NBER WORKING PAPER SERIES

REAL BALANCES, THE EXCHANGE RATE AND INDEXATION: REAL VARIABLES IN DISINFLATION

Stanley Fischer

Working Paper No. 1497

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 1984

The research reported here is part of the NBER's research program in Economic Fluctuations. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Paper #1497
November 1984

Real Balances, the Exchange Rate and Indexation: Real Variables in Disinflation

ABSTRACT

The recent appreciation of the dollar is widely believed to have reduced the output costs of the disinflation. But there remains the question of whether those early gains have to be repaid when the exchange rate depreciates.

The first question taken up is the effect of real exchange rate appreciation on the sacrifice ratio, or output cost, of disinflation. There is no unambiguous presumption that exchange rate appreciation reduces the sacrifice ratio. The direct favorable effects of cheaper imports on consumer prices, on the prices of imported inputs, and on wage demands, may be outweighed by the unemployment resulting from the reduced demand for exports.

In the second part of the paper I examine the affects of wage indexation on the sacrifice ratio. Economists have argued that wage indexation speeds up disinflation; policymakers take the opposite view. The distinction between *ex ante* and *ex post* indexing, defined in the paper, explains these different views. *Ex ante* wage indexation speeds up disinflation. With *ex post* indexation the real wage automatically rises when the inflation rate falls. Even so, *ex post* indexing may speed up disinflation. But there has to be subsequent downward adjustment of the wage if long-term unemployment is to be prevented.

Stanley Fischer
Professor of Economics
MIT, E52-280A
Cambridge, MA 02139
(617)253-6666

REAL BALANCES, THE EXCHANGE RATE, AND INDEXATION: REAL VARIABLES IN DISINFLATION

Stanley Fischer*

It has long been known that at some stage in a disinflation process initiated by a discrete reduction in the growth rate of the money stock, the rate of inflation must fall by more than the reduction in money growth. The reason is that the demand for real balances in the new low inflation steady state will be higher than in the high inflation equilibrium: the economy produces real balances by causing the price level to grow more slowly than the nominal money stock.

In an economy with fully flexible prices, credible government policy and rational expectations, the start of a disinflation program can be accompanied by a discrete rise in the money stock that will prevent the price level jumping and thus inflicting capital gains and losses on nominal creditors and debtors. However, the credibility problem posed by such a policy is obvious: to start a disinflation program with an increase in the money stock is to court the suspicion that announcements and actions are not closely related. The difficulty is compounded by the similarity between a stock increase in the money stock and a change in its growth rate when data are reported at discrete intervals.

---

*Department of Economics, M.I.T. and Research Associate, NBER. An earlier version of this paper was written while I was Max Bogen Visiting Professor of Economics at the Hebrew University, Jerusalem. I am indebted to Rudiger Dornbusch and Robert Gordon for comments, to Patricia Mosser for research assistance, and the National Science Foundation for financial support.

In an economy where prices are not perfectly flexible in the short run, as a result for example of long-term contracts, the increased demand for real balances that accompanies a disinflation process increases the output costs of disinflation, or the <u>sacrifice ratio</u>. The sacrifice ratio is the ratio of the percentage of GNP (at an annual rate) lost to the reduction in the inflation rate. For instance, the sacrifice ratio for the United States disinflation, 1980-85, was about 5, meaning that over that five year period cumulated GNP showed a reduction of 25 percent of one year's output while the inflation rate fell by about 5 percent, from 10 percent to 5 percent. This sacrifice ratio is broadly consistent with the predictions of a model with price stickiness induced by the existence of long-term labor contracts.[1] It is somewhat below earlier predictions of the output costs of disinflation by Arthur Okun (1978) but in line with predictions, such as that of Robert Gordon (1982), that allowed for exchange-rate changes as an extra channel through which monetary policy affects the inflation rate.

The increase in real balances is the best known of the real or relative price adjustments that take place during a disinflation. In this paper I examine in detail two other, less well understood, real phenomena that may play an important role in determining the output costs of disinflation. The first is the exchange rate appreciation that accompanies monetary restriction that starts the disinflation process. The second is the role of indexation. In each case there is a puzzle that needs resolution.

It is commonly argued that exchange rate appreciation during the United States disinflation reduced the costs of the disinflation process relative to costs that would have been incurred had the real exchange rate been held

[1] The calculation of the sacrifice ratio and its consistency with a simple contracting model are presented in Fischer (1984).

constant. The argument is that the rapid response of the exchange rate brought the inflation rate down rapidly and further put pressure on wages through enhanced foreign competition. (Rudiger Dornbusch and Fischer (1984)). Countering this analysis are two points: first, any exchange rate appreciation has eventually to be reversed, thus implying that the early gains on the inflation front are transformed into later losses; second, to the extent that the exchange rate appreciation increases competitive pressure, it does so through the creation of unemployment. Willem Buiter and Marcus Miller (1983) conclude that exchange rate appreciation and subsequent depreciation during a disinflation does not affect the sacrifice ratio.[2]

In the case of indexation, theoretical analysis shows that indexation reduces the output costs of disinflation by permitting a more rapid response of wages to the reduced rate of price increases. But policymakers typically argue that wage indexation is a prime obstacle rather than an aid to disinflation.

In this paper I analyze the roles of the exchange rate and indexation in disinflation, using simple models with long-term contracts and rational expectations. In Section I, I present an open economy model in which the sacrifice ratio is not independent of the path of the exchange rate during disinflation. The real exchange rate appreciation typical at the start of a disinflation may either increase or decrease the sacrifice ratio relative to the loss when the real exchange rate is held relative to the loss when the real exchange rate is held constant. I identify the sources of the

[2]Buiter and Miller include a core inflation rate in the Phillips curve: this rate is determined either by the current rate of money growth or by adaptive expectations. E. John Driffill (1982) has extended the Buiter-Miller analysis to examine optimal disinflation policies.

ambiguity, and the parameters determining the relative sacrifice ratios in Section I.

In Section II, I turn to indexation, where the distinction between *ex post* and *ex ante* indexation is essential.[3] Actual indexation is typically *ex post*, with the current wage adjusting to lagged price levels. As a result, the real wage tends to *rise* in a disinflation when wages are indexed. This increase in the real wage is probably the source of the view that indexation of wages is an obstacle rather than an aid to disinflation.

I. The Exchange Rate and Disinflation.

Suppose a disinflation program starts with a permanent reduction in the growth rate of money, not anticipated to that point but fully credible thereafter. Wages, set in contracts, are not fully flexible. Given wage stickiness, the disinflation program produces a recession. Over time, wages adjust and the economy moves towards full employment. The sacrifice ratio is a measure of the output loss during the transition to lower inflation.

The question in this section is how the openness of the economy affects the sacrifice ratio. The Dornbusch (1976) overshooting result shows that the real exchange rate will typically appreciate when the growth rate of the money stock is reduced. The appreciation occurs because the restrictive monetary policy raises the domestic nominal interest rate, while foreign nominal interesst rates are either unchanged or increase less than the domestic rate. Interest rate equalization then requires the expectation of a depreciation of the domestic currency. Given long run neutrality of money, a

---

[3]Mario H. Simonsen (1983), who in 1965 helped design ex ante indexation in Brazil, shows the effects of lagged indexation on real wages.

depreciation can be expected only if the real exchange rate is currently above the equilibrium level.

The model presented in this section includes four channels through which the exchange rate appreciation affects the sacrifice ratio. First, to the extent that imported goods are consumer goods, exchange rate appreciation directly affects the CPI, tending to speed up the price response to the reduced growth rate of money. To the extent that the CPI is the price level relevant to the demand for nominal balances, the more rapid response of prices means a smaller reduction in real balances and less deflationary pressure. Second, if imported goods are factors of production, the appreciation reduces costs, and thus has a favorable effect on domestic supply price, again tending to reduce the sacrifice ratio. Third, if wages adjust to the expected price level, any quick success in reducing the price level will have the effect of reducing wages negotiated during the adjustment period. The more rapidly wages come down, the smaller the output loss. Fourth, exchange rate appreciation reduces the trade surplus, thereby reducing demand for domestic goods and output. This effect increases the sacrifice ratio.

Because the effects do not all operate in the same direction, it is not surprising we do not find an unambiguous answer to the question of how exchange rate appreciation during a disinflation affects the sacrifice ratio.

The model is a modified IS-LM type with inflation and real interest rate neutrality in the long run. Wages are set in contracts. Perfect capital mobility provides covered interest parity. The model consists of:

(1) $m_t - p_t = y_t - ai_t$

(2) $y_t^s = b_1(q_t - \bar{w}_t) + b_2(q_t - e_t)$

(3) $y_t^d = -cr_t + d(e_t + p^* - q_t)$

(4) $p_t = \mu q_t + (1 - \mu)e_t$

(5) $\bar{w}_t = \theta\, {}_{t-1}w_t + (1 - \theta)\, {}_{t-2}w_t$

(6) ${}_{t-1}w_t = {}_{t-1}p_t + h\, {}_{t-1}y_t$

(7) ${}_{t-2}w_t = {}_{t-2}p_t + h\, {}_{t-2}y_t$

(8) $i_t = r_t + {}_tp_{t+1} - p_t = r^* + {}_te_{t+1} - e_t$

Notation is: p_t = ln CPI

q_t = ln price of domestic output

$\bar{w}_t$ = ln of geometric average nominal wage

e_t = ln nominal exchange rate

${}_{t-i}p_t = E[p_t | I_{t-i}]$ where I_{t-i} is the information set at $(t - i)$

${}_{t-i}y_t = E[y_t | I_{t-i}]$, where y_t is ln domestic output.

${}_{t-i}w_t$ = ln wage set <u>in</u> period t - i to apply <u>at</u> period t.

r_t = real domestic interest rate.

i_t = nominal domestic interest rate.

* denotes foreign variables (p^* will be assumed equal to zero)

The exchange rate affects both aggregate supply, in equation (2), and aggregate demand, in (3). In both cases an appreciation (decrease in $(e - q)$) tends to increase excess supply. The CPI, in (4), is directly affected by the exchange rate through the price of finished goods imports. Note the distinction between the CPI, relevant to the demand for real balances and the definitions of the nominal interest rate, and the price of domestic output, q, which appears in the supply function (2) and in the net export term in (3).

Labor contracts are for either one or two periods: $_{t-1}w_t$ is the wage set for t at time t - 1, in all one-period contracts and in half the two-period contracts; $_{t-2}w_t$ is the wage set at t - 2 for period t, in half the two period contracts.[4] The coefficient θ is the proportion of wages that were set one period back. Those wages are set on the basis of expected prices and the expected level of output. Labor contracts are the source of imperfect price flexibility, and the reason the adjustment to an unanticipated reduction in the growth rate of money causes a recession.[5] Slow adjustment of expectations--about either policy directly or the rate of inflation--is an alternative source of slow adjustment. I will comment below on the implications of slow expectations adjustment for the relative costs of disinflating with and without exchange rate appreciation.

Treating the average wage and expectations as predetermined, the model is one in which aggregate demand (determined from the money and goods market equilibrium conditions (1) and (3)) and supply (2) interact to determine the price level and output. Given expectations, we can think of (8) as an equilibrium condition that helps determine the exchange rate.

We want now to examine the output costs of a disinflation program. These costs can, in a model like that presented here, be reduced by announcing the program some time in advance, and also by sophisticated manipulation of the growth rate of money during the adjustment period. But because of credibility problems, I assume the policy change takes the form of

[4] Note that $_{t-i}w_t$ is not the expectation at (t - i) of a random variable, w_t, but instead is the wage fixed at (t - i) to apply in period t.

[5] Contracts are for no more than two periods for the sake of simplicity. They are for more than one period to allow the speedier initial disinflation that occurs with exchange rate appreciation to influence the path of nominal wages.

an unannounced and immediate fall in the growth rate of money by one (percent). To analyze dynamics I assume expectations are rational and that the change in monetary policy is fully credible once the initial cut in money growth takes place:[6] the policy change maintains the new lower growth rate of money.

The adjustment to the reduced growth rate of money will be over within two periods, that is, by the start of period two. This is because the longest labor contract is for two periods: within two periods all outstanding labor contracts have been renegotiated, taking into account the lower steady state inflation. By period two the real exchange rate is back to its equilibrium level. Denoting by Δp_j the change in the price level (and similarly for other variables) in period j relative to the level it would have attained had there been no change in monetary policy, we have

$$(9) \quad \Delta p_j = \Delta q_j = \Delta e_j = -[j + 1 + a] \qquad j \geq 2.$$

The inflation rate accordingly falls by one in steady state, while real balances rise relative to their previous level by the amount a, as a result of the lower nominal interest rate. The coefficient a, which is the extent to which the nominal interest rate affects velocity, determines the magnitude of the increase in real balances that has to take place during the disinflation.

During periods zero and one there are changes in real variables, including real output and the real exchange rate. To examine the

---

[6] In Fischer (1984) I examine the costs of disinflation when expectations of policy adjust slowly to changes in policy. As should be expected, a lack of credibility increases the sacrifice ratio. David Backus and John Drifill (1984) present a game-theoretic analysis of the role of credibility in determining the output costs of disinflation.

determinants of the real exchange rate appreciation, it is useful to work back from the period-one relationship between the exchange rate and domestic output price.[7]

$$(10)\quad \Delta e_1 - \Delta q_1 = -\frac{(1+a)(2+a)b_1(1-\theta)}{b_1(1-\theta)x_1+(1+a)x_2}$$

where $\quad x_1 = d + c\mu + (1+a) - \mu$

$$x_2 = (1+b_1h\theta)(d+c\mu) + b_1\theta(1-\mu) + b_2$$

The period one real appreciation is an increasing function of the proportion $(1-\theta)$ of two-period contracts, of b_1, the effect of the real wage on supply, and a, the interest elasticity of money demand; it is a decreasing function of h, d, c and b_2. These results can be summarized as showing that factors that tend to produce larger price level responses by period one to the change in monetary policy undertaken in period zero, reduce the extent of the real appreciation.

Going back one period we find

$$(11)\quad \Delta e_0 - \Delta q_0 = \frac{b_1}{d+c\mu+b_2}\,\Delta q_0 + \frac{c\mu}{d+c\mu+b_2}\,(\Delta e_1 - \Delta q_1)$$

Since the nominal wage is predetermined and does not respond to the change in monetary policy in period zero, the structure of contracts (θ) does not directly enter (11). Given Δq_0, the expectation of period one's real

---

[7]The model is solved by noting that $\Delta m_0 = -1$, $\Delta m_1 = -2$, $\Delta m_2 = -3$, and $\Delta p_2 = \Delta e_2 = -(3 + a)$ and then working back from the period 1 to the period zero equilibrium.

appreciation $(\Delta e_1 - \Delta q_1)$ affects the current real appreciation by its effect on goods market equilibrium through the real interest rate. But of course Δq_0 is affected by all the parameters of the model. Further manipulation of equation (11) does not, however, provide a tractable form of the expression for $(\Delta e_0 - \Delta q_0)$. The complete solution of the model is contained in the Appendix.

In steady state (that is, period two and after), the inflation rate falls by one. The sacrifice ratio is accordingly equal to the sum of output losses in periods zero and one:

$$(12)\quad SR1 = -[\Delta y_0 + \Delta y_1]$$

General expressions for Δy_0 and Δy_1 are presented in the Appendix.

Using the aggregate supply function, we obtain a convenient expression for the sacrifice ratio:

$$(13)\quad SR1 = -\Big[b_1\Delta q_0 + b_2(\Delta q_0 - \Delta e_o) + \frac{(1-\theta)b_1}{1+b_1 h\theta}\,\Delta q_1 + \frac{b_2+b_1\theta(1-\mu)}{1+b_1 h\theta}\,(\Delta q_1 - \Delta e_1)\Big]$$

We will later refer back to equation (13) in comparing the sacrifice ratio with and without exchange rate appreciation. Equation (13) shows clearly the basis for the conventional view that exchange rate appreciation reduces the sacrifice ratio: with Δq_0 and Δq_1 given, the appreciation in both periods zero and one reduces SR1. The zero'th period appreciation has a supply side effect through b_2; the first period appreciation has both a supply side effect and, through the term $b_1\theta(1-\mu)$ an effect that arises because the appreciation reduces the CPI and thus wages in period 1.

Understanding of the open economy effects on the sacrifice ratio is gained by examining the special case in which there are only one period contracts (θ=1). In this case there is no second period loss of output and the sacrifice ratio is just equal to

$$\Delta y_0 = -\frac{b_1(1+a)^2(d+c\mu)}{D_0}$$

where $D_0 = (1+a)(b_1+b_2+d+c\mu) + b_1(d+c\mu-\mu) > 0$

In this case, the output loss is increasing in (a, b_1, c, d, μ) and decreasing in b_2. The loss increases in a because the required increase in real balances to adjust to the new equilibrium is greater the larger is a; increases in b_1 becasue the rise in the real wage has a larger supply effect the larger is b_1; increases in c because the effect on aggregate demand of the increase in the real interest rate is bigger the larger is c; increases in d because the real exchange rate appreciation reduces aggregate demand more the larger is d;[8] and is increasing in μ because the larger is μ, the greater the effect of the exchange rate appreciation on the price level and thus on the real interest rate.[9] The output loss decreases in b_2 because the exchange rate appreciation reduces the costs of imported inputs.

The main question we want to investigate is whether the sacrifice ratio is higher or lower as a result of the real exchange rate appreciation. To answer this question we have to specify the alternative policy: the alternative examined here is to keep the real exchange rate constant at its steady state level during the disinflation. This is carried out through a capital import tax that effectively isolates the domestic capital market and prevents domestic real interest appreciation from causing exchange rate appreciation. With the real exchange rate held constant, the differential

[8] If there was a J-curve, this effect would be delayed.

[9] Note that μ mostly enters the expression for Δy_0 in the form $c\mu$.

between the domestic output price and CPI remains constant in the disinflation process.[10] Indeed, the dynamics of disinflation become those of a closed economy.

The sacrifice ratio when the real exchange rate is held fixed can be calculated as:[11]

$$(14)\quad SR2 = - b_1[\Delta q_0 + \frac{1-\theta}{1+hb_1\theta}\Delta q_1]$$

Comparing (13) and (14), and noting that in (14), $\Delta q_1 = \Delta e_1$, we appear to see that the real exchange rate appreciation reduces the sacrifice ratio--both through the cost side and because it speeds up the adjustment of wages.

However this intuitive comparison of (13) and (14) is misleading in implicitly treating Δq_0 and Δq_1 as independent of exchange rate behavior. The domestic price level falls more when the exchange rate appreciates, and on those grounds appreciation tends to increase the output loss. Thus it is not obvious that SR1 $<$ SR2, i.e. that the sacrifice ratio is smaller with exchange rate appreciation.

Indeed, as Table 1 shows, there is no unambiguous relationship between SR1 and SR2. The output costs of disinflation may be either larger or smaller when the exchange rate is allowed to appreciate than when it is held constant. Table 1 suggests both the sources of the ambiguity and the determinants of the extent of output loss when the exchange rate adjusts.

---

[10] In the modified system, through appropriate choice of constants, equation (3) loses the terms following d; (4) becomes $p_t = q_t$, and the second equality in (8) is removed.

[11] General expressions are presented in the Appendix.

Table 1 Disinflation With and Without Exchange Rate Appreciation

(Base case is: $a=.25$, $b_1=.75$, $b_2=.15$, $c=.15$, $d=.2$, $\mu=.8$, $\theta=.5$, $h=.5$)

Parameters*	With appreciation					Without appreciation				
	Δy_0	Δy_1	$\Delta e_0-\Delta q_0$	$\Delta e_1-\Delta q_1$	SR1	SR2	Δy_0	Δy_1	Δq_0	Δq_1
Base case	-.29	-.32	-1.27	-1.01	.61	.73	-.31	-.43	-.41	-1.34
a=.1	-.26	-.31	-1.17	- .97	.57	.81	-.36	-.45	-.49	-1.42
a=1	-.41	-.40	-1.75	-1.26	.81	.66	-.23	-.43	-.30	-1.36
b_2=0	-.36	-.39	-1.59	-1.23	.76	.73	-.31	-.43	-.41	-1.34
b_2=.6	-.18	-.21	- .80	- .66	.39	.73	-.31	-.43	-.41	-1.34
d=0	-.08	-.19	-2.23	-1.57	.27	.73	-.31	-.43	-.41	-1.34
d=.8	-.44	-.45	-0.54	-0.49	.89	.73	-.31	-.43	-.41	-1.34

*In each case, only one parameter value varies from those in the base case.

In particular, the direct supply (b_2) and demand (d) side effects of the exchange rate appreciation can by themselves reverse the relationship between SR1 and SR2. For instance, when $b_2 = 0$, we find SR2 < SR1, but with b_1 somewhat larger, the inequality is reversed. With b_2 equal to the direct effect on output supply of a reduction in the cost of imported materials, the reason for this result is obvious. Similarly, with d, the direct effect of the exchange rate on aggregate demand equal to zero, SR1 < SR2. The interest elasticity of money demand likewise has a significant impact on the sacrifice ratio. A low elasticity of money demand tends to produce relatively small appreciations and a lower sacrifice ratio.

Although analytical results are difficult to derive, calculations of examples over a wide range of parameter values show the following intuitive features: increases in b_1, the sensitivity of output to the real wage increase the sacrifice ratios for both models; increases in c, the real interest elasticity of aggregate demand likewise increase the sacrifice ratios in both models; an increase in μ--a reduction in the significance of imported goods in the CPI--increases the sacrifice ratio in the case where the exchange rate appreciates; increases in θ, the proportion of two year contracts, increase the sacrifice ratio for both models; increases in h, the sensitivity of the wage to expected output, reduce the sacrifice ratios for both models. None of these results is in any way surprising.

If all contracts are one period ($\theta = 1$) we can show directly the factors determining the relationship between SR1 and SR2. Using the expressions for Δy_0 and Δy_1 in the appendix, with $\theta = 1$, we obtain

$$(15)\quad SR1 \gtrless SR2 \text{ as } d \gtrless c\left(\frac{1}{a} + 1\right)\left[1 - \mu + \frac{b_2}{b_1}\right]$$

Note first that without a sizeable direct effect of the appreciation on aggregate demand (d), the sacrifice ratio with appreciation (SR1) is bound to be less than that without appreciation (SR2). The effects of b_2 and μ on the inequality are similarly straightforward: the larger the supply effect (b_2) and the larger the weight ($1 - \mu$) of the exchange rate in the price index, the more likely SR2 is to exceed SR1. Similarly, the larger is c and the smaller are a and b, the more likely is SR2 to exceed SR1.

These results clearly establish that the sacrifice ratio is not invariant to the path of the exchange rate, contrary to the Buiter-Miller result (op. cit.). There are two reasons for the different results. First, the alternative policy of controlling the exchange rate through taxation of capital inflows is not considered in Buiter-Miller. Second, in this model wages respond to expected policy actions, whereas Buiter-Miller require expectations to be affected only by actual rates of inflation. In their case it takes unemployment rather than expected policy actions to force down the core rate of inflation.

Although the normal presumption would be that exchange rate appreciation reduces the sacrifice ratio, that is not necessarily so. Large aggregate demand effects of the appreciation can make for large output losses. Of course there is a general presumption that the output costs of disinflation can be made lower when both the exchange rate and price of domestic output can be adjusted optimally. But whether the appropriate policy is to appreciate or depreciate the exchange rate depends on the parameters of the economy.

II. Indexation and Disinflation.

Indexation of wage payments to the price level can take several forms. We distinguish among *ex post*, *ex ante*, and *lagged ex post* indexation. In discussing these forms of indexation, we assume that the price index is available only with a lag, typically two weeks, after the month to which is applies. The lag is in practice about a month since the index refers to prices centered on the middle of the month. We take the lag of the index as given.

Ex post indexation would make the wage payment for, say, June, contingent on the actual June price index. The June wages could, for instance, be paid on the day after the index appears. By that date the price level that determines the real value of the wage is different from the price level for which the wage was calculated. Given the price index lag, there is no way of providing a truly certain real wage. In light of this difficulty, *ex post* indexation is in practice lagged: the wage paid at the end of June is adjusted for price level changes up to and including May (providing indexing is monthly). The distinction between ex post and lagged ex post indexing turns on whether anyone who worked in June and then leaves the job will later receive compensation for the June price rise. If they receive compensation, indexation is genuinely ex post; if not, it is lagged ex post.

Ex ante indexation makes the nominal wage paid in June conditional on the price level expected at the end of May to obtain in June. Such indexation is important only in long term contracts. If contracts are for only one period, then the nominal wage will in any event reflect the price level expected to obtain in the period of work. Ex ante indexation has been used (by the government) in Brazil, but is not widely practiced.

To clarify the discussion, consider wage setting with one and two period contracts in a closed economy version of the model of Section I. Some wages for period t were set at the end of (t - 1): they are determined by

(16) $_{t-1}w_t = {}_{t-1}p_t + h\,{}_{t-1}y_t.$

Since these wages are set for the next period, there is no indexing. but wages negotiated for t at the end of (t - 2) may be indexed: they are set by the formula

(17) $_{t-2}w_t = (1 - \lambda_1 - \lambda_2)\,{}_{t-2}p_t + \lambda_1 p_{t-1} + \lambda_2\,{}_{t-1}p_t + h\,{}_{t-2}y_t.$

The term in λ_1 represents lagged ex post indexing of the wage: the wage for period t is adjusted on the basis of the actual period (t - 1) price level. Ex ante indexation is represented by the coefficient λ_2: the wage for period t is adjusted on the basis of the price level expected at the end of (t - 1) for period t.

Ex ante indexation is a method of effectively reducing contract length in an economy with long term contracts, with respect to expected price level changes. For $\lambda_2 = 1$ (and $\lambda_1 = 0$) ex ante indexed wages are, with respect to the price level, the same as those in one period contracts.

The difficulty with ex post indexation (from now on we omit the 'lagged') can be seen by examining (17) when all variables take their expected values. In that case

(18) $w_t - p_t = hy_t - (1 - \theta)\lambda_1(p_t - p_{t-1})$

Given the wage equation (17), the real wage is lower the higher the inflation rate. This phenomenon has been analyzed by Modigliani and Padoa-Schioppa (1978) and Simonsen (1983); in effect it makes for a long-run tradeoff between inflation and output. Such a tradeoff no doubt would not persist since it takes only a negotiation over the wage level to remove it. During a disinflation, the nominal wage level has to be negotiated down; however, the adjustment leaves the real wage unchanged. Such an adjustment at the beginning of a disinflation program is likely to arouse the suspicions of labor, and to be resisted until the disinflation shows signs of working. Because of the difficulty of renegotiating the level, ex post indexation creates difficulties for successful disinflation through its automatic effects on the real wage.[12]

The complete model now consists of

(1) $m_t - p_t = y_t - ai_t$

(19) $y^s_t = b(p_t - \bar{w}_t)$

(20) $y^d_t = -cr_t$

(5) $\bar{w}_t = \theta_{t-1}w_t + (1 - \theta)_{t-2}w_t$

(8) $i_t = r_t + {}_tp_{t+1} - p_t$

---

[12]If the wage bargain aims to reach the equilibrium real wage, then the wage formula may be re-negotiated as contracts re-open. I refer to this possibility in footnote 14 below.

and the wage equations (16) and (17).[13]

We now consider the output costs of disinflation under three alternative assumptions about indexing: no indexation ($\lambda_1 = \lambda_2 = 0$); complete *ex ante* indexing ($\lambda_2 = 1$); and complete lagged *ex post* indexing ($\lambda_1 = 1$). Once again, a disinflation program is instituted in period zero by reducing the growth rate of money by one. For purposes of analysis we assume there is no readjustment of the base wage level with *ex post* indexation.

In the case of both non-indexed and *ex ante* indexed wages, the real adjustment to the disinflation takes the form of a temporary reduction in output. With *ex post* indexation there is a permanent reduction in output. Using Δ to indicate the change in a variable relative to its previous path, we obtain:

$$(21)\quad \Delta y_0 = b\Delta p_0$$

$$(22)\quad \Delta y_1 = \frac{b(1-\theta)}{1 + bh\theta}\left[(1-\lambda_2)\Delta p_1 - \lambda_1 \Delta p_0\right]$$

$$(23)\quad \Delta y_2 = -\frac{b(1-\theta)\lambda_1}{1 + bh} = \Delta y_j \qquad j > 2.$$

The general outline of the results can be seen from (21)-(23). With no indexation, real adjustment takes two periods. With complete *ex ante* indexing, output is below its full employment level only in period zero. All contracts thereafter adjust fully for the expected lower prices, and there is no further output loss. This is the basis of the argument that indexation helps speed up disinflation.

However, comparison of the sacrifice ratio between the non-indexed ($\lambda_1 = \lambda_2 = 0$) and *ex ante* indexed cases requires some care. The impact effect of the disinflation is different in the two cases. The price level in

[13] The coefficient b_1 in equation (2) is replaced in (19) by b.

period zero falls more when the system is fully indexed than when it is not indexed. This is because the price level adjustment in period one is greater in the indexed system and thus the real interest rate in period zero is higher and output is lower.

Accordingly, with ex ante indexation the impact effect of the disinflation is greater: the initial recession is more serious (provided the demand for money is interest elastic). But the recession is over more quickly. The question then arises whether the total output cost is greater in the indexed case. Simple calculations show that the total scrifice ratio is higher when wages are not indexed than when they are. Ex ante indexation of wages accordingly reduces the output costs of disinflation by producing a shorter, sharper recession when the new monetary regime goes into effect.

The comparison between the non-indexed and ex post indexed systems is interesting. The long run calculation is clear: if the real wage level is not adjusted downwards at some stage, the sacrifice ratio for the ex post indexed system is infinite, and larger than the sacrifice ratio for the non-indexed system. But the comparison in the early stages of disinflation is not unambiguously in favor of the non-indexed system.

Assume for purposes of discussion that $a = 0$, so that the real interest rate channel by which expected future deflation affects current output is cut off. In period zero the nominal wage is given. The extent of the zero'th period recession is thus the same between the two systems. (If a were not equal to zero, the first period recession would be bigger in the indexed system.)

We want now to compare output losses in period one. In both systems those wages that were negotiated at the end of period zero have reacted to the disinflation program. In the indexed system, indexed wages are reduced to a level below those on non-indexed contracts, as a result of the lower price level in period zero. The presumtpion is then that output costs in period one will be lower in the indexed system.

In the non-indexed system the price level in period 1 is lower by an amount

$$(24)\ \Delta p_1(NI) = -\frac{2}{1 + \frac{b(1-\theta)}{1 + bh\theta}}$$

In the indexed system the price level falls by more:

$$(25)\ \Delta p_1(EPI) = -\frac{2 + \frac{b(1-\theta)}{(1+b)(1+bh\theta)}}{1 + \frac{b(1-\theta)}{1 + bh\theta}}$$

The more rapid deflation in the indexed system is a result of the lower average nominal wage level in period 1 in that system, for output in the indexed system is given by

$$(26)\ \Delta y_1(EPI) = -\frac{b(1-\theta)(1+2b)}{(1+b)[1 + bh\theta + b(1-\theta)]}$$

while the output loss in the non-indexed system is

$$(27)\ \Delta y_1(NI) = -\frac{2b(1-\theta)}{[1 + hb\theta + b(1-\theta)]}$$

The latter output loss is larger.

The conclusion is then that even <u>ex post</u> indexation may be an aid to rapid disinflation, by permitting some flexibility in the right direction in wages set by long term contracts. But unless the base level nominal wage is reset appropriately, <u>ex post</u> indexing will create more long run output costs than would occur in a non-indexed system.[14]

The appropriate level readjustment takes place automatically with <u>ex ante</u> indexing. That is why <u>ex ante</u> indexation provides the lowest sacrifice

[14]If the wage level under <u>ex post</u> indexation is negotiated down at the reopening of each contract, then disinflation has a lower output cost with ex post indexation than when wages are not indexed.

ratio. But *ex ante* indexation, it has to be recognized, is an unusual concept in that it explicitly sets wages on the basis of some agreed upon price level forecast. Such forecasts are used by both sides to wage negotiations, but they typically remain in the background. It is not difficult to imagine that negotiators could agree that the forecasts of some respected institution or economist could serve this purpose.

III. Conclusions.

In this paper I have examined the consequences for the sacrifice ratio of changes in real variables that may take place during a disinflation. In addition to the well known reduction in the price level relative to trend arising from an increase in the demand for real balances, we considered the effects of exchange rate appreciation and wage indexation on the costs of disinflation.

There appears to be no unambiguous presumption about the effects of exchange rate appreciation on the output costs of disinflation. But contrary to other results, we did not find the sacrifice ratio to be invariant to the path of the exchange rate. The major factors tending to make disinflation with exchange rate appreciation less costly are a large supply side effect of the real appreciation, and a large share of imports in the consumer price index. A large demand side effect through reduced net exports can be sufficient to make the sacrifice ratio with appreciation larger than that when the real exchange rate is held constant.

Indexation, *ex ante* or *ex post*, speeds up the response of the economy to disinflation. In the early stages of the disinflation, indexation reduces the extent of the recession (measured by total loss of output relative to trend) caused by an unannounced but thenceforth fully credible reduction in the growth rate of the economy. But unless there is a base nominal wage adjustment, the application of ex post indexing by formula will have a long term recessionary effect. Such real wage level effects of indexation may well account for the blame it receives an an impediment to disinflation.

REFERENCES

Backus, David and John Driffill (1984). "Rational Expectations and Policy Credibility Following a Change in Regime," unpublished, Queen's University.

Buiter, Willem H. and Marcus Miller (1983). "Real Exchange Rate Overshooting and the Output Cost of Bringing Down Inflation: Some Further Results," in Jacob A. Frenkel (ed.), Exchange Rates and International Macroeconomics, University of Chicago Press.

Dornbusch, Rudiger (1976). "Expectations and Exchange Rate Dynamics," Journal of Political Economy (Dec.), 1161-76.

——— and Stanley Fischer (1984). "The Open Economy: Implications for Monetary and Fiscal Policy,"unpublished, M.I.T.

Driffill, E. John (1982). "Optimal Money and Exchange Rate Policies," Greek Economic Review, 4, 3 (December), 261-283.

Fischer, Stanley (1984). "Contracts, Credibility, and Disinflation," NBER Working Paper #1339.

Gordon, Robert J. (1982). "Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment," in Martin N. Baily (ed.)., Workers, Jobs, and Inflation, Brookings Institution.

Modigliani, Franco and Tommaso Padoa-Schioppa (1978). "The Management of an Open Economy with '100% Plus' Wage Indexation," Princeton Essays in International Finance.

Okun, Arthur (1978), "Efficient Disinflationary Policies," American Economic Review (May), 348-352.

Simonsen, Mario H. (1983). "Indexation: Current Theory and the Brazilian Experience," in Rudiger Dornbusch and Mario Simonsen (editors), Inflation, Debt, and Indexation, M.I.T. Press, 99-132.

Appendix

This appendix contains general expressions for changes in the price level, exchange rate, outut, and real interest rate following the change in monetary policy.

1. When the real exchange rate is allowed to adjust, we obtain

$$\text{(A1)}\quad \Delta y_1 = -D_1^{-1}(1+a)(2+a)b_1(1-\theta)(d+c\mu)$$

$$\text{(A2)}\quad \Delta q_1 = -D_1^{-1}(1+a)(2+sa)x_2$$

$$\text{(A3)}\quad \Delta e_1 = -(2+a)\{1-D_1^{-1}b_1(1-\theta)(d+c\mu-\mu)\}$$

$$\text{(A4)}\quad \Delta r_1 = \mu(\Delta q_1-\Delta e_1)$$

$$D_1 = (1+a)x_2+b_1(1-\theta)x_1$$

$$x_1 = (d+c\mu)+(1+a) - \mu$$

$$x_2 = (1+b_1h\theta)(d+c\mu) + b_1\theta(1-\mu) + b_2$$

$$\text{(A5)}\quad \Delta y_o = \Delta y_1 \frac{c\mu}{d+c\mu} D_o^{-1}[b_1\mu-(1+a)(b_1+b_2)]$$
$$+b_1(a\Delta e_1-1)(d+c\mu)D_o^{-1}$$

$$\text{(A6)}\quad \Delta q_o = D_o^{-1}[-\frac{c\mu}{d+c\mu}\Delta y_1(1-\mu+a-b_2) + (b_2+d+c\mu)(a\Delta e_1-1]$$

$$\text{(A7)}\quad \Delta e_o = D_o^{-1}[\frac{c\mu z_2}{d+c\mu} + (a\Delta e_1-1)z_1]$$

$$\text{(A8)}\quad \Delta r_o = \mu(\Delta e_1-\Delta q_1)-\mu(\Delta e_o-\Delta q_o)$$

$$D_o = z_1(1+a+b_1)-b_1z_2$$

$$z_1 = b_1+ b_2+d+c\mu$$

$$z_2 = b_1+ b_2+\mu.$$

2. When the real exchange rate is held fixed,

$$\Delta q_j = \Delta e_j = \Delta p_j, \qquad j=0,1$$

Then

(A9) $\Delta y_1 = -G_1^{-1} \left[b_1(1-\theta)c(1+a)(2+a)\right]$

(A10) $\Delta q_1 = -G_1^{-1} \left[(1+b_1 h\theta)c(1+a)(2+a)\right]$

(A11) $\Delta r_1 = -\frac{\Delta y_1}{c}$

$$G_1 = \left[(1+b_1 h\theta)c(1+a) + b_1(1-\theta)(c+a)\right]$$

(A12) $\Delta y_o = G_o^{-1} b_1 c \; (a\Delta q_1 - 1)$

(A13) $\Delta q_o = G_o^{-1} c \; (a\Delta q_1 - 1)$

(A14) $\Delta r_o = -\frac{\Delta y_o}{c}$

$$G_o = b_1(c+a) + (1+a)c$$