2). Echoing a result emphasized much earlier by Eckstein and Brinner (1972) for the period 1955-1970, they found substantial time variation in the coefficient of lagged inflation, and virtual stability in the intercept and the coefficient of the inverse unemployment rate. Their estimated coefficient for lagged inflation is low during periods of low inflation and approaches one only in the inflationary middle years of the sample period.

The Brainard-Perry finding has two implications for research on the relation between inflation and unemployment. First, any procedure that assumes the Phillips curve has the classical property a = 1 for every level of inflation, while the value of that coefficient has in fact been shown to vary over time, is misleading. Second, a better strategy is to search for a broader encompassing theory of which the convex and negatively sloped long-run trade-off of the pre-1968 low-inflation era and the vertical long-run Phillips curve of the medium-to-high inflation period of the 1970s and 1980s would be two (testable) special cases.[5] This could shed light on the U.S. and Canadian inflation puzzles of the 1990s along the way.

Constructing new theories is harder than discarding old ones. Beginning seven years ago, we went back to more fully consider the implications of two ideas that had been around for a long time. The first idea was that money wages could be downwardly rigid. They could readily increase, but were rarely cut. In combination with the high degree of heterogeneity observed among labour and product markets (e.g., Lipsey 1960; Perry 1970), this could generate a Phillips curve that would be negatively sloped, convex and flat at low inflation rates and vertical at higher inflation rates. Tobin had sketched out these implications in his Presidential address to the American Economic Association (Tobin 1972). The second idea was that the degree to which firms and workers incorporate expected inflation into their current wage and price decisions could, for various reasons, be an increasing function of recent inflation. Eckstein and Brinner had used such an assumption in accounting for the speed up of inflation in the early 1970s (Eckstein and Brinner 1972). We have looked carefully at both these ideas, providing behavioral and empirical evidence for their importance, building them into macroeconomic models of a generalized Phillips curve, and estimating these models with data from the United States and Canada. The results of our investigation so far are contained in Akerlof, Dickens and Perry (1996; 2000) for the U.S. side, and in Fortin (1996), Dickens (2000) and Fortin and Dumont (2001) for the Canadian side. The following two sections give an account.

DOWNWARD NOMINAL WAGE RIGIDITY

The reason that firms seem extremely reluctant to cut workers' wages is for fear of losing their good employees and suffering a serious drop in morale and productivity. Except in extreme circumstances, most people consider it very unfair, even insulting, for a firm to cut wages – while they consider it less unfair if a firm fails to raise wages in the face of high inflation (Bewley 1999). In the 1950s and 1960s, the general view was indeed that downward money wage rigidity was an important feature of the economy and that consequently very low inflation was harmful to growth (e.g., Schultze 1959; Samuelson and Solow 1960). But since the validity of this assumption is now doubted by some, we have found it useful to look at direct microeconomic evidence that it matters.

Direct microeconomic evidence

Studies of general wage changes in manufacturing, union contracts, employer surveys, and our own phone survey of workers have allowed us to directly examine whether wage cuts are frequent. These data carry the systematic message that, while wage changes vary across firms, few employees receive wage cuts even when inflation is low. Many receive wage increases and many no wage change at all, but the distribution is abruptly truncated at zero (Akerlof, Dickens and Perry 1996). Wilson(1999) and Altonji and Devereux (1999) study personnel files from large U.S. corporations, and similarly conclude that nominal wage cuts almost never occur. In Canada, private-sector union wage settlements in the 1990s are a particularly interesting example of a wage change distribution spiking at zero (Fortin 1996). Over the nine-year period 1992-2000 for which the annual median wage settlement ranged from 0.5 to 2.4 percent, 67 percent of the 1,500 major settlements granted first-year base wage increases, 31 percent imposed wage freezes, and only 2 percent brought wage cuts (Department of Human Resources Development, various issues). For this particular group of workers, this constitutes first-hand evidence of substantial thinning of the wage change distribution in the negative range and strong resistance to money wage cuts.

A few Canadian authors (e.g., Crawford and Harrison 1998; Crawford 2001) tend to play down this evidence based on union contracts in two ways. First, they define a wage freeze as one that extends over the entire life of a contract. They argue that the presence of wage increases in the second and third years of a multi-year contract indicates that there is room left for reducing the value of the overall settlement, which is taken as proof that the first-year freeze is not really binding. We disagree with the strong assumption this implies for the extent of intertemporal substitution in wage payments that can be allowed by capital markets, particularly in the case of the financially-squeezed firms that are led to impose first-year wage freezes precisely for this reason. Second, these authors argue that the administrative or other costs of increasing or decreasing base wages by a small amount make an important contribution to the spike at zero wage change in major union settlements. But it is hard to believe that large unionized firms that are already incurring the substantial costs of negotiating collective agreements, are concerned about the morale of their employees, and support entirely computerized payrolls, would find the menu cost of giving a small pay raise prohibitive.

In further contrast to our work, McLaughlin (1994) has argued that money wages are almost as flexible downward as upward. He bases his claims on wage changes reported for the same workers in panel data taken a year apart. Examples are the U.S. Panel Study of Income Dynamics (PSID) and the Canadian Survey of Labour and Income Dynamics (SLID). But the use of such panel data to assess the extent of nominal wage rigidity is seriously biased because of severe contamination from reporting error. People often cannot remember (or simply don't bother to accurately report) their wages to survey takers. A large fraction of respondents make such errors, which also are large in magnitude. In consequence, "wage changes" computed in this manner are in fact as much a reflection of reporting error as they are of actual wage change. Several researchers have challenged the McLaughlin results. A finer examination of the distribution of nominal wage changes in the PSID data leads Kahn (1997) to uncover substantial rigidity for wage earners. Card and Hyslop (1997) confront the problem of measurement error in the PSID data directly and reach the opposite conclusion from McLaughlin. They conclude that such data indicate "a reasonable prima facie case for the existence of downward wage rigidity for a significant fraction of workers." Shea (1997), commenting on Card and Hyslop, finds strong evidence of the importance of measurement error by comparing union workers reported wages in the PSID to the wages specified by their union contracts. While 21.1 percent of the union workers Shea can match to their contracts report lower wages in one year than a previous year, only 1.3 percent had contracts that specified wage cuts. The difference is probably due to reporting error in the PSID. Altonji and Devereux (1999) strengthen Card and Hyslop's conclusion. They use the PSID data to estimate a model of wage determination that nests downward nominal rigidity as well as flexible wages and directly incorporates a model of measurement error in wage reports. They conclude that "the PSID data overwhelmingly rejects the hypothesis of perfect flexibility." They also find some evidence that nominal wage cuts may occur in extreme circumstances.

Downward nominal wage rigidity seems to characterize labour markets in many countries. Studies by Agell and Lundborg (1999) for Sweden, Beissinger and Knoppik (2001a; 2001b) for Germany, Fehr and Goette (2000) for Switzerland, and Dwyer and Leong (2000) for Australia (2000) all find evidence of significant wage rigidity. In the case of the United Kingdom, the evidence so far is less clearcut (Smith 2000; Nickell and Quintini 2001). In the case of Canada, the datasets are either free of reporting error, but not nationally representative (e.g., the major wage settlements database mentioned above); or else, they are representative, but contaminated by error (e.g., the SLID). The Canadian wage settlements data is strongly supportive of downward nominal wage rigidity, while no study has yet subjected the Canadian SLID to the same kind of detailed modeling as Altonji and Devereux (1999) have done for the the U.S. PSID. However, given the broad similarity of U.S. and Canadian labour markets, it would be extremely surprising if the degree of wage rigidity in Canada was lower than that found in the United States.

Macroeconomic implications

If downward nominal wage rigidity is such a significant and persistent feature of U.S. and Canadian labour markets, what are its macroeconomic implications? Tobin (1972, 11) summarized them as follows: "A model where wage change is never negative implies a long-run Phillips curve that is very flat for high unemployment and becomes vertical at a critically low rate of unemployment." Tobin arrived at this conclusion by envisaging a situation whereby, in the absence of any wage rigidity, the money wage change at individual firm i would be ω_i. This unconstrained (or notional) wage change ω_i could be described by a classical equation such as (4) transposed to the individual firm level. It could be positive (a pay raise) or negative (a pay cut), depending on supply and demand conditions. But if downward nominal wage rigidity was the rule in labour markets, so that the money wage could not decline at all, the actual wage change $(\dot{w}/w)_i$ at firm i would be equal to ω_i only if the latter was positive; if ω_i was negative, $(\dot{w}/w)_i$ would be zero.[6]

The reason that downward nominal wage rigidity can have major macroeconomic consequences is its interaction with heterogeneity of experience at the microeconomic level. The economy is composed of a very large number of firms with a wide diversity of experience. In both good times and bad, some firms and industries do better than others. Relative wages need to adjust in order to accommodate these differences in economic fortunes. If inflation and productivity growth proceed at a fairly rapid rate so that average nominal wage growth is, say, 10 percent a year in the economy as a whole, then relative wages can easily adjust. The unlucky firms can raise the wages they pay by less than 10 percent, while the lucky firms can give above-average increases. Under such circumstances, it does not matter much that nominal wages cannot be cut, because in any given year only a very small fraction of the unlucky firms need to reduce their relative wages by more than 10 percent to make the appropriate economic adjustment. However, if inflation and productivity growth are low, so that average nominal wage growth is, say, 4 percent or less, then the maximum reduction in relative wages that is possible without cutting money wages is 4 percent, not 10 percent. In this kind of environment, a significantly higher fraction of the unlucky firms – all those requiring a reduction greater than 4 percent in their relative wages – will not be able to make the needed adjustment.

Two types of consequences follow. First, downward nominal wage rigidity will force a microeconomic reallocation of labour from constrained firms, whose relative wages remain too high because nominal wage cuts are ruled out, to unconstrained firms, which do not suffer from this problem. Second, and crucially, as inflation is pushed to lower levels, downward nominal wage rigidity and market heterogeneity imply that a rising percentage of wages become unresponsive to anti-inflationary pressure. Moreover, this is a permanent development. Even if there is a rapid turnover in the group of firms that hit the wall of no wage cut, at any point of time the percentage of such unresponsive firms in the aggregate will be increased permanently by the lower inflation. To compensate, a given further reduction in inflation requires imposing permanently stronger anti-inflationary pressure on the declining fraction of unconstrained firms. This will be achieved through higher permanent unemployment in the aggregate. Equivalently, the anti-inflationary pressure from any given level of unemployment weakens permanently as inflation declines, so that further reduction in steady inflation can only be sustained through higher permanent unemployment.[7] It should also be intuitively clear that a greater degree of heterogeneity increases the percentage of unresponsive firms for any given level of inflation and, hence, the level of permanent unemployment.

The distinction we make between the microeconomic effect involving a simple reallocation of labour across firms and the macroeconomic effect of generating a rise in aggregate unemployment is important to grasp. Having found no significant negative impact of downward nominal wage rigidity on employment at the micro level, some researchers have inferred that downward nominal wage rigidity is macroeconomically irrelevant (e.g., Faruqui 2000; Farès and Hogan 2001). This is an obvious non sequitur, since the absence of any microeconomic disemployment effect does not remove the need for aggregate unemployment to rise permanently in order to offset the increased downward resistance of average wages and prices as inflation is being reduced.

The key macroeconomic relation in the presence of strict downward money wage rigidity and heterogeneity is the connection (call it F) between the economy-wide average actual wage growth, $\dot{w}/w$, which is partially constrained by wage rigidity, and its two main determinants: the average unconstrained wage change that would be observed in the absence of any rigidity, ω, and the degree of dispersion (or standard deviation) of these unconstrained wage changes, σ. We write this as:

(7) $$\dot{w}/w = F(\omega, \sigma) .$$[8]

The aggregate response function F has four important properties. First, downward nominal wage rigidity means that $\dot{w}/w$ is always positive and always exceeds ω. Second, actual average wage growth $\dot{w}/w$ is a function of ω whose slope is positive, but does not exceed one. Increases in the unconstrained average wage change ω will be accompanied by one-for-one increases in the actual wage growth of unconstrained firms and by no increase at all in the actual wage growth of firms that are still constrained. Therefore, actual average wage growth $\dot{w}/w$ will increase, but by less than ω. To illustrate, if k = 20 percent of wage changes are constrained at zero, then an increase of one percentage point in the average unconstrained wage change ω will generate an increase of 1 – k = 0.8 percentage point in average actual wage growth $\dot{w}/w$. The percentage 1 – k operates as an attenuation factor. Third, $\dot{w}/w$ is a convex function of ω. The responsiveness of $\dot{w}/w$ to variations in ω will itself increase with ω because, as ω becomes larger, k declines. There are fewer and fewer constrained and unresponsive firms and more and more unconstrained and responsive firms. Eventually, for ω large enough, every trace of rigidity disappears, actual wage growth $\dot{w}/w$ coincides with ω and responds one for one to changes in ω. This corresponds exactly to the classical case described by equation (4). Fourth, for given ω, actual average wage growth $\dot{w}/w$ is an increasing function of the wage change dispersion σ – more heterogeneity is inflationary. Greater dispersion around the same average ω means that higher values of individual ω_i's above the average ω are balanced by lower values below ω. But in calculating the impact on actual wage growth, the weight of the lower unconstrained values will count for less, because the negative ω_i's carry zero weight due to downward nominal wage rigidity. Hence, the net effect will be an increase in $\dot{w}/w$.[9,10]

Assume nothing else is non-classical in the model, so that the unconstrained average wage change is described by the same kind of linear equation as (4):

(8) $$\omega = \pi^e - cu + x = \pi^e + q - c(u - u^*) + \varepsilon ,$$

and prices are still set as a markup over trend unit labour costs ($\pi = \dot{w}/w - q$). Then, the short-run Phillips curve with downward nominal wage rigidity is given by:

(9) $$\pi = F[\omega; \sigma] - q ,$$

with the expression in (8) substituted for ω.[11] Given the properties of the function F, inflation π is a negatively sloped and convex function of unemployment u. In equation (9), the standard deviation of the unconstrained wage change distribution, σ, is assumed constant.[12]

The corresponding long-run Phillips curve is then obtained as usual by setting $\pi^e = \pi$ and $\varepsilon = 0$ in equation (8) and then solving equation (9) for steady inflation as a function of permanent unemployment. We write this trade-off as:

(10) $$\pi = G[-c(u - u^*); \sigma] - q \,.$$

A notable property of this equation is that faster productivity growth improves the permanent inflation-unemployment trade-off unambiguously. It allows for lower unemployment given the inflation rate, or for lower inflation given the unemployment rate.

How sensitive is steady inflation to a permanent change in unemployment along the long-run Phillips curve given by (10)? Consider an increase of one percentage point in unemployment. By (8), the average unconstrained wage change ω will take a drop of c points. But if k percent of wage changes cannot be made smaller because they are already constrained at zero, then actual wage growth $\dot{w}/w$ and inflation π will only decrease by (1 – k)c points in the short run. For example, if c = 0.5 and k = 20 percent of wage changes are actually wage freezes, then the slope of the short-run Phillips curve (9) will be (1 – k)c = 0.4 at this point.

An important property of equation (9) is that the attenuation factor (1 – k) working through F weakens the effects on $\dot{w}/w$ of changes not only in unemployment, but in *every* determinant of ω and by the same proportion. In particular, the dynamic feedback from expected inflation onto current wage growth and inflation is also attenuated by the wage rigidity. This brings us back to the type of situation assumed to prevail in the 1950s and 1960s and described earlier by equation (2), where there is only partial pass-through of cost of living increases from one year to next. The attenuation factor (1 – k) plays the same role in equation (9) as the partial indexation factor, a, in equation (2). By analogy, under wage rigidity the full long-run response of inflation to a one-point increase in unemployment will be equal to (1 – k)c/k, that is, to the short-run response (1 – k)c divided by one minus the attenuation factor. With the same illustrative values c = 0.5 and k = 0.2 as before, the long-run inflation response through G is (1 – k)c/k = 2 points of additional inflation. Conversely, lowering inflation by one point in this low-inflation range will require unemployment to rise permanently by k/[(1 – k)c] = 0.5 point. This means going from 3-percent inflation to zero inflation would raise permanent unemployment by 1.5 points – actually by more, given that by convexity k itself rises with declining inflation.

As a result, the long-run Phillips curve with downward nominal wage rigidity given by (10) will be negatively sloped and convex.[13] It will have the additional key property that the threshold unemployment rate u^* no longer defines the *unique* sustainable rate of unemployment (the NAIRU) as in the classical model leading to the vertical long-run Phillips curve, but the *lowest* sustainable unemployment rate (the LSRU). This can be seen by noting that, in a long run where $\pi^e = \pi$ and $\varepsilon = 0$, equation (8) can be written:

(11) $$\omega = \dot{w}/w - c(u - u^*) \,,$$

given that $\pi + q = \dot{w}/w$. Since ω never exceeds $\dot{w}/w$, u never falls below u^*. Only when inflation is so high that no firm in the economy is wage-constrained (k = 0) will equality hold between ω and $\dot{w}/w$, and hence between u and u^*. Put another way, the negatively sloped and convex long-run Phillips curve lies everywhere to the right of the vertical asymptote $u = u^*$, and permanent unemployment is closer to its lower bound u^* the higher the rate of steady inflation.

As emphasized earlier, complete downward nominal wage rigidity is too stark an assumption. First, even if wage cuts are rare, sometimes they do occur in firms experiencing severe financial problems. Second, firms could partly get around the effects of strict downward wage rigidity by finding alternative ways to reduce labour costs, such as cuts in nonwage benefits and freezes in compensation associated with merit, promotion and seniority. Third, previously laid-off workers might be reemployed only at lower wages. Under such circumstances, the distribution of wage changes would not be completely truncated at zero and nullified below zero, but would instead be only partially blocked at zero and become thinner in the negative range. Empirical evidence against the strict nominal rigidity hypothesis is provided by Altonji and Devereux (1999), Bewley (1999) and Crawford and Harrison (1998). All empirical experiments reported below allow for the possibility that downward nominal wage rigidity might be less than complete.

Macroeconomic evidence

In Akerlof, Dickens and Perry (1996), we used postwar U.S. macrodata to estimate and confront two polar Phillips curves: the model with no downward nominal wage rigidity, and our model with strict wage rigidity. In the no-rigidity case, actual average wage growth $\dot{w}/w$ is equal to unconstrained (or notional) average wage growth ω. In the strict-rigidity case, $\dot{w}/w$ is equal to F(ω, σ) as in equation (7). In both cases, ω is given by $\pi^e + q - c(u - u^*) + \varepsilon$ as in equation (8), and inflation by $\pi = \dot{w}/w - q$. In this experimental framework, our model with downward nominal wage rigidity did marginally better than the model with no rigidity in predicting the rate of inflation in the postwar period up through 1995.[14,15] Djoudad and Sargent (1997) replicate the analysis with Canadian macrodata, and find that our model with wage rigidity does a significantly better job of predicting inflation over the postwar period (and particularly during 1990-96) than the model without rigidity.

Figure 3 pictures our long-run U.S. Phillips curve with downward rigidity using its estimated parameters c = 0.5, u^* = 5.2 percent, σ = 3 percentage points and the average growth rate q = 1.5 percent for U.S. productivity over 1974-1995. For medium to high inflation rates (π above 4 percent), the average notional wage change ω is large enough to leave only a negligible fraction of firms facing nominal wage constraints. In this inflation range, actual wage growth and notional wage change are practically the same ($\dot{w}/w$ = ω), permanent unemployment is equal to the traditional unique NAIRU (u^* = 5.2 percent), and the long-run Phillips curve is vertical. However, as inflation falls below 4 percent, nominal wage constraints are increasingly frequent, and the amount of permanent unemployment required to sustain declining inflation rises at an increasing rate. The long-run Phillips curve become negatively sloped, convex, and nearly flat at very low inflation rates – as stated in the above quote by Tobin. The theoretical prediction of our model that reducing inflation from 3 percent to zero would raise permanent unemployment by 1.5 points or more is very precisely borne out by our statistical results and pictured by Figure 3.

As a strong test of the usefulness of our model, we attempted an ambitious exercise. The behaviour of U.S. prices during the Great Depression has always defied explanation through the model described by equation (5), for which the long-run Phillips curve is everywhere vertical. Unemployment was always above any reasonable estimate of the NAIRU, so the vertical long-run Phillips curve view predicts accelerating deflation for the entire decade of the 1930s. In fact, there was deflation for the first few depression years, as unemployment rose to unprecedented levels. But then a year of significant inflation was followed by a period of low inflation, more deflation, and then inflation again.

We took our model and the model based on the vertical long-run Philips curve, which were estimated using U.S. postwar data, and back-cast the price behaviour of the Great Depression in each case. The model based on the vertical long-run Phillips curve goes wildly off track, whereas our model (which embodies the effects of nominal rigidity) tracks the Great Depression with uncanny accuracy. Both models predict deflation in the early 1930s. However, in the mid- to late 1930s the model based on the vertical long-run Phillips curve predicts continuing deflation. Our model predicts that the effects of nominal rigidity finally catch up with the economy and create positive and varying inflation rates, despite high unemployment. Further, when the model is estimated using only data for the 1930s, results are almost identical to those in the postwar data. Parameter estimates for the model based on the vertical long-run Phillips curve estimated on the same data are imprecise and non-sensical. Djoudad and Sargent (1997) get similar results in their attempt to back-cast Canadian inflation during the Great Depression with their Canadian versions of the models with and without wage rigidity.

To summarize, we have found that downward nominal wage rigidity is a significant and persistent feature of the North American economy. We have shown theoretically and empirically that a long-run Phillips curve with this property helps understand a wide range of inflation experience from the 1930s to the 1990s. It can explain price behaviour during the Great Depression. It encompasses the convex and negatively sloped trade-off of the low-inflation period of the 1950s and 1960s as well as the vertical long-run Phillips curve of the medium-to-high inflation period of the 1970s and 1980s. And by showing that low and stable inflation can persist over a wide range of unemployment rates, it offers an explanation for the divergent U.S. and Canadian experience during the 1990s. The implications for monetary policy are crucial. Zero inflation is an inappropriate target, involving needlessly high costs in unemployment and lost output and profits. While the permanent unemployment cost of reducing inflation to 4 percent from 6 percent or more appears to be small, pushing inflation from 3 percent down to zero could raise permanent unemployment by 1.5 points or more, which would be more costly than any benefits that full price stability might bring.[16] We return to the issue of such possible benefits below.

NEAR-RATIONAL NEGLECT OF LOW INFLATION

Incorporating the realistic view of downwardly rigid money wages and heterogeneous markets into Phillips curve analysis helps understand the rich diversity of inflation experience from the Great Depression to the 1990s within a broader framework. This has been an important theoretical and empirical first step away from the piecemeal and ad hoc approach of the existing literature, which has had to invent a new explanation every time the vertical long-run Phillips curve seemed to be experiencing some shift. Our further modeling, which challenges the conventional treatment of expectations, alters the standard NAIRU model substantially further.

Direct evidence and rationale

We see how people actually *use* expectations in making decisions, rather than how they *form* them, as the key to modeling inflation. Thus, we question the central assumption of NAIRU models that expected inflation is always fully incorporated into the price- and wage-setting decisions of firms and workers. There is ample empirical evidence from time series to motivate this approach.

Recall the Brainard-Perry finding, which we have mentioned above. The U.S. Phillips curve estimated over the period 1960-1998 displays substantial time variation in the coefficient of lagged inflation, and virtual stability in the coefficients of other explanatory variables, across periods of low versus high inflation. We have felt it important to check whether the Brainard-Perry result with U.S. data is a chance occurrence arising from a particular specification of the inflation-unemployment trade-off, or whether it is robust and holds up in a large number of specifications.

To this end, we sorted the period from 1954 through 1999 into two samples: low-inflation quarters when the trailing five-year average of CPI inflation was below 3 percent (or alternatively, 2.5 percent), and high-inflation quarters with this average in excess of 4 percent. The samples have mean inflation rates of 2.0 percent and 6.3 percent, respectively. We then estimated a large number of specifications in which we varied the measure of unemployment and the measure of inflationary expectations. We tried the unemployment rate for all workers, the rate for prime-age males, and a rate adjusted for demographic change. We used adaptive measures of expected inflation (up to three years of lagged inflation) as well as two direct survey measures. Our findings support the Brainard and Perry results. We consistently found the coefficient on inflationary expectations to be substantially larger in regressions estimated with the high-inflation samples than for the comparable specification estimated with the low-inflation samples (Akerlof, Dickens and Perry 2000).

In light of such evidence, we set out to formulate a more comprehensive model incorporating both downward nominal wage rigidity *and* the idea that firms and workers partially ignore inflation when it is low. Three strands of evidence on actual behaviour suggest to us that the classical assumption that expected inflation is always fully incorporated is wrong. First, psychological studies show that decisionmakers often "edit" the information available to them, ignoring much that is potentially relevant in order to concentrate on the few factors they deem most important (Kahneman and Tversky 1979). Furthermore, studies of perception show that a stimulus must pass a threshold before it is even perceived, let alone used. Second, from interviews with compensation professionals, we infer that wage setters do not behave in the way that most economic models assume. Rather than choosing a real wage target and then adjusting the nominal target fully for expected inflation, they use a "decision heuristic" in which they mix information about inflation with a variety of other information relevant to wage setting in unsystematic ways that are not likely to yield the result economists assume. Third, research on perceptions of inflation by Shiller (1997) and research on money illusion by Shafir, Diamond and Tversky (1997) show that the public fails to understand inflation as a general-equilibrium phenomenon. They believe that inflation will make them poorer because it bids up the prices of the goods they consume, but they systematically underestimate the offsetting tendency of inflation to boost their own nominal wages. Therefore, in periods of moderate inflation, so long as their wages do not decline, employees view favorably the salary increases they get and generally remain satisfied with their jobs.

Any of these departures from classical economic theory implies that expected inflation will be less than fully incorporated into price- and wage-setting decisions of firms and workers. We further argue that wage- and price-setters may have good *economic* reasons for ignoring inflation when it increases from zero to a small value. Basically, the economic cost to them is negligible. This, we point out, makes ignorance of inflation "near-rational." We arrive at this conclusion by assuming that firms set wages and prices, and workers respond to the wages offered according to their view of job and wage opportunities outside the firm. The crucial issue is how wage and price setting varies with inflation. Even when inflation is low, some firms' wage and price setting fully incorporates expected inflation. In other firms, wage and price setting responds fully to current conditions in their labour market, but less than fully to expected inflation, perhaps even ignoring it completely. Because all firms adjust to current market conditions each time they set wages, the wage in firms that fail to take full account of inflation trails the average wage, though only by a small, noncumulating percentage. Prices in all firms are a markup over expected unit labor costs. The cost in lost profits from less than complete attention to inflation is negligible when inflation is low, but this cost grows quickly with inflation. As a consequence, the fraction of firms that fully incorporate expected inflation in setting their own wages and prices varies with the inflation rate. In a climate of little or no inflation, a large fraction of firms do not fully adjust their wages and prices, but this fraction declines when inflation rates are higher.

Macroeconomic implications

The key macroeconomic implication of near-rationally ignoring low inflation is that, when inflation is between zero and some moderate rate, higher inflation within this range is accompanied by lower unemployment; but when inflation increases beyond some level, the beneficial effect on employment ceases to increase, begins to reverse and eventually disappears.

This trade-off reflects two opposing effects. The first effect concerns firms that continue to pay less than full attention to inflation. When inflation begins to increase above zero, the wages and prices of these firms fall somewhat behind those of firms that do pay full attention. As a result, these firms sell more goods and employ more workers than they would if they set their prices higher. The lower prices of their goods also leave consumers with more to spend, increasing demand for the goods of other firms, and raising total employment. The second effect concerns firms that change their behaviour. At the higher inflation rate, those firms shift their pricing to fully incorporate expected inflation and, as they do, wages and prices rise more, reducing some of the benefits to employment and output from the first effect.

In the low-to-moderate inflation range, the first effect dominates and higher inflation is associated with lower unemployment. But beyond some threshold inflation rate, the second effect dominates and the trade-off goes the other way: higher inflation is associated with higher unemployment. An important implication is that there must exist an unemployment-minimizing inflation rate where the two effects exactly offset each other and where permanent output and employment cease to increase and begin to decrease. That threshold inflation rate is greater than zero but moderate, and unemployment rates associated with zero inflation or high inflation are significantly higher. Crucially, the LSRU corresponding to the threshold inflation rate under the joint theory of near-rational ignorance of low inflation and downward nominal wage rigidity may be *less* than the standard NAIRU (which we have called u^*).

In this economy, the unconstrained average wage change equation is one in which the coefficient on expected inflation, a, is less than one in the low-inflation range where some near-rational neglect is found, but rises with inflation and eventually approaches one when the rate of inflation is high enough. It is a slightly amended version of equation (8):

$$\omega = a\pi^e - cu + x = a\pi^e + q - c(u - u^*) + \varepsilon \,, \tag{12}$$

in which the parameter a is not constrained to equal one, but can take values between 0 and 1. In Akerlof, Dickens and Perry (2000), we show that if the thresholds at which wage and price setters are no longer willing to tolerate losses from ignoring inflation and switch to fully rational behaviour are normally distributed, the inflation-sensitivity coefficient, a, can be modeled as:

$$a = N[d + e\pi_L^2] \,, \tag{13}$$

where N is the cumulative distribution function of the standard normal distribution, d and e are parameters to be estimated, and π_L represents the effects of past inflation on the likelihood that people will act rationally toward inflation. This characterization of the way people use inflationary expectations allows the data to determine whether our theory about partial ignorance of low inflation is true or false. If the estimated value of d were, say, 2 or higher and that of e were not negative, then the coefficient of expected inflation, a, would never fall below 0.97, and there would be practically no room for changing experience with inflation to affect the value of a. The data would support the full-rationality theory. But if d turned out to be low enough, and e positive and high enough, then partial-ignorance theory would fare better. The inflation-sensitivity coefficient, a, would be significantly less than one when inflation is zero, and it would increase toward one with rising inflation.

With the same definitions and conditions as earlier, the connection between wage growth and unconstrained wage change is still given by $\dot{w}/w = \omega$ under no rigidity, and by $\dot{w}/w = F(\omega, \sigma)$ under strict rigidity, where ω is now described by equation (12) and parameter a by equation (13). The short-run Phillips curve is then derived from the markup equation $\pi = \dot{w}/w - q$, and the long-run Phillips curve from setting $\pi^e = \pi$ and $\varepsilon = 0$ in equation (12) and solving for steady inflation. At this level of generality, our model encompasses all competing paradigms: classical theory with no wage or price rigidity, downward nominal wage rigidity, and partial ignorance of low inflation. It allows the data to decide which theory or combination of theories fits the facts better.

Macroeconomic evidence

In Akerlof, Dickens and Perry (2000), we estimated several versions of the Phillips curve from our encompassing model with U.S. macrodata for the postwar period. To provide a check on the robustness of our findings, we used a large number of combinations of measures of expected inflation, unemployment, price inflation and wage growth. Nearly all the estimates we got for d and e confirmed our theory of near-rational partial neglect of low inflation and indicated that large, sustainable gains in employment are available by operating the economy at inflation rates moderately above zero rather than either at zero inflation or high inflation. Although U.S. macrodata cannot robustly separate the effect of downward nominal wage rigidity from that of near rationality, they do reject the pure model with no rigidity in favor of some combination of these two theories. The densest cluster of estimates for the unemployment-minimizing inflation rate spans a range from 2 to 3.5 percent. Most estimates of the reduction in permanent unemployment from operating the economy within that interval of inflation rates were in the range from 1 to 4 percentage points.

In Fortin and Dumont (2001), our model of the inflation-unemployment trade-off was tested with Canadian postwar macrodata. The Canadian estimates decisively reject the vertical long-run Phillips curve, and they further indicate that downward nominal wage rigidity and partial neglect of low inflation both matter significantly and separately.[17] The no-rigidity hypothesis is strongly rejected by the data. Estimates of d and e are consistent with expected inflation having a small effect on the wage bargain at very low rates of inflation and rising to 0.99 for inflation rates of 4.5 percent and beyond. The Canadian Phillips curve with wage rigidity and partial neglect of low inflation offers a natural explanation of the “missing deflation” puzzle afflicting the vertical long-run

Phillips curve (with no wage-price rigidity) during that decade. If the long-run Phillips curve is assumed to be vertical, the large amount of excess unemployment which accumulated over 1992-2000, but did not generate deflation, remains a mystery. In our framework, this extra unemployment turns out to be just what is needed to keep inflation very low on the flat portion of the amended Phillips curve.

Figure 4 traces out the long-run Phillips curve generated by the Fortin-Dumont estimates. For inflation rates above 6.5 percent, the hypothesis that the long-run Phillips curve is vertical cannot be rejected statistically. Permanent unemployment is close to its estimated asymptotic sustainable value u^{*} = 6.1 percent. As inflation falls below 6.5 percent, the downward rigidity of nominal wages begins to be felt. The long-run Phillips curve becomes negatively sloped and convex. Around 4.5 percent inflation, the rate experienced in the 1980s, permanent unemployment reaches a local maximum of 7 percent (point A). Then, the partial neglect effect sets in and reverses the slope of the curve until unemployment finds it lowest sustainable level at 5.3 percent with an inflation rate of 2.8 percent (point B). As inflation is further reduced, the wage rigidity and partial neglect effects combine to raise unemployment very rapidly: the next 2-point decline in inflation – to 0.8 percent from 2.8 percent – adds 3.3 points to the unemployment rate.

On this estimated long-run Canadian Phillips curve, point B, with inflation at 2.8 percent and unemployment at 5.3 percent, would seem close to the social optimum. Going above point B to higher unemployment and higher inflation on the positively sloped segment of the long-run Phillips curve is clearly socially inferior. Nor is going below point B on the negatively sloped segment of the curve attractive. The social loss from higher permanent unemployment increases so rapidly that the benefits from reducing inflation would have to be very large for the suggestion to move the economy significantly below point B to make sense. If, as has been the case in Canada since 1992, the central bank holds core inflation around 1.5 percent (at point C) instead of allowing it to increase toward 3 percent, the unemployment rate remains around 7 percent and is prevented from declining into the 5.5 percent range. This underlines the point that the long-run Phillips curve is very flat in the low-inflation range: a *small* increase in inflation can have a *major* beneficial effect on output and employment due to the combined effects of wage rigidity and near rationality.

It would be unrealistic to consider the particular shape of the long-run Phillips curve illustrated in Figure 4 as estimating the contour of the inflation-unemployment trade-off for Canada with a high degree of precision. The statistical results we have reported for the United States and Canada are not meant to pin down very precise numerical targets for inflation and unemployment. We would emphasize two aspects. First, these estimates provide fairly robust support for the distinguishing qualitative features of our general model, with some combination of downward nominal wage rigidity and near-rational ignorance of low inflation. Second, they provide a consistent interpretative framework for economic historians and useful guides for policymakers.

For economic historians, our results offer a coherent explanation of price behaviour over several decades for the United States and Canada. This explanation avoids constant reliance on ad-hoc interpretations and adjustments and gets rid of narrow concepts such as the NAIRU. Our general unifying framework encompasses the flat long-run Phillips curves of the low-inflation decades of the 1950s, 1960s and 1990s, the vertical long-run Phillips curves of the higher-inflation decades of the 1970s and 1980s, as well as the very unusual behaviour of unemployment and inflation during the 1930s. For policy makers, our main message is that holding inflation below 2 percent or above 3.5 percent likely entails significant permanent losses in employment in either country and that permanent unemployment will probably be minimized at some inflation rate in the 2 to 3.5 percent range – such as the 2.8 percent rate corresponding to point B in the Canadian example in Figure 4. It is entirely possible that the lowest sustainable unemployment rate could be less than 4.5 percent in the United States and less than 5.5 percent in Canada – the gap between the two being due to international differences in unemployment measurement and market structure.

POLICY DISCUSSION

We now address two objections that have been leveled at our general approach as a tool of economic policy. The first objection is that downward nominal wage rigidity and near-rational neglect of low inflation constitute "irrational" behaviour that is untenable as a long-run assumption. The second objection is that our policy analysis puts too much emphasis on the benefits of maximum employment and too little on the benefits of price stability. We then summarize the policy implications from this discussion.

The persistence of "irrational" behaviour

Even as the empirical case for downwardly rigid wages and partially ignored inflation has strengthened, some economists have argued that this is such "irrational" behaviour on the part of firms and workers that low inflation over many years will eventually lessen their resistance to wage cuts and will bring them to take inflation fully into account. The source of their scepticism is clear. It may indeed look inconsistent that the same workers who would accept a pay increase of 5 percent when inflation is 10 percent would stiffly resist a pay cut of 3 percent when inflation is 2 percent, given that the two situations represent exactly the same drop in real purchasing power. Similarly, it may seem odd that the same workers who are adamant that their wages be fully indexed when inflation is 10 percent would take such a relaxed attitude toward partial indexation when inflation is 2 percent. Hence the perception that it would be rash to hang the conduct of monetary policy on the thin rod of such "obviously untenable" assumptions for the long run.

We have three reactions to this kind of challenge. First, we think a philosophical debate about what is or is not "rational" leads nowhere. People always have reasons for what they do, subject to their perceptions and constraints. As recently shown by Shiller (1997) and Bewley (1999) among others, they do not always think and behave as some economists who are ignorant of psychology and sociology think they should. The matter of interest here is whether the money wage rigidity and near-rational ignorance of inflation that have actually been observed in a low inflation environment will persist or not. This is an empirical question that cannot be settled by appealing to a priori beliefs about what is or is not rational, but only by reading and interpreting the factual evidence.

Second, the evidence we see gives no hint that the phenomena of wage rigidity and near rationality will lose strength as the experience of very low inflation is prolonged. Concerning wage rigidity, the ethnographic and survey evidence we cite in Akerlof, Dickens and Perry (1996) is very strong that workers' resistance to nominal wage cuts is tied to their fundamental feelings about fairness and their suspicions of employer motives. This makes it unlikely to disappear over time. The experience of the Great Depression confirms that impression. After considerable deflation in the early 1930s, resistance to nominal wage cuts apparently stiffened in the mid- to late 1930s. Legal and institutional changes supporting wage rigidity were put in place. A decade of high unemployment, episodic deflation and zero inflation on average left nominal rigidity an even more important feature of the economy than before.

Further confirmation of a deeply rooted socio-economic norm against wage cuts can be found in the ten years of less-than-2 percent inflation and low productivity growth in Canada from 1991 to 2001 that have produced no discernible tendency for wage cuts to become more common in major union contracts. The persistence of downward nominal wage rigidity in prolonged periods of low inflation has also been observed in Germany and Switzerland. The German microdata examined by Beissinger and Knoppik (2001a; 2001b) offers the same picture of systemic wage rigidity over the period 1975-1995. The Swiss experience gives striking evidence of the persistence of nominal wage rigidity in a long period of slow nominal growth during the 1990s (Fehr and Goette 2000). At the end of this long period, *more* nominal wage rigidity was found than at the beginning.

Evidence of persistent near rationality is inscribed in the numerous Canadian and U.S. studies of the extended period of low inflation in the 1950s and 1960s that came to the conclusion that wage growth kept responding less than fully to lagged inflation. The recent results obtained by Brainard and Perry (2000) and ourselves indicate that the low levels of inflation of the 1990s in the United States and Canada have brought back the under-response of wage growth and actual inflation to expected inflation. Overall, we have several decades of North American evidence indicating that partial neglect of inflation is a permanent characteristic of low-inflation regimes, and that a one-to-one connection between actual inflation and expected inflation emerges only in periods of moderate to high inflation.[18]

For those who still have doubts about our reading of the evidence, we have a third – strategic – reaction. We think that the economic cost of assuming that wage rigidity and near rationality will vanish while they do not is much higher than the cost of assuming they will not fade away while they do. In the first case, the burden of going from 3 percent inflation to zero inflation is a permanent increase of 3 percentage points or more in unemployment. In the second case, the cost is 3 additional points of inflation. We perceive the unemployment cost in the first case to be higher by an order of magnitude than the inflation cost in the second case. In other words, our strategic thinking is that, if a central bank cannot be sure of whether wage rigidity and near rationality will disappear or not, it is much better off maintaining the a priori position that they will not.

This argument rests on a comparison between the benefits to society from a permanent reduction in inflation and those from a permanent reduction in unemployment. This brings us to discuss the second objection to the use of our approach as a tool of economic policy, namely that we put too much emphasis on the benefits of minimum unemployment and too little on the benefits of minimum inflation.

The benefits of price stability

We have argued that inflation rates above and below the range of 2 to 3.5 percent are bad because they raise the sustainable rate of unemployment by an important amount – as illustrated in Figure 4. But permanent inflation can also affect resource allocation, and hence aggregate output and welfare, beyond its impact on unemployment. Most frequently cited are damaging effects of inflation on economic uncertainty, relative price variability, the extent of nonproductive activities, and saving and investment. The research literature on these costs of inflation is very large. For example, in his survey of the most important contributions of the 1990-1997 period, O'Reilly (1998) lists more than 250 studies. Here, we are looking for guidance on the selection of an inflation target in the low-inflation range. What are the direct output and welfare benefits of reducing inflation, say, from 5 percent to zero? Are only minor microeconomic benefits or major macroeconomic gains at stake?

We make a distinction between three types of studies: purely microeconomic, general- or partial-equilibrium, and macroeconometric. A good example of the first type is the study of the effects of inflation on relative-wage variation across occupations and across employers done by Groshen and Schweitzer (1996; 1999). They use an extensive microdataset that tracks the average salaries of several occupations in about 75 firms per year over 40 years. They find that higher inflation raises *interoccupational* wage-change variation, which they interpret as a beneficial "grease" effect facilitating real wage adjustment in the presence of downward nominal wage rigidity à la Tobin. They also detect an inflation-induced increase in *interemployer* wage-change variation, which they take as a distortionary "sand" effect arising from inflation uncertainty, adjustment costs and timing constraints in the face of aggregate nominal shocks. On balance, they conclude that the net welfare effect of inflation is beneficial (grease dominates) but statistically insignificant at levels up to 5 percent, and that it is detrimental (sand dominates) above 5 percent.

The Groshen-Schweitzer study is a clever exploitation of microdata meant to shed light on a particular aspect of the inflation process. But for those interested in macroeconomic consequences, this sort of study raises three concerns. First, the analysis is partial and focuses on a limited number of effects of inflation – in the present case, relative-wage variability. Second, strong questionable hypotheses have to be made to bring out the microeconomic results, like the particular connection between inflation and inflation variability assumed here by Groshen and Schweitzer. Third, the mapping from partial microeconomic results to global macroeconomic implications requires further strong untested hypotheses on the reaction of the aggregate economy. It is hazardous to rely on purely microeconomic studies such as this one for macroeconomic guidance.

A second type of studies of the effects of inflation are simulations of numerical general- or partial-equilibrium models of the economy. Most influential in recent years has been Feldstein's (1997; 1999) analysis of the distortions caused by the interaction between inflation and capital income taxation. To illustrate the pitfalls of this simulation approach, we present a detailed review and criticism of his modeling stategy.

According to Feldstein, there is a very large welfare loss from keeping inflation at 2 percent rather than zero because it is the nominal returns to savings that are taxed, and thus 2 percent inflation takes away significant real returns from savers' opportunities. Basically, this leads people to save too little and consume too much while they are young. To calculate the magnitude of the welfare loss resulting from the distortion, Feldstein constructs a numerical partial-equilibrium model to simulate the effect on economic welfare of reducing inflation from 2 percent to zero. Using benchmark parameters for the United States, he estimates such a decrease in inflation would result in a permanent one-time increase in welfare valued at some 1 percent of GDP.

The basic problem Feldstein raises is that of the welfare burden of capital income taxation in general, of which the interaction with inflation is one aspect. A natural remedy would be to index this form of taxation to the cost of living, but Feldstein claims this is technically, administratively and politically difficult. We address the Feldstein calculation from a different angle. We argue that it is model-specific and marred by important omissions. There are no tax shelters, no income uncertainty, no allowance for the declining marginal utility of consumption, and his two-period framework leaves no opportunity for consumption out of interest income prior to retirement.

The first omission is Feldstein's failure to take account of savers' many opportunities to shelter the returns on savings for retirement from taxation. There are a variety of forms of saving in which the principal and interest earnings are not taxed prior to retirement, such as defined contributions and defined benefit pensions, 401(k)'s, annuities, and IRA's in the United States, and RPP's and RRSP's in Canada. Studies have shown that few workers are without some form of sheltered source of saving, and that almost no workers' sheltered savings exhaust their limits. Gale and Sabelhaus (1999) report that since 1990 tax favored net retirement savings in the United States have been more than half of all net savings in financial assets, and that in 1998 78 percent of net financial savings was in tax favored retirement vehicles. This fraction has been growing over time from 20 percent in the 1960s to 28 percent in the 1970s to 44 percent in the 1980s.

Feldstein's second omission is his failure to take account of uncertainty. His model has no uncertain component in earned income or in returns to savings. The presence of a random component to earned income would greatly reduce welfare losses from capital income taxation, and thus from inflation, because variable income gives workers a reason to save when young as a precautionary motive, especially for times of unemployment. Simulations reported by Engen (1993) and confirmed by many other investigators show that the omission of uncertainty about income will raise the welfare loss from capital income taxation by a factor of ten.

Feldstein's third omission occurs in failing to consider the consequences of the declining marginal utility of consumption on the welfare loss due to tax distortions. This omission has important interactions with the existence of tax shelters. To illustrate, suppose that there are two types of people, lower-income and higher-income. The lower-income constitute 80 percent of the population. They do 20 percent of the savings, not enough to use up their 401(k), IRA or RRSP allowances for tax deferral. The higher-income constitute the remaining 20 percent of the population, and do 80 percent of the savings. They have exhausted their opportunities for tax exempt savings. Further, the savings of those higher-income savers are sufficiently large that their cutback in savings due to capital income taxation results in reduced allocative efficiency.

What is the percentage loss in national welfare? Ignoring both tax shelters and income distribution, Feldstein uses his simulation model to value the loss at 0.92 percent of GDP. Without declining marginal utility of income, but taking account of tax shelters, he would reestimate the loss in welfare at 0.74 percent of GDP – 80 percent of the 0.92 percent. In contrast, the common welfare function used in the welfare literature (e.g., Mirrlees 1971; Fair 1971) would value equal percentage losses equally across income levels. Since 20 percent of the population is in the higher-income group, the implied loss of welfare would be valued at 0.18 percent of national income – 20 percent of the 0.92 percent. Indeed, counting the beneficial effects from the tax revenue collected, there would be a net gain in welfare. This follows from the fact that the increase in capital income taxes due to inflation will be paid by higher-income taxpayers, but the revenues collected will alleviate the tax burden of the middle- and lower-income groups. Because of the progressivity of the income tax, the net welfare benefits of higher inflation are likely to be positive, since the revenue collected replaces revenues from sources with higher marginal impact on welfare.

Feldstein's fourth omission arises from his failure to allow for consumption out of interest income prior to retirement. This causes him to exaggerate the interest elasticity of savings, and hence to overestimate the welfare loss from capital income taxation. The heart of his analysis is a two-period model in which people save out of labor income in the first (pre-retirement) period and then consume out of the resulting accumulation in the second (post-retirement) period. Feldstein assumes that the interest elasticity of savings out of *earned* income is 0.4. But the two-period approach leaves no possibility for consumption out of interest income prior to retirement, so that Felstein is in fact assuming that the interest elasticity of savings out of *interest* income prior to retirement is 1.0. As a result, Feldstein's implicit estimate for the interest elasticity of savings out of *total* income is some average of 0.4 and 1.0, which must exceed 0.4. This omission results in a miscalibration of his model relative to empirical estimates of the interest elasticity of savings out of total income found in the literature. Feldstein's assumption of a 0.4 interest elasticity is obtained from Ballard, Shoven and Whalley (1985), who in turn had based it on previous work by Boskin (1978). However, the Boskin estimate of 0.4 was for the interest elasticity of savings out of *total* income, not for the interest elasticity of savings out of *earned* income alone.

If *any* one of these omissions is important empirically, Feldstein's estimate of the welfare loss from the interaction of 2 percent inflation with capital income taxation will be reduced by a significant amount. In one case, the welfare loss becomes in fact a welfare gain. A fortiori, correcting for *all* these omissions will either reduce the welfare loss estimated by Feldstein to insignificance or transform it into a welfare gain.[19] Finally, it should be borne in mind that there are additional costs of operating with zero inflation, apart from the permanent unemployment costs we have identified here. The present situation in Japan reminds us that, without some inflation, the danger of occurrence of a deflation is real, and policymakers will be unable to set negative real interest rates when they need to.

Besides purely microeconomic studies such as Groshen and Schweitzer (1999) and simulation studies such as Feldstein (1997), a third type of contributions have been macroeconometric studies of the impact of inflation on aggregate output. Large panel datasets covering many countries over several decades are used to regress cumulative real GDP on initial real GDP and rich sets of determinants that are either exogenous or suitably instrumented, including the inflation experience.

Among recent macroeconometric studies, the contribution by Robert Barro (1997) has been the most influential. His panel study of about 100 countries for the three periods 1965-1975, 1975-1985 and 1985-1990 finds that inflation rates above 15 percent are definitely harmful for real growth. However, for countries and periods with average inflation rates below 15 percent, he cannot detect any significant effect of inflation on real GDP. Other country panel studies providing detailed checks for robustness reach similar conclusions (e.g., Levine and Renelt 1992; Sarel 1996; Sala-i-Martin 1997). The failure to capture consistent effects of inflation on real GDP (or investment) in periods of moderate inflation has brought many to recognize that the benefits from reducing the distortions associated with a moderate rate of inflation have "proven difficult, thus far, to quantify or to demonstrate empirically." (Ragan 2000; Bank of Canada 2001b) Those country panel studies are particularly unhelpful for detecting welfare effects in the range of inflation rates from zero to 4 percent, first because they contain very few sample observations falling in that interval, and second because they constrain the effects of inflation on real GDP to be constant and always of the same sign. They certainly offer no basis for ruling out gains from low inflation relative to complete price stability.

The general conclusion from the above discussion about the benefits of price stability is that nothing stands in the way of considering the unemployment-minimizing rate of inflation as the socially optimal rate of inflation along a long-run Phillips curve with wage rigidity and near rationality. Equivalently said, minimal unemployment is nearly the same as optimal unemployment. In the Canadian example of Figure 4, reducing inflation by just half a percentage point below the unemployment-minimizing rate – from 2.8 percent at point B to 2.3 percent – would increase permanent unemployment by 1.1 points – from 5.3 per cent at point B to 6.4 percent. The current economic literature contains no evidence of any comparable macroeconomic benefits from inflation reduction to offset this loss. The net social loss from higher permanent unemployment increases so rapidly when inflation is reduced below the unemployment-minimizing rate at point B that only those who hold extreme and unsupported views about the costs of inflation would want to move the economy to any significant distance from point B. A fortiori, pursuing the goal of full price stability would be entirely misguided.

Policy implications

Taking into account the usual statistical uncertainty, we conclude that monetary policy can have a major lasting impact on prosperity, not by achieving full price stability, but by searching for the unemployment-minimizing inflation rate in the range of 2 to 3.5 percent. This "search-for-optimum" strategy requires the U.S. Federal Reserve and the Bank of Canada to be opportunistic on the expansionary side and tighten only if there are tangible signs that core inflation begins to exceed 3 percent and keeps rising.

The record of the last decade indicates that the Federal Reserve followed exactly this monetary strategy in lifting the U.S. economy from the recession of the early 1990s and managing the following expansion. Many observers (e.g., Mankiw 2001) argue that the Federal Reserve may have been engaged in "covert inflation targeting" at a rate of 3 percent – within the target range we recommend. The Federal Reserve strategy has been very successful. The U.S. unemployment rate declined to around 4 percent in the late 1990s, which had been unseen since the late 1960s, while U.S. core inflation remained inside the 2-to-3 percent range for most of the time. In contrast, Canada has not followed our recommended strategy. Not a coincidence in our view, its economic performance has not been as satisfactory. The Bank of Canada's efforts to achieve low inflation have been more ambitious and more rigid than the Federal Reserve's approach. In the early 1990s, the Bank sought and obtained a strict official mandate to bring inflation down to a specified target within some inflation-control target range. Since 1995, the official inflation target has been 2 percent, and the official target range 1 to 3 percent. In fact, actual core inflation has been kept within the lower half of the target range, averaging 1.5 percent over 1995-2001. The Canadian unemployment rate reached a minimum of 6.8 percent in 2000 and did not return to 1960s levels. The divergent macroeconomic outcomes in the United States and Canada conform precisely with what our general model predicts would happen under the different monetary strategies adopted by the two countries.

We believe Canada would greatly benefit from a more flexible monetary strategy that would explore the range of inflation rates from 2 to 3.5 percent. This would increase the probability that the national unemployment rate would decline to 5.5 percent or less as a result. Unfortunately, this will probably not happen in the near future, since Canadian authorities have recently renewed both the 2 percent inflation target and the 1-to-3 percent inflation-control target range until the end of 2006 (Bank of Canada 2001a).

CONCLUSION

The now-conventional view of the Phillips curve was developed in the late 1960s and early 1970s. According to this view, prices will accelerate or decelerate depending on whether unemployment is below or above a unique threshold level, the "natural rate of unemployment", whose empirical counterpart is called the "non-accelerating-inflation rate of unemployment" – the NAIRU. Conversely, if unemployment is at the NAIRU level, any existing rate of inflation will keep going. The NAIRU is thus the only sustainable rate of unemployment. It is determined by real market structure, not by monetary policy. Conversely, inflation is the only variable that monetary policy can control. Actual unemployment will move to the NAIRU level under a monetary policy that maintains any steady inflation rate. This classical view is marked by a sharp dichotomy between real factors, which determine unemployment, and monetary factors, which affect inflation alone. It admits no long-run trade-off between inflation and unemployment. The resulting long-run Phillips curve has a two-dimensional geometric representation as a vertical line with unemployment on the horizontal axis and inflation on the vertical axis – as in Figure 2 above.

Our recent work on the Phillips curve leads to the contrasting view that at low levels of inflation – 3.5 percent or less – there is likely to be a significant negative long-run trade-off between inflation and unemployment. In this low-inflation range, higher long-run inflation targets result in lower long-run average rates of unemployment. The practical relevance of this result is underlined by the fact that inflation rates in the United States and Canada have averaged 3 percent or less in five of the eight decades since 1920. Relatively high inflation rates such as those observed in the 1970s and 1980s turn out to have been infrequent. It is no coincidence that it is in those two decades that the vertical long-run Phillips curve gained so much in popularity.

The Phillips curve that is vertical in the long run cannot explain the events of the 1990s either in the United States or in Canada. Contrary to prediction, in the United States the very low level reached by unemployment has failed to trigger a price acceleration; and conversely, in Canada the very high average level of unemployment has failed to trigger a price deceleration. The U.S. and Canadian long-run Phillips curves of the 1990s, in other words, look pretty flat. Economists who are strong believers in the notion of the unique NAIRU have tried to save the situation for the vertical long-run Phillips curve by allowing the NAIRU or inflationary expectations to move over time in such a way that, true or false, that framework can always fit the facts. While we do not deny the possibility that the sustainable rate of unemployment can change from time to time for structural reasons, we have argued that simply positing a shift in the NAIRU anytime the rate of inflation doesn't behave the way the classical theory predicts is neither good science nor a good guide for policy if it is possible instead to develop a theory that can explain these failures.

Our alternative strategy has been to broaden the current theoretical framework to revive and test two old ideas that, while sounding unconventional, nevertheless make good intuitive sense. These ideas were widely accepted in the 1950s and 1960s: that money wage cuts are considered very unfair by workers and, for morale reasons, only used by firms in distress, and that low inflation rates are often partially ignored by wage and price setters because their effects are quite small and compete with other concerns and perceptions. According to our theory, downward nominal wage rigidity and near-rational neglect of inflation are important operative features of the economy at low levels of inflation, but become inoperative at higher levels of inflation. This more general theory has the power to generate a vertical long-run Phillips curve in periods of high inflation such as the 1970s and 1980s, and a negatively sloped, convex and eventually flat long-run Phillips curve in periods of low inflation such as the 1950s, 1960s and 1990s. It also provides a faithful account of the very unusual behaviour of unemployment and inflation during the 1930s.

With this background, we have reviewed the theoretical underpinnings, the macroeconomic implications and the empirical evidence we have presented in a series of papers in the last few years concerning nominal wage rigidity and near-rational ignorance of inflation. Relying on several decades of evidence in the United States and Canada, we have stessed that these two phenomena are present not only in the short-term transition from high to low inflation, but are lasting features of a low-inflation economy. We have allowed a fair competition between the alternative theories and let the data give the verdict. We have also implemented a very large number of statistical experiments to make sure the empirical results were not obtained by chance, but were fairly robust to various changes in specification.

The evidence we have been able to generate for the United States and Canada rejects the vertical long-run Phillips curve in favor of our amended version with wage rigidity and near rationality, which is exemplified in Figure 4 above. The major empirical implication of our results is that, in the United States and Canada, there exists an unemployment-minimizing rate of inflation located somewhere between 2 and 3.5 percent. At inflation rates that are less than 2 percent or greater than 3.5 percent, unemployment is permanently higher. Furthermore, the minimum sustainable rate of unemployment could be less than 4.5 percent in the United States and less than 5.5 percent in Canada – the gap between the two being due to international differences in unemployment measurement and market structure. We further argue that the direct benefits of price stability, relative to 2 to 3.5 percent inflation, are much smaller than the permanent costs of raising unemployment to achieve price stability. That is, minimum unemployment is nearly the same as optimal unemployment.

The key policy implication of our results is that the U.S. Federal Reserve and the Bank of Canada should stand ready to explore the range of inflation rates between 2 and 3.5 percent in search of the lowest sustainable unemployment rate in each country. They should be opportunistic on the expansionary side, and retract only when there are genuine signs that inflation threatens to rise beyond that range. Our recommendation is based on an important strategic consideration: the economic cost of assuming that wage rigidity and near rationality are nonexistent or will soon disappear while they do not is incommensurably higher than the cost of assuming they are here to stay while they are not.

Notes

Lead footnote:

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[1] Phillips and Lipsey also identified some impact from the *rate of change* of unemployment. Several authors used the aggregate profit rate as an additional wage pressure variable. Those determinants are omitted here for simplicity.

[2] More realistic equations included indirect taxes, the cost of capital, import prices and cyclically-sensitive markups as additional determinants of the aggregate price level.

[3] Earlier assessments were more optimistic. The early long-run trade-offs were closer to the specification $\pi = 30/u - 5$ (e.g., Samuelson and Solow 1960, Perry 1966). The latter means $\pi = 0$ percent for u = 6 percent, and $\pi = 2.5$ percent for u = 4 percent. Both curves give the (out-of-sample) extrapolation $\pi = 5$ percent for u = 3 percent.

[4] Lucas (1973) made the further conjecture that inflation could be reduced at no cost at all if a credible announcement to that effect could be made by the central bank. The job of disinflation would be entirely done by the concomitant rational decline in expected inflation, which would eliminate the need for even a transitory increase in unemployment. However, this extreme "new classical" idea has not survived the evidence provided by the Volcker disinflation and numerous other empirical tests.

[5] This would apply not only to the last half-century of North American data, but also to the more than one century of British data covered by the original Phillips (1958) and Lipsey (1960) studies, which were massively dominated by low-inflation years. The long-run trade-offs estimated by Phillips and Lipsey were actually nearly vertical in high-inflation periods and nearly flat in low-inflation periods.

[6] The precise definitions of the actual and notional wage changes are $(\dot{w}/w)_i = [w(i,t) - w(i,t\text{-}1)]/w(i,t\text{-}1)$ and $\omega_i = [w^n(i,t) - w(i,t\text{-}1)]/w(i,t\text{-}1)$, respectively, where w(i,t) and $w^n(i,t)$ are the actual and notional nominal wages at firm i in year t. Assuming wage cuts never occur is an obvious exaggeration, since they are observed episodically in real

economies. We initially keep the no-wage-cut assumption for expository purposes, but relax it below. Empirical studies mentioned above as well as our own, reported below, have experimented with less extreme forms of rigidity.

[7] As our earlier definition $u^* = z^*/c$ makes clear, permanent unemployment is a decreasing function of the slope of the short-run Phillips curve, which measures the short-run responsiveness of inflation to changes in unemployment. Since downward nominal wage rigidity weakens that responsiveness as inflation declines, permanent unemployment must rise.

[8] In the case individual unconstrained wage changes ω_i are normally distributed with mean ω and standard deviation σ, F is linear homogeneous in ω and σ and takes the specific form $F(\omega; \sigma) = \omega.N(\omega/\sigma) + \sigma.n(\omega/\sigma)$, where N and n are the cumulative distribution and probability density functions of the standard normal distribution, respectively.

[9] Formally, the four properties are $F(\omega; \sigma) > \max(0, \omega)$; $0 < F_\omega = 1 – k < 1$, where k = percentage of wage changes constrained at zero; $F_{\omega\omega} > 0$ and F tends to ω as ω becomes large; and $F_\sigma > 0$.

[10] Note that equation (7) treats the effects of downward nominal wage rigidity on actual nominal wage growth somewhat differently from the analysis presented in Akerlof, Dickens and Perry (1996). Equation (7) presents a single-period or static view of nominal rigidity, whereas the empirical modeling done in Akerlof, Dickens and Perry (1996) captures the effects of nominal rigidity by constructing a variable “S” that is dynamic and allows the effects of nominal rigidity to accumulate from one period to the next. However, this dynamic effect is likely to be unimportant unless average notional wage growth is zero or negative for several years (such as during the Great Depression).

[11] This equation is a simplification. It omits effects from the *change* in unemployment that are explicitly derived in Akerlof, Dickens and Perry (1996; 2000).

[12] In contrast, Crawford (2001) and Crawford and Wright (2001) find some evidence of a tightening of the wage change distribution among Canadian major wage settlements as inflation declines. This is not too surprising, since it is known that a major objective of unions is to minimize wage heterogeneity, and it is arguable that this is more easily achieved in a lower-inflation environment. These union contracts cover only about 10 percent of private non-farm employment.

[13] Note that the convex shape of the long-run Phillips curve here reflects the convexity of the F function, which is purely generated by downward nominal wage rigidity and market heterogeneity. It is entirely consistent with a linear unconstrained wage change relation such as (8). Naturally, if ω was itself a convex function of u (with b/u replacing -cu, for example), then the convexity of the long-run Phillips curve would be even more pronounced.

[14] Note that equation (7) can be identically written as $\dot{w}/w = \omega + [F(\omega; \sigma) - \omega]$. The expression in brackets, $F - \omega$, is the difference between average actual wage growth and the average unconstrained wage change. In Akerlof, Dickens and Perry (1996), we regressed $\dot{w}/w$ on the time-series determinants of ω from equation (8), and we simultaneously calculated the value of a variable we called "S", which is related to $F - \omega$, by a complex recursive procedure.

[15] For the period since 1995, our model with downward nominal wage rigidity has overpredicted inflation by roughly the same amount as the pure model with no rigidity. Among the wide range of specifications of our later model with *both* nominal rigidity and near rationality (Akerlof, Dickens and Perry 2000, to be discussed in the next section) are ones which can accommodate the behaviour of inflation since 1995, but not all specifications outperform the vertical long-run Phillips curve in this regard.

[16] We also conducted thousands of simulation experiments that gave the same order of magnitude for the unemployment cost of reducing inflation. These experiments suggest that the cost of lowering inflation from 3 percent to zero is likely to be an increase in unemployment of 1 to 4 percentage points.

[17] Canadian results have not been checked for robustness as extensively as U.S. results. Dickens (2000) estimates several specifications for Canada and finds that they all yield qualitatively similar results. These results confirm the finding by Fortin and Dumont that nominal wage rigidity and near rationality do matter for Canada.

[18] We are reluctant to extend the argument to the pre-1930 era. Prior to the Great Depression, there were deflations and long periods of price stability where nominal wages seemed downwardly flexible. Many industrial relations researchers see modern industrial relations arising during the 1920s (e.g., Jacoby 1985). Until then, there had been little in the way of permanent employment, and the labour market was much closer to an auction market than today.

[19] Our criticism of the Feldstein paper also applies to a paper by Desai and Hines (1999), which extends Feldstein's model and simulations to show that the gain from achieving price stability in an open economy would be larger than in a closed economy. Cohen, Hassett and Hubbard (1999) calculate that inflation raises the user cost of capital for various kinds of business assets. However, the magnitude of the effect they find and its welfare consequence appear to be small.

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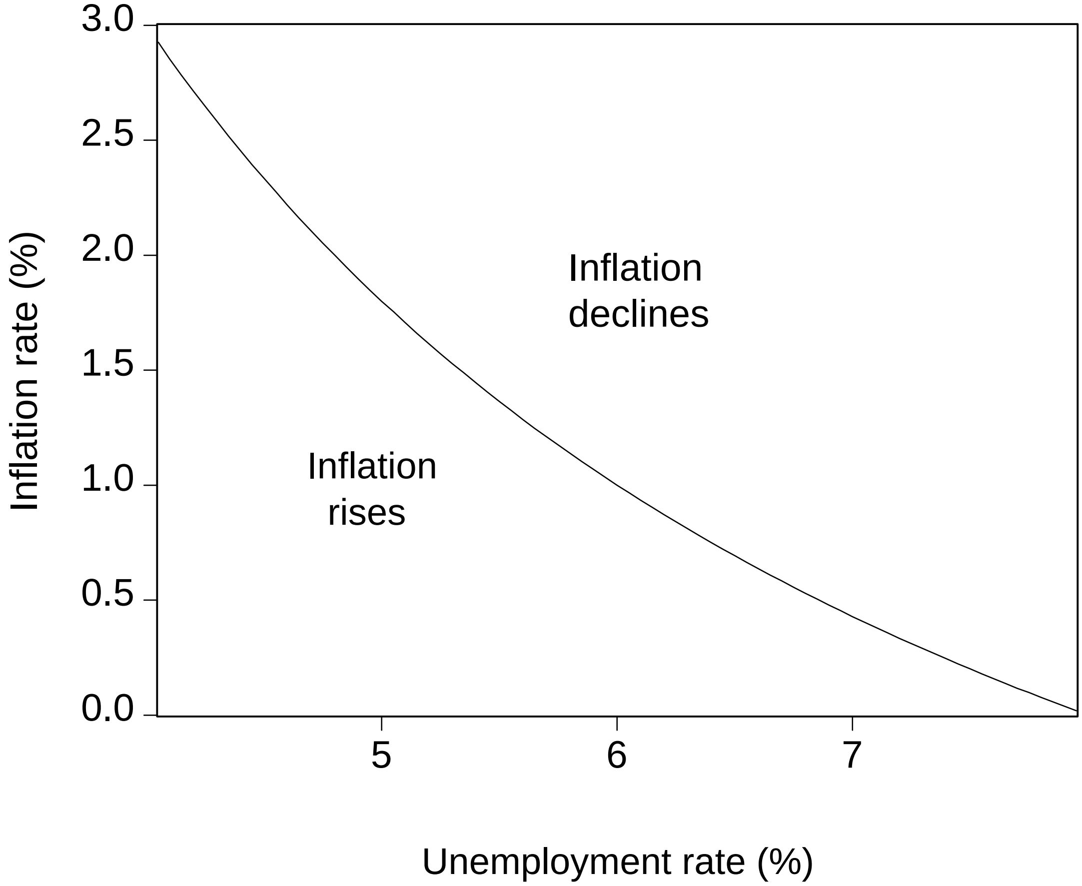
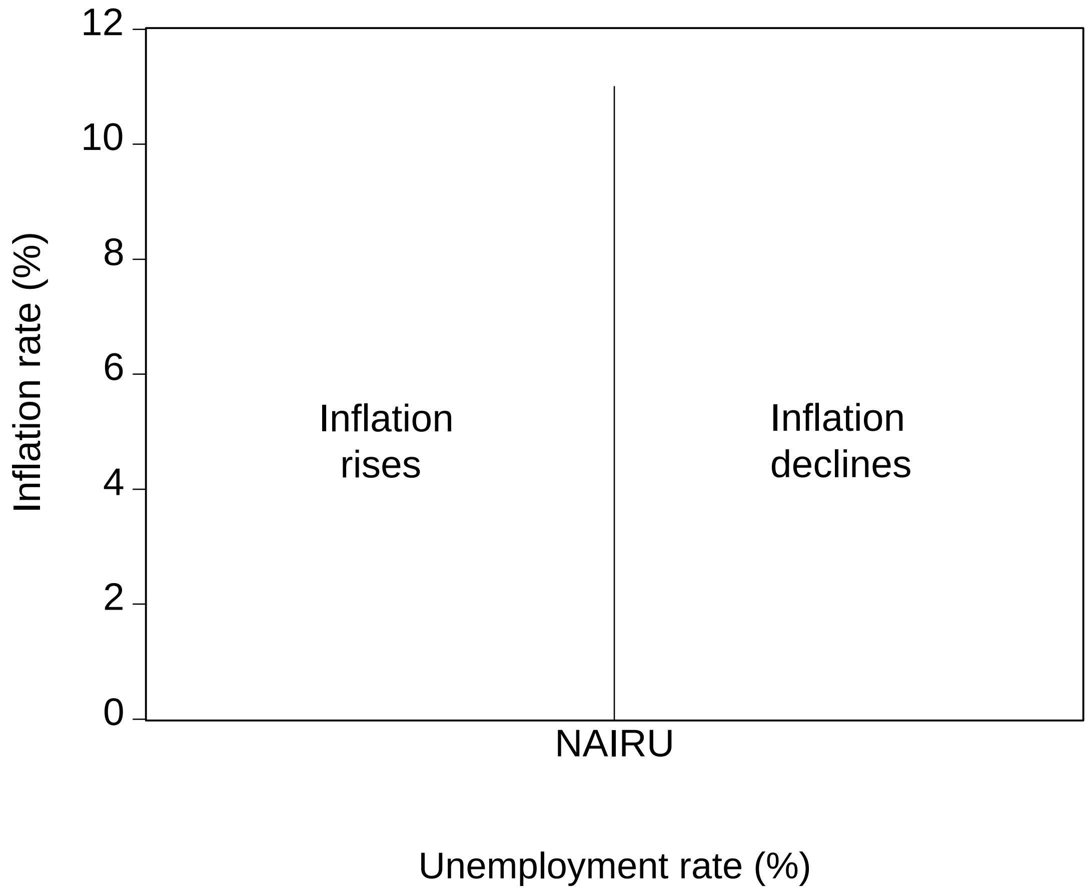
Figure 1
The negatively sloped long-run Phillips curve,
1950s and 1960s vintage



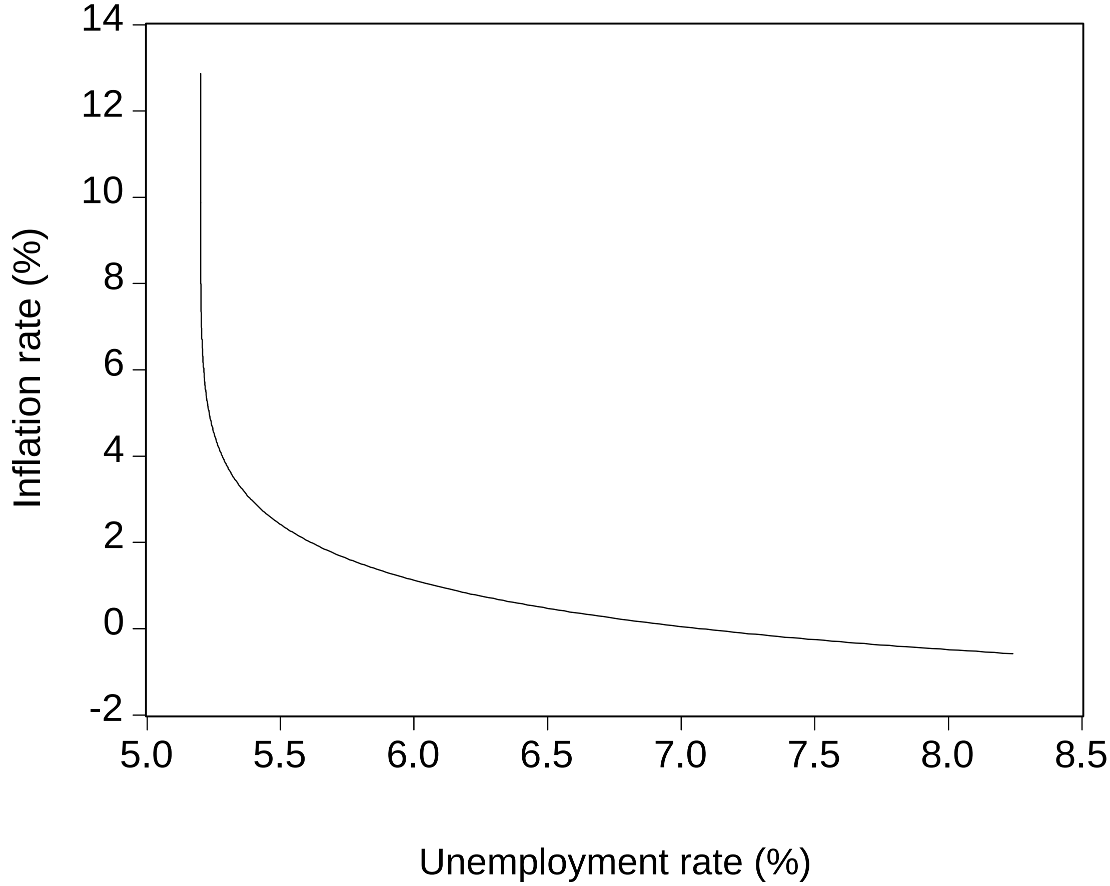
Source: Calculated as i = 24/u - 3.

Figure 2
The vertical long-run Phillips curve,
1970s and 1980s vintage



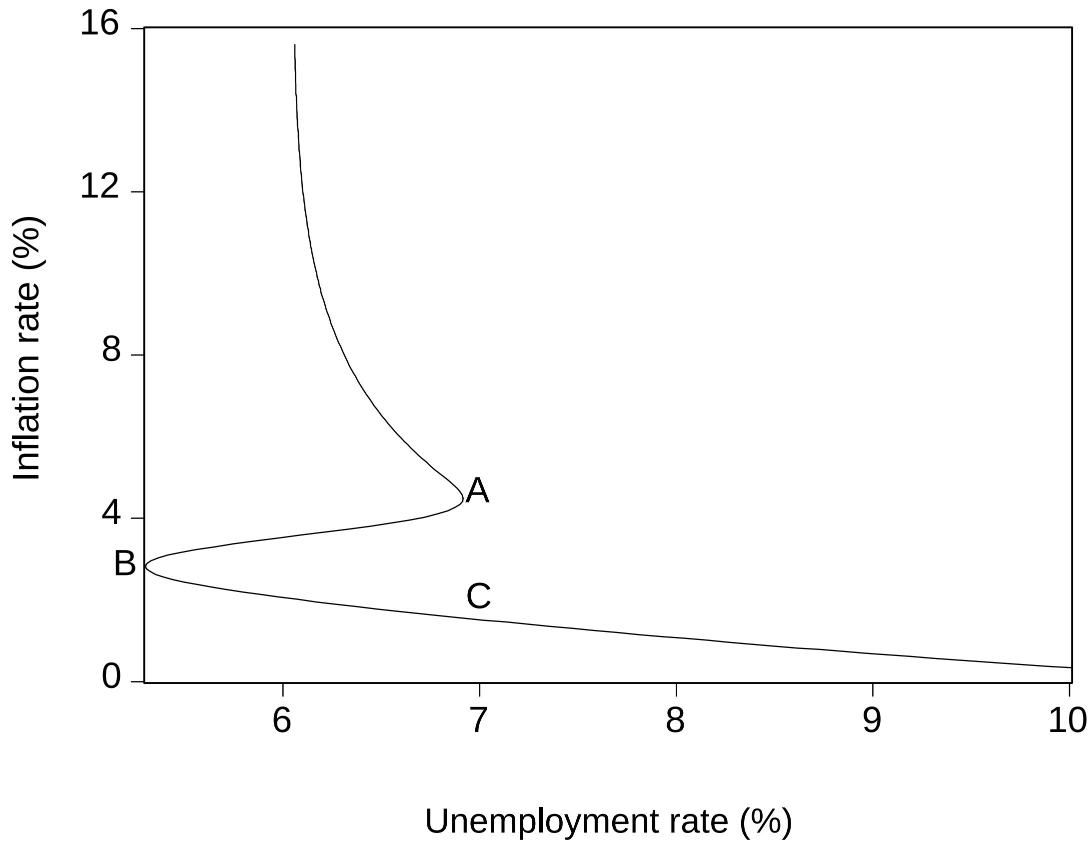
Source: Calculated from u = NAIRU.

Figure 3
The long-run Phillips curve
with downward nominal wage rigidity



Source: Akerlof, Dickens and Perry (1996).

Figure 4
The long-run Phillips curve
with downward nominal wage rigidity
and near-rational partial neglect of low inflation



Source: Fortin and Dumont (2000).