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by

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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

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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.

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 sacrifice ratio. 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 Okun (1978) but in line with predictions that allowed for exchange-rate changes as an extra channel through which monetary policy affects the inflation rate [Gordon (1982)].

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

One method for dealing with the credibility problem associated with the increase in real balances during a disinflation is to wait until credibility has been established by the creation of a deep recession before providing an increase in the nominal money stock. Table 1 shows that there was such an increase in the money stock in the United States in the period 1982:4-1983:2. The sharp increases in the rates of growth of money were at the time blamed on shifts in the demand for money, and can also be attributed to Federal Reserve concern over the international debt problem. They are nonetheless consistent with the Fed's having relieved the excess deflationary pressure arising from the increase in the quantity of real balances demanded as a result of disinflation.

Table 1. U.S. Money Growth and the Recession

	M1 growth	M2 growth	Unemployment rate
1980	9.4	9.0	7.1
1981	5.1	9.3	7.5
1982:1	10.7	9.9	8.7
1982:2	2.2	7.5	9.3
1982:3	6.3	9.7	9.8
1982:4	16.3	11.0	10.5
1983:1	13.4	22.1	10.2
1983:2	12.1	11.0	9.9
1983:3	9.8	7.1	9.2

Source: Data Resources, Inc.

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, and 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 program relative to costs that would have been incurred had the real exchange rate been held 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 [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 increase competitive pressure, it does so through the creation of unemployment. The analysis of Buiter and Miller (1983) concludes that exchange rate appreciation and subsequent depreciation during a disinflation does not affect the sacrifice ratio.

In the case of indexation, theoretical analysis shows that indexation reduces the output costs of disinflation by permitting a more rapid res-

ponse 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 use simple models with long-term labor contracts to examine the output costs of disinflation. The analysis presented in Section I below shows that the sacrifice ratio is not independent of the path of the exchange rate during the disinflation, but does not establish a presumption as to whether exchange rate appreciation reduces or increases the sacrifice ratio. The analysis of Section II distinguishes ex post from ex ante indexation. Actual indexation is typically ex post: as a result, the real wage tends to rise in a disinflation when wages are indexed. This 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

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:

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

$$(2) \qquad y_t^s = b(q_t - \bar{w}_t)$$

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

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

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

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

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

$$(8) \qquad i_t = r_t + {}_t p_{t+1} - p_t = r^* + {}_t e_{t+1} - e_t$$

Notation is: p_t = CPI

q_t = price of domestic output

$\bar{w}_t$ = average nominal wage

e_t = nominal exchange rate

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

${}_{t-i}y_t = E[y_t | I_{t-i}]$

${}_{t-i}w_t$ = wage set in period $t - i$ to apply at period t

r_t = real domestic interest rate.

Other notation is standard. Relevant variables are logarithms.

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, 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.[2] The coefficient θ is the proportion of wages that were set one period back.

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, we assume the policy change takes

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[2] Labor contracts are the source of imperfect price flexibility; two-period contracts are included so that the dynamics of disinflation are affected by exchange rate behavior; contracts are for no more than two periods for the sake of simplicity.

the form of an unannounced and immediate fall in the growth rate of money by one (percent). To analyze dynamics we assume expectations are rational and that the change in monetary policy is fully credible once the initial cut in money growth takes place: 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_i the change in the price level (and similarly for other variables) in period i relative to the level it would have attained had there been no change in monetary policy, we have

$$\Delta p_i = \Delta q_i = \Delta e_i = -[i + a] \qquad i \geq 2. \tag{9}$$

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.

During periods zero and one there are changes in real variables, including real output and the real exchange rate. As in the standard Dornbusch (1976) model, there is exchange rate overshooting, with the real exchange rate appreciating relative to its steady state level. There is also a temporary recession, resulting from the inflexi-

bility of wages which are high relative to the price of output. The recession occurs not only because of a supply side effect through high real wages but also because the reduction in real balances reduces aggregate demand and because the exchange rate appreciation reduces net exports.

To examine the 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.

$$(10) \qquad \Delta e_1 - \Delta q_1 = b(1 - \theta)\left[\mu c + d + \frac{b\theta(1 - \mu)}{1 + hb\theta}\right]^{-1} \Delta q_1 \ .$$

The period-one real appreciation is an increasing function of the proportion $(1 - \theta)$ of two-period contracts and a decreasing function of the parameters c and d through which the interest and exchange rate appreciations affect output.

Going back one period, we find

$$(11) \qquad \Delta e_0 - \Delta q_0 = \frac{b}{\mu c + d} \Delta q_0 + \frac{\mu c}{\mu c + d} (\Delta e_1 - \Delta q_1)$$

Since the nominal wage is predetermined, the structure of contracts does not directly enter (11): the extent of the real appreciation is determined by the aggregate supply (b) and demand (c and d) parameters, much as in (10).

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

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

$$= -b\left[\Delta q_0 + \frac{(1 - \theta\mu)}{1 + hb\theta}[\Delta q_1 - \Delta e_1] + \frac{1 - \theta}{1 + hb\theta} \Delta e_1\right]$$

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 between the domestic output price and CPI remains constant in the disinflation process.[3] Indeed, the dynamics of disinflation become those of a closed economy. The sacrifice ratio can in this case be calculated as:

$$(13) \qquad SR2 = -b\left[\Delta q_0 + \frac{1 - \theta}{1 + hb\theta}\,\Delta q_1\right] .$$

Comparing (12) and (13), and noting that in (13), $\Delta q_1 = \Delta e_1$, we see that (12) includes a term in $(\Delta q_1 - \Delta e_1)$ that is missing from (13). Since the real exchange rate appreciates in the disinflation, the extra term in (12) tends to reduce the sacrifice ratio. The coefficient of $(1 - \theta\mu)$ on this term suggests it is present because the exchange rate appreciation can be reflected in one period contracts and because the price level to which the wage adjusts is the CPI and not the price of

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[3] 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.

output [hence the coefficient $(1 - \theta\mu)$ is smaller the larger is μ, or the more important is the role of the exchange rate in determining the CPI].

The suggestion is, then, that the exchange rate channel may reduce the output costs of disinflation by reducing the nominal wage level during the disinflation process: the quick success in bringing down prices through appreciation feeds into wages and thus reduces the sacrifice ratio.

This intuitive comparison of (12) and (13) does not however establish that the sacrifice ratio is lower when the exchange rate channel is permitted to operate. The argument above omits several channels through which the exchange rate affects output. For instance, when the real exchange rate appreciates, the demand for output falls more than when the exchange rate is held constant.

The impact effect of the change in the growth rate of money can be discussed by assuming all contracts are for only one period. In that case the real exchange rate will be back at its equilibrium level in period 1. Under those conditions, the effect on output and the sacrifice ratio is proportional to the period zero change in the price of domestic output. If $\theta = 1$, we obtain:

$$(14) \qquad \frac{SR1}{SR2} = \frac{d}{c(1 - \mu)[1 + 1/a]} .$$

The sacrifice ratio when the exchange rate appreciates (SR1) tends to exceed that with fixed rates (SR2) the higher are d, μ, and a, and the lower is c.

When the exchange rate appreciates, aggregate demand is reduced by a fall in net exports: hence the term in d. The larger is $(1 - \mu)$, the more the exchange rate appreciation reduces the excess demand for money: hence the term in $(1 - \mu)$. The interest rate appreciation is lower (when the exchange rate appreciates) the higher is c and the smaller is a.

With the relative impact effects of the stabilization program dependent on parameter values, it would be surprising if there were in general an unambiguous relationship between SR1 and SR2. Indeed, as Table 2 shows, there is no such unambiguous relationship. Permitting the exchange rate channel to operate may either increase or reduce the sacrifice ratio.

Table 2. Disinflation With and Without Exchange Rate Appreciation

(Common parameter values are: $b = 1$, $c = .25$, $d = .5$, $\theta = .5$, $h = .5$)

	With appreciation				Without appreciation		
Parameters	SR1	Δe_1	Δq_1	Δq_0	SR2	Δq_1	Δq_0
$a = .25$, $\mu = .1$	.665	-2.03	-1.40	-.33	.962	-1.37	-.41
$a = .25$, $\mu = .5$	.862	-2.18	-1.47	-.42	.962	-1.37	-.41
$a = .5$, $\mu = .5$	1.000	-2.43	-1.64	-.50	.954	-1.39	-.40

There is certainly no reason to believe that the sacrifice ratio is invariant to the path of the exchange rate, contrary to the Buiter-Miller

(op. cit.) result. But, despite this effect of the exchange rate appreciation in reducing second period nominal wages when the exchange rate is flexible, it is not certain whether the exchange rate appreciation reduces the output costs of disinflation. 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 or lep 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 it 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

$$(15) \qquad {}_{t-1}w_t = {}_{t-1}p_t + h\,{}_{t-1}y_t \,.$$

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

$$(16) \qquad {}_{t-2}w_t = (1 - \lambda_1 - \lambda_2)\,{}_{t-2}p_t + \lambda_1 p_{t-1} + \lambda_2\,{}_{t-1}p_t + h\,{}_{t-2}y_t$$

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 (16) when all variables take their expected values. In that case

$$(17) \qquad w_t - p_t = hy_t - (1 - \theta)\lambda\ (p_t - p_{t-1})$$

Given the wage equation (16), the real wage is lower the higher the inflation rate. This phenomenon has been analyzed by Modigliani and Padoa-Schioppa (1978): 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.

The complete model now consists of

$$m_t - p_t = y_t - ai_t \tag{1}$$

$$y_t^s = b(p_t - \bar{w}_t) \tag{18}$$

$$y_t^d = -cr_t \tag{19}$$

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

$$i_t = r_t + {}_t p_{t+1} - p_t \tag{8}$$

and the wage equations (15) and (16).

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:

$$\Delta y_0 = b\Delta p_0 \tag{20}$$

$$\Delta y_1 = \frac{b(1 - \theta)}{1 + bh\theta}[\Delta p_1(1 - \lambda_2) - \lambda_1 \Delta p_0] \tag{21}$$

$$\Delta y_2 = -\frac{b(1 - \theta)\lambda_1}{1 + bh} = \Delta y_i \qquad i \geq 2 . \tag{22}$$

The general outline of the results can be seen from (20)-(22). 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 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 sacrifice 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 nominal 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 regression 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 presumption 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

$$(23) \qquad \Delta p_1(NI) = - \frac{2}{1 + \frac{b(1 - \theta)}{1 + bh\theta}}$$

In the indexed system the price level falls by more:

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

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

$$(25) \qquad \Delta y_1(EPI) = - \frac{b(1 - \theta)(1 + 2b)}{(1 + b)[1 + bh\theta + b(1 - \theta)]}$$

while the output loss in the non-indexed system is

$$(26) \qquad \Delta y_1(NI) = - \frac{2b(1 - \theta)}{[1 + hb\theta + b(1 - \theta)]}$$

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.

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

This paper has examined 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.

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 as an impediment to disinflation.

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